‘Soft metrics’: development and application of a framework for the measurement of human and organisational factors in projects

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‘Soft Metrics’: Development and application of a framework for the measurement of human and organisational factors in projects

Jonathan Benn

Doctoral Thesis submitted in partial fulfilment of the requirements for the award:
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Abstract

The 'soft metrics' project was a defence industry sponsored research activity undertaken to develop project performance analysis and control capabilities for systems engineering operations within BAE SYSTEMS. The 'soft' focus of this work addresses the less 'tangible' human and organisational factors that influence project effectiveness as measured by key contractually-determined cost, quality and time parameters related to delivery of the product. The key research objectives were: 1) to investigate the nature and influence of soft performance issues in projects, 2) to explore the extent of existing research and development knowledge for control of soft factors, 3) to develop an appropriate practical approach to the analysis and measurement of soft issues with tools to support project performance management efforts, and 4) to make a feasibility case for the research product through application and validation in operational case projects.

The research approach involved in-depth, qualitative study of four relevant case projects undertaken to define the industrial context for application, support an iterative development process and validate the results of development efforts towards the specification of an integrated soft metrics tool and approach. An industry scoping study and detailed review of relevant research and operations management literature revealed a gap in current project management metrication practices regarding soft factors analysis and measurement capability. Building upon existing sociotechnical performance factors models an applied Human and Organisational Performance (HOP) modelling framework was developed for the representation of dependencies between 'upstream' process indicators and 'outcome' effectiveness criteria in a systems engineering project context. Review of human sciences research literature and subsequent refinement through case-based investigation led to the identification of over 100 potential human and organisational performance variables with which to populate the HOP model, representing a variety of 'soft issues' known to influence performance in industry project based operations. Implicated factors were associated with issues relating to: team composition, human knowledge and experience, work group climate and cohesion, functional autonomy, task and goal characteristics, human workload, motivation, stakeholder communication and project management decision-making processes, amongst others. A variety of soft metrics and techniques for quantification of these factors were developed through a multi-facet approach to measurement that involved decomposition of broad, higher-level variables into specific sub-factors. Appropriate subjective judgement-based items and objective criteria were defined to numerically quantify variance in specific sub-factors.

To provide a practical, integrated solution an application process with detailed sub-activities was developed to allow project management teams to identify and analyse 'soft' performance problem issues and select appropriate soft metrics for proactive monitoring and control within the project's lifecycle. This process was subsequently successfully implemented in three systems engineering case projects. Through implementation of a structured approach in focus groups, project managers reported they were able to identify and reason about complex human and organisational factors that had previously been managed intuitively, and relate them to specific effects upon project performance outcomes to support risk assessment. A variety of performance-critical 'system preconditions' were identified and linked to key outcome objectives within the HOP modelling framework, through their impact upon specific human activities or 'behavioural' variables that represented human performance in the project work environment. In terms of feasibility, project work groups reported that the soft metrics approach was of potentially high utility in supporting performance control through project planning, work process improvement efforts and project performance review activities, providing that practical issues associated with the level of effort currently involved in the implementation of the prototype tool were resolved. This work highlights metrication of human and organisational factors in projects as an important and viable area for future research work to support enhancement in operations performance management capabilities.
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Section 1
INTRODUCTION

This thesis reports research work undertaken to develop and apply a framework for the analysis and measurement of human and organisational performance factors within systems engineering projects. The area related to the application of measures of human and organisational determinants to monitor performance is known as 'soft metrics' in the applied project management environment. In introducing the work reported within this thesis, the following sections outline the project's background, key research objectives, rationale for the research methods selected and culminate in an overview of the structure of the thesis.

1.1 Background to the project

The Soft Metrics Research Studentship for this project was jointly funded by an academic-industrial collaborative arrangement, as part of the Industrial CASE scheme. The award itself was held between April 2001 and April 2004. BAE SYSTEMS was the host organisation in collaboration with the EPSRC. The CASE scheme allows industrial organisations to sponsor research in areas directly related to commercial and industrial interests as well as forging links with academic departments to facilitate the applicability of research in a particular industrial domain. The CASE research student is jointly supervised both by academic and industry sponsors and receives direct access to the industrial environment in which the research is to be applied.

As an industry-sponsored project, the Soft Metrics work was subject to both academic and industrial requirements from BAE SYSTEMS. Access was provided to BAE SYSTEMS operations (systems engineering and development projects, personnel, research networks and documented working-practices) for the purposes of establishing a clear context for application and to provide case projects to scope and validate the research output. Technical progress and issues arising within the project were reviewed and managed from the academic perspective by project supervisors at Loughborough University, and from the integrated industry-academic perspective through the Systems Integration Consortium (SIC) research.
network, which was set up by BAE SYSTEMS in 1999 as a forum for discussion of related research areas of interest to the organisation's operations. The SIC reported to a steering group that comprised lead industry and academic research and development sponsors. This body was responsible for the governance of several specific industry-academic partnership projects aimed at developing BAE SYSTEMS operational capability for future technological and commercial advantage. Loughborough University's participation involved a portfolio of related research projects, of which the soft metrics work was one, linked by the theme of organisational capability acquisition. The work reported within this thesis was therefore conducted with the overriding aim of developing specific operational capability for practical project management and control systems in BAE SYSTEMS, with the specific focus of work relating to the area popularly known within the engineering management domain as "soft metrics": the measurement of uncertain human and non-technical "process" issues that impact upon operational performance.

1.2 General Research Objectives

The metrics project was 'proof of concept' in nature, designed to deliver knowledge regarding the feasibility and potential costs/benefits of a soft metrics program, rather than a fully deployed and operational solution in the applied industrial environment identified for this work. The soft metrics research question is a relatively new area of research, requiring 'proof of concept' study to be performed first before significant resources are committed to development and integration of a soft metrics program within industrial operations. The research area itself may therefore be regarded as novel, with current practical knowledge regarding a soft metrics operational capability in project management and control activities being relatively immature. As with all conceptual development projects, the project opened with broad requirements that were updated throughout the course of the project, as more was learnt about the research topic, application environment and feasibility of the proposed solution. Defining the exact requirements and specific functionality for a metrication system and process was therefore part of the research undertaken and not a starting condition that could be specified with any great degree of certainty at project onset.

The project adopted a case-based, iterative development approach that sought to deliver successive approximations of the work product for validation and feedback, throughout the project's course. The specific requirements that were developed during the course of the project are outlined in section 2.4 of this thesis. By way of an introduction to the research reported in this thesis, the broad overriding research objectives that represent the main areas of interest for the soft metrics project are summarised in figure 1.2a below.
Main research objectives

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>1</td>
<td>Identify ‘soft’ issues impacting upon project performance</td>
</tr>
<tr>
<td>2</td>
<td>Explore current best practices for analysis, measurement and control of human and organisational variables in projects</td>
</tr>
<tr>
<td>3</td>
<td>Develop practical approach and tools for analysis and measurement of soft issues in projects</td>
</tr>
<tr>
<td>4</td>
<td>Make utility and feasibility case for soft metrics concept and tools</td>
</tr>
</tbody>
</table>

*Figure 1.2a: Main research objectives for soft metrics research project*

1.3 Research approach and method

In addressing the research approach and methods employed within the soft metrics project, the following sub-sections consider the underlying ‘systems’ research paradigm and the nature and sequence of research activities undertaken during the course of the project. In addition to these issues, this section also states the rationale for the principal means of data collection and analysis within the project.

1.3.1 Research paradigm: a ‘systems’ approach

In an introductory text to the social science of organisational behaviour, Buchanan and Huczynski (1997) offer some consideration to the difficulties of applying an empirical, natural sciences approach to the study of social phenomenon. Alternative methods are therefore warranted, as social and human variables within complex socio-technical systems are typically difficult to quantify and often cannot be adequately expressed numerically. The result is an increased reliance upon the observer’s judgement, intuition and understanding of the situation that forms the context of the study.

Several authors (e.g. Checkland & Scholes, 1990; Senior, 2002) advocate a ‘soft’ systems approach to cope with the problems associated with soft complexity in socio-technical and organisational systems. Checkland (1999) states that the systems discipline is an alternative approach to the reductionist methods employed in conventional science’s experimental paradigm, for application in instances which display ‘organised complexity’, such as in whole organisational and social system entities. Empirical reductionist approaches seek to reduce complex phenomenon to the operation of a series of simple, controllable and measurable
variables with the aim of achieving scientifically reproducible results. In contrast, systems thinking acknowledges that complex interactions take place between many conditions within and beyond the boundaries of a system. The resulting ‘emergent’ behaviour is difficult to causally model without adopting an all-encompassing view of the whole entity and critically considering where to draw the boundaries between what to include in the systems model and what to leave out. Checkland states that ‘systems thinking’ is a more appropriate tool for application in management science and for the study of complex human society and human activity or work systems, which display characteristics of organised complexity.

An important issue derived from the study of organisational complexity is that modern organisations are complex systems that display high levels of tightly coupled, interdependent elements (Perrow, 1984). High dependency therefore exists between an organisational systems' social and technological components; characteristics associated with human elements, the organisation of work and the more tangible structural or technological elements are integrated within cohesive work systems within the organisation. A second important aspect of complex systems is that their behaviour is characteristically non-linear, sometimes discontinuous and therefore essentially unpredictable. The resulting systemic complexity means that organisational systems are often opaque to organisational developers who possess the task of intervening in the functioning of the broader system in order to effect some change or improvement that will deliver enhancements to existing outcome performance or establish some new performance capability, without adversely affecting other aspects of organisational functioning. Problems such as these are subsequently compounded when organisational development efforts are aimed at the medium to long term, due to the non-static nature of organisational systems.

In response to these considerations, an ‘action research’ methodology was employed within the soft metrics project (e.g. Saunders et al, 2000). Inherent in this approach, the researcher is acknowledged as part of the social system in which the research is designed to effect change. Through operating within the applied environment the research product can be developed with fuller knowledge of: 1) specific requirements and need within the application domain, 2) social and political implications of the proposed change, and 3) opinions and views of the end-users. This perspective in effect allows the researcher to develop knowledge of the entire sociotechnical system that forms the area of study for development through networking and in-depth qualitative study afforded by contact with individuals within the organisational system of interest. Close ties to the target application environment also ensure the availability of feedback and potential case scenarios in which to test the developed solution at intermediary stages of the project, supporting iterative development.
1.3.2 Research process and key activities

The general course of the soft metrics research activities undertaken within this project was iterative in nature, based upon production of successive approximations of the end product which were validated and offered for feedback in the operational environment in which the work was conceived to apply. Figure 1.3.2a below depicts the main logical workflow between specific activities undertaken during the course of the project to achieve its main research objectives. The diagram depicts the main iterative processes and feedback loops in addition to the main workflow within the project plan. Consequently, the research process was not specifically linear in nature and had to be flexible to respond to opportunities in the applied operational environment. Simultaneous activities were therefore performed and earlier phases of the project revisited to further refine the output of the research work in light of new knowledge that became available.

Figure 1.3.2a: Research process and key activities
The main sequence of workflow within figure 1.3.2a represents a logical sequence of activities or project phases designed to build upon the achievements of previous stages. The initial activity (activity ‘A’ in the figure) involved formulation and clarification of the problem the soft metrics research project was attempting to address, through establishing broad research and specific functional requirements, identification of a defined user-group and system boundary and development of a clear research plan with defined intermediary objectives represented by ‘deliverables’ submitted to industry for comment and feedback. Following initial specification of objectives, base research activities were performed including critical review of relevant literature (activity B1) and execution of an industry scoping study (activity B2). The literature review activity involved building a clear knowledge base representing industry best practices and current academic knowledge for the soft metrics area, through identification and analysis of existing applied approaches and research findings. The industry scoping study utilised an available ongoing capability development project within BAE SYSTEMS to identify the application context and need for the soft metrics work product. Both activities fed back into definition of the research requirements, as new knowledge was uncovered representing what it was feasible to achieve through the research effort. The scoping study also provided an environment in which to gather evidence of the validity of potential human and organisational performance variables identified through the literature review and was subsequently used to refine the focus of the literature review.

Following the initial activities outlined above, the process of iterative development of a potential solution to the research problem began (activity ‘C’), based upon experience within the scoping study and findings from the literature review concerning the current knowledge gap in existing research. This activity represents the development of soft metrics and an approach to analysing soft issues in industry projects. Experience within the research work undertaken generated key development issues that were again used to feed back into the requirements for the project as new knowledge was gained regarding what it was practical to achieve within the scope and constraints of the project. The output from the development activities undertaken within the project was validated at various stages in two main activities. Theoretical validation (activity ‘D1’) involved a conceptual exercise in which the emerging approach was applied to a hypothetical scenario, based upon known human and organisational processes, in order to assess its adequacy for dealing with traits that might be encountered in an operational environment. The theoretical validation activity therefore represents assessment of the emerging tool and proof of the concept from an expert knowledge perspective, based upon its applicability to processes defined through review of existing research and expert knowledge in the area.

The industry case-based validation activity (activity ‘D2’) represented application and evaluation of the emerging tool and associated methods within three operational industrial
projects, in order to assess fitness for purpose, effectiveness and practical feasibility. This activity represents the main means of capturing usability and evaluative data for the soft metrics project that fed into data analysis and interpretation activities (activity 'C'). Both quantitative and qualitative data were captured and analysed during this process in order to make a clear proof of concept case for the emerging metrics tool and approach, which could then be used to further develop the research product according to experience within operational projects and during theoretical validation. Finally, overall conclusions were drawn and the knowledge gained as a result of experiences within the soft metrics research project was considered (activity 'D'). During this final phase of the project, reported research findings were related specifically back to the project requirements and initial problem statement, in order to assess what had been achieved.

1.3.3 General methodology and rationale for case-based approach

The principal research method employed within the soft metrics project was in-depth study of relevant case scenarios. Consideration of several issues was relevant in the selection of this approach as appropriate. The intangible, ambiguous nature of many human-related variables in the workplace means that they are not easily observable and hence difficult to operationalise and define in measurable criteria compared with 'harder', technical parameters. Social research involving the study of motivational factors, perceptions and knowledge requires specific knowledge of the application context and extensive contact with the individuals that form the focus of study. Human systems are dynamic rather than static, with changing membership and organisation. Social environments, such as those found within organisations, are unique and complex situations which confound attempts to generalise knowledge relevant in one setting to another and make interactions between variables complicated and opaque to the external observer. The result of such complexity in 'soft' variables is often profound problems of interpretation, which may be confounded when the researcher adopts an empirical, reductionist methodology that ignores qualitative evidence that establishes the exact nature of cause and effect relationships and that explores observed phenomenon in depth.

What were predominantly qualitative methods were selected as appropriate for research activities executed within the context of the soft metrics research project. This decision was made on the basis of several practical and theoretical considerations. As industry-sponsored research, a clearly defined context for application of the soft metrics research product was identifiable. The soft metrics research project aimed to prove the concept and validity of soft metrics tools for support of performance control processes in the specific environment represented by BAE SYSTEMS' project operations. From this perspective an in-depth
prototyping development process was necessary to demonstrate the feasibility and utility of
the research product and large-scale, cross-sample quantitative analysis to determine the
generalisability of emerging soft metrics tools and techniques was considered unwarranted,
where in-depth qualitative analysis of applicability within the target environment was feasible.
Accordingly an in-depth qualitative case-study approach was adopted due to ready
availability of specific projects through the industrial sponsor and limited opportunity for
identification of a large-scale sample.

Due to the highly interdependent nature of potential performance variables in complex
sociotechnical systems, adopting a holistic 'systems perspective' in establishment of a
research approach was considered important. Such an approach does not seek to reduce
what are complex functional processes and behaviours to the operation of a limited set of
'experimental' variables, but adopts a multivariate approach to account for emergent
properties and complex interactive processes within more comprehensive systems models.
The focus upon sociotechnical factors in broad organisational systems requires a multitude of
factors and influences to be considered and qualitative methods were selected as appropriate
for this aim, due to the requirement for large-scale samples in robust multi-factor statistical
applications.

As artefacts of the functioning of human activity systems, soft issues are predominantly
associated with subjective human experience of the working environment and perceptual
processes. Appropriate methods of study identified therefore include in-depth knowledge
elicitation methods implemented through structured interview and focus groups, rather than
broad quantitative survey-type measures. Soft performance issues in projects are
idiosyncratic and context-specific in nature, requiring more explorative, action research based
approaches rather than prescriptive quantitative methods, which anticipate specific issues.
The aim for the development of soft factors support tools was therefore comprehensiveness in
coverage of potential human and organisational issues that might arise in varied operational
scenarios rather than focus upon a specific human or organisational issue.

Due to the issues raised above and the necessity to develop practical approaches and
methods applicable within a specific applied context as represented by the operations of the
industrial sponsor of the soft metrics work, a case-based methodology was employed
extensively throughout this project. As the application context was predefined, the soft
metrics research effort could focus upon a number of specific industry scenarios for in-depth
qualitative analysis, as opposed to adopting a cross-sectional, large-sample research
approach. During the case studies, a variety of methods were employed including focused
group discussions, qualitative analysis of text recorded from comments made during the case
studies, quantitative data collection against set items and open-structured exercises which
allowed participants to try out various features of the emerging soft metrics tool and attempt to analyze performance processes within their own projects. Qualitative data was recorded extensively throughout the validation exercises and later analyzed for themes relating to defined topics of interest, as specified from a list of important constructs or variables identified from the literature review, for development of both the features of the research product and evaluation of its effectiveness.

*Figure 1.3.3a* below illustrates how an evidence base supporting the features of the developing soft metrics tool and approach was built based upon specific validating data. As will be outlined later in the thesis, the emerging tools and approach representing the proposed solution to the soft metrics research problem comprised three key functional products: A) a human and organizational performance modelling framework (or HOP model) with sample performance factors linked to B), a set of metrics and measurement methods for quantifying soft factors, and C) a structured application process for analysis and measurement of soft issues within operational projects.

---

**Evidence Sources**

1. **Theoretical Research**  
   Literature review, Best practices, Conceptual modelling exercise

2. **Scoping Study**  
   Industry-based internal capability development project

3. **Application Pilot Study**  
   Industry-academic partnership systems development project

4. **Validation Case Studies**  
   3 Industry-academic partnership systems development projects

**Research Products**

- **A. HOP Model**
- **B. Soft Metrics Set**
- **C. Application Process**

---

*Figure 1.3.3a: Soft metrics research evidence base*

In the formulative stages of the soft metrics research project that culminated in initial specification of the research product, theoretical research and early industry data provided the main evidence sources for the validity and feasibility of the emerging tool. Theoretical information from the literature review, existing industry best practice guides and an early
conceptual modelling exercise all contributed to development of the initial versions of the tool. A scoping study employing an industry-based capability development project was used to define key functional attributes and application context for the proposed solution. Following later iterative cycles that saw the metrics tools and approach developed to a more mature operational status, case-based evidence was employed extensively to validate the research product, using evidence gained from an application pilot study to refine and justify the features of the process by which the tool would be applied in actual case projects, followed by execution of three detailed case-studies using industry projects. These latter case studies involved application of the soft metrics tool and approach to analyse and measure soft performance processes within systems engineering case projects of interest, and capture feedback and evaluative data concerning the tools feasibility and effectiveness. The four research activities depicted within figure 1.3.3a therefore represent the key evidence base for justification of the soft metrics tool and approach in its final form. Relevant information and data collected within each of these four activities will be discussed throughout this thesis.

As industry-sponsored capability development projects, the case projects used to validate the soft metrics research approach and emerging tool were themselves operational and performance-critical projects subject to a social and political context that involved multiple stakeholders with different interests and perspectives on the outcomes of project activities. The soft metrics work itself represents an attempt to develop formalised and reliable methods for the analysis and reporting of soft issues that may affect project performance for project management and control, but no such formal method currently exists and subjective opinions of project personnel is therefore relied upon in the qualitative studies reported later in this thesis. As such, the information gained from executing the metrics tool validation processes for individual case projects must be treated with a degree of sensitivity and absolute confidentiality to preserve the trust inherent in the industry-academic partnership and as was evident from the willingness of respondents to give frank and honest accounts and opinions of human performance issues.

In executing the validation process during the actual case studies, concerns over the confidentiality of some of the response items were respected and the researcher sought guidance from respondents regarding permissible use of data obtained during the validation exercises. In reporting the findings from the case studies, where possible qualitative accounts of performance factors and issues are summarised to apply upon a more generic level and exclude project-specific details that might allow the identification of the specific case project in question or the views and opinions of specific individuals. Where it is necessary to present non-aggregated project-specific data, projects will be coded as 'Systems Engineering Project 1-3', e.g. SEP1, SEP2, etc. to preserve anonymity in the results.
1.4 Overview of thesis structure and content

Where possible this thesis follows a logical structure based upon historical development of the proposed soft metrics solution. Following an introductory preamble to the topic area, the principle methods and aims are detailed, followed by an account of the literature reviewed. Conceptual refinement towards an applied approach is then summarised followed by case-based results from application of the solution, discussion of issues raised by the study and summary of overall conclusions.

Through the necessity to present the reader with a logical, linear report of knowledge gained from undertaking the soft metrics research project, each individual section within this thesis may report the results of more than one research activity and provide evidence of knowledge gain against multiple project requirements. By way of an introduction to the structure of the document, figure 1.4a below relates each main section of the thesis to the key research activities it reports (as summarised in figure 1.3.2a above) and the key project requirements with which it may be associated (discussed in section 2.4).

<table>
<thead>
<tr>
<th>Thesis section</th>
<th>Key research activities reported</th>
<th>Key project requirements answered</th>
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<tbody>
<tr>
<td>2 Research context and aims</td>
<td>A) Formulate and clarify soft metrics research problem</td>
<td>Specifies all project requirements in detail</td>
</tr>
<tr>
<td>3 Literature review</td>
<td>B1) Perform critical literature review</td>
<td>1a) Define possible human and organisational performance factors and key mechanisms of influence &lt;br&gt;2) Explore current best practices for analysis, measurement and control of human and organisational variables in projects</td>
</tr>
<tr>
<td>4 Conceptual development</td>
<td>B2) Conduct industry scoping study &lt;br&gt;C) Develop solution &lt;br&gt;D) Theoretical validation</td>
<td>1b) Investigate presence and impact of human and organisational factors in operational industrial projects &lt;br&gt;3b) Develop integrating human and organisational performance model for representation of causal influences affecting project performance</td>
</tr>
<tr>
<td>5 Applied human and organisational performance model and metrics</td>
<td>C) Develop solution</td>
<td>3) Develop practical approach and tools for analysis and measurement of soft issues in projects</td>
</tr>
<tr>
<td>6 Validation process</td>
<td>C) Develop solution</td>
<td>3c) Develop application process for analysis of soft issues in projects and selection of appropriate metrics</td>
</tr>
<tr>
<td>7 Results and analysis</td>
<td>D2) Industry case-based validation &lt;br&gt;E) Data analysis and interpretation</td>
<td>1b) Investigate presence and impact of human and organisational factors in operational industrial projects &lt;br&gt;4) Make utility and feasibility case for soft metrics concept and tools</td>
</tr>
<tr>
<td>8 Discussion of key research findings and issues</td>
<td>F) Draw conclusions and capture knowledge gain</td>
<td>Discusses research findings against all project requirements</td>
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*Figure 1.4a: Structure of thesis relating to research activities and project requirements*
In terms of the actual content of the sections within this thesis, section 2 'Research context and aims' defines the broader research context in which the soft metrics work took place, the research problem, organisational context and boundaries as dictated by envisaged users for the output of the work before decomposing the general research objectives identified into specific project requirements. Section 3 of the thesis comprises discussion of relevant research and practical literature reviewed within the project and provides a summary of existing knowledge regarding theoretical issues for performance measurement systems (section 3.1), human and organisational performance models (section 3.2), human and organisational performance factors (section 3.3), operational effectiveness criteria (section 3.4) and existing research measures and project management metrics (section 3.5). The literature review is necessarily a large section of this thesis due to the scope of knowledge it was necessary to draw together to establish a firm theoretical base for development in 'breakthrough' proof of concept areas. The literature review therefore represents integration of theoretical social or human sciences knowledge with practical project management techniques, and is drawn together in section 3.6 which summarises relevant findings for the development of an adequate solution to the soft metrics problem.

Section 4 'Conceptual development' draws upon conclusions from the literature review regarding human and organisational performance models and potential soft performance factors to outline development of a conceptual modelling framework for representation of key performance processes within sociotechnical systems (section 4.2). Findings from an early scoping study in the industrial environment are also considered in section 4.1 in order to define the context for application of the soft metrics research output. The conceptual modelling framework is applied to a hypothetical 'team performance' scenario in section 4.3, in order to provide evidence for the theoretical validity of the approach for representation of human and organisational performance processes in work group operations. The concepts developed within section 4 of the thesis are refined into applied tools and methods in section 5 of the thesis, which outlines development of an applied human and organisational performance model (section 5.1) and applied soft metrics (section 5.2). Section 5 of the thesis therefore provides a summary of the integrated tools and solutions developed during the course of the soft metrics research project for analysis and measurement of soft performance issues in operational projects.

In order to explore the feasibility and utility of the proposed soft metrics solution, practical processes were developed for the application and validation of the modelling framework and measures in operational systems engineering projects. Section 6 of the thesis provides an overview of these processes and serves as a methodological preamble to the results from a series of project case studies undertaken, reported in the subsequent section (section 7).
For the sake of convenience, sub-sections within both sections 6 and 7 are divided according to key stages in the application and validation process.

Section 8 of the thesis comprises discussion of key findings and implications from the validation studies as well as broader conclusions that may be drawn from knowledge gained throughout the course of the soft metrics research project for development of soft performance measurement systems. The discussion in this section represents knowledge gained from undertaking the project and considers key issues associated with development of the original research assumptions (section 8.1), soft performance factors (section 8.2), the need for human outcome criteria in performance control systems (section 8.3), conclusions for modelling human and organisational performance processes (section 8.4) and definition of appropriate measures (section 8.5). Section 8.6 summarises the feasibility and utility case made for the soft metrics tools and approach that forms the output from research efforts reported in this thesis and represents the main proof of concept argument. Section 9 'summary of key conclusions' then provides an overview of research findings against the project requirements (section 9.1), before section 9.2 considers lessons learnt during the course of the project and provides a statement of personal development as a result of undertaking this work. Section 9.3 offers consideration of the achievements of this project in terms of the broader context of an emerging soft metrics discipline and possible future work.
The soft metrics research project was an R&D project sponsored by industry to explore the concept of soft metrics and associated methods in order to provide information and evidence supporting the case for feasibility and usefulness of soft metrics tools in an applied project management context. This section of the thesis elaborates upon the problem context, outlines the broader research context in which the soft metrics project was situated, defines key users and concludes with a detailed specification of industry and academic requirements.

As a proof of concept project in what proved to be a relatively undeveloped area of knowledge, the requirements for the soft metrics research work were refined throughout the course of the project as a result of involvement with the applied industrial environment in a series of case studies and review of relevant literature, both of which contributed to clarification of the research question and definition of the knowledge gap to be filled by research efforts and activities. As an ongoing process, the requirements definition reported in section 2.4 below represents a summary of knowledge gained during the course of the project regarding the necessary functional attributes of a soft metrics system and approach to addressing the issue of soft factors in projects. It does not represent the historical state of objectives at the start of the project and this is intentional to provide the reader with the necessary statement of objectives at this early stage of the thesis, against which the activities and results of later sections may be appraised.

Accordingly, subsequent sections of this thesis will make explicit reference to the research objectives outlined in this section. Information regarding the initial identification of need that gave rise to the soft metrics research objectives may be found in section 2.2 below, which discusses the initial problem statement in more detail, following a brief outline of the broader research context that addresses capability development process research at Loughborough University.
2.1 Capability development research context

The soft metrics research project undertaken under industry sponsorship at Loughborough University was done so as one part of a broader research project that was focused upon development of a Capability Development and Deployment Process (CDDP) for the industrial partner BAE SYSTEMS; a systems engineering and integration company in the technology-driven aerospace and defence industry.

BAE SYSTEMS may be described as a global systems engineering organisation structured around a 'project-process matrix', representing the dual aims of maintaining a high level of engineering process competency whilst sustaining competitive viability through project-focused business management. In this context, currently ongoing work on specification of a formalised CDDP was undertaken with the aim of delivering a commonly accepted model capable of developing generic, reusable processes in order to counter a tendency for fragmentary and localised process improvement efforts that are considered inefficient from a business-wide perspective. Additionally the CDDP research aimed to provide a directed process for the deployment of these new capabilities into existing project operations and organisational structures.

Siemieniuch and Sinclair (2000; 2002) outline the requirements and structure of the developing CDDP, the main features of which are reproduced here in a table of aims and specifications for the CDDP (figure 2.1a) and high-level representation of the CDDP (figure 2.1b). A requirement for new metrics and metrication methods, is incorporated in the aims and requirements for the CDDP derived from a detailed scoping study performed at the onset of the project (Siemieniuch and Sinclair, 2000). In addition to the metrication strand of CDDP research, work was also undertaken in two other related areas: 1) the establishment of a decision-support system (DSS) to provide an effective means of interaction with and navigation through the CDDP for project managers, and 2) the development of several Change Management Guides to provide practical resources for managers involved in deployment.
<table>
<thead>
<tr>
<th>Aims for CDDP research:</th>
<th>Functional Requirements for the CDDP:</th>
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<tbody>
<tr>
<td>☐ Enable the improvement, development, deployment, and evaluation of new processes with</td>
<td>☐ Set of fully interoperable sub-systems with clearly identified process steps for each sub-system</td>
</tr>
<tr>
<td>the global aim of commonality and reusability</td>
<td>☐ Tools, techniques, methods and metrics to carry out sub-processes</td>
</tr>
<tr>
<td>☐ Provide key contribution to organisational learning and application of best practice</td>
<td>☐ Associated Change Management process, methods and tools</td>
</tr>
<tr>
<td>☐ Deliver effective capability acquisition and process renewal capability</td>
<td>☐ Metrification methods and process (including new &quot;soft&quot; metrics where required)</td>
</tr>
<tr>
<td>☐ Integrate with appropriate knowledge management infrastructure</td>
<td>☐ Dynamic simulation tools</td>
</tr>
<tr>
<td>☐ Develop simulation tools to explore alternatives and consequences of proposed organisational change</td>
<td>☐ Feedback loops to enable continuous improvement of CDDP</td>
</tr>
</tbody>
</table>

*Figure 2.1a: Research aims and functional requirements for development of a Capability Development and Deployment Process (CDDP)*

The CDDP itself is a translation of BAE SYSTEMS’ current Lifecycle Management process (LM02/02). LM02/02 is mandated throughout BAE SYSTEMS’ operations and therefore encompasses a very broad range of R&D and Capability development projects. Necessarily the process model embodied within LM02/02 is generic and as such is specified at a high level of abstraction. The CDDP aims to translate this model into a more practical and functional tool for application within BAE SYSTEMS, principally through specification of lower level activities, work flows, inputs/outputs, resources and intermediary deliverables that are implicated throughout a capability development project.

The problem of a potentially broad range of application projects for the CDDP model is resolved through the employment of several differing “templates” tailored to specific types of capability development project (Siemieniuch, 2004). The templates, with which project managers can interact through the CDDP’s Decision Support System, are designed to provide process models for differing scopes of project ranging from “proof of concept” to “full deployment” projects. Accordingly, proof of concept project templates emphasise earlier project definition and R&D phases in the overall capability development process at the expense of later deployment, integration and support phases, which may be superfluous to requirements if the aim of the project is merely to demonstrate the feasibility of a concept as opposed to achieving a fully developed and rolled-out product that is integrated and deployed within the organisations operations. In contrast, a full deployment project template might include the entire process from conception and definition to deployment and support, or may emphasise the latter phases of the capability development and deployment process where concept and definition is already known, as is the case when a software upgrade with known functional requirements is the new capability being introduced.
By the project definitions embodied in the CDDP, the soft metrics research project described in this document may be considered to be an example of an R&D-oriented proof of concept project, whereas the Capability Acquisition Project (CAP1) outlined in section 4.1 is an example of a project designed to deliver full deployment of a specific capability. In order to understand the soft metrics research project in the context of the broader CDDP project, it should also be noted that as a high-level or meta-process which spans all levels within the organisation, the CDDP may be considered to operate at a strategic or tactical level. As a project which seeks to develop knowledge regarding the feasibility and application of specific project-management tools, the output from the soft metrics research project is intended for the operational level, i.e. repeated application in low-level systems engineering and capability development projects and their project teams.

In large scale systems engineering organisations which focus upon capability acquisition and leverage of capability-based assets as the main source of competitive advantage, there exists an implicitly accepted understanding of the term "validation" in capability development efforts to mean proof of feasibility and utility of a product for its intended application in the organisational context in question. This industry-driven assumption is pertinent to all
associated R&D efforts and holds specific implications for the direction of the soft metrics research; particularly the form of the evaluation process for the product of the research efforts. Whilst in academic enquiry and psychological research in particular the activity of "validating" a proposed model for some real world phenomenon will involve the assessment of validity across a broad range of cases, it should be noted at this introductory stage of this thesis, that in the context of BAE SYSTEMS' capability development programs, the soft metrics research is "validated" in line with the industrial definition of the term: the extent to which the research product is effective within the specific environment represented by BAE SYSTEMS' operations. Thus, all future uses of the term "validation" and "validation process" within this thesis refer to the activity of establishing a feasibility case for the proposed soft metrics solution, within the context of the capability development concerns of the research sponsor.

2.2 Definition of research problem

The initial research problem statement that the soft metrics project was implemented to address originated within conclusions drawn from an early scoping study of BAE SYSTEMS' capability development operations. The following extract outlines the problem succinctly:

The main focus of the current metrics set is on what could be called 'hard' issues and particularly those relating to the output of the process (i.e. the product). There is less certainty about measuring 'soft' issues such as motivation, resistance to change, efficacy of human resource configurations, organisational structures and policies, working practices, etc. (Siemieniuch & Sinclair, 2000, p13).

The report therefore highlights the current focus of performance management systems upon 'hard' technical issues in operations, with metrification efforts largely confined in scope to 'outcome' or 'results' criteria that are closely associated with the work product and customer-defined requirements such as cost, quality and time parameters. Due to a lack of practical knowledge and tool support, capability for measurement of the 'softer' human and organisational process factors is limited or non-existent in current practices.

The increasingly complex, integrated systems that form the products of systems engineering projects require increasingly complex organisational structures and work processes to successfully integrate the required knowledge across a range of functional disciplines and collaborating organisational entities. Complexity in products and processes means that the accuracy and capability of performance measurement and control systems becomes critical to the achievement of contractual commitments. The ability to quantify slippage against planned time and cost parameters provides the necessary retrospective indicators to identify
performance problems as they occur. Conceivably, there is much to be gained from complementing these tracked outcomes with a proactive perspective that seeks to predict problems on the basis of work process quality issues, in which the conditions of the human and organisational work system figures highly.

The degree to which the issue of defence industry project performance has surfaced in industry-specific publications and even attracted public attention through the media is evidence that addressing the upstream or process determinants of operational outcome criteria associated with delivery on time, within budget and to customer specifications is a valid concern for operations research.

In the software systems engineering domain, for example, Paulk comments upon a growing ‘software crisis’ in the US defence industry: “the ability to develop and deliver reliable, usable software within budget and schedule commitments continues to elude most software organisations” (1995, p3). Evidence cited in support of this claim includes a review of 17 major software contracts, in which the average 28-month schedule over ran by 20 months. Paulk attributes excessive late and over-budget delivery of products to a fundamental inability to manage work processes effectively, resulting in chaotic, undisciplined projects. In January 2004, the UK defence industry came under scrutiny by the British media in response to the National Audit Office’s Major Projects Report (2004), which identifying a £2.7 billion overspend attributable to four delayed long-term projects (Times UK, 2004a; 2004b). The highlighted projects included Eurofighter (60 months late; £1bn over budget), Nimrod (71 months late; £400m over budget), Astute submarine (43 months late; £1bn over budget) and Brimstone missile (£126m over budget). Whilst ‘technical issues’ may be the primary cause of such occurrences, project management and control techniques are certainly implicated as valid areas for operations research that seeks to enhance performance management capabilities. Central to the project management toolset is the development of appropriate performance measurement systems (e.g. Neely, 1995) and associated research into areas such as the measurement of soft performance factors must be considered to be both important and timely.

In considering the general problem context that the soft metrics work aims to address, some attention must be given to defining the concept of 'soft factors' and the problems they pose for operations management. Goranson (1999) writing about practical tools and theory to support agile virtual enterprises, states that the biggest problem facing enterprise modelling efforts is ‘soft’ factors, or factors about which there is uncertainty due to either the enormity of effort required to incorporate influences related to such factors in the enterprise model or a lack of knowledge as to how these factors operate in reality:
Complexity is a killer. But it's not the biggest information bogeyman threatening the enterprise. The inability to represent soft stuff is. Soft stuff is stuff you don't know much about....You find this condition in situations you cannot fully model because of expense. Or maybe you just don't know how it really works. Social and cultural interactions are of this type. Or maybe you are trying to do some modelling of the future, and you just cannot predict in detail. These are all soft stuff. (Goranson 1999 p.239)

Goranson specifies social and cultural dynamics as the factors that shape the so-called 'soft' infrastructure within an organisation. The soft infrastructure is determined by social and psychological laws, community and business cultures. As inbuilt culture and behaviour, soft infrastructure is less amenable to engineering efforts than 'harder' elements such as workflow, business processes and physical infrastructure. As a function of personalities, group dynamics and types of interaction, systems engineering activities aimed at soft infrastructure are largely confined to assessment and selection of individuals and teams, with current understanding of deeper levels of operation of these variables being limited by existing knowledge.

As is evident from this discussion, there is currently limited maturity in practical knowledge regarding the modelling and effects of soft factors in organisational functioning, and a clear need to enhance the capabilities of project performance measurement methods to encompass 'upstream' performance determinants, such as human and organisational factors. These are the dominant problem issues that the soft metrics research project attempts to address. Estimates as to the extent of the human and organisational contribution to overall organisational performance vary, but it is generally accepted that it is an important one, as is evident from the finding that business process reengineering efforts may fail in implementation due to 'soft' resistance to change issues (Marjanovic, 2000) and that projects may over-run or under-perform considerably due to a lack of process and organisational maturity (Paulk, 1995).

The specific research requirements implemented to address the research problem are outlined in section 2.4 below, following definition of the intended users of the research output. For the purposes of the research undertaken during the course of this project, the term 'soft metrics' may be defined as referring to the following statement of purpose:

The application of measurement-based techniques to human and organisational variables that influence the performance of work processes, in order to provide useful management information regarding causal process factors that influence the quality of
achieved work products. Such information may then be used for work process improvement to enhance the quality of the end product.

2.3 Organisational context and intended users

Prior to consideration of detailed aims and requirements for the soft metrics research project, this section of the thesis addresses the organisational context in which the research took place, including consideration of the cultural context, definition of intended users and imposed research boundaries. In depth investigation of the organisational context including culture, working practices and terminology was undertaken as part of an initial scoping study that sought to define the potential users of the soft metrics tool and approach defined in this thesis (reported in section 4.1). In order to provide the reader with a logical application context for evaluation of this work, the intended users and boundaries that define the scope of applicability of the soft metrics approach developed during the course of this research project are summarised below, followed by consideration of how the specific organisational context influenced the assumptions and goals inherent in the soft metrics project brief.

BAE SYSTEMS may be described as a matrix-structured, project-based organisation in which human resources are configured to achieve specific project objectives that represent individual customer contracts and internal capability development goals. Temporary and long-term multidisciplinary teams are created to integrate effort across functional boundaries within the organisation to engineer complex systems products and services. Consequently, BAE SYSTEMS operations are structured by project, with dynamically changing team-based structures being implemented to undertake specific project tasks. The basic functional and accountable unit within BAE SYSTEMS may therefore be considered to be the Integrated Project Team (IPT).

The scope of the soft metrics research project may be considered to be bounded by focus upon the 'project' as a temporary organisational unit and the 'project management team' as the basic functionally autonomous unit that tactically manages and controls project activities at the operational level, including performance monitoring and review processes. As the body that makes critical decisions regarding the organisation of work to meet externally imposed objectives, the project management team may be regarded as the accountable level within BAE SYSTEMS operations and key stakeholder for advancement in project performance monitoring and control techniques. To the extent that research efforts within the soft metrics project have employed detailed case studies of internal change and R&D based capability acquisition projects, the output from this work may be considered to be directly applicable to systems engineering efforts of this type. As human and organisational performance
processes may be considered generic features of organisational system functioning, it is hoped that the output from this work may be applicable to a broad range of project-based operations, in a variety of disciplinary areas beyond systems engineering.

It is anticipated that the soft metrics tool will be particularly useful at the tactical and operational level of BAE SYSTEMS' project operations, in the analysis of project organisation, project planning and project control. In so much as the methods may be used to assess and compare processes across projects, they may be applied at a strategic or business level and may be used to contribute to broader process development and organisational design efforts. The primary intended user for the soft metrics approach embodied in this thesis is therefore the integrated project management team, including: project management personnel, project performance review boards, process improvement managers, project HR professionals and any self-governing project work group empowered for performance analysis and control of its own work processes.

Applied research involving the participation of collaborating organisations with an invested interest in the outcome of the work is invariably influenced by, and subject to the assumptions of, the cultural and political organisational context in which the researcher proposes to effect change. The organisational context for the soft metrics research, represented by the BAE SYSTEMS extended enterprise, is no exception and the evident cultural attitudes and values, shaped by a pervasive 'engineering discipline', led to several prior assumptions in the original definition of focus and aims for the soft metrics research being made. The influence of a predominantly engineering-focused culture is especially evident in the title definition of this project: 'soft metrics'.

In an engineering project management culture that is largely data-driven, a tendency exists to look to the definition of a set of project parameter metrics to provide the focus for human effort towards project performance control and improvement. Such a tendency is evident from the well-known and often quoted maxim: "you can't manage what you can't measure" and from the popularity of engineering process capability maturity models that build towards quantitative process control as the exemplar of best practice. Naturally, in the definition of a project to develop capability for control of 'soft' factors impacting upon project performance, BAE SYSTEMS defined a 'management metrics' based approach.

The influence of engineering-determined values may also be found in the other half of the 'soft metrics' term. The term 'soft' tends to be applied, in an engineering context, as a catchall for factors that fall outside of certain, readily observable (and hence understandable) phenomenon. Thus, from a technical engineering perspective, complex human activity and organisational systems that exhibit high interdependency and comprise multiple autonomous
agents may be appropriately considered to be 'soft' in that they exhibit superficially unpredictable behaviour about which it is difficult to reason with any high degree of certainty. In light of these considerations, the metrics research project inherited at outset an 'engineering' brief represented by the very term: 'soft metrics', which encapsulates the requirement to capture in practical, measurable 'metrics' what are largely intangible and empirically evasive factors. In response to these requirements, the soft metrics research effort adopted the case-driven methodology outlined in section 1.3 of this thesis, in order to develop an approach to the research problem that was both valid for application within the 'engineering' environment of BAE SYSTEMS' operations and sensitive to the assumptions made by a predominantly engineering project management culture as to the metrics content of the research product. The following section will now consider the functional requirements for the soft metrics project in more detail.

2.4 Project requirements specification

As an industry sponsored proof of concept project, the requirements for the soft metrics research and development work were not confined to functional requirements for an emerging soft metrics tool, but also included the capture and dissemination of key knowledge regarding the feasibility and utility of the concept. Figure 2.4a below comprises a table of specific requirements derived from the broad research objectives stated in section 1.2 of this thesis. As stated previously, the soft metrics research project formed a sub-project of what was a close and intensive industry-academic collaborative effort. Accordingly, the requirements included within the table may be broadly classified as serving principally academic or industrial interests, according to whether they refer to objectives associated with the development of specific tools or more general, abstract knowledge. The table also indicates the proposed output, in terms of work product, that may be associated with each specific requirement. Throughout the remainder of this thesis, the requirements referenced within the table below will be referred to in order to outline the basic objectives that each research activity addressed.
<table>
<thead>
<tr>
<th>Main research objectives</th>
<th>Specific project requirements</th>
<th>Main interest</th>
<th>Proposed output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Identify 'soft' issues impacting upon project performance</td>
<td>1a Define possible human and organisational performance factors and key mechanisms of influence</td>
<td>Academic</td>
<td>Human and organisational performance constructs with definitions and possible interactions</td>
</tr>
<tr>
<td></td>
<td>1b Investigate presence and impact of human and organisational factors in operational industrial projects</td>
<td>Industrial</td>
<td>Case-based human and organisational performance factors and mechanisms of influence</td>
</tr>
<tr>
<td>2 Explore current best practices for analysis, measurement and control of human and organisational variables in projects</td>
<td>2a Identify and evaluate suitable performance models and frameworks for human and organisational variables</td>
<td>Academic</td>
<td>Evaluation of existing approaches and knowledge</td>
</tr>
<tr>
<td></td>
<td>2b Identify and evaluate suitable metrics and measurement methods for quantifying human and organisational variables</td>
<td>Academic</td>
<td>Evaluation of existing approaches and knowledge</td>
</tr>
<tr>
<td>3 Develop practical approach and tools for analysis and measurement of soft issues in projects</td>
<td>3a Develop specific metrics to address key human and organisational performance factors</td>
<td>Industrial</td>
<td>Suitable metrics for applied industry environment including new measures where required.</td>
</tr>
<tr>
<td></td>
<td>3b Develop integrating human and organisational performance model for representation of causal influences affecting project performance</td>
<td>Industrial</td>
<td>Generic framework for classification of performance factors and depiction of influences</td>
</tr>
<tr>
<td></td>
<td>3c Develop application process for analysis of soft issues in projects and selection of appropriate metrics</td>
<td>Industrial</td>
<td>Structured process with embedded resources and activities for analysis and quantification of soft performance issues in projects</td>
</tr>
<tr>
<td>4 Make utility and feasibility case for soft metrics concept and tools</td>
<td>4a Evaluate practicality and effectiveness of soft metrics tool in operational industrial projects</td>
<td>Industrial</td>
<td>Reported data and associated analysis of practicality and effectiveness of new methods</td>
</tr>
<tr>
<td></td>
<td>4b Evaluate feasibility of soft metrics concept including current limitations and knowledge gap</td>
<td>Academic</td>
<td>Reported evidence of effectiveness and limitations of approach and future research objectives/tool requirements</td>
</tr>
</tbody>
</table>

*Figure 2.4a: Detailed soft metrics research project requirements related to general research objectives*

From the industrial perspective, the soft metrics project was planned and structured around the achievement of intermediary milestones, represented by key reports and deliverables that were submitted to BAE SYSTEMS, the sponsoring organisation, and discussed in the associated industry-academic research network. These deliverables represented the main industrial requirements for the soft metrics research work and documented knowledge acquired in the research activities for the sponsor, in order to establish a basis for future
capability development activities associated with soft metrics tools. The general nature and sequence of these intermediary deliverables is outlined below:

1) Report on human and organisational performance factors and conceptual approaches
2) Working document comprising inventory and evaluation of existing metrics
3) Report on Industry case project scoping study and proposed metrication framework
4) Report detailing tool application and validation processes
5) Report on results of validation studies and analysis of feasibility
6) Submission of final metrics and integrating framework with best practice guidelines for this area

From an academic perspective, the soft metrics project was implemented to contribute new knowledge in a number of key areas associated with the application domain. The 'soft metrics' area of interest represented a relatively immature area in terms of applied knowledge and the particular brief for this soft metrics project: the practical measurement and analysis of human and organisational factors for project performance management within capability acquisition scenarios, may be regarded as novel. Accordingly, the key knowledge outcome that the soft metrics research project aimed to achieve was a cross-disciplinary approach to specific applied problems, through the refinement and integration of relevant areas of research knowledge and expertise ranging from human factors and social sciences to project operations management techniques. In terms of the output from this endeavour, this thesis represents the principle medium for the communication and report of associated results and research findings in this area.
The review of literature relevant to the soft metrics research is outlined and discussed in this section of the thesis. Due to the nature of the research problem, literature from a diversity of sources ranging from theoretical social sciences research to applied project management techniques was reviewed and integrated in order to formulate a suitable approach to the soft metrics problem that represents best practices and current state of knowledge relevant to the area. The literature review outlined in this section of the thesis is important to the 'proof of concept' industrial objectives specified for the soft metrics research project, in that it represents a summary of relevant existing knowledge and potential gaps to be explored in development of a practical solution. Figure 3a below depicts the structure and purpose of the literature review, and relates the different areas of literature covered to the aspects of the soft metrics solution that they support.

The performance measurement theory and systems design areas incorporated literature related to practical operations management and theoretical perspectives upon valid performance indicators. Specific key issues were identified associated with process-outcome control theory and intellectual capital theory, which were used to inform the development of the entire soft metrics tool, both in the structure of the modelling framework and the specification of its performance factors. These issues are reported and discussed in section 3.1 below. In response to the requirement to identify and describe the influences of potential soft factors in projects, human sciences and work psychology literature was reviewed to establish a set of key human and organisational performance factors that existing research suggests are linked to operational performance (section 3.3). The operational performance objectives that are conventionally used as organisational performance outcome indicators are discussed in section 3.4.
In order to inform the development of the modelling framework employed in the soft metrics approach, existing examples of human and organisational performance models were evaluated for key features and applicability to the problem context (section 3.2). Finally, in order to identify feasible measures to quantify human and organisational factors, literature from two complementary areas was reviewed and is reported in section 3.5. These areas included existing management metrics associated with established performance measurement systems and measures employed in human sciences research efforts. Review of these two complementary areas was necessary as conventional project performance control techniques were found to be limited in their coverage of human and organisational parameters.

3.1 Performance measurement theory

There have been several notable attempts made in the research and management sciences literature to address performance measurement systems as a defined topic of interest (e.g. Neely, Gregory and Platts, 1995). As an emerging discipline several key conceptual issues are identifiable as important theoretical underpinnings upon which to base development and application of new performance measurement systems. In this section of the thesis, three such theoretical areas are considered in more detail, having emerged from themes identified...
through review of literature relevant to the objectives of the soft metrics research project. The issues considered include the implications of complexity in modern organisational operations for performance measurement and control, the necessity for proactive process measures to complement reactive outcome measures and an emerging focus upon 'human capital' and other intangible assets to drive operational performance in contemporary, knowledge-intensive enterprises.

3.1.1 Complexity and Performance Measurement

Modern complexity and the dynamic nature of complex socio-technical systems necessitates increasingly sophisticated performance monitoring and control methods to understand the factors which influence an organisation's processes and output. Siemieniuch and Sinclair (2000) define complexity as interaction between the organisation's entities that result in unpredictable behaviour of the organisational system: its autonomous elements (people), work processes, technical infrastructures and the environmental context within which it exists. Various characteristics of contemporary organisational systems are responsible for eliciting complex emergent behaviours, including: the presence of multiple agents on multiple levels (i.e. individuals, teams and larger units), with varying degrees of autonomy, performing varying tasks at varying times with varying goals. Further complexity is introduced through consideration of interaction between the elements of the system; between agents in an environment through a potentially large volume of parallel communication channels. The result is that centralised ‘top-down’ adaptation and control strategies are not likely to be successful and that a more self-organising approach to the achievement of organisational goals is required.

With regards to performance management systems in particular, the implications of complexity are that no relatively stable optimum state for operational processes exists, rather successful management means the achievement of prolonged periods of coherence in which the functioning of the organisational system becomes predictable. To this end, permanent organisational planning and control is required, utilising continuous process measurement to track the state of the organisational system and understand the likely impact upon outcome of observed perturbations in process operations. Achieving understanding of system dynamics through monitoring the condition of the human and organisational elements of the system is no less important than monitoring the more technical aspects of the system, and to this end comprehensive performance measurement systems; their measures and integrative frameworks, must address soft process issues as well as hard outcomes.
3.1.2 Outcome criteria and intermediary indicators

A distinction between what will be referred to here as 'process' and 'outcome' variables is inherent in the approaches of many authors attempting to consider the methodological implications of adopting specific performance indicators in order to further understanding of how complex factors interact to influence performance within an organisation (e.g. Meister, 1990; Olve et al, 1999). The distinction may be considered to be synonymous with 'lead/lag measures', 'results/determinants', 'final/intermediary criteria' and 'dependent/independent variables'. The practical implications of distinguishing between intermediary and outcome performance criteria are far reaching and this section attempts to describe relevant issues for monitoring and control systems in organisational performance management practice.

Figure 3.1.2a below represents the important issues involved in the outcome-process metrics distinction. The need to classify variables within this dichotomy is apparent from the fact that effective performance management involves more than merely quantifying 'value' at the produced outcome-end of organisational endeavour, but monitoring the processes responsible for those outcomes, in order to influence their value. The outcome-process distinction is also related to a systems view of organisational functioning, in which the effectiveness or performance of the organisational system is an emergent property of interaction and processes between and within all elements that comprise the system as a whole. The implications of this reasoning are that modular attempts to monitor specific outcomes towards the end of a causal sequence within the system, will not provide the depth of information required to generate a meaningful understanding of the state of the system at any one time. The essence of attempting to measure organisational processes is that it generates proactive knowledge capable of leading decision-making in order to manipulate future outcomes of productive effort. Process measurement, if executed adequately, will therefore involve the establishment of projective metrics; specific measures which provide the basis for extrapolation into the future.

The outcome-process distinction is inherent in much of the reviewed literature relating to methodological approaches to performance measurement and management. The focus of conceptual efforts to define 'intellectual capital' in organisations, for example, in so much as they attempt to measure the less tangible factors that influence an organisation's functioning and effectiveness, such as indicators of 'knowledge' and the 'means to achieve ends' (Edvinsson & Malone, 1997), represents a 'process-oriented' perspective that advocates measurement of the determinants of outcomes, rather than the outcomes themselves. Human knowledge may therefore be regarded as intermediary performance criteria, providing its influence upon more conventional outcome variables associated with organisational performance has been established. The outcome-process metrics distinction is also
consistent with the distinction made between classes of variables in statistical modelling techniques; that between independent and dependent variables, which Bontis (1998) refers to as 'antecedent' variables and 'consequent' variables, respectively. Quality management efforts that focus upon monitoring production processes as opposed to mass inspection of the product, such as statistical process control (e.g. Slack et al, 2001), embody this distinction between outcome and process measurement approaches.

**Figure 3.1.2a: Key distinctions between outcome and process metrics**

Brodbeck (1996) states that a distinction between 'intermediate' or process criteria and 'final' or output criteria is identifiable in most models and theories of work group functioning. Such a distinction is based upon the theoretical assumption that final performance is a function of intermediate performance and even models that adopt purely process or outcome criteria nevertheless support a distinction between these two important typologies of criteria for measurement. The distinction between these two classes of variables therefore represents a causal sequence that proceeds from processes to outcomes, the assumption being that process indicators of performance represent the causal origins of the final results or outcomes of organisational efforts and activities. From the perspective of attempting to model the interactions between variables that influence performance, the process-outcome measures distinction represents a useful yet not completely unlimited heuristic for understanding interaction between complex organisational factors. Research work aimed at consideration of the appropriate structure or framework of a human and organisational performance model is described later in this thesis *(section 4.2)* and represents further exploration of these issues.
Consideration of the relationship between outcome and process variables holds important implications for measurement practices and specifically the ability of the organisation to learn about the systemic interactions of elements within its structure, and its ability to maintain performance levels in the face of changing environmental and contextual conditions over time. Work that seeks to understand the processes and determinants influencing organisational failure, an extreme negative example of one possible outcome of organisational functioning, offers useful principles regarding the distinction between outcome and process variables which can be productively applied to the subject of organisational performance.

Reason (1997) offers an example of how the process-outcome measures distinction can be usefully applied in organisations to support learning and the continual adaptation to uncontrollable perturbation in the operating environment necessary for continued success. The specific methodology implied by the distinction between process and outcome measures is linked to the fact that outcome measures may be considered to be 'reactive' in orientation and process measures 'proactive' or projective, looking forward to future performance outcomes. Reactive and proactive measures are therefore complementary in nature, both giving valuable information about the state of the organisational processes underlying performance. Outcome measures are useful for 'reactive' analysis, after the event, to reveal the patterns of cause and effect that contribute to any specific state of organisational performance or effectiveness. Multiple analyses over time using a common classificatory framework will allow the establishment of patterns indicating which factors or organisational variables, in which contextual conditions, are regularly responsible for specific systemic outcomes. The identified systemic human and organisational variables will therefore provide an indication of the 'health' of the system at any one point in time, allowing proactive intervention should the need arise. In this sense careful monitoring of outcomes and analysis of their determinants will guide the valid and cost-effective selection of proactive measures for sampling on a regular basis. Refinement of a sub-set of these key process variables responsible for performance itself represents a process of organisational learning.

The process of using the value of outcome or dependent variables to specify and update a set of predictive, independent variables may be said, from a strategic perspective, to rely upon history to direct future organisational monitoring and control mechanisms. Inherent in this approach is the risk of specification error, in which total variance in the dependent measure is not adequately accounted for by the set of predictive, process measures specified at any one time. Two specific forms of specification error may be identified. Criterion deficiency refers to the situation in which total variance in the outcome measure is only partially accounted for by process measures; a situation which risks loss of organisational control due to the operation of unknown factors influencing performance. Criterion contamination, on the other hand, refers to the situation in which the predictive variables set taps variance irrelevant to the
operation of the dependent variable. Additionally, with organisations being complex open systems that interact with and are responsive to external environmental conditions, there are dangers inherent in an approach that relies upon past experience to predict the future. The lesson for measurement and control systems is to employ what may be termed 'roaming' metrics, which monitor variables not known to be directly related to performance outcomes, to guard against the eventuality in which situational conditions cause novel factors to conspire in novel ways to influence outcomes. This would imply a need for redundancy or 'slack' in the metrics set in order to yield adaptive, useful data in the long term.

Proactive process measures are likely to tap the 'soft' variables that represent the systemic antecedents of human and organisational performance, such as those relating to workplace design, tools and equipment, procedures, supervision, workload, time scheduling, training and experience, job planning, staffing methodologies, role design and allocation, group-working, leadership and cultural influences, amongst others. The challenge for a soft metrics system is to relate these measures to the more conventional outcome indicators of organisational or project performance: predominantly the product-oriented dimensions of cost, quality and time. Figure 3.1.2b below represents this problem. With process-oriented organisations configuring and re-configuring structures in response to requirements for product-organised activities, it becomes increasingly important to identify the human and organisational factors that relate to overall project success, as indicated by customer requirements for cost-effective functionality. A soft metrics system must therefore provide predictive indicators, based upon human performance variables, for project success, in order for organisational monitoring and control systems to inform the development of work processes.

Generally, organisations are quick to adopt a retroactive orientation to performance management through the evaluation and appraisal of indicators associated with the outcomes of productive effort, especially where those outcome indicators may be derived from customer requirements. It is more difficult, however, to employ effective proactive strategies, which involve accurate understanding of how systemic variables interact during the processes involved in production. Proactive and projective strategies have been derived from tracing causal paths from outcome variables back through the operation of a system to identifiable antecedents that may be far removed from the outcomes they influence and superficially hidden within the complexity of the system and from those responsible for managing performance. With increasing complexity in contemporary, flatter-structured organisations, systems become increasingly opaque to organisational developers. Academics and practitioners interested in managing organisational development activities therefore need to adopt a systemic rather than modular view in their approach towards metrciation of organisational variables, one in which the performance of the organisation in terms of it's output, and in terms of it's ability for self-renewal, is measured continuously and
simultaneously at various levels of the organisational system. A literature review of academic work and specifically research variables studied in the context of organisational dynamics research represents a productive starting point to begin untangling the complicated dynamics of causal processes which comprise the antecedents of important outcomes such as cost, quantity, quality, time and error.

Figure 3.1.2b: The challenge for soft performance measurement systems: relating 'soft' performance determinants to 'hard' outcome variables

Making the distinction between process measures of behaviour and outcome indicators of performance, and measuring each separately, allows the organisation to identify when disparities occur between these two classes of indicator. Such practice allows the researcher to identify when high levels of performance activity do not correspond with high effectiveness in terms of the production of valued outcomes, and to investigate the reasons why. Such effects may be due to the influence of external conditions beyond the organisation's control, for example, which may have an overriding effect upon the outcomes of performance, regardless of the state of the system. The fact that commercial industrial organisations operate in unpredictable environments due to non-static operating conditions means that efforts to manage future performance solely on the basis of past history is a fundamentally flawed approach, that is likely to result in the repetition of previous mistakes. The repeated attribution of the causes of catastrophic accidents to 'human error', as opposed to tracing their more appropriate systemic origins, as various documented instances of organisational failure testify, is a poignant reminder that organisations must adopt predictive, forward-looking
strategies as well as retroactive analysis of past performance, in order to operate both safely and successfully.

### 3.1.3 Intellectual Capital theory and application

The 'intellectual capital' perspective (Edvinsson & Malone, 1997; Stewart, 1997; Gray, 2001) represents an attempt to develop methods to systematically identify, measure and manage the subjective, less visible factors that concern human, social and organisational influences upon operational performance. The concept of 'Intellectual Capital' offers the idea that the functioning of a modern organisation, and ultimately its effectiveness, is determined equally by the intangible, collective human intellectual ability in the organisation, as well as its more tangible technological and physical components. Edvinsson and Malone state that intellectual capital as a theory, and efforts to value intellectual assets, have long existed as 'common sense' intuition. Variables associated with intellectual capital are commonly considered to be subjective factors driven by hearsay, intuition, gut feeling and insider information.

According to Edvinsson and Malone, the intellectual capital movement represents a shift in emphasis from the management and measurement of tangible financial and physical assets to a focus upon knowledge as the most significant and valuable factor for an organisation's continued high performance. Contemporary organisations are becoming increasingly knowledge intensive in response to requirements for more adaptive structures, more flexible, customised products, customer participation in the design and manufacturing process and the linking of developers, suppliers, distributors and strategic partners in complex chains. With integral aspects of organisational functioning outsourced to strategic partners, it becomes important to assess the value of knowledge delivered.

Edvinsson and Malone claim that so-called 'intangible' assets, such as individual skills and know-how, IT systems, designs, trademarks, supplier relationships and customer franchise, to name just a few, comprise over 80% of a company's total value and are typically worth four or five times a company's tangible book value. Furthermore, in the recent past an over-emphasis upon financially and physically-oriented outcomes have inhibited organisations' ability to distribute resources to maximum effect, particularly with regards to future performance, in areas such as long-term investment in R&D and work force training activities.

Siemieniuch and Sinclair (1999) offer an evaluation of intangible human knowledge based upon a market capitalisation method that utilises organisations' published accounts. Discrepancy between stock market value and net tangible assets may therefore be taken to be an indication of 'knowledge in action', less some 30% representing the value of non-human
knowledge embedded in tangible organisational structure and codified information, leaving an approximate fraction of one half to two thirds of an organisation's total value residing within its human knowledge. As Siemieniuch and Sinclair point out, this human knowledge represents approximately 60% of an organisation's continued operational capability and 100% of its innovation potential.

The 'intangible' nature of intellectual capital performance variables raises important methodological issues relating to the measurement and reporting of indicators, by making objective, quantifiable measurement difficult. Total intellectual capital measurement would involve capturing the qualitative subtleties of dynamic processes, such as the use of knowledge in an organisation, which can often only be accurately expressed in narrative form. Quantifying measures, however, is appealing as it allows the formalisation of data formats and methodologies, which enables relative comparisons to be made across different measures and between time periods, as in comparison of the extent of growth in a variable over time, for example. Quantifiable metrics are also more readily benchmarked against past performance and that of other external organisations. If the aims and objectives embodied in the intellectual capital approach to performance measurement are to be realised, a metrication system must not only provide a 'snapshot' of the shape of an organisation's intellectual capital, but also an indication of the dynamics of intellectual capital over time. A future capability-oriented metrication system must not only indicate the current shape of a company's intellectual capital, but also its dynamic, through providing changing 'real-time' indicators, as opposed to the traditional annual or periodic report. The fact that the intangible variables classed as intellectual capital cover a broad range of dimensions of organisational functioning means that any adequate measurement system will be multi-dimensional incorporating several disparate types of information.

The approach to identifying performance indicators to aid management processes advocated by intellectual capital theory is one that focuses upon supporting human and organisational capabilities for future performance potential through attempting to measure the less visible antecedents of future effectiveness, as well as the 'soft' and often subjective variables involved in the process of development which will eventually deliver new capability. Future efforts in this area must usefully attempt to elaborate on the conceptual definition of 'human' capital, an important dimension of an organisation's overall intellectual capital, by drawing upon research in human sciences. For example, the emergence of work group norms and shared working practices represents the development of one form of intellectual capital, namely the practical expertise and tacit knowledge in individuals associated with how to conduct and undertake effective team-based projects.
3.2 Evaluation of human and organisational performance models and frameworks

In considering the issues associated with different types of human and organisational performance variables according to their status as process or output factors and the requirement for representation of intangible factors in organisational systems functioning, it becomes important to consider the various modelling approaches that have been proposed to visualise complex interactive performance processes. This section of the thesis therefore outlines existing human and organisational performance models and associated modelling frameworks identified through review of relevant human and management sciences literature.

The key criteria for identification of appropriate models to aid in forming a theoretical basis for the soft metrics work was that each model in content was proposed as a representation of key human and organisational performance processes and may therefore be considered to represent a theoretical or applied perspective on factors which are facilitative to the effective functioning of an organisation. With this aim in mind, the models outlined below all contain some implicit or explicit statement of outcome or organisational effectiveness criteria, linked to other variables through representation of functional relationships. As such, the models of interest may be considered to be 'human and organisational performance models', rather than systems representations of organisational structures and relationships, for which there is already an established, available literature (e.g. Vemadat, 1996; Goranson, 1999).

As the scope of a performance factors model is not limited to representations of tangible system elements but is capable of encompassing all possible functional performance variables, the frameworks outlined here provide the starting point for assessment, diagnosis and analysis of organisational problems or opportunities, and are not bounded by any specific technical focus or perspective. To the extent that each model addresses the less tangible human and organisational processes that describe the more organic aspects of organisational functioning and behaviour, they may be considered to be organic 'soft systems' models (Harrington, 1991).

In content, the human and organisational performance models identified within the literature review all comprise a series of 'performance variables', with some depiction of the nature or sequence of influences between these factors. The factors incorporated within the model are, by definition, 'soft' human and organisational factors or determinants of human and organisational performance, this latter category including technical aspects of a system such as information technology or various infrastructures, where these factors have a specific influence upon human performance. The models may employ some classificatory framework to group or structure the specific variables they contain according to type or function, and the
factors themselves may or may not be linked to specific measures at this stage, depending upon the practical application of the model and whether it is intended as a descriptive, theoretical representation or as an applied parametric model populated with quantified values. The models may incorporate both static factors (or conditions) and dynamic factors, such as human activities and behaviours that are temporally dependent or expected to vary in time.

In origin, each model falls into one of two broad classes: either operational, management science based frameworks that support practical tools and performance measurement systems, or research-based conceptual models that offer theoretical explanations for organisational functioning. The overriding, unifying criterion employed in each case was representation of human and organisational processes that may be used to enhance performance-related outcome criteria. This ensured that the models identified were practically performance orientated. Accordingly, the models are presented in two sub-sections of this section of the thesis: section 3.2.1 outlines and discusses various research-based models and approaches, whereas section 3.2.2 addresses the management science based models and frameworks.

In terms of evaluation of the various modelling approaches outlined in this section, various points of analysis and comparison are used with a theoretical base that may be found in the conceptual work of Meister (1990) and Schaffer (2000); both authors addressing the modelling of sociotechnical systems as a topic with suggestions of various criteria for categorisation and assessment of models. Accordingly, the analytical criteria employed in this section of the thesis include issues related to depth, type and applicability of content, and are outlined in more detail below.

A key descriptive criterion for sociotechnical performance models is related to the distinction between process and outcome variables. Models vary in the degree to which they focus upon system outcome criteria and 'upstream' or process variables that represent the mechanisms of functioning within the system that generate the outcome (Meister, 1990). In order for a performance model to be suitable for application in the domain of soft performance factors research, it must therefore specify both outcome and process factors in content; outcomes to identify the dependent variables that represent observable functioning of the system, and processes to specify the human and organisational mechanisms that produce the outcome.

A further evaluative criterion considered in appraisal of human and organisational performance models within the literature includes content and applicability relevant to the soft metrics research aim. The extent to which each model addresses human and organisational factors, as opposed to technical content, must be considered, along with the level of detail and depth of influences captured. Finally, applicability to the target domain: a project-based
systems engineering environment that employs cross-functional workgroups as the basic organisational element, was considered. This latter issue is partly synonymous with the question of appropriate level of analysis employed within each model, i.e. whether the model addresses organisational level, sub-unit/work group level or individual level performance processes or integrates performance processes across multiple levels of analysis.

3.2.1 Theoretical research-based criterion models

This section comprises a summary and aggregation of input-process-output frameworks and associated work group criterion models, as well as addressing models that are more theoretical in basis, due to content that addresses what are largely conceptual research variables or psychological constructs. The models in this section are taken largely from work psychology and group dynamics literature and provide examples which address social psychological and individual psychological processes relevant to human performance in the working environment.

In the context of work group effectiveness, several authors have adopted an input-process-output framework in order to classify the factors affecting performance and the relationships between these variables (e.g. West, 1996a; Guzzo & Shea, 1992; Tannenbaum, Salas & Cannon-Bowers, 1996). The input-process-output model is a useful framework for examining the interaction of factors that influence performance, as it seeks to identify determinant or intermediary criteria that are responsible for producing observed effects upon outcome variables. Classifying important performance variables in an input-process-output framework represents an attempt to illustrate the fact that the variables which influence produced outcomes, and hence the performance of an organisation, do not do so in a simple, linear manner, but interact dynamically, in more complicated causal sequences. There are therefore intermediary stages of interaction between so-called 'inputs' and the outcomes of organisational functioning, which represent the additional interaction of other variables that mediate or modify the causal sequence in some way.

*Figure 3.2.1a* below offers a summary of variables from several simple models that attempt to classify work group performance factors in terms of an input-process-output framework. In these models, inputs such as the nature of the task, team composition, organisational context and cultural context, affect the output or effectiveness of work groups both directly and indirectly via work group processes such as leadership, communication, decision-making and cohesiveness.
Brodbeck (1996) criticises the input-process-output heuristic used extensively to provide a context for factors affecting work group effectiveness in the research literature. Accordingly, input-process-output approaches over-emphasise the internal activities of work groups, at the expense of variables associated with how well the work group integrates with its external environment. Actively engaging in boundary management and efforts which coordinate work group activities with their broader systemic context, such as the use of ‘probing’ strategies to elicit multi-constituency requirements (Gladstein-Ancona, 1990), are important additional aspects of work group performance, which lead to greater work group effectiveness. Simple input-process-output models are therefore limited in their capacity to depict specific interactions between variables that may be considered to exist at differing levels of analysis of organisational structures, which are all subsumed within the broad input-process-output classification inherent within the framework. Accordingly, Brodbeck (1996) includes internal and external collective strategies as key performance dimensions in his criterion model for the study of work group functioning, reproduced here in figure 3.2.1b below.

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**Figure 3.2.1a: Combined, simple input-process-output model of work group performance, after: West (1996a), Guzzo & Shea (1992), and Tannenbaum, Salas & Cannon-Bowers (1996)**

<table>
<thead>
<tr>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Group composition</td>
</tr>
<tr>
<td>Knowledge</td>
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<tr>
<td>Skills and abilities</td>
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<tr>
<td>Demographics</td>
</tr>
<tr>
<td>Motivation</td>
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<tr>
<td>Attitudes and values</td>
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<tr>
<td>Personality</td>
</tr>
<tr>
<td>• Task design</td>
</tr>
<tr>
<td>Task organisation</td>
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<tr>
<td>Task complexity</td>
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<tr>
<td>Task type</td>
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<tr>
<td>• Group characteristics</td>
</tr>
<tr>
<td>Power distribution</td>
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<tr>
<td>Group resources</td>
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<tr>
<td>Group autonomy</td>
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<tr>
<td>Cohesiveness</td>
</tr>
<tr>
<td>Group culture</td>
</tr>
<tr>
<td>• Work structure</td>
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<tr>
<td>Group norms</td>
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<tr>
<td>Collective strategies</td>
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<tr>
<td>Communication structure</td>
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<tr>
<td>Work assignment</td>
</tr>
<tr>
<td>• Organisational context</td>
</tr>
<tr>
<td>Information</td>
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<tr>
<td>Training</td>
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<td>Reward systems</td>
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<tr>
<td>Resources</td>
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<tr>
<td>Task design</td>
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<tr>
<td>Organisational culture</td>
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<tr>
<td>Inter-group climate</td>
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<tr>
<td>Management control</td>
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<td>• Extra-organisational context</td>
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<table>
<thead>
<tr>
<th>Processes</th>
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<tr>
<td>• Co-ordination</td>
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<td>• Leadership</td>
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<td>• Intra-group communication</td>
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<tr>
<td>• Inter-group communication</td>
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<tr>
<td>• Conflict resolution</td>
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<tr>
<td>• Social interaction</td>
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<tr>
<td>• Decision-making</td>
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<tr>
<td>• Problem-solving</td>
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<td>• Boundary-spanning</td>
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<tr>
<td>• Team building</td>
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<td>• Group training</td>
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<td>• Feedback appraisal</td>
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<tr>
<td>• Planning</td>
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<td>• Target setting</td>
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<table>
<thead>
<tr>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>• Productive outcomes</td>
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<tr>
<td>Quantity</td>
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<tr>
<td>Quality</td>
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<tr>
<td>Time</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Error</td>
</tr>
<tr>
<td>• Innovations</td>
</tr>
<tr>
<td>New products</td>
</tr>
<tr>
<td>New processes</td>
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<tr>
<td>Organisational development</td>
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<tr>
<td>• Individual outcomes</td>
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<tr>
<td>New task knowledge</td>
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<td>New task skills</td>
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<tr>
<td>New task abilities</td>
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<tr>
<td>Motivation</td>
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<tr>
<td>Well-being</td>
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<tr>
<td>Job satisfaction</td>
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<tr>
<td>Personal development</td>
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<tr>
<td>• Group outcomes</td>
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<tr>
<td>Group viability</td>
</tr>
<tr>
<td>New group goals</td>
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<tr>
<td>New group norms</td>
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<tr>
<td>New group processes</td>
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<tr>
<td>New group communication patterns</td>
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<tr>
<td>Group learning</td>
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</table>
The main features of the criterion model include the fact that effectiveness outcomes comprise social and personal criteria, in addition to innovations, to supplement productive output and the model separates out situational constraints inherent in the broader organisational context and temporal dimensions. The model makes a 'modified' assumption, regarding the relationship between performance and effectiveness, in as much as the external environment and level of work group autonomy mediates the efficiency with which performance elicits effective outcomes. It also includes temporal aspects of work group functioning that may account directly for performance or effectiveness, or both simultaneously. The model deliberately varies from an input-process-output framework in that situational constraints modify the relationship between work group processes and outcomes, and in so doing direct attention to contextual factors that are beyond the control of the work group.

*Figure 3.2.1c* below depicts a model of work group effectiveness proposed by Tannenbaum et al (1996) as a guide for team research, which expands the simple input-process-output framework to incorporate various classes of variables within each area. This model may therefore be considered to represent a greater depth of influences and describes interaction between various processes and variables in detail. Contextual factors determined by the broader organisational environment are represented in the team effectiveness model as external characteristics that have a universal influence upon all processes and variables within the model. Within the 'inputs' category, the model also represents the influence of individual-level characteristics of the personnel that comprise the team, yet acknowledges that collectively, as a unit, the team also exhibits important characteristics that may be analysed in terms of effectiveness. Further inputs to performance processes include the organisation of
work and team tasks, including factors such as task complexity and communication structure. These factors are presumed to be team variables, as opposed to features of the organisational context, implying a level of autonomy or control over working processes that alludes to a self-organisational capacity for the team. In this sense, the model may be applied comfortably to autonomous integrated project work groups that are charged with an overall requirement or objective, and possess sufficient functional autonomy to organise work and break down broad goals into individual work tasks, according to available team structures and task knowledge.

![Diagram of Organisational and situational characteristics]

**Figure 3.2.1c: Team effectiveness model (Tannenbaum et al, 1996)**

The team effectiveness model adopts a human-centred view of performance processes and effectiveness criteria within organisations. Within the output category of the model, the work group's operational or formal effectiveness criteria are represented under the team performance factors category. The model also recognises and represents human and social outcomes from work group functioning, such as enhanced knowledge and working processes, which contribute to achievement of the team's work-product goals. The feedback arrow is also an important addition, representing learning and development that enhances the team's future functional capability through modifying input factors over time.

Overall the team effectiveness model provides a detailed and comprehensive framework for the analysis of human performance processes within team-driven organisations, and serves to illustrate the complexity of possible interactions and influences between human and
organisational variables. As it employs specific categories that group factors, the model implies that all variables within each category influence linked categories of factors in the same way. The authors have determined an appropriate level of depth of interactions to depict within the model in the interests of representing major influences whilst reducing complexity to a minimum to aid comprehension of the user or reader. Conceivably, specific influences might be traced between individual sub-factors within the team effectiveness model that would provide a higher level of information by representing the system on a lower level of abstraction. It should be noted that all of the models within this section of the thesis are limited in terms of their ability to describe specific interactions in this way, perhaps most importantly in the case of operational or product-related performance criteria, which is often depicted as a general outcome category linked to more complicated process elements.

In addition to modelling functional performance processes and effectiveness criteria, other authors that address work group performance factors have adopted different approaches. One such approach is that proposed by Castka et al (2001), depicted in figure 3.2.1d, that seeks to represent the key enablers or preconditions for the successful implementation of High Performance Teams (HPTs). The model depicted in figure 3.2.1d is based upon the framework offered by the authors, elaborated with factors identified from their accompanying commentary.

![Diagram of HPT factors and implementation](image)

**Figure 3.2.1d: Factors for the successful implementation of High Performance Teams (HPTs; adapted from Castka et al, 2001)**

Inherent in this model is the dichotomy between what may be regarded as ‘system factors’, which includes work process aspects, organisational contextual factors (such as culture) and performance measurement systems, and ‘human factors’, which includes variables at the
group and individual levels. 'Soft' factors permeate this model at all levels of analysis, from individual differences and human 'needs' on the level of the individual within the workgroup, through group factors associated with the working environment and climate specific to the work group. At the organisational level, strategic alignment in values and objectives is considered. The prevalence of soft factors within the model may be expected and is a consequence of the human systems focus and purpose of the model: to facilitate the implementation and support of high performance group working capabilities within an organisation. A notable omission from the model, however, is specific results or outcome criteria, other than 'high performance teams', that describe the dimensions of performance or effectiveness that the factors within the model support.

Hackman and Oldham's Job Characteristics research and associated diagnostic survey (1974; 1975; 1976) resulted in the development of a Job Characteristics Model, that is aimed at specification of determinant factors for various outcome variables at the individual level of analysis. The Job Characteristics model is depicted in figure 3.2.1e below.

The Job characteristics model can be employed in job design to enhance the experience of work for increased satisfaction, motivation and performance outcomes, through linking the features of jobs to the individual's experience of those features. Individual differences in the desire for growth and development are accounted for in the mediating person factor 'Growth Need Strength' (GNS). Enriching the features of the job may therefore not lead to enhanced performance if the individual's GNS is low. The model represents the interaction between
person and contextual or work environment characteristics, and as such is sociotechnical in perspective.

Within the Job Characteristics model, the five important features of jobs for effective human functioning refer to the extent to which a job makes use of different skills and abilities, involves a whole and meaningful piece of work, affects the work of other organisational members, gives the individual freedom, independence and discretion in carrying it out and provides information about ongoing performance attainment. The implementing concepts within the model are activities that may be used to support enhancement of the motivating potential of a job. The Job Characteristics model may be considered to be a suitable human and organisational performance model as it encompasses individual level variables and outcomes, key characteristics of work organisation for effective human performance, linked to operational outcomes subsumed within the 'performance quality' variable. The model is also applicable as its core job dimensions may be equally applied in the analysis of project work roles that are encountered in the systems engineering domain.

Figure 3.2.1f below depicts the 'high performance cycle' of Locke and Latham (1990) as an example of performance models that address processes that operate predominantly at the individual level of analysis. Here, the performance model is proposed to illustrate the factors and influences that describe one specific aspect of the individual's functioning; that relating to motivational processes. As a theoretical research model that subsumes various established approaches to understanding motivational processes, the high performance cycle may be considered to represent an integrated theory of motivation.

As is predominantly the case in psychological research models, variables and their interactions are structured according to functional behaviour, as opposed to any specific classificatory framework. Accordingly, different types of factors representing different levels of analysis within an organisational system are subsumed within various functional classes according to their nature of influence. In the high performance cycle, specific high goals, high expectancy and self-efficacy are associated with high performance outcomes that lead to modified reward expectations, job-satisfaction and commitment to organisational goals. This relationship is mediated through mechanisms or processes that affect the individual over time, such as effort, persistence, direction and task strategies.
The impact of the mediating mechanisms within the model upon the achievement of high performance is moderated by several factors that subsume both individual level and organisational contextual variables, including level of ability and level of task complexity. Although a representation of human processes on the individual level, the purpose of the model is to represent theorised motivational processes that impact upon performance, and in terms of practical support for work performance, the model lacks global consideration of determinant factors due to adherence to this perspective. The model does however show that when organisational performance determinants are considered from the perspective of the human individual, the necessity to consider willingness as well as ability to achieve work objectives means causal models must include variables representing the influence of psychological processes that cannot necessarily be depicted in simple linear sequences.

The congruence model of organisational behaviour proposed by Tushman et al (1986) and depicted in figure 3.2.1g below represents a more global view of behavioural processes within the entire organisation, that impact upon performance. As such, the congruence model represents a comprehensive approach to the modelling of performance factors within an organisation that is not limited to the perspective of the individual or work group, and which specifies separate output criteria that relates directly to separate individual, sub-unit and organisational levels of analysis within a sociotechnical system.

Figure 3.2.1f: Locke and Latham's (1990) high performance cycle of motivation (source: Foster, 2000)
In terms of applicability to the systems engineering domain, the congruence model is used to describe relevant organisational behaviour by Blanchard (1990) in a guide to engineering project management tools and techniques. It may therefore be considered to be relevant to application in support of project-based organisational functioning and management. Inherent within the model is the assumption that organising for a successful project involves maximising the congruence between inputs, strategy, elements in the transformation process and desired outputs. In terms of the behavioural aspects of the model, which represent the processes that translate inputs to outputs, several classes of variables are specified associated with strategic governance, work organisation, formal and informal structures and individual level variables. Strategies are developed under the influence of environmental factors, available resources, traditions and history of the organisation, and are translated into operational tasks and objectives. The actual organisation and specification of work tasks are outlined to implement the strategy within the framework of formal and informal organisational structures and within the constraints of human capabilities and requirements.

The congruence model of organisational behaviour represents an important contribution to engineering management science, in its inclusion of individual level criteria representing the human elements of an organisational system and representation of the informal organisational structure, which recognises the importance of informal management practices, interpersonal relationships and working arrangements. All of these factors may be associated with the contribution of evolving social networks and embedded tacit knowledge to enhancement of overall organisational performance.
3.2.2 Applied models from the management sciences literature

The applied models in this section are from the management sciences literature and may be considered more practically applied in content than the theoretical models outlined in the previous section of this thesis, which are predominantly aimed at explaining complex processes or providing a structure for research within specific domains. The examples below were identified due to their focus upon human and organisational factors that contribute to organisational performance, and all have a sizable volume of literature associated with their application.

The People Capability Maturity Model (PCMM) (Curtis, 2002; Curtis, Hefley & Miller, 2001), depicted in figure 3.2.2a, offers over twenty ‘key process areas’ addressing human and organisational factors that contribute to organisational performance. As a progressive criteria model, the people capability maturity model may be applied to assess the degree of maturity in human resource and other processes that impact upon human capability within an organisation. The framework is prescriptive in that it assumes the characteristics of effective organisations embedded within it are universal.

The process maturity levels within the PCMM are acquired in succession and are based upon a standard framework common to a series of capability maturity models in different areas of organisational operations (e.g. Paulk, 1995). In the model, high maturity organisations are characterised by increased process control and predictability through measurement of operations. The effect is to deliver enhanced, repeatable organisational performance and continuous process improvement. Development of processes up through the levels in the model is enabled by specified ‘key process areas’ for each discipline, in this case human resource management practices. Through analysis of status and performance in the key process areas specified within this framework, the organisation can support continuous improvement up through the maturity levels within the model.
### Developing people capability

<table>
<thead>
<tr>
<th>Process maturity levels</th>
<th>Key process areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Initial</strong></td>
<td>Inconsistent management</td>
</tr>
<tr>
<td></td>
<td>Continuous workforce innovation, Organisational performance alignment, Continuous capability improvement</td>
</tr>
<tr>
<td><strong>2. Managed</strong></td>
<td>People management - Repeatable practices</td>
</tr>
<tr>
<td></td>
<td>Mentoring, Organisational capability management, Quantitative performance management, Competency-based assets, Empowered workgroups, Competency integration</td>
</tr>
<tr>
<td><strong>3. Defined</strong></td>
<td>Competency management - Competency-based practices</td>
</tr>
<tr>
<td></td>
<td>Participatory culture, Workgroup development, Competency-based practices, Career development, Competency development, Workforce planning, Competency analysis</td>
</tr>
<tr>
<td><strong>4. Predictable</strong></td>
<td>Capability management - Measured and empowered practices</td>
</tr>
<tr>
<td></td>
<td>Compensation, Training and development, Performance management, Work environment, Communication and coordination, Staffing</td>
</tr>
<tr>
<td><strong>5. Optimising</strong></td>
<td>Change management - Continuously Improving practices</td>
</tr>
</tbody>
</table>

#### Figure 3.2.2a: People Capability Maturity model (PCMM; adapted from Curtis, 2002)

The PCMM is predominantly action-oriented and as such identifies activities that form enablers for enhanced performance. Whilst the activities themselves, their presence/absence or level, may be considered to be determinant or process factors for high performance, it is not clear from the model alone what the expected performance outcomes affected are, other than 'maturity'. In scope, the model addresses organisational level activities most commonly associated with the human resources function, but the activities themselves are aimed at the support of individual and work group performance and encompass a broad range of human and organisational factors. Exact causal influences, however, are not directly specified.

Kaplan and Norton's 'Balanced Scorecard' model (1993; 1996a; 1996b) has received much attention in the performance management literature due to its premise of supplementing traditional financial performance indicators with other 'balanced' perspectives that aim to provide a more complete performance assessment for strategic business management. Much work has been undertaken on the application and assessment of benefits associated with the balanced scorecard (e.g. Olve et al, 2000; Simons, 2000). The main framework of the balanced scorecard is reproduced within **figure 3.2.2b** below.
Schaffer (2000) classifies the balanced scorecard as a 'Performance systems architecture', which addresses performance processes only, as opposed to an organisational system architecture that seeks to accurately represent a holistic view of the organisation's complete structural elements and interrelationships. As a 'performance systems architecture', it inevitably embodies the model developer's own perspective upon what the important or key variables and processes for performance are, from the larger sub-set that represents the properties and functioning of the complete system.

From a soft factors perspective, the 'learning and growth' perspective within the balanced scorecard framework attracts the most attention, due to its orientation towards enhancing the capabilities of people, systems and organisational processes. Inherent in the approach, objectives in the learning and growth perspectives are considered to be drivers for achieving high performance outcomes in the other three scorecard perspectives and include targets associated with employee capabilities, motivation, empowerment and alignment. Although a principle exponent of the view that tangible outcome criteria such as financial performance variables are largely dependent upon the quality of complex human and organisational processes, especially where a strategic, long-term perspective is adopted, the balanced scorecard only informally supports causal analysis of performance processes and does not explicitly specify causal influences. The assumption that organisational-level performance outcomes are the result of factors that operate within the four perspectives is more implicit. As a well-established method aimed at universal performance measurement practices with
supporting tools, the balanced scorecard may be considered to be applicable to all operations and business environments that are process-centred and report performance against set criteria. The balanced scorecard addresses functioning and assesses performance at the organisational level of analysis.

Another popular performance model from the management sciences literature finds its origin in the quality management movement. The European Foundation for Quality Management model (EFQM, 1998), sometimes referred to as the European Business Excellence model, clearly distinguishes between outcome factors ('results') and process factor determinants ('enablers'). The EFQM model is reproduced in figure 3.2.2c below.

The EFQM model aims to improve European business through the application of Total Quality Management principles and is based largely upon the US Malcolm Baldrige Award. The factors included within the model encompass employee-focused as well as customer-focused criteria, which are linked to non-financial measures. From a human perspective, the leadership, people management and people satisfaction factors are of particular interest. Importantly, the EFQM model recognises that tangible business results are only one facet of the results of organisational functioning, and that other softer criteria may also be evaluated in order to determine the achieved level of success. The model also depicts the outcomes: people satisfaction, customer satisfaction and impact upon society as 'upstream' variables from business results, highlighting the implication that human processes drive business performance.

An important functional characteristic of the EFQM model is that it incorporates weightings assigned to each factor, that represent the priority of each factor in contribution to the overall concept of 'excellence'. Equal weightings are assigned to the results and enablers categories.
(50%), implying that business excellence is achieved through equal attention to retrospective outcomes and more proactive process factors. Developing effective leadership and people management processes to increase satisfaction of employees may be estimated as contributing almost a third of the necessary capability to achieve excellence in operations.

The EFQM model is offered as a universal guiding framework for support of performance on a business-wide or organisational level, but it may also be applied upon lower sub-levels to address performance in more localised organisational structures, such as projects or work groups. Figures 3.2.2d and 3.2.2e below depict two EFQM model variants, developed to apply to individual projects and teams, respectively. To the extent that the EFQM model is applicable in these scenarios, it may be considered to represent important performance processes for systems engineering project management teams.

Within Bryde's (2003) Project Management Performance Assessment (PMPA) model, 'project management leadership' involves raising awareness of quality management concepts, supporting development towards the objective of a broader role for project-based operations in the organisation and extending projects beyond the aim of managing output from unique, capital-intensive activities to encompass softer projects such as change management or capability development. Key leadership performance factors included promotion of open, two-way partnerships between customers and suppliers, development of a shared, common project language and implementation of team-based operations. The human focus upon project personnel recognises a need to plan and manage human resources from the individual project's perspective, as well as in terms of broader organisational level competencies and the provision of appraisal, reward and recognition for project-relevant performance.

![Figure 3.2.2d: Modified EFQM model for Project Management Performance Assessment (PMPA; Bryde, 2003)](image-url)
In terms of research findings associated with development and application of the PMPA model, Bryde states that failure to establish a common project language is often cited as a reason for poor project performance, though this factor overlaps with inability to establish open customer-supplier partnerships. Relative proximity of project personnel was found to have a detrimental effect upon performance in projects that incorporated geographically dispersed team members. The importance of developing processes to increase project capability, specifically in the area of human capability of project team members, was also highlighted. Critical strategies for obtaining this were found to include: staff training and development, staff recruitment and team selection, all of which prioritised technical skills, emotional drive, people skills and organisational knowledge as important facets of human competency for project-based operations.

Castka et al (2003) have applied the EFQM model to work groups in order to measure teamwork culture. The Teamwork Excellence Model (TEaM) preserves the results criteria specified in the original EFQM model, but adds a third category of factors: 'team enablers' to describe several factors that account for successful implementation of high performance teams. The intermediary team enablers category accounts for how organisational enablers allow key results to be achieved through team-working processes and includes factors such as team knowledge and skills, group culture, alignment and interaction with external entities and team-working processes.

Several performance models have been developed from the perspective of intellectual capital as the key performance driver in modern knowledge-intensive enterprises (e.g. Stewart, 1997; Gray, 2001; Skyrme, 1998; Sveiby, 1997). Figure 3.2.2f below depicts the ‘Skandia IC Navigator’ (Edvinsson & Malone, 1997) that was developed in order to enhance the visibility and measurability of intangible and soft assets that represent the performance capability, and

![Figure 3.2.2e: Modified EFQM model of Teamwork Excellence (TEaM; Castka et al, 2003)](image-url)
hence value, of an organisation. As with many of the models reported in this section of the thesis, the Skandia Navigator includes a temporal dimension, with the 'financial focus' representing outcome or results criteria that are conventionally recorded in a company’s balance sheet. Financial criteria are classed as 'historical' in focus, meaning that they are retrospective indicators or ‘lag’ measures that can only indicate the value of results after the event. 'Upstream' determining factors are therefore represented in the more proactive ‘today’ and ‘tomorrow’ areas of the model, in which human capability, work processes and renewal and development efforts are represented. It is notable that the human focus is depicted as central in influences within the model, underlying all other factors. Edvinsson and Malone state that the human system is the only ‘active force’ within the model, representing “the heart, the intelligence and the soul of the organisation” (1997, p69).

The Skandia Navigator provides an overview of the relationship between what may be regarded as a number of broad categories of performance factors and as such is limited in its descriptive content regarding specific factors and exact mechanisms of influence, without the benefit of accompanying documentation. In scope, however, the model represents the important contribution that the intellectual capital movement makes to the definition of soft factors or ‘intangibles’ that underpin performance processes. Accompanying the model in figure 3.2.2f is a breakdown of intellectual capital, based upon work by Gray (2001) to represent specific factors that populate the perspectives depicted within the model. Intellectual capital may therefore be broken down into ‘human capital’, representing skills, knowledge, culture and capabilities of people in the organisation, ‘structural capital’ representing process knowledge captured by the organisation and ‘stakeholder capital’ representing the value of established collaborative relationships and reputation.

More recent work addressing human capital has focused upon the human contribution to organisational performance and one model arising from this area of work is the ‘Human Capital Monitor’ (Mayo, 2001), depicted in figure 3.2.2g below. As a performance model, the Human Capital Monitor clearly depicts soft determinant factors for financially based outcomes,
Including human capability, human development and retention activities and human motivation and commitment.

<table>
<thead>
<tr>
<th>PEOPLE AS ASSETS</th>
<th>PEOPLE MOTIVATION AND COMMITMENT</th>
<th>PEOPLE CONTRIBUTION TO ADDED VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Asset Worth:</td>
<td>Work Environment:</td>
<td>Financial</td>
</tr>
<tr>
<td>- Capability</td>
<td>- Leadership</td>
<td>Non-financial</td>
</tr>
<tr>
<td>- Potential</td>
<td>- Practical support</td>
<td>Current</td>
</tr>
<tr>
<td>- Contribution</td>
<td>- The work group</td>
<td>Future</td>
</tr>
<tr>
<td>- Values Alignment</td>
<td>- Learning and development</td>
<td></td>
</tr>
<tr>
<td>Maximising Human Capital:</td>
<td>- Rewards and recognition</td>
<td></td>
</tr>
<tr>
<td>- Acquisition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Retention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Growth</td>
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</tbody>
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Figure 3.2.2g: The Human Capital Monitor (Mayo, 2001)

Through recognising the importance of capability and willingness of people to contribute value to an organisation, the human capital monitor makes an important contribution to definition of soft performance processes for modelling efforts. The model also highlights interaction between human capabilities and features of the work environment, such as the systems and processes put in place to guide human effort and behaviour. Both the intellectual capital performance models depicted here may be considered to be general frameworks representing organisational level processes, as opposed to team or individual level functioning. To the extent that they focus upon the operation of human systems, variables and perspectives contained within both models may be usefully applied at all levels of the organisation to identify or classify specific factors that influence individuals, work groups or definable sub-units such as the project organisation.

3.3 Human and organisational performance factors

Dinsmore (1990) states that of all performance issues encountered in project operations, at least 50% and potentially as much as 75% are due to 'behavioural', people problems as opposed to technical issues. Control of soft factors in project operations is therefore paramount for successful organisational functioning. In order to establish an adequate conceptual research base upon which to develop a practical approach to the problem of measuring soft factors in projects, relevant human and management sciences research literature was reviewed. This activity was undertaken in order to: 1) identify potential human
and organisational factors that impact upon operational performance in a work environment, and 2) explore research evidence of dependencies and associations between factors in order to achieve a theoretical understanding of causal links to feed into a model of human and organisational performance processes. According to conceptual distinctions made in an earlier section of this thesis, the human and organisational performance factors discussed below may all be considered ‘upstream’ process indicators for performance outcome criteria.

Through initial review of the research literature and early interviews with project supervisors, a number of potential areas of interest were established for further investigation. These topic areas included: work group composition, group cohesion, leadership, autonomy, resource adequacy, goal and task characteristics, workload, cultural factors, IT, motivation, performance feedback, decision-making, group development, organisational learning, planning and scheduling, boundary issues, innovation, well-being, and trust.

In the sub-sections that follow, key research findings and theoretical considerations identified from relevant literatures are summarised under each of the general topic areas listed above. In reviewing the literature, the focus was upon identifying links to organisational performance where possible, and identification of key variables for subsequent development and implementation in an applied soft metrics approach. Due to the broad scope of these topic areas and volume of research literature reviewed, this current section of the thesis summarises what were regarded as the main research findings in each area. For more detailed and elaborative consideration of research-based knowledge relating to the key human and organisational performance factors outlined below, the reader is referred to appendix A. Key operational effectiveness criteria representing variables for the assessment of organisational performance outcomes are summarised in a later section of this thesis (section 3.4).

3.3.1 Work group composition factors

In considering work group composition factors and individual-level characteristics of work group members that have been found to impact upon the performance of the team, several variables have been studied including: homogeneity or heterogeneity in work group composition structure, work group size and demographic or person-characteristics of work group members such as age, gender, ethnicity, educational level, training, ability levels, personality, attitudes and values, professional background, status and geographical location (e.g. West, 1996a; Jackson, 1996; Unsworth & West, 2000). Demographic homogeneity in terms of age, sex and educational level tends to predict group cohesiveness, rather than influencing work group effectiveness directly (West, 1996a). Certain individual characteristics
are known to influence the effectiveness of group decision-making processes, including communication skills, egocentricity, propensity to dominate group discussions, status, gender and hierarchy, though little clear evidence exists as to how the personality of individual group members affects work group performance directly (West, 1996a). Brown (1988) identifies social conformity as an important factor leading to withholding of information that contradicts the dominant view represented by majority opinion, which influences the effectiveness of decision-making processes.

The size of a work group has been identified as having an impact upon its effectiveness. Stroebe and Frey (1982) state that 'coordination' process losses can occur in larger groups due to the increased requirement to arrange times for meetings, coordinate tasks, integrate and pass on information, resulting in detriment in effort available for directly productive work. Larger groups may also expend more effort in coordinating interactions during group discussion and decision-making processes (Unsworth & West, 2000). In terms of heterogeneity in age, Jackson et al (1991) reports that staff turnover rates are higher in teams that vary in terms of group members' ages and age may influence the level of conflict in the group through risk-taking propensity and problem-solving approaches.

Watson et al (1993) suggests that culturally heterogeneous groups may experience less effective intragroup communication, especially in newly formed teams, though other evidence suggests that work groups incorporating cultural diversity in group composition, exceed the performance of their monocultural counterparts due to benefits associated with the diversity of perspectives inherent in a culturally heterogeneous group (Smith and Noakes, 1996). Smith and Noakes also offer several factors that may impede performance in culturally diverse groups, however, including: language problems, differing approaches to interpersonal relationships, differing perspectives on time, varied preferred leadership styles and formation of sub-groups within the team.

In terms of ability level, group problem solving performance is generally a positive function of average group member ability level (West, 1996a), though this relationship is not simply linear and the extent to which a group member's ability level influences group performance can be affected by other factors such as status, popularity and political processes within the group. Heterogeneity in functional background has been identified as a factor more likely to impact upon team performance (e.g. West, 1996a; Unsworth and West, 2000) resulting in more creative decisions of higher quality than professionally homogeneous groups. Diversity in task-relevant skills and knowledge therefore leads to greater team effectiveness. Related research results include the finding that diversity in educational specialisation within a team leads to more adaptive organisation and more effective strategic change (Wiersema and Bantel, 1992), as well as clearer corporate strategy (Bantel, 1993). In terms of knowledge
requirements for composition of successful teams, Siemieniuch, Sinclair and Fairclough (1999) highlight knowledge relating to operational procedures, human resources, products, equipment, control processes, quality assurance and the functional domain as important. Fletcher (2000) offers several important managerial competencies that may be considered in the selection of individuals for high performance management teams, including: problem analysis and judgement capability, planning and organisational capability, motivation of others, achievement and energy, and tenacity or resilience.

3.3.2 Group cohesion, leadership and autonomy

Group cohesion may be defined as the degree of liking or attraction between group members and their liking for the group itself. Unsworth and West (2000) offer several research findings concerning the relationship between 'cohesive' groups and high performance. Cohesiveness can influence work group effectiveness by increasing motivation and group members' helping behaviours. Members of socially integrated groups consequently experience higher morale and job-satisfaction. Highly cohesive work groups also incur less coordination and communication costs and can therefore apply more attention to task-related activities such as problem solving. Accordingly, cohesive groups are reported to devote more time to planning and problem analysis. Mullen and Copper (1994) reviewed evidence from forty-nine separate studies of the cohesiveness-performance effect and report that there is a statistically significant relationship between group cohesiveness and group task performance. The direction of influence, however, remains to be clarified and may be strongest from performance to cohesiveness, i.e. successful, high performance fosters greater intra-group cohesion.

Bass (1990) proposes two types of leadership styles that motivate and direct work groups towards the achievement of their performance goals. 'Transactionial' leadership employs transactions, exchanges and contingent rewards and punishments to change team members' behaviour. This style focuses upon task-oriented behaviours, and interventions to reinforce required behaviour and deploy sanctions for negative performance. In contrast, the 'transformational' leadership style involves influencing and inspiring team members through charisma and visioning, and motivating individuals towards completing tasks as part of a team rather than just focusing upon group members individual objectives and performance. Markiewicz and West (1997) suggest three main functions in which group leaders must be competent: group management, coaching individuals and leading the group. Group management capability involves setting clear objectives, clarifying the roles of work group members, evaluating individual contributions and developing individual tasks, providing feedback on group performance and reviewing team processes, strategies and objectives.
The ability to coach individuals requires listening, recognising and revealing individuals' thoughts and opinions, giving feedback and agreeing goals. Leading the group involves creating favourable performance conditions for the work group, building and maintaining the work group as a performing unit and coaching and supporting the group.

In a meta-analysis of 131 field studies of organisational change by Macy and Izumi (1993), the authors concluded that the creation of autonomous workgroups, with substantial responsibility for their own work, had a positive impact upon financial measures of organisational performance. Cordery (1996) offers several reasons for improved work group performance as a result of self-management, including: increased speed in decision-making, higher innovation and creativity, a more trusting and open group working climate, individual empowerment and increased self-efficacy. The impact of autonomous functioning on the individual's job characteristics, including autonomy, feedback, task significance, task identity, and skill variety, is related to enhanced work performance through increased job satisfaction, motivation and lower absenteeism (Hackman and Oldham, 1976). Work group autonomy is linked to leadership by Gulowsen (1979) who states that type of leadership may influence the degree to which a work group can decide where, when and how to work, can decide how to sub-divide tasks and assign them to group members, can influence the formulation of goals and can self-determine group composition. Leadership style is also synonymous with cultural performance determinants and research has shown that the pervasive style of leadership evident in an organisation's culture may have a direct impact upon team level performance achievement (Chalmers, 2001).

3.3.3 Resource availability and quality

Peters and O'Connor (1980) highlight the importance of adequate resource provision for effective human performance within the organisation. Even though individuals may be knowledgeable or skilful and motivated enough to be able to successfully accomplish a task, they can be prevented from doing so by unavailability of resources, or inadequate quantity and quality of resources. In terms of the types of resources required for effective team performance, the availability of resources such as people, money and equipment, as well as the appropriateness of the work technology used, affects the relationship between work group processes and effectiveness (West, 1996a). Similarly, Tannenbaum, Salas and Cannon-Bowers (1996) state that an important prerequisite of effective performance and team success is that a work group's resource needs are met. The work group's resource needs include time allowed for members to work on the group's tasks, access to information necessary to complete the tasks, necessary equipment and personnel made available, appropriate or
available organisational policies and commitment over the long term to group-member development and skill-acquisition.

### 3.3.4 Group goal characteristics

Pritchard et al (1988) reports research in which the incremental effects of introducing group feedback, goal setting, and incentives upon productivity were measured using organisational units in a military context. The reported average increases in productivity over established baseline performance were 50%, 75% and 76% respectively, indicating the importance of group feedback and goal setting for work group effectiveness. In a review by Weldon & Weingart (1994) of more than thirty studies of group goals and group performance in various work settings, it was concluded that the introduction of group-based goals led to better performance and productivity, with specific and difficult goals in particular leading to improved performance over more general and easier to achieve objectives. Several factors relating to work group objectives are highlighted as important for optimal performance, including: comprehensiveness of goal-setting activities covering all aspects of functioning, availability of feedback regarding progress towards goal achievement, ability to break down group goals into individual-level work objectives and management of failure. Goal commitment on the part of group members was also found to be an important factor influencing goal attainment. Commitment to objectives was found to be influenced by the attractiveness of the goal, the perceived difficulty of the goal, the presence of competing goals and the goal commitment of others in the group. In the goal-setting theory of motivation (Locke, 1968), several important variables associated with inherent characteristics of task goals are highlighted that influence performance through increasing motivation. These factors may be summarised as: goal difficulty, compatibility of goals, goal specificity, goal acceptance and inherent feedback.

### 3.3.5 Task and role characteristics

Work group task characteristics can be classified in terms of the cognitive requirements they place upon work group members. Kent and McGrath (1969) conclude that much of the variance in work group performance can be accounted for by the nature of the task itself. Employing various work group outcome indicators such as issue involvement, originality and action orientation, Kent and McGrath found that differences in the inherent cognitive features of tasks influenced group effectiveness outcomes. Production tasks tended to result in high originality but low issue involvement, whereas discussion tasks had the opposite effect. The degree of visibility of individual's performance to other team-members is particularly important if negative effects associated with 'social loafing' are to be avoided (George, 1992). The degree to which task design within the group incorporates the facility to both identify and
evaluate individual contributions may therefore be identified as an important performance factor. According to Guzzo and Shea (1992), group member's tasks and roles should be designed in such a way as to be unique, important and make a meaningful and visible contribution to the effectiveness of the work group, if individuals are to be motivated and work effectively with others towards achieving the groups objectives.

Warr (1987; 1996) offers nine categories of work environment features that influence employee well-being and experienced job-satisfaction, which in turn influence motivation and performance. The important work environment characteristics from a human perspective may be summarised as: opportunity for personal control, opportunity for skill use, presence of externally generated goals, variety in work experience, clarity in the working environment, opportunity for interpersonal contact and provision of a valued social position, amongst others. Similarly, Hackman and Oldham (1976; 1980) offer several job dimensions that interact with characteristics of the individual to influence work performance. 'Skill variety' refers to the extent to which work activities utilise different skills and abilities of the individual and 'task identity' refers to the degree to which the job involves completion of a 'whole', identifiable and meaningful piece of work. The degree to which the individual's work impacts upon the lives or work of other people and broader society is represented in the 'task significance dimension' and 'autonomy' refers to the inherent freedom, independence and discretion available in the performance of the work task. Finally, the availability of relevant information regarding the individual's performance is incorporated in the 'feedback' dimension. In analysis of work group task structures, several temporal dimensions have been identified as potential performance factors, including task concurrency, succession and coordination features (McGrath and O'Connor, 1996).

3.3.6 Workload

Tattersall (2000) states that mental workload, which may be loosely defined as the costs that humans incur in performing tasks, is a multidimensional concept that is difficult to measure and which incorporates aspects such as time pressure, mental load and stress or frustration. Mental workload therefore represents the operation of factors associated with features of the work task, relative to the characteristics and experience of the individual. Mental workload is an increasingly important performance factor due to increasing cognitive demands in modern jobs. Tasks demands that are too high or too low may lead to degradation in observed performance. Consideration of workload also implicates other antecedent factors as a human worker's performance cannot be improved indefinitely simply through 'working harder'. Humans must be motivated to sustain high mental effort through attention to task demands and awareness of the operating goals. Siemieniuch, Sinclair and Fairclough (1999) outline
various constructs that can be used to classify workload level for individual operations in a process, including: temporal demands, operation criticality, operation uncertainty, operation complexity, degree of precision required and the required level of mental or physical effort.

3.3.7 Organisational culture and group working climate

Many culturally determined aspects of organisations have been addressed by organisational culture and climate research, including organisational effectiveness (e.g. Denison, 1990) and safety (e.g. Grote and Künzler, 2000). Unsworth and West (2000) define work group climate as shared perceptions, values and beliefs regarding formal and informal policies, procedures and practices, that may influence performance, productivity and innovation. Research into the factors that influence innovation in work groups (e.g. West, 1990; West & Anderson, 1996) propose four factors that are required to create an effective climate for innovation, including: shared vision, participatory culture, support for innovation and commitment to high quality task performance.

Successful team-based organisations require commitment to skill development, well-being and support of employees. Where the climate is characterised by high control, low autonomy for employees, lack of concern for employee welfare and limited commitment to training, group-working effectiveness will suffer as a result (Markiewicz & West, 1997). Mohrman et al (1995) demonstrates that inter-team competition is a major threat for team-based working, as competing teams may develop more commitment to their own success than to that of the organisation on a whole, which may in turn lead to the withholding of vital information and support from other 'competing' teams. A competitive culture may, therefore, promote individual work group goals above and without reference to the broader goals of the organisation.

3.3.8 IT Support

The adequacy of information technology to facilitate human communication is an important factor that may influence operational performance. One of the biggest challenges for information technology to support modern working practices lies in achieving functional socio-technical integration. Computer Supported Cooperative Work (CSCW) systems must therefore adequately integrate with social processes within an organisation, if they are to be accepted and functional (Eason, 2002). According to McGrath and O'Connor (1996), technology and communications technology in particular, holds important implications for the temporal patterning of communication in work groups. In an evaluation of the use of CSCW systems in the automotive industry, Siemieniuch and Sinclair (1999b) comment upon the role
of information and communications technology in supporting information-handling and collaborative working of groups that are geographically distributed throughout the supply chain. Several technological issues are important for the performance of distributed work groups, including: adequate IT support for human networking, integration of information management systems and provision of effective tools that allow on-line, available, up-to-date and accurate temporal scheduling. The potential impact of IT adequacy on performance is demonstrated by Davenport and Prusak (1998) through quantifiably measured productivity increases and savings in both money and time achieved following the implementation of virtual team-working technology in an organisation.

3.3.9 Human motivation and performance feedback

Buchanan and Huczynski (1997) define motivation as the internal psychological process of initiating, energising, directing and maintaining goal-directed behaviour. Several conceptual approaches to the study of motivational processes have been proposed in the research literature (e.g. Vroom, 1964; Locke, 1968; Locke and Latham, 1990). Locke (1968) states that motivation is influenced by specific intrinsic characteristics of work tasks, namely features associated with the goals of work task activities. Locke and Latham (1990) propose an integrated theory of motivation that depicts motivation as a complex process, subject to various moderating factors. Job satisfaction, for example, does not influence motivation directly but acts through influencing commitment to the organisation's goals in determining high performance. Well specified, high yet attainable goals, high expectancy on the part of the individual and high self-efficacy all influence performance through increasing the effort, persistence and sense of direction in the individual's approach to work tasks. This effect is moderated by the individual's commitment to the organisation's goals, their ability, task complexity and inherent feedback and broader situational constraints. Vroom (1964) proposes three factors that affect human performance through influencing motivation for effective activity in the work-place. 'Expectancy' and 'instrumentality' refer to the belief that an individual's performance will be instrumental in achieving desired outcomes. Desirability of outcome is the third factor, representing perceived rewards that are not necessarily confined to external rewards such as pay incentives, but may incorporate intrinsically rewarding features of the task itself.

Fletcher (2000) highlights the link between performance feedback and motivation, by stressing that the very act of giving feedback provides motivation as people have an inherent desire to know the efficacy of their actions and behaviour. Feedback is important for performance on an individual level, which is supported and improved by supplying information regarding the effectiveness of ongoing behaviour. Formalised performance feedback
processes in the organisation, such as staff appraisal or evaluation procedures, also provide motivation by governing the allocation of rewards and reinforcing positive performance through offering incentives related to salary and personal development opportunities. Assessment practices that involve target-setting also have a motivating effect by directing the individual's efforts towards the achievement of specific goals.

3.3.10 Decision processes

Courtney (2001), in a consideration of the personal or individual perspective in organisational decision-making, identifies several important individual-level variables that influence decision-making style, including: individual experiences, training, intuition, values, ethics, personality factors and attitudes to risk. Research indicates various instances of apparent negative performance effects resulting from the aggregation of individual's work efforts in group situations. Rogelberg et al (1992), for example, reports that whilst groups make better decisions than the average quality of individual's decisions when rated by experts, they consistently fail to exceed the quality of decisions made by the most capable group members when working as individuals. Similarly, Diehl and Stroebe (1987) in their study of 'brainstorming' groups, report that the quality and quantity of ideas produced by individuals working alone exceeds those produced when individuals work together. Other research, however, highlights important performance benefits achieved through team-based working practices. The multi-disciplinary work team literature suggests that group-working procedures aimed at functional integration convey performance benefits due to varied participation and combination of a broad range of experience and expertise brought to bear upon group tasks (e.g. Jackson, 1996).

Unsworth and West (2000) specify several sequential sub-activities or stages within work group decision-making processes, including: problem recognition and definition, solution generation, solution analysis and choice, followed by solution implementation. Maier (1970) found that work groups which focus upon the problem as well as the solution, are more effective. Defining the problem through analysis improves work group decision-making and defining the problem from a variety of different perspectives produces a broader range of possible solutions.

'Groupthink' is a group decision-making 'syndrome' reported by Janis (1982, 1989) in which groups may make erroneous decisions due to a pre-occupation with maintaining internal agreement over consideration of the quality of group decision-making. Groupthink is most likely to occur in groups with a dominant supervisor, and in highly cohesive groups. Groupthink is also more likely to occur in conditions that foster isolation of the group from
alternative perspectives and sources of information and is characterised by decision-making and group behaviour that is not based upon rational information and reality, but rather is motivated by group-consensus seeking. In contrast with high cohesiveness, conflict in the group decision-making process can have a positive effect upon group performance, by promoting the elaboration of views, the integration of opinions and the search for new information and ideas (Tjosvold, 1985; 1991). Constructive controversy in intra-group interactions has been found to be an important factor influencing the innovativeness of work groups (West & Anderson, 1993).

3.3.11 Work group development and learning

The time dimension becomes important for work group effectiveness in the consideration of group developmental sequences and other temporally determined factors, implying that over the course of time, different factors will become prominent in influencing work group effectiveness (e.g. Tuckman, 1965; Smith & Noakes, 1996; McGrath & O'Connor, 1996). Tannenbaum, Salas and Cannon-Bowers' review of efforts to promote work group effectiveness (1996) incorporates a temporal dimension in the definition of work group effectiveness, defining performance in terms of how well the team accomplishes it's goal or mission and its ability to develop and regenerate itself, allowing it to sustain its performance and accomplish its mission over a period of time. This consideration becomes important for the effectiveness of a work group's functioning, which may not reach optimum output until various factors associated with the novelty of the situation in a newly formed group are overcome.

From a review of over fifty studies of group-working, Tuckman (1965) proposes a theory of group development incorporating several stages. According to this developmental approach, groups progress through different stages of socio-emotional activity and associated task behaviour over time. Initial formative stages involve periods of orientation and dependence, followed by stages of conflict, resolution, role-taking and problem-solving, culminating in eventual disengagement. Argote & McGrath (1993) propose four generic 'CORE' processes (Construction processes, Operations processes, Reconstruction processes and External Relations processes) as descriptive of activities that take place in the typical work group life-cycle. Similarly, McGrath and O'Connor (1996) state that groups are dynamic systems that develop and change over time. A work group's functioning is therefore affected by several key temporal processes during its lifecycle: the origins and subsequent development of a group as a socio-technical system, the processes by which the work group performs its tasks, changes in the group as a function of its own developmental and task performance experience, and dynamic changes that occur in groups as a result of changes in their
environments and composition. The concept of synchronisation or coordination of multiple activities in time represents an important factor that influences group task performance. Synchronisation involves issues such as task concurrency, succession and coordination of individual work activities that contribute towards the group's overall objectives.

The development of established group norms, working procedures and routines over time is also highlighted as an important natural process of learning that distinguishes high performance teams. West (1996b) states that group-working practices enable organisations to maintain 'memories' of knowledge and lessons learnt relating to organisational functioning. Through group experience, shared knowledge and skills develop which are then retained, even if one member leaves the group. Information therefore continues to be maintained in group memory. Mohrman, Cohen and Mohrman (1995) identifies the fact that work groups enable organisations to learn and retain learning more effectively as one of the main reasons why organisations should implement group-based working approaches.

3.3.12 Planning and scheduling

McGrath and O'Connor (1996) conclude that the relationship between imposed deadlines and performance goals is important to productivity. The authors advocate the expansion of the concept of goal setting beyond the dimension of quantity to include issues of quality and timing as well. Organisational scheduling activities are defined as the matching of specific periods of time to specific sets of activities and to specific social units (i.e. individuals and groups) that are to perform those activities. McGrath and O'Connor summarise the main challenges faced by work groups in the planning of the performance of complex tasks that require coordination and synchronisation: work groups must plan to allocate available resources, including temporal ones, in order to match resource availability with the demands of the task and situation, they must plan the coordination of both content and timing of the actions of multiple individuals with one another, synchronising actions within and between individual group members and must plan the scheduling of individual task activities, by anticipating what actions and events will take place and when they will occur.

Kelly, Futoran and McGrath (1990) found that imposing deadlines or temporal markers on task performance sequences entrain factors such as rate of productivity and patterns of interaction. Two specific planning considerations were identified as important, namely: 'capacity' and 'capability'. Regarding capacity, when initial task performance attempts raise problems of capacity, individuals and groups speed up their rate of production to compensate on subsequent tasks, even if time constraints have been relaxed. When initial task
performance attempts raised problems of capability, individuals and groups slowed down their rate of production on subsequent attempts.

3.3.13 Process loss and boundary issues

Steiner (1972) uses the term 'process losses' to refer to the detrimental effects of certain social processes on the effectiveness of work group behaviours, such as group decision-making. These processes are a direct result of collective working methods and can result in work groups achieving performance outcomes that are less effective than the aggregate of individual’s efforts. Process losses therefore mean that actual team productivity is less than potential productivity. Stroebe and Frey (1982) specify two categories of process losses: coordinational and motivational. Coordination process losses occur due to the problems associated with arranging and integrating other people in group-working practices. Motivational process losses occur when individuals use less effort in performing a task in a group, than when performing the same task by themselves.

Groups that engage in environmental scanning behaviour have a better chance of discovering a problem before it becomes unmanageable (Cowan, 1986). Brodbeck (1996) stresses the importance of considering the externally-oriented, environmental integration activities of work groups, for effective functioning. The author cites examples such as ‘boundary management’, in which the way a work group is integrated into a larger system through coordination with other stakeholder groups such as suppliers, peers and customers is an important dimension of work group performance, and therefore work groups which are shown to be actively managing these external demands are more effective.

3.3.14 Innovation

In a study by West and Anderson (1993) designed to investigate which sub-set of indicators, out of a number of measured factors, best predicted innovation in work groups, it was found that group innovativeness was inversely related to the size of work group and the level of resources available to the work group. Additionally, several factors were found to be very effective predictors of work group effectiveness, including: goal commitment, level of group member interaction, level of information sharing, group member influence over decision-making, practical support for attempts at innovation and task orientation (the latter indicated by constructive controversy and group performance monitoring processes).

West (1990) divides team innovation into two successive components: idea generation and implementation, suggesting that innovation processes in work groups result in two distinct
outcomes; the innovations themselves and their subsequent implementations or deployments in the organisation. Brodbeck (1996) makes the point that 'implemented innovations' are themselves performance outcome indicators of work group effectiveness and not easily subsumed under other headings such as productive output or personal/group criteria. The effectiveness of work group functioning is therefore partly expressed by how well innovative ideas are translated into new products, methods and services.

3.3.15 Well-being

The association between employee well-being, job-satisfaction and performance has been the subject of much research, which reveals high complexity in interactions between these variables. Warr (1996) offers three dimensions for the measurement of employee well-being: 1) overall pleasure − displeasure (sometimes referred to as satisfaction − dissatisfaction), 2) anxiety − comfort and 3) depression − enthusiasm. Warr comments upon the relationship between employee well-being and job performance, stating that although it is often presumed that high well-being leads to increased performance, it is difficult to establish the direction of causality, e.g. high job-satisfaction could result in increased performance or may conversely be the result of successful (high) job performance. Alternatively, a third unspecified factor (such as some feature of the work environment or management practice) might be responsible for both high job performance and high satisfaction independently. Absenteeism and its converse, employee attendance, are also important organisational performance indicators due to lost time and productivity. Absenteeism is influenced by a number of different types of variables. On the individual level, sickness, social and family pressures can influence the decision to attend work. On the organisational level, the presence and effectiveness of policies to encourage attendance, support from a supervisor and culturally determined attitudes towards attendance can all influence absenteeism.

3.3.16 Trust

Goranson (1999) defines trust as "confidence through experience" and states that trust is important in the development of adaptive unofficial communication networks that often "take up the slack" where formal networks and systems are limited. Unofficial social networks based upon trust are highly personality-oriented and evolve through close collaboration. Trust in both agents, and the communication channels that connect them, is considered important for successful enterprises. Goranson offers a distinction between two types of trust: inductive trust and deductive trust. Inductive trust may be defined as "common confidence" that a specific outcome of interaction with the trusted entity will be achieved based upon historical experience of interaction with that entity. Deductive trust is not based upon reliability,
however, but knowledge of circumstances surrounding the interaction. As such, deductive trust recognises that experience with an entity may change due to changing circumstances and contextual factors. Inductive trust is often subjective and based upon personal relationships, whereas deductive trust may be considered to be more objective, more essential for successful decision-making within enterprises and can be modelled, analysed and measured. Whereas inductive trust is based upon repeatability and works with static situations and known agents, according to Goranson, deductive trust is based upon insight and can accommodate unknown agents in dynamically changing situations.

### 3.4 Operational effectiveness criteria

Having reviewed literature relevant to identification of human and organisational performance factors in section 3.3, in the interests of comprehensiveness, some consideration of the key operational effectiveness criteria that these factors influence is warranted. Where operational performance is concerned, organisations tend to monitor standard effectiveness dimensions associated with the timely delivery of an effective work product. Accordingly three interdependent variables are measured: costs (budgetary performance), quality (achieved functionality) and time (schedule performance). These outcomes are interdependent in the sense that they may be traded off against one another: product quality may be enhanced through increasing financial and temporal resources available to a project, costs may be cut by compromising achieved product functionality and projects may deliver early through reducing quality or increasing other resources available to the work effort such as level of man-power (at increased cost). Some agreed compromise is therefore specified in project operations, usually represented by a contractual agreement with the customer, for delivery of an adequate product within reasonable budgetary and scheduling constraints.

Cost, quality and time performance criteria represent 'tangible' outcomes of work effort and are the focus of several conventional project planning and control techniques, such as the 'Program Evaluation and Review Technique' (PERT), 'Critical Path Method' (CPM) and 'Earned Value Management' (EVM) (see Burke, 2003 for more details). Some account of these performance outcome variables is given in the vast majority of standard operations management texts, and the following sections draw largely upon the definitions and discussions offered by Slack et al (2001). This text was chosen for the literature review specifically because it discusses two additional performance outcome criteria that may be considered in order to evaluate the value of an organisation: flexibility and dependability.
3.4.1 Quality

Burke (2003) comments that the quality dimension refers to the degree to which a work product conforms to the customer's requirements. Similarly, Slack et al (2001) states that quality means 'doing things right' and providing error-free goods and services that are 'fit for their purpose'. In manufacturing and engineering, quality means ensuring products satisfy specifications and are reliable. Quality is a fundamental dimension of operations performance that is easily judged by customers (e.g. 'is the product right or wrong?') and as such is a major determinant of customer satisfaction or dissatisfaction.

Quality has important internal implications for the organisation. Increased quality through increased accuracy or decreased errors in micro operations in the organisation reduces time costs incurred through necessary remedial action. High quality internal processes increase the dependability of the organisation from the external perspective of the customer. Goranson (1999) states that quality is difficult to manage effectively due to the fact that it is commonly measured by the absence of negative attributes within the work product, such as defects, errors, etc. Where this occurs, quality and what causes it is not measured directly and hence the relationship between quality level and the factors that influence it may not be establishable.

3.4.2 Time

'Speed' refers to the time gap between customer order and delivery of a product or service (Slack et al, 2001) and is an important aspect of competitive potential. Internally, fast decision-making, movement of materials and information all contribute to the ability of an organisation to respond rapidly to external customer requirements. Speed also has internal implications for efficiency, however. Inventories build when components and materials are moved through the stages of an operational process and accumulate at each stage whilst they await transportation or operation, meaning that materials in reality take more time to pass through a process than is actually objectively required to perform the necessary operations upon them. Initiatives such as 'Just-In-Time manufacturing' and lean operations approaches aim to increase the speed of operations materials through the production process for increased efficiency and subsequent cost benefits. Speed also reduces risks associated with forecasting customer demand in the future. By decreasing throughput time, the length of time period over which the organisation must predict external product demand is decreased, resulting in increased forecasting accuracy and reduced wastage due to stock quantity errors.
3.4.3 Dependability

Slack et al (2001) states that dependability means the ability to deliver products or services to customers on time or to schedule. High internal dependability promotes overall effectiveness as a result of time and cost savings, and increased stability. Operations are invariably structured according to a plan or project schedule, one of the aims of which is to keep the operations facilities and resources as continually occupied with productive processes as possible. Disruption in internal supply of materials or information will lead to time loss as remedial action is taken and the utilisation of the operations resources for production will also be disrupted if it becomes necessary to wait for a specific component. Localised disruption in the internal supply chain may have potentially far-reaching disruptive consequences that may eventually affect the customer, and which will consume additional time, effort and resources in order to be dealt with. Ineffective use of time translates into increased costs, as resources such as employees still require pay regardless of whether they are utilised optimally or not.

In terms of 'stability', dependability holds implications beyond cost and time effects. Through continued dependable functioning an operation builds up a degree of trust between sub-operations that allows them to concentrate time and efforts in non-directly production-oriented activities such as internal process improvement and development. Where dependability is low, operations tend to spend this valuable internal investment time in remedial or corrective action rather than productive action.

3.4.4 Flexibility

Flexibility, according to Slack et al (2001), refers to the ability of the organisation to change its operations in some way: either its purpose, process for achieving that purpose or the time at which it performs that process. Developing flexibility within the operation conveys advantages to internal customers within the operation. Flexibility in, for example, the ability to quickly move human resources to new areas of production speeds up response time to customer requirements. The ability to change or adapt quickly from one mode of production to another saves time; requiring staff and technology to be flexible and not require prolonged time to adapt. Flexibility in the types of product an organisation can deliver to its customers may also be considered to be synonymous with 'development capability' in the operations management literature, which has been proposed as an important organisational performance criteria associated with speed, efficiency and quality dimensions (Wheelwright and Clark, 1992).
Flexibility in operations can also help the organisation to maintain schedule when disruptions in the supply chain occur, helping to maintain dependability. Externally, the requirements for flexibility can largely be related to customer requirements:

- **Product or service flexibility**: the ability to introduce different types of products or services according to demand. In engineering and manufacturing, the ability to be able to adapt or reconfigure existing human and technical resources, as well as successfully introduce new ones, in order to produce new models and products.

- **Mix flexibility**: the ability to produce a wide range of products. Most operations' components are involved in the production of more than one type of product at any one time. The staff, technology and organisation of operations components need to be capable of accommodating this variety.

- **Volume flexibility**: the ability to deliver varying volumes of products and services through changing the level of output or activity. An essential requirement as all operations to some extent will have to cope with fluctuating demand for their output.

- **Delivery flexibility**: the ability to change the timing of the delivery of the product or service, usually in the direction of supplying sooner than originally scheduled. This may involve the rush production of an essential component at disruptive cost to the existing production schedule in manufacturing.

### 3.4.5 Cost

Slack et al (2001) state that the ways in which operations management can influence costs depends largely upon where those costs are incurred. An operation incurs costs in terms of: 1) the staffing costs, 2) the facilities, technology and equipment costs which involve the buying, maintenance and running costs of the operations hardware, and 3) the costs for materials that are consumed or transformed in the operation. Burke (2003) summarises the costs incurred by projects as: direct costs (those associated with a project work activity) and indirect costs (or operational 'overheads'). Within these categories a project will incur time-related costs, labour costs, procurement costs, transport costs, project office costs and project team costs. All the other operations performance objectives: quality, dependability, flexibility and speed, affect cost. Slack et al offers the following examples of how these productive output variables all relate to cost:

- **Quality**: High quality operations reduce remedial time and effort spent correcting errors that can also cause costly disruptions to internal customers processes.

- **Speed**: Fast operations increase cost efficiency by reducing the level of in-process inventory between micro-operations and the associated administrative overheads.
• Dependability: Dependable operations mean predictable production and effective planning and scheduling. Wasteful disruption to production is therefore avoided and other micro-operations can also operate more efficiently.

• Flexibility: Flexible operations adapt to changing circumstances quickly and without disrupting the rest of the operation. Flexible micro-operations can change tasks quickly and without wasting time or capacity.

3.5 Review of existing metrics and measures

Goranson (1999) states that social and cultural dynamics in a business context confound any decision-making process based upon rules and analyses of hard facts. Conventional modelling approaches are challenged to represent social and cultural dynamics that do not obey clear, well-behaved rules of cooperation; necessitating the involvement of "soft sciences" to provide metrics which, for example, are capable of measuring the cost of cultural differences between collaborating partners in a virtual enterprise. Although retrospective accounting and predictive indicators of cost may be considered "hard", dependent measures, observing cost variation as a function of cultural and social dynamics necessitates the measurement of softer human and organisational variables as the independent measures that influence the observed values of outcome measures.

During the course of the soft metrics research project, many existing performance measurement approaches and metrics were reviewed in order to provide a clear theoretical basis for development of 'soft metrics' for application within the industrial context. Generally this project found a lack of existing approaches that may be considered to embody 'soft metrics'. Available literature tended to reveal either practical performance metrics from the project management literature that were relevant to specific applications only (e.g. Fenton, 1991; Möller and Paulish, 1993; Maskell, 1991) or more involved research measures that addressed human and organisational factors from the human sciences literature (e.g. Drasgow and Schmitt, 2002; Brannick et al, 1997; Fields, 2002). Very few existing approaches provided concise, practical project management metrics that addressed human and organisational performance processes.

In order to track literature-based measures and the development of an appropriate set of 'soft' measures and associated approaches applicable to the systems engineering problem domain, a working document comprising an inventory of evolving measures and methods was established early on in the soft metrics project. This database comprised the measures collected from review of research and operations literature, tracked their subsequent development and adaptation where appropriate, and provided a useful database for the
documentation of new measures that were developed in response to specific requirements identified during the course of the project. The structure of the metrics inventory allowed each individual metric to be documented, including the performance factor in the Human and Organisational Performance (HOP) modelling framework with which it was linked, sub-factors and measurement scales, principal sources and references, and evaluative assessment of fitness for purpose. The metrics inventory itself is reproduced in appendix H of this thesis. Many of the measures identified through the literature review were subsequently adapted for application within a systems engineering project management environment and linked to key performance factors within a conceptual model. For more details regarding the development of specific measures during the course of this project, the reader is referred to section 5.2 of this thesis, which outlines the state of the developed soft metrics toolset prior to validation phases of the research project. In the sub-sections that follow, various existing metrics and approaches to measurement of human and organisational factors identified within the literature reviewed during the course of the soft metrics research project are outlined.

3.5.1 Project size metrics

Various established measures and indicators exist for quantification of overall project size and the size of individual project work packages (e.g. Burke, 2003; BAE SYSTEMS, A). Project size metrics were considered within the scope of the soft metrics research project in order to provide contextual information regarding the profile of a specific project. As parameters used in general project planning and resource allocation, measures of project size are based upon objectively quantifiable parameters associated with the work product, human and financial resource requirements, and are generally applied at the project or organisational level of analysis. The majority of size metrics may also be applied for individual project phases if a more detailed level of analysis is required. On this basis, current and historic projects can be compared for abnormalities (i.e. a particularly effort-intensive deployment or testing phase) and the reasons for observed variations subsequently investigated.

Budgetary size based upon project cost estimation (BAE SYSTEMS 1) may be taken as a general indicator of project size, representing commitment of resources to the project, effort involved, project duration and the importance of the project to the business. Various work effort metrics (BAE SYSTEMS 1) exist which may also be used to estimate size in terms of human and temporal resource consumption. The number of man-hours per work package (or cost of the man-hours) is measured and can be aggregated for the whole project. Actual values against estimates can be tracked over time to determine trends and predict budgetary problems. On the basis of data regarding level of effort involved in specific work tasks, larger work packages may be decomposed into smaller packages for ease of management control.
The software engineering domain has made a large contribution to the existing project management metrics toolset, driven by escalating levels of complexity and prominence of software-based systems (Paulk, 1995). Many practical metrical systems for technical parameters in software engineering projects exist (e.g. Hutcheson, 2003; Möller and Paulish, 1993; Fenton, 1991), including measures of product or system size that may be taken as indicators of project size. Function point analysis is an accepted sizing metric in software engineering and IT development projects for the measurement of units of work, based upon functional characteristics of the software deliverable (Garmus and Herron, 2001). Project work package size may also be quantified based upon size of individual system sub-components on the lowest level of the product breakdown structure, using indicators such as number of lines of code in software sub-systems, for example (BAE SYSTEMS, 1). Potentially large work packages can be identified as requiring increased monitoring and control effort. Work packages larger than the organisation has experienced to date represent potential problem projects that may strain the organisation’s capability. Tracking size of work package achieved to date against estimates gives an indication of the accuracy of project size estimation. When the degree to which the actual work package size value exceeds the initial estimate is plotted over time, an indication of trends that may lead to project size problems can be gained.

In terms of the applicability of size metrics to the systems engineering project domain, general size metrics are practical, low effort-intensive measures that yield unambiguous and useful data. As has been mentioned previously, established metrics relating to function points and code generation were developed with a specific focus upon software project metrical in mind, and as such these specific techniques may apply to a subset of systems engineering projects that involve software-based deliverables.

3.5.2 Project complexity indicators

Measurement of project uncertainty provides an indicator of complexity inherent in the project and allows the identification of the degree of uncertainty inherent in the overall project task. Understanding inherent uncertainty levels form the basis for adjustment of project planning, control and management approaches to accommodate inherent levels of complexity (De Meyer, 2002). Projects with high uncertainty may exhibit an inability to define specific project sub-tasks during planning, provide contingent alternatives and adhere to a unified project vision during their lifecycles.
De Meyer's scale identifies four increasing levels of uncertainty: variation, foreseen uncertainty, unforeseen uncertainty and chaos. As the level of uncertainty increases through the scale, flexible management methods that allow the project vision to change and adapt during its course become increasingly appropriate. Methods based upon predefined, fixed task sequences, such as those specified by many commercially available project management tools, become less appropriate as the uncertainty level rises. Risk management based upon planned remedial strategies that are contingent upon foreseeable circumstances are therefore more appropriate at the variation or foreseen uncertainty end of the scale (i.e. low uncertainty). High uncertainty projects, such as those that cannot rely upon established base knowledge in a discipline or technical area, must adopt risk management strategies that are based upon flexibility and learning, rather than contingent cause and effect planning, as potential 'causes' may not be foreseeable at project onset.

3.5.3 Critical Task Method metrics

There has been much development effort aimed at human capability assessment in the research literature (e.g. Dunnette and Fleishman, 1982) but one more recent approach in particular stands out as prominent for the purposes of developing practical soft metrics for the systems engineering project domain. Nagy's (1999) Critical Task Method (CTM) was identified as an important approach during the literature review, as one of few human factors measures to address both human willingness (motivation) and capability (experience), and to be clearly specified as a systems engineering project management metric through the inclusion of practical implementation steps and control processes related to this operational environment. The method itself incorporates three principal metrics, relating to task-specific experience, skills and motivation level. In terms of method and practicality, the approach incorporates clear process steps and guidelines to support continuous improvement in project teamwork allocation practices. The approach explicitly links soft factors to project performance outcomes, and provides a methodology for measuring soft factors to control outcome performance. The approach is aimed principally at the software systems engineering domain but applies equally to all systems engineering projects. CTM has been applied over an extended time period (7 years at publication) in project networks ranging in size from 200-700 individual tasks and types ranging from hardware communications systems to software development programs. The author claims the CTM has facilitated risk management decision-making, effective resource allocation before task execution and increased reliability of project estimation. It is further claimed that application of CTM results in a nominal increase in project execution reliability of 80%, allowing significant increases in the accuracy of project parameter estimation.
The measures themselves are designed to support work allocation within project work groups and therefore are applied on the level of the individual work group member, who is charged with executing a specific project task as dictated by the project work breakdown structure. Inherent in the approach is the assumption that individual characteristics of work group members and characteristics of the tasks they are assigned interact to influence project performance outcomes. Although applied principally at the individual level, higher-order metrics may also be calculated by aggregating scores across individuals onto a work group or organisational unit level. CTM requires that autonomous group-based working practices be established within the organisation for project management and control. Work groups must be assigned by project and have complete autonomy over the work task breakdown structure for that project, including control over task composition and allocation, if these aspects are to be altered to support human skill-use and motivation. CTM employs the Critical Path Method (CPM, e.g. Burke, 2003), which must therefore be an established operational practice, and also presumes that project management can determine a critical path within the project network or project work structure.

In terms of application, Critical Task Method metrics may be applied to support all project teamwork allocation and task performance, both in capability development projects and other systems engineering projects. The Critical Task Method prescribes a detailed control process to support enhanced project performance through control of 'soft' variables. This process involves work group project tasks being analysed and classified as critical or non-critical according to the critical path method. 'Soft' measures are then taken for each individual's tasks, measuring task specific motivation, experience adequacy and skills adequacy. High capability and motivation tasks are then identified as 'asset tasks', whose time and resources can be consumed to support low motivation and capability critical tasks, which pose a risk to the project achieving its performance objectives. Individual and group problem solving takes place to trouble-shoot problem tasks, which are then manipulated to support improved performance through: 1) increasing confidence, knowledge or training, 2) using a different task approach, 3) modifying the physical resources, 4) modifying the support of human resources, or 5) increasing the incentives to perform the complexities of the task. Following manipulation, soft metrics are measured again to quantify variation in task capability and motivation scores. Pre- and post-problem solving data is tracked and compared, along with task and project outcome data (i.e. cost and time) to establish where strengths and weaknesses in process improvement lie.

The metrics themselves test if the individual has the required capability and motivation to complete a specified task within time and budgetary constraints. The implication is that task characteristics, individual characteristics and task performance constraints are dynamically related and that 'trading off' one can be used to support another. Put another way, if project
budget and schedule overruns are permitted, human capability and motivation requirements for task execution fall and therefore the critical task method is designed to prevent projects failing to meet their overall performance objectives through deficient task motivation and human capability. The whole approach is based upon the assumption that project performance is directly influenced by these three 'soft' factors. Proactive control of project outcomes, such as budget and scheduling performance, should therefore be possible through manipulating task characteristics, project work breakdown structure, function allocation within work groups and supporting group member motivation and skills/experience acquisition.

3.5.4 Job Diagnostic Survey measures

Work undertaken by Hackman & Oldham (1974; 1975; 1976), focuses upon the area of job analysis or design to assess the effectiveness of work task characteristics relative to human performance. Measurement of job characteristics in organisational research invariably aims to identify and quantify the features of jobs or tasks that motivate people to work harder or allow individuals to attain a higher level of performance. The measurement instrument most closely associated with job analysis in the research literature is the Job Diagnostic Survey (Hackman and Oldham, 1974; Idaszak and Drasgow, 1987) which comprises various measurement items designed to probe individual's satisfaction with task characteristics and inherent features of the work role and environment, including skill variety, task identity, task significance, task autonomy, job-feedback, feedback from others and dealings with colleagues (Fields, 2002).

Responses made to measurement items within the Job Diagnostics Survey utilise 7-point Likert scales against statements regarding the characteristics of an individual's work. In order to make the accuracy of responses more robust, specific anchors are used to clarify scale indices, rather than just 'Agree - Disagree', i.e. for the skill variety item: 1 = Very little: The job requires me to do the same things over and over again; 4 = Moderate variety; 7 = Very much: The job requires me to do many different things using a number of different skills and talents. Instructions given to respondents in the original job diagnostic survey asked individuals to respond as objectively as possible and to be careful not to give affective responses - i.e. to show liking or disliking through their responses.

3.5.5 Balanced scorecard measures

Kaplan and Norton's (1996a) 'Balanced Scorecard' approach to performance measurement incorporates several people-focused, non-financial measures to track growth and development in an organisation. The measures are aimed at evaluating the state and rate of
renewal of human capital resources within the organisation and include objective metrics that quantify strategic reskilling of the work force, work group orientation and strategic alignment.

The 'rate of strategic reskilling' metric proposed for application within the balanced scorecard framework involves measuring time taken to develop employees to required levels of competency and allows focus upon development cycle time per employee in order to increase the efficiency of the strategic reskilling process. It is a useful metric where reskilling needs to be undertaken on a large scale, usually revealing a significant gap between future needs and present competencies, as measured along dimensions of skills, knowledge, and attitudes. Another metric, the 'strategic job coverage ratio', tracks the number of employees qualified for specific strategic jobs relative to anticipated organisational needs. Organisational needs are defined in terms of which skills and qualifications are required for which capability and where to deliver specific goals. The strategic job coverage ratio metric therefore seeks to provide a human resource capability metric with a strategic focus.

The third metric focuses upon 'strategic alignment' and is designed to measure the alignment of individual and organisational sub-unit goals, reward and recognition systems. Measures of strategic goal alignment within and across the organisation, work group and individual levels reflect cultural issues such as conflicting goals of sub-groups within the organisation. Finally, the 'level of group orientation' metric measures the extent and use of teaming practices in the organisation; the rationale being that in work groups, individual's goals become aligned with each other and with those of the broader organisation.

3.5.6 People capability maturity measures

The People Capability Maturity Model framework (Curtis, 2002) provides one of the most comprehensive process improvement and management metrication methodologies available in the literature reviewed during the course of the soft metrics research project. The metrics specified for assessment of people capability maturity are all activity-oriented, designed to evaluate the effectiveness 'key process areas' associated with the human resource management function. The measures incorporate objective criteria for assessment and may be grouped under the categories depicted in figure 3.5.6a below, representing the processes and activities with which they are associated.
Certain measures within the framework are financially-based human resource accounting indicators that may fall beyond the scope of human and organisational performance factors, yet the majority of the metrics do not rely upon subject, judgement-based methodology and as such comprise more objective criteria less amenable to bias and conflicting interpretation. The measures also form one aspect of a broader tool to assist in human resource capability development within organisations that includes detailed assessment and process guidelines within an integrated framework. Due to the fact that objective ‘capability maturity’ type criteria do not rely upon subjective measures, they are limited in their ability to describe the full range of human and organisational factors that operate to influence project performance. This is particularly the case for ‘softer’ performance aspects associated with employee’s experience of project work and conditions, or motivational variables that may influence willingness as well as ability to optimally perform project work. These factors can only be directly addressed by survey-type measurement items, which sound individual’s perceptions and opinions of the project environment. The focus upon activities within the human resource function, as opposed to direct assessment of human and organisational factors means that the measures may not be directly applicable in diagnosis of human and organisational performance issues at the project level.

3.5.7 Organisational communication audits

Price (1997) offers a number of diagnostic measures of communication effectiveness within an organisation that may be summarised as addressing four main dimensions of organisational communication. The four communication sub-factors include: 1) Formal-informal communication (formality) referring to the distinction between officially and unofficially transferred information, 2) Vertical-horizontal communication (direction) referring to transfer up and down the hierarchy between subordinates and superordinates or within one level of the hierarchy between peers, 3) Personal-impersonal communication (level of personality) referring to whether or not the communicative situation is such that it allows mutual influence,
and 4) Instrumental-expressive communication (instrumentality) referring to job-related (instrumental) versus non-job related (expressive) communication.

In terms of factors influenced by communication, general consensus in the literature is that effective communication is an essential prerequisite for project performance and overall organisational performance. Applying metrics to measure communication effectively, however, is not a simple task and extensive communication-wide audit methodologies have been developed for this purpose (e.g. Hargie & Tourish, 2000). Penley and Hawkins (1985) propose a measurement instrument for assessment of vertical communication in supervisor-subordinate relationships. Originally organisational behaviour research measures, five dimensions of communication are tested: task communication, performance communication, career communication, communication responsiveness and personal communication.

The task communication dimension measures the extent to which supervisors convey instructions to subordinates as to what activities need to be performed, describe changes in the workplace and indicate policy. Performance communication measurement items assess the degree to which supervisors transmit information about the quality of subordinate's work. Career communication measures the extent to which supervisors review training opportunities with subordinates and offer career advice, whilst communication responsiveness measures assess the degree to which supervisors listen and respond to issues raised by subordinates. The personal communication dimension indicates the level of informal and non-work related information exchange that takes place, including the extent to which family and non-work-related interests are discussed in the supervisor-subordinate relationship.

3.6 Key conclusions from literature review

Due to the scope of literature reviewed to support development efforts in the area of soft metrics tools and methods, it is important at this stage to summarise some of the key research findings gained from review of existing research literature and knowledge. In consideration of broad conceptual issues for performance measurement as a discipline, it becomes apparent that measurement of 'upstream' process factors has little practical value unless clear links to an organisation's operational success criteria are established. Soft metrics research efforts therefore need to establish clear dependencies between causal human and organisational processes and operational effectiveness criteria relating to delivery of work products within valued cost, quality and time parameters. In this sense, specifying the causal links between results and their determinants, means that monitoring those determinants through metrication practices will provide useful 'performance indicators' to guide control of processes and operations towards achievement of specific goals.
From review of various human and organisational performance models it becomes apparent that many existing performance frameworks exist for varying purposes, including: organisation-wide assessment of performance excellence and quality, prescriptive definition of facets of performance for measurement and description of human and organisational processes for social sciences research activities. Performance models may be classified according to their origin as applied management or theoretical research frameworks, and vary in their level of analysis ranging from offering broad complementary performance perspectives to the specification of multiple interacting criteria with sub-factors.

The models identified vary in terms of their applicability to a contemporary systems engineering industrial environment, though examples may be found that address both project organisational structures and work groups. For development of the soft metrics approach embodied within this thesis, three key conclusions may be drawn from critical review of existing human and organisational performance frameworks:

- Performance in organisational systems is dependent upon human and organisational factors and processes in addition to technical factors. 'Softer' outcomes representing human capability acquisition are therefore important for continued high performance in changing environments.
- Any model or integrative framework that seeks to adequately represent performance processes must complement outcome criteria with 'upstream' process factors.
- In order for a performance model to be maximally useful in application it requires: 1) factors specified in detail, 2) specific interactions that represent mechanisms of influence, and 3) quantitative weightings for comparative analysis of the impact of specific factors.

Accordingly, input-process-output models (e.g. West, 1996a) for the representation of dependent and causal variables, in human and organisational performance models, were identified as a useful theoretical framework for modelling internal work group mechanisms within the soft metrics work. The need to incorporate external factors associated with the broader organisational context in which the work group is situated (Brodbeck, 1996) within performance models was also identified as an important point for development efforts, as was the necessity to include feedback interactions between outcome factors and inputs (Tannenbaum et al, 1996). From review of existing theoretical and applied performance models it becomes apparent that attempts to depict human and organisational processes within human activity systems must incorporate representations of motivational processes (Hackman et al, 1975; Locke and Latham, 1990), team performance factors (e.g. Castka et al,
2003) and human intellectual capital (e.g. Edvinsson and Malone, 1997). Future performance modelling development efforts within the soft metrics research project were undertaken based upon the conceptual base provided by this literature.

The literature review of human and organisational performance factors establishes overall organisational performance and functioning as a complex, multi-dimensional concept. A multitude of possible human and organisational factors that existing research has focused upon are identifiable as important for performance and effectiveness in organisations. These factors span all levels of the organisational system, for example: motivation and knowledge at the individual level, through group cohesion and autonomy at the work group or sub-unit level, to broader resource adequacy and cultural factors at the organisation-wide level. Figure 3.6a below lists human and organisational factors or constructs, identified within the literature review, that historical research has linked to organisational performance, functional effectiveness or productivity. These factors represent potential ‘soft’ variables to be addressed by the practical soft metrics process that is the focus of development efforts within this project.

![Figure 3.6a: Summary of potential human and organisational performance factors identified from review of human sciences research literature](image)

Review of existing measurement practices reveals that current project management metrics are limited in their coverage of potential ‘upstream’ human and organisational performance...
factors, such as those summarised above. Research-based measures must therefore be relied upon to provide a theoretical basis for quantification of human and organisational performance factors, yet there is considerable distance between large-scale survey instruments and focused project management metrics in terms of practicality and feasibility for repeated application in a project management environment.

With a large number of potential human and organisational performance factors identified for measurement in a soft factors metricalation system, the emphasis for future development efforts within this research project was placed upon specification of an appropriate integrative framework to accommodate the evident complexity in interactive processes between research variables. Practical scoping activities were also undertaken within industry in order to explore the relevance of literature-derived human and organisational factors to the target application environment. The subsequent section of this thesis (section 4) provides an account of activities undertaken to refine the conceptual focus of the soft metrics work towards practical application of the knowledge gained from review of existing literature.
Section 4
CONCEPTUAL DEVELOPMENT

The research activities outlined in the sections that follow represent what may be considered to be ‘conceptual’ development within early phases of the soft metrics research project. These activities included the execution of a scoping study for the soft metrics development effort, which employed an operational BAE SYSTEMS capability acquisition project. Based upon conclusions drawn from the literature review, work began towards construction of a conceptual research model to map specific influences between soft performance factors identified within existing research studies and to develop a practical approach towards modelling the softer aspects of functioning in organisational systems.

In this section of the thesis, section 4.1 below outlines key features of the industry scoping study undertaken as part of the metrics research, including identification of specific examples of soft performance issues in the industry project case reported. Section 4.2 outlines development efforts to conceptually model soft performance processes and section 4.3 reports the outcome from application of the resulting conceptual modelling framework to represent soft performance issues in a hypothetical work group scenario.

4.1 Research Scoping Study: Industry Capability Acquisition Project CAP1

Through the industrial sponsor for the soft metrics research project, access was provided to an ongoing operational capability acquisition project within BAE SYSTEMS in order to define the key features of the applied industrial environment for the research output and to investigate issues and requirements for the research work. In the interests of confidentiality, the specific industry project that formed the focus of this scoping study will be referred to as Capability Acquisition Project (CAP) 1.

CAP1 was an internal change project within BAE SYSTEMS, designed to develop enhanced software capability to support computer aided design (CAD), manufacture and product data
management within ongoing operational programs. The project focused upon the implementation of a number of minor and major modifications to existing systems, including the provision of specific upgrades for multiple internal 'customers'. The impetus for CAP1, as defined in the business case, centred upon decreasing support costs and risks to ongoing program operations posed by currently unsupported versions of operating systems and CAD software.

4.1.1 General method employed

The general methods employed in undertaking the scoping study involved qualitative analysis of information acquired from attending project management review meetings, reviewing project-specific documentation such as standard operational guides and review-meeting minutes, and interviews with key project personnel to clarify interpretation and elaborate upon project issues raised. Current metrization and performance control practices employed within the project were identified and reviewed through obtaining more detailed information from standard operational guidelines and documentation.

Early performance factors identified from the literature review conducted for the soft metrics project were presented to project personnel associated with CAP1 for general feedback regarding applicability and issues in each individuals' own experiences, relating to specific soft issues. Project manager's comments regarding soft issues not covered by the literature review were also recorded and analysed for later attention in development efforts. The process of qualitative analysis applied to this material consisted of identifying: 1) the human and organisational or 'non-technical' issues arising in the project's development, and 2) grouping these factors based upon several headings that emerged logically from the content of the material. Performance factors identified were then used to populate a conceptual modelling framework and the implied interactions between performance variables were mapped according to performance processes observed in the project. The results from these modelling efforts are reported in more detail later in the thesis, in section 5.1.2. The following sections report information concerning the projects work process, existing measurement methods employed and human and organisational issues identified through interviews with project personnel.

4.1.2 Project work process

As background to CAP1, a summary of the work process followed by the project as specified by a sequence of key project management activities is presented in figure 4.1.2a below, based upon BAE SYSTEMS' Lifecycle Management Capability Maturity Criteria. Each phase
of the project culminated in a peer review that evaluated the degree to which specific 'deliverables' and criteria had been met. These reviews represented a logical sequence of 'phase gates' to ensure the project built upon the achievements of previous phases and could not progress to subsequent phases prematurely, in order to reduce operational risks.

The CAP1 project was on-going and at the time of the soft metrics research study had reached the phase 3 review stage. Apparent from the activities listed in figure 4.1.2a is the operational complexity of internal capability development projects of this type, which is emphasised by consideration of the fact that the actual technical capability developed was considered relatively 'minor' compared with other software support development efforts.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Project management activities</th>
</tr>
</thead>
</table>
| 1 Develop vision and establish feasibility | - Obtain senior management sponsorship  
- Capture project requirements  
- Outline the business case and costs/benefits analysis  
- Define the process change and integration Implications  
- Provide a statement of work including details of the project task and the human resources involved  
- Select the package and document decision process  
- Create risk plan and log  
- Identify project stakeholders  
- Produce level 1 plan or programme including estimated phase lengths  
- Define future technology direction model, assumptions, constraints and key performance factors |
| 2 Detailed planning and establishment | - Prepare detailed requirements specification upon which to base solution  
- Develop detailed solution specification to meet the project requirements and obtain agreement from customer and process owner  
- Prepare detailed management plan for all aspects of the project  
- Ensure management plan and statement of work are implemented  
- Perform affordability review  
- Identify and plan development team training requirements  
- Review implications of change for target process and organisation  
- Define communications strategy for project stakeholders  
- Define post-deployment support requirements  
- Assess implications for personnel issues such as roles and responsibilities  
- Outline end user training requirements  
- Define user population and location  
- Produce level 3 plan or programme with resources allocated and obtain stakeholder agreement  
- Consider security policy implications  
- Define responsibilities for updating data dictionary, data cleansing activity, legacy data migration and data load  
- Set up development environment  
- Relate implicated technology capabilities with business processes |
| 3 Development | - Review affordability and define any changes to scheduled costs  
- Confirm all roles and responsibilities within the management plan are supported  
- Draft training materials and user guide  
- Produce detailed population matrix including roles, locations and processes to guide deployment of correct capability to correct users in correct locations  
- Define organisation transition plan including implications for changes to HR configurations and policies  
- Implement any security activities  
- Confirm communications material is in place and ready to be updated  
- Confirm training requirements, produce training schedule and initiate production of training materials  
- Review level 3 plan confirming any deviations with stakeholders and add detailed deployment activities to the programme  
- Define how support requirements will be satisfied  
- Produce integration test plan  
- Test against new requirements and log then follow up faults arising  
- Establish integration test facilities are in place for each defined programme  
- Confirm responsibilities for test data  
- Plan data dictionary, data cleansing, legacy data migration and data load activities  
- Produce data migration software  
- Agree and develop interfaces  
- Define application architecture and modify system architecture model  
- Produce instructions for installation of the change into the test environment  
- Produce logical technology model including detailed description of hardware, software and networking that makes up the technological infrastructure |


<table>
<thead>
<tr>
<th>Phase</th>
<th>Project management activities</th>
</tr>
</thead>
</table>
| 4 Integration and test | - Review affordability and define any changes to scheduled costs  
- Produce process and integration test report confirming that all integrated elements of the change, process, tools and people have been completed as agreed and any limitations and work-arounds are documented  
- Obtain confirmation from the process owner that the change still conforms to the original vision  
- Finalise and deploy organisational transition plan  
- Confirm training programme is implemented and progressing  
- Obtain confirmation from customer and process owner that the communications material has been updated  
- Ensure back-up and recovery processes are in place  
- Ensure process and organisation is in place to control future access requests  
- Plan project QMS incorporation of new working methods, procedures and user guides  
- Confirm support plan is in place, both local and from developers  
- Ensure data dictionary, data cleansing, legacy data migration and data load activities are complete  
- Ensure modified interfaces have undergone simulated production environment testing  
- Update level 3 plan incorporating finalised deployment plan including responsibilities, assumptions, dependencies, risks and ensure all deployment activities are still on schedule  
- Produce performance engineering model including certification  
- Produce installation Instructions  
- Produce physical technology model for fully configured system  |
| 5 Pre-production test | - Confirm final statement of benefits with customer  
- Establish benefit tracking method including metrics for measurement of benefits against predicted values and responsibilities  
- Ensure roll back strategy has been defined should deployment fail  
- Conduct deployment readiness review with potential users  
- Prepare software release note comprising applications and utilities  
- Prepare capability release note including what the user can expect and any concessions  
- Ensure changes to project QMS are defined, agreed and implemented  
- Ensure support environment and appropriate resources are in place  
- Confirm all training is complete and that the target audience attended  
- Prepare communications report specifying whether all communications were achieved and that the audiences needs were achieved  
- Confirm all re-organisation requirements have been met and any relocation has been completed  
- Ensure intensive support has been planned  
- Confirm pre-production testing has been completed  
- Plan full volume testing in the production environment post deployment  
- Report testing of secure environment and security penetration  |
| 6 Deploy and project close | - Complete and document lessons learnt review including all stakeholders and conduct post implementation review of feedback, performance and customer satisfaction  
- Produce benefit achievement report  
- Confirm all outstanding actions from previous review are completed  
- Produce communications strategy to formally communicate outcome of the change programme  
- Perform data cleanliness audit to ensure new processes are producing the expected results  
- Define user group for future change projects  |

Figure 4.1.2a: Key project management activities in CAP1 project work plan

4.1.3 Performance measurement and soft factors tool support in CAP1

Within the CAP1 project management environment the dominant method of project control and parameter estimation relied upon standard Earned Value Management (EVM) indicators to track achievement against contractual commitments associated with cost and time. The EVM technique monitors performance against anticipated work schedule and associated costs of project work activities over time. This is achieved through tracking actual spend and schedule performance for comparison with predicted values. On this basis, potential risks associated with slippage in the project schedule may be anticipated for remedial action. Eventual project spend at delivery may also be anticipated and trends in cost and schedule data during intermediary project phases can be used to identify if the project is likely to run...
into resource problems before delivery. Project task planning and risk analysis was supported by conventional 'Critical Path Method' techniques (CPM) that forecast project work schedules based upon logical dependencies and sequence of individual tasks within the project work breakdown structure.

Regarding softer issues associated with work group composition and human factors, discussion with CAP1 work group members yielded two known approaches to the consideration of individual-level variables that can be used to provide a team profile or consider group composition factors. Both the 'Belbin' approach to team roles and the 'Myers-Briggs' personality inventory provided a means of structuring optimal or high performance work groups based upon group dynamics and personality profiling approaches. The Belbin approach in particular considers the work group level in its specification of diversity in group composition as an important requirement for successful teams. Within CAP1, the Belbin approach was not formally applied, although managers were aware of its conceptual basis and therefore knowledge regarding group dynamics was available during work group specification. The Myers-Briggs inventory was not applied specifically in project personnel configuration practices and applied more to the human resource function's standard selection processes.

Organisation-wide surveys of employee satisfaction were implemented on a regular basis and reported on an organisational sub-unit level through the use of a standard Employee Opinion Survey (EOS). No such measures or surveys were therefore undertaken at the level of the functional project work group within the organisation to track process aspects of the project work system relating to human and organisational effectiveness. Relevant metrics development work was identified as being undertaken in association with BAE SYSTEMS, which addressed the measurement of development effort in software engineering projects through application of an English language-based protocol or 'Process Engineering Language' (PEL; Clark and Morris, 2002). PEL was piloted in BAE SYSTEMS with reported benefits over work effort quantification based upon conventional product and work breakdown structures.

4.1.4 Stakeholder management issues

Some of the most critical project performance issues raised by the CAP1 study, from a human and organisational perspective, were those that centred on stakeholder management and communication. Due to the support role of internal change projects and apparent from the CAP1 project requirements, capability development projects incorporated multiple separate and integrated development activities which were destined for deployment into a number of...
different operational project contexts comprising varied system and data environments. This placed large emphasis upon the ability of the development project team to coordinate and communicate between a number of different stakeholders and organisational entities. Early in the development project an initial stakeholder list within the project management plan was agreed. There were 28 key stakeholders defined, including individuals who may be regarded as the core CAP1 development team. An additional 15 senior management stakeholders were also identified. In terms of the diversity of interests represented by the CAP1 stakeholder list, several organisational entities were represented, as outlined below:

- The CAP1 development team or work group directly responsible for work performed within the project.
- Personnel representing the three main program interests or customers for the CAP1 work-product, including process, capability (both development and deployment), engineering and manufacturing management.
- Personnel from the support functions including training, software support and IT services.
- External consultants representing the primary developers of the software tools undergoing modification in CAP1.
- Independent reviewers to critically evaluate project work progress in order to reach an objective decision regarding whether all necessary project work criteria had been met at each stage of development.

Due to the diversity of interests represented in the stakeholder management plan, important non-technical factors contributing to project success included the ability of the team to effectively disseminate and communicate technical knowledge regarding project issues and progress to a wide audience of key stakeholders (whose provision of information and input regarding dependent projects and activities was considered essential). During discussion with CAP1 personnel, several barriers to effective stakeholder management were highlighted.

A key issue identified was the availability of key stakeholders to attend CAP1 meetings and availability for communication regarding project progress and issues. This was partly due to the fact that the customers for internal change projects were themselves engaged within operational programs. There were instances when the CAP1 management process was delayed due to periods of criticality within customer projects that demanded priority from key personnel. Comments made regarding lack of availability of key personnel due to other projects taking priority highlighted an influence upon decision-making processes within the project management work group. The lack of information from or representation of a particular stakeholder interest may, therefore, have a negative impact upon the group's ability to make prompt decisions and direct action.
A further issue related to the availability of stakeholders and key management sponsors is the gaining of authorisation for units of project work. Due to the fact that much project activity was not locally funded but funded by the project customers, any lack of formal authorisation meant that the change project cost schedule was running with an inherent level of risk. Such a situation was regarded as undesirable but necessary if the project was to make progress during periods when sponsors were unable to respond immediately to requests for authorisation. Making progress towards project goals in such a situation was regarded as requiring a degree of trust.

During the initial and subsequent CAP1 review meetings, communication with key and senior management stakeholders figured highly upon the agenda. The purpose of a number of actions and management activities therefore centred on ensuring stakeholders engaged with or 'bought into' the project and were aware of the release rationale and relevant project issues arising during development work. One such action implemented was the creation of a CAP1 web page as part of the communications strategy to ensure stakeholders were kept informed. The CAP1 project emphasised the importance of the stakeholder management activity to several project success factors, including the negotiation of resources for the project and the management of project requirements. It was commented that the communication of the CAP1 release rationale to key stakeholders and senior management was important in order to develop 'ownership' and agreement for the project requirements. Supporting stakeholder knowledge regarding project progress and issues arising provided a basis for more effective requirements negotiation (stakeholders were more aware of the constraints under which the project was operating). Stakeholder expectations for what the project would eventually deliver were therefore more effectively managed, which in turn was likely to influence customer satisfaction with the deployed solution.

4.1.5 Project work group autonomy issues

Within CAP1 a cross-functional team was implemented to produce and support systems products and services. The integrated project team organisational structure was intended to empower project personnel with management and control responsibilities for the project and a level of functional autonomy regarding the planning and organisation of project work tasks. The team was also responsible for performance monitoring and control activities that took place at a series of peer-approved reviews scheduled to coincide with key phases in the project's lifecycle management plan.
In the context of CAP1, however, the general comment was made that change project managers lacked authority and empowerment. The focus of project management efforts was regarded as involving the obtainment of work authorisation from senior management sponsors and involving human resources from other projects in the change process. Change project managers felt that their role involved coordinating and influencing other stakeholders involved in the process, in addition to managing the actual change project itself. Although the project work group possessed functional autonomy over the organisation or breakdown of project work tasks and how the actual capability solution was achieved, control over when work packages were ultimately executed was regarded as resting with the customers who funded the project work.

4.1.6 Communication and coordination issues

The requirement to maintain effective communication between projects and their customers, especially regarding requirements management processes, was emphasised by a cost escalation in the CAP1 project that was ascribed in part to additional requirements made for extra capability following initial cost planning. The projected cost was further extended to accommodate increased process complexity incurred as a result of pressures to conform to scheduling constraints imposed by one of the customer programs. A link between the requirement for closer coordination between ongoing projects and project outcome performance was therefore demonstrated.

In negotiating a new schedule for a discreet deployment to an individual customer, the CAP1 project effectively incurred penalties in terms of organisational effort. Two distinct versions of the software code had to be managed and maintained, pre-production testing needed to be performed twice at increased cost and project process management activities such as phase gate review activities were performed separately for different customers. The overall benefits, however, could only be understood from consideration of the constraints and potential benefits within dependent projects, again placing the emphasis upon effective communication, compatibility between different projects' objectives and the ability to consider a broader organisation-wide business perspective, rather than just local project goals. In the context of an integrated project management work group, it was considered important to foster effective communication and decision-making based upon clear, cohesive and commonly agreed goals.

Communication and coordination issues were identified as an inherent feature of the integrated project team organisational design, which spans functional boundaries and hence a diversity of interests and micro-cultural perspectives. One issue raised of particular
importance to change project management, was the question of what role specification and knowledge was necessary to enable effective coordination across functional and other organisational boundaries. Another important aspect of communication of information involved a longer-term perspective; the capture of knowledge through documentation as the project progresses provides a traceable history of key design decisions and the opportunity to apply lessons learnt in future projects.

4.1.7 Work group composition and knowledge adequacy

The ready availability of project-specific knowledge within the work group was highlighted as an important factor for project success. Historical examples within project personnel's experiences were cited in which key technical engineering knowledge related to specific systems was lost due to relocation of human resources and changes to organisational configurations, resulting in rework where new requirements arose relating to those systems. The fact that critical technical knowledge regarding the system that was the focus of development within the CAP1 project resided beyond the boundary of the immediate project management team, in the original software development organisation, placed added importance upon networked communications, collaborative working and stakeholder management activities for successful project performance and timely remediation of problem issues arising.

4.1.8 Motivational processes

During problems experienced by CAP1 regarding the receipt of budgetary authorisation for the performance of ongoing work, several comments were made indicating the potential demotivating effect upon project personnel of hold-ups in the project's development. Due to a directive from senior management not to undertake work that wasn't formally assigned budgetary resources from the customer, a cut-off date was set to cease work towards deployment for a customer dependent upon the provision of budgetary resources. The implied result, that a section of the human resources allocated to the CAP1 project would be without project work tasks, was deemed undesirable, not only because of the loss of productivity and associated costs, but due to the demotivation that would be experienced by project personnel who were left in doubt as to their purpose and value to the project. This issue raises the need to consider human outcomes such as variation in general motivation or morale as a result of project events.
4.1.9 Trust and work group cohesion issues

Trust between organisational entities was identified as a key enabling factor for effective collaboration to occur between separate project interests. Demonstrable instances of the role of trust included the facilitation of project work processes in situations arising due to ambiguity in formalised work authorisation and issues surrounding customer expectations. In these circumstances, productive work proceeded on the basis of informal agreement, as is evident where work authorisation was forthcoming or unplanned, minor requirements were agreed for incorporation in the developed capability as the project progressed. Where negotiations concerning scheduling took place, a level of trust was necessary to openly discuss the constraints under which other projects were operating and sensitive performance issues that were experienced within those projects. Work group cohesion or sustainability was identified as an important outcome of project experience that determined the team's ability to continue working effectively together as well as to benefit from shared work experiences through development of broadly understood team working practices. Through experience, informal working practices and a unique group 'climate' developed, as well as interpersonal, networked knowledge regarding where specific skills and expertise resided within the organisation.

4.1.10 Organisational structure issues

Comments regarding organisational structural issues made from the experiences of CAP1 personnel included the statement that often the hierarchy within the organisation was too high. Consequently, key management sponsors and stakeholders didn't always get to know about and lend support to key change project issues and concerns. The delegation that was reported to occur hampered effective knowledge dissemination to empowered stakeholders regarding change project activities. At the higher levels of project organisation, the management sponsor was regarded as far removed from the operational issues that concerned the CAP1 project. The result was over-delegation in general and at project performance review meetings in particular, with subsequent implications for the feasibility of informed and empowered decision-making processes.

4.1.11 Key conclusions from the CAP1 scoping study

Apparent from experience within the CAP1 project environment is the fact that the project management process involved a high level of organisational activities: communicating and coordinating between multiple stakeholders, negotiating agreement between various organisational entities with differing objectives or perspectives and managing the trade-off between interdependent project parameters. All of these activities took place within the
boundary of resource and other constraints that dictated the level of autonomy the project work group could exert over the structure and performance of the project work tasks. Resource constraints identified included financial and human resource issues but also many less tangible constraints such as the availability of scheduled time, the availability of relevant information to support decision-making processes and the provision of authorisation to execute individual work packages, in addition to technical issues that dictated the functional properties of the product and where work effort was prioritised.

From an organisational perspective, the nature of internal change projects such as CAP1 is such that there exists a high level of complexity in project objectives and, necessarily, the work processes that deliver them. This is due to the fact that projects of this nature, even those involving what may be considered to be 'minor' software upgrades, are based upon multiple requirements for deployment of individually tailored solutions to multiple customers. A series of discrete capability solutions may therefore require development, testing and integration within various operational environments to a deployment schedule that is accepted and coordinated with the ongoing programs of the project’s customers. The effectiveness of the project management process involving the coordination, negotiation and resolution of the organisational and technical issues arising from integrating work across projects therefore becomes paramount to the success of the whole project effort. For this reason it is important to understand the factors that influence the effectiveness of these management activities and support them with appropriate measures where possible.

In CAP1, the effort expended in coordinating group meetings, communicating between group members and ensuring all involved were well informed were considered to be project management activities that were peripheral to and detracted from the resources available for control of actual 'productive' work. Change project managers on CAP1 suggested that it was the peripheral tasks and activities, which surround the actual development work, that caused the most problems and which contributed the biggest source of uncertainty in planning and project parameter estimation. The integrated project team organisational structure is therefore implemented in project-function matrix organisations in an attempt to facilitate the high level of communication and collaboration across functional boundaries that is necessary in the engineering of complex systems and products.

Within the context of the CAP1 project environment, it was possible to identify human and organisational issues underlying the technical processes within the execution of project work that impacted upon the smooth running of the project and management process, and ultimately upon the projects operational performance. Soft performance issues identified included: stakeholder communication, work group autonomy, work group composition, motivational processes and trust between organisational entities, amongst others. Within
CAP1 project management operations, there was an evident lack of specific measures to quantify the extent of these problem issues and a lack of support for analysis of the impact of these factors upon operational outcome criteria relating to cost, quality and time objectives.

That experienced project managers were conversant with soft systems issues and their relationship to performance, in addition to those relating to control of technical aspects of the organisational system, was evident from the output of the interviews. Awareness and control of soft factors in operational projects currently relies upon the intuition and managerial capabilities of experienced project lead personnel. Experienced managers are aware that soft issues may influence the performance of the project, but are generally unsupported in terms of tools and formal, specified processes in their efforts to control these factors. There is a large volume of project documentation and formal deliverables that mandated project lifecycle management approaches require be completed, regarding the technical or 'hard' factors within a project, throughout its phases. The introduction of a formally defined, structured process for the identification and analysis of soft factors within the project environment would therefore significantly contribute to enhanced performance improvement capabilities through complementing well-established technical or 'hard' systems approaches with a soft factors perspective.

Performance management review processes and metrics implemented to monitor performance factors within the project were predominantly focused upon monitoring progress towards the achievement of operational outcome objectives related to contractual commitments. A general conclusion made by project personnel was that the lack of 'soft metrics' employed in project operations represented a more general lack of capability to analyse soft issues in current operational project management knowledge. Project managers in CAP1 emphasised the primary importance of operational outcome measures as the key value indicators driving the success of business activities. A soft metrics capability would therefore involve the ability to analyse hard metrics data regarding project performance, from a soft perspective. A key requirement for the soft metrics work identified from experience in the CAP1 industrial context is therefore the need for a broader analytical process that is not necessarily confined to specific metrics.

The CAP1 case study identifies a clear need for formal metrics and performance analysis processes capable of addressing human and organisational systems functioning. Development of appropriate tools and approaches to this problem within the soft metrics research project began with conceptual modelling efforts to represent the relationships between potential soft factors and functional performance (see section 4.2 below). The CAP1 project scenario is revisited later in this thesis in the development of an applied performance-modelling framework, outlined in section 5.1.
4.2 Conceptual development of a ‘soft’ factors modelling framework

Goranson (1999) highlights the importance of complementing information captured in quantitative form with relevant causal relationships represented in models, through stating that most quantitative information suffers from the "accountant’s syndrome":

\[
\text{Effects are measured, usually in the form of time and cost, but the complex causal relationships that a robust model would capture are lacking. (Goranson 1999 p.104)}
\]

In order to develop a clear conceptual basis and rationale for the measurement focus of the soft metrics research, efforts were undertaken to model the complex causal relationships between human and organisational factors evident from the review of theoretical and empirical literature reported in section 3 of this thesis. The principle aims in this undertaking were: 1) to integrate empirical research findings regarding the performance influences of specific soft factors into a more holistic model representing the functioning of a complete human and organisational system, and 2) to develop conceptual understanding of an appropriate modelling framework for representing performance processes of this type. In considering the functional requirements for a conceptual human and organisational performance model, two key modelling activities are implicated:

- **Identification of soft factors**
  Identify key classes of human and organisational variables that represent performance factors in human activity systems
- **Specification of interactions**
  Provide a framework and method of mapping the influences between variables in order to represent performance processes in human activity systems

Following outline of methodological considerations for modelling performance processes, this current section of the thesis describes general dimensions of performance or effectiveness for human-based systems. Early conceptual modelling efforts are then outlined which culminated in specification of a comprehensive modelling framework for the entire organisational system. This section then concludes with a theoretical exercise in which the framework is applied to represent human and organisational performance processes identified in the research literature to demonstrate the utility of the framework.

The conceptual models outlined in this section of the thesis represent an iterative development process that began with general conceptual influence maps and culminated in the specification of a more practical modelling framework with defined performance factors.
that was applicable to the target industrial domain. Inherent in this developmental sequence is refinement of the scope of modelling efforts, from global modelling of performance processes across all levels of the organisation, to a more specific, narrow focus upon the work group as the primary functional unit in project-based organisations.

### 4.2.1 Methodological approach

Once a volume of literature relevant to organisational performance had been reviewed, and as a subsequent ongoing process, gradual refinement of the identified performance factors and their interactions was performed to create a conceptual model of the 'soft' determinants of human performance. Several early versions of the performance models appear in this current section of the thesis and appendices B, C, D and E to give an indication of intermediary stages in the development process.

Several methodological issues are important with regards to the refinement of factors for inclusion within the conceptual model. Through successive iterations of the conceptual model and experience within the industrial context, a definitive set of human and organisational performance factors began to emerge. With much of the literature yielding overlapping and reciprocal performance factors, a sub-aim of the literature review process was therefore to reduce redundancy amongst the factors proposed to account for performance, by integration and conceptual clarification. This process was akin to efforts made to ensure a minimum of specification error in multi-factor statistical research, in terms of the requirements to ensure the inclusion of sufficient relevant factors only, in order to account for the variance in the target variable: in this case performance, and the omission of all other irrelevant factors. Borman (1991) offers a related concept by highlighting the importance of 'criterion relevance' of the variables used to measure performance. 'Deficiency' and 'contamination' are therefore two important issues for criterion relevance; deficiency referring to when a set of criteria does not measure all the important areas of performance-influencing factors present and contamination occurring when criterion measurement taps variance which is irrelevant to performance.

Drawing upon empirical evidence from the literature review, knowledge regarding the relative importance and interaction effects of specific performance determinants was compiled in order to inform the process of selection of specific performance factors for inclusion within the conceptual model. Another methodological consideration pertinent to the development work for the conceptual model was practical consideration of the 'measurability' of performance-relevant factors defined within the framework. Jackson (1996) raises an important point concerning the relationship between actual measurable variables and the underlying
constructs they are proposed to indicate. Figure 4.2.1a below provides an illustration depicting the relationship between readily detected attributes of individuals and underlying construct variables. Certain relevant variables associated with individuals' functioning in the workplace, such as skills, knowledge and expertise, are often 'underlying' constructs, only detectable by measuring more readily available, 'surface' attributes such as departmental membership and formal certification.

<table>
<thead>
<tr>
<th>Task-related attributes</th>
<th>Target underlying constructs</th>
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</thead>
<tbody>
<tr>
<td>Department/unit membership</td>
<td>Knowledge and expertise</td>
</tr>
<tr>
<td>Organisational tenure</td>
<td>Skills</td>
</tr>
<tr>
<td>Formal credential and titles</td>
<td>Physical abilities</td>
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<tr>
<td>Education level</td>
<td>Task experience</td>
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*Figure 4.2.1a: Example relationships between readily detectable attributes and target underlying constructs (adapted from Jackson, 1996)*

Whilst on a conceptual level, it is necessary to model and understand the effects that less tangible constructs such as knowledge and culture have upon performance, it is equally important to understand the relationship between these constructs and practically applicable indicators that may be employed to quantify them, such as organisational unit membership and formally demonstrable work-experience. Cultural factors also represent a great challenge for modelling efforts, as they are synonymous with intangible factors for which it is difficult to specify objective criteria. In terms of the measurement of cultural aspects, questionnaire and other measures can only 'diagnose' cultural aspects based upon observable 'symptoms' (Grote and Künzler, 2000) or quantifiable instances of 'behaviour' (Childress and Senn, 1999).

Accordingly, in the refinement of performance variables for population of the conceptual modelling framework, efforts were undertaken to decompose broad, underlying constructs into more observable criteria, as is represented by groupings of major factors with sub-factors in several of the conceptual models that follow. In order to select suitable individual variables their relevance to several key performance dimensions for human systems was considered, the details of which are outlined in the following section.
4.2.2 Generic performance dimensions for human systems

In developing a conceptual framework for modelling performance processes in human-based systems, considerable attention was given to the classification of potential soft factors into broad types according to the function of an individual variable relative to key dimensions of performance. Review of literature related to human and organisational performance yielded many potential factors of several different classes including both activities and properties or 'state' variables. A classificatory framework was therefore required to represent the relationship between different types of variables and the aspects of performance or functioning that they described.

Although writing in the context of work group functioning and effectiveness, Brodbeck (1996) outlines three important generic performance dimensions that should be considered in analysis of broader human systems: performance, effectiveness and productivity. Drawing upon the work of Campbell and Campbell (1988), Brodbeck states that 'performance' may be defined as an aggregate of those behaviours that are relevant for achieving the goals specified, 'effectiveness' is the degree to which the performance outcomes approach the specified goals and 'productivity' refers to how efficiently a particular level of effectiveness is achieved. One of the appealing features of these definitions is that they may be applied equally to organisational productivity and individual performance, making them independent of any particular level of analysis within the organisation. Performance, effectiveness and productivity may therefore be said to describe generic concepts of performance as opposed to being tied to any one specific level within the organisation.

Figure 4.2.2a below provides a diagrammatic illustration of a framework for classifying performance relevant variables in the operation of human systems. Boxes within the diagram represent various relevant classes of variables that must be addressed in consideration and evaluation of the performance of human systems, including situational constraints, goals, behaviour and outcomes. The actual performance dimensions for evaluation are represented by the relationships between the classes of variables and encompass goal adequacy, procedural adequacy, effectiveness and productivity. The broad classes of variables within the framework are grouped according to various boundaries. Performance goals, behaviour and achieved outcomes may be considered to be properties of the human system, within the control of operations management efforts. Situational constraints, on the other hand, are external to the human system and hence form contextual influences for operational activities and are beyond the direct control of the organisational system considered.
The classes of variables and performance dimensions within this framework are specified in such a way as to be generically applicable across all levels of an organisation, representing autonomous functioning of individuals, work groups and the organisation as a whole. The framework draws upon the conceptual distinction made between 'performance', the actual act of 'doing' referred to in this framework as 'behaviour and activities', and the 'outcomes' of that behaviour. The framework also illustrates the interrelated nature of the dimensions that describe organisational performance, implying that a comprehensive performance measurement system must first find adequate indicators for each entity and then seek to analyse the relationships between them. An appropriate example can be found in considering performance on one organisational sub-level; that of work group performance.

The levels of various dimensions of performance can be assessed and measured through comparison of work group activities or behaviour, the performance goals for those activities, the results or outcomes of activity and the pervasive situational context. In this sense a measure of work group productivity can be derived from how efficiently activity produces outcomes. The measures of outcomes themselves do not indicate how effective a work group is, as gaining this information requires a value judgement achieved by comparison of outcomes with the original goals or objectives for activity. Similarly, the goals and
requirements of behaviour themselves, in order to provide an accurate template for indicating the effectiveness of results, must be appropriate in the situational context of the immediate organisation and broader environment. Finally, analysis of ongoing work group behaviour relative to performance goals gives a proactive indication of the adequacy of procedures for achieving valued work group outcomes.

From consideration of issues associated with various performance dimensions in human systems it became apparent that conceptual performance modelling efforts needed to focus upon the relationship between outcome variables representing achieved productivity and activities or behavioural variables that represent actual human functioning within the system. It is important to note that the models presented in this discussion depict the conceptual relationship between variables identified as important performance determinants. As with the models reviewed in the literature (see section 3.2), these models represent structured influence diagrams of performance factors, with the arrows representing causality or influence. The models presented here do not represent a structural 'system' model or architecture and the arrows do not represent workflows or the transmission of information.

4.2.3 Early conceptual models

A key finding from review of relevant empirical research literature was that human and organisational performance factors were highly interrelated and present at all levels of analysis within organisational systems. Accordingly, early conceptual modelling activities began with attempts to classify identified performance constructs according to the level of the organisation at which they originated. Figure 4.2.3a below consists of an overview of an early model that groups factors according to origin in one of several embedded layers of an organisation.

In this representation, a boundary is drawn around performance factors that may be described as inherent within the organisational system, with all contextual factors and factors beyond the control of the organisational system, such as technological developments and competition, lying outside it’s boundaries as features of the external environment. Within the organisational system, various embedded sub-levels are represented, including the unit or work group level representing the sub-division of the organisation’s work force and the individual level, representing the people that populate each team or work group. At the organisational level, performance factors include broad cultural variables, work and performance feedback processes, IT adequacy and strategic level goals. Within the work group level, relevant performance factors include leadership, group-working climate, autonomy level and group composition factors amongst others. Critical performance factors
at the individual level include motivation, knowledge, well-being and personal characteristics. A more detailed breakdown of the performance factors included within this embedded-layered model may be found in appendices B and C, which consist of an alternative early version of the multi-level model and a reproduction of the model in figure 4.2.3a, with expanded variables to show sub-factors.

The key feature of the embedded-layers model is the fact that it represents integration of multiple perspectives in its adoption of a holistic view of human and organisational performance processes within an organisation. The implication for monitoring and control systems for human and organisational performance factors is that personal, team and organisation-wide perspectives must be included as performance at each successive layer of the organisational system aggregates to contribute to performance on higher levels, within the constraints of the external environment. In this sense, organisational performance is the result of aggregated individual team functioning plus organisational level factors, and team performance is a result of aggregated individual human performance, plus team-level factors. In its descriptive capacity to explain actual human and organisational performance processes it was considered lacking in two critical respects: 1) there were no interactions within the model to show proposed directions of influence or link variables in causal sequences, and 2) the factors were only structured according to level of analysis rather than functional relationships to performance outcomes or performance processes.
To address these limitations, conceptual modelling efforts turned towards construction of general influence maps to represent specific interactions between performance factors identified at specific levels of analysis. Figure 4.2.3b below depicts one such early influence map, with factors structured around organisational, work group and individual performance. In this model, performance factors at each level of the organisation are presumed to affect the functioning of people, teams and the organisation as a whole.

![Conceptual Performance Model](image)

**Figure 4.2.3b: Early conceptual performance model with influences at individual, work group and organisational levels of analysis**

Apparent from the conceptual model in figure 4.2.3b is the complexity of interactive processes between soft factors in organisational systems. This trend becomes even more apparent from the expanded influence map included within appendix D. Several key features are inherent within these early conceptual models resulting in the need for a more comprehensive modelling framework capable of structuring variables according to type and function. Regarding the performance factors and interactions depicted within figure 4.2.3b above, these features may be summarised as:

- **Multi-stage chains of influence:** A performance factor may be more directly or indirectly associated with performance and functioning. It may have a direct influence,
such as the influence of motivation upon individual performance, or the influence of a factor may be mediated by other factors: both trust and cohesiveness act upon work group performance through the level of collaboration present. The result is expanding chains of influence as the determinants of an entity's functioning are analysed.

- **Multiplicity of Influences:** Each performance factor may have multiple influences on multiple factors. For example: job-satisfaction may influence both well-being and motivation; organisational culture impacts upon both group cohesiveness and trust.
- **Impact upon multiple levels of functioning:** Each performance factor may influence multiple levels of functioning within the organisation directly, in addition to aggregation effects between levels. For example, communication systems may be associated with both organisational level and work group level performance, and leadership impacts upon both the group and individual levels.

### 4.2.4 Towards a comprehensive modelling framework

Building upon lessons learnt in initial attempts to model human and organisational performance processes, a broad conceptual framework was developed to structure influences and categorise performance variables according to functional origin. Ultimately, understanding performance processes in the entire organisational system, requires the adoption of a framework that is capable of integrating the interacting variables across all levels of the organisation, in order to explore contextual and aggregation effects. **Figure 4.2.4a** below outlines a template for a global model of organisational performance, upon which the influence of variables affecting performance can be mapped to specific activities and outcomes of those activities, on each sub-level of the organisation.
Modelling variables across organisational sub-levels in this way enables representation of how organisational behaviour can be deconstructed into lower level performance processes. The delineation between each level's factors can be made in terms of the issue of control: when an entity, whether it be an individual, work group or organisation cannot exert positive influence over the factors that influence it's processes and outcomes, those factors may be considered to be 'higher level' variables. Accordingly, this generic, high-level model may then be populated with specific performance factors and interactions according to classification within the framework. Three main classes of variables are identified within the framework as operating at each level of the organisational system. The three classes may be described as follows:

- **Behaviour and activities**: refers to variables that are concerned with actual productive and interactive processes, or the act of 'doing', that represents human functioning within the organisation. A key feature of these variables is that they represent activities, processes and behaviour that occur over time and as such depict various transformation processes. In this sense they may be described as temporally active variables. These variables may also be purposeful goal-oriented,
productive activities, or represent social processes that inevitably occur where people interact.

- **Outcomes**: refer to quantifiable variables that represent the results of human functioning, in the form of tangible output and work products or other incidental results such as changes in the state of the human system. Outcomes therefore comprise static ‘state’ variables that represent output from the system and are linked to determining behavioural factors.

- **Contingency factors**: refer to a broad class of variables incorporating factors that influence the relationship or interaction between activities and their outcomes. Contingency variables lie outside of the activity and outcome frames and may be linked to activities or outcomes directly, or through other mediating variables of any type. It is also possible that contingency variables themselves can be influenced directly by the outcomes of work group functioning through feedback processes representing learning and work process improvement. Contingency variables are static, quantifiable variables that form inputs or exert some contextual influence upon work group functioning or processes and therefore represent situational conditions for the human system.

The framework is therefore based upon the relationship between ‘activities’ or ‘behavioural’ variables and the ‘outcomes’ of these processes, the predominant rationale being that the level of the individual outcome variables to which they are linked indicates effectiveness of functioning. A third category comprising ‘contingency factors’ or ‘preconditions’ is included to represent contextual variables and situational constraints that influence performance processes and functioning either directly or through mediating various relationships between activities and outcomes. Hence, the efficiency with which human functioning translates into productive output may be considered to be ‘contingent’ upon the presence and operation of these precondition variables. *Figure 4.2.4b* below depicts the template structure for classifying performance variables at a single sub-level of the organisation.
Using performance factors identified in the literature review and associated empirical evidence of the dependent influences of these variables, detailed human and organisational performance models were constructed for the individual and work group levels of organisational behaviour. These two levels were focused upon in detail in conceptual development efforts as they represented the more amenable levels of the organisational system for human factors analysis; the organisational level being more a strategic management issue. The organisational level is represented in the work group level model nevertheless as several organisational-level factors were identified as having a contextual influence upon work group functioning and specific influences relating to these factors were therefore mapped. In order to provide the reader with an example of the analysis and refinement process for development of the conceptual models depicted below, the work group level model at an intermediary stage of development is included within appendix E.

Figures 4.2.4c and 4.2.4d below depict the conceptual performance factors models for the individual and work group levels of functioning, respectively. Within each of the models, the level of interest is expanded to depict full contingency-behaviour-outcome causal sequences and influencing factors from other levels of the organisational system are depicted as peripheral. Due to the complexity of interactive processes between many variables it is necessary to present the overall model in separate levels in this way. Note that the boxes
that contain the variables, in many cases, represent a broad class of sub-factors identified from the literature as having common principal influences. The models incorporate many complex interactions and a multitude of different performance factors reflecting human and organisational variables that empirical research has highlighted as important for effective performance. For further explanation of how the model represents specific performance influences and functional processes, the reader is referred to section 4.3 of this thesis, which includes a more detailed breakdown of the work group level of the model. The subsequent section of the thesis (section 4.2.5 below), outlines the reasons for identification of the work group level as of particular interest for the soft metrics research work.
Figure 4.2.4c: Conceptual model of human and organisational factors influencing performance on the level of the individual within the organisation.
Figure 4.2.4d: Conceptual model of human and organisational factors influencing performance on the level of the work group within the organisation
4.2.5 Level of analysis: the primacy of the work group in project operations

From experience gained through the industry scoping study, it became apparent that the dominant functional unit within BAE SYSTEMS' project operations was the work group or 'Integrated Project Team' (IPT). Temporary and long-term multidisciplinary teams were created to integrate effort across functional boundaries within the organisation to produce and support systems products and services. The IPTs were assigned with management and control responsibilities for their projects and had a high degree of functional autonomy regarding the planning and organisation of project work tasks. The teams were also responsible for performance monitoring and control activities that took place at a series of peer-approved reviews scheduled to coincide with key phases in the project's lifecycle management plan.

Following conceptual development of the modelling framework in the soft metrics research, the decision was made to apply the approach to human and organisational performance processes and contextual factors that impacted upon project management teams, representing a narrowing of the focus of the modelling work from organisational-level systems to work group functioning and effectiveness. This decision allowed research efforts to focus upon the specific human systems of interest in depth and was justified through experience within the applied industrial environment in which 'organisational performance' was found to be largely driven by individual project performance, that in turn was a function of project management team effectiveness and contextual influences. Subsequent modelling efforts culminating in the development of an applied human and organisational performance (HOP) modelling framework therefore sought to represent processes at the work group level as the primary level of analysis. Higher-level contextual factors were only considered to the extent that they impacted upon team performance and lower-level factors associated with the individual level were integrated within 'work group composition' factors.

As project management team performance is identified as the focus of further conceptual development efforts it becomes appropriate at this stage to give some consideration to the definition of working groups as functional sub-units within organisations. West (1996b) comments that organisations are growing in size and becoming structurally more complex, increasing the need for groups of people to work together in coordinated ways to achieve the organisations goals. Complexity in organisational systems results in increasing sophistication and expansion of work-place concepts, the language used to describe them and information technology to support work processes. It is therefore necessary to facilitate human contact between individuals in the work-place through team-based work processes if shared understanding of information is to develop.
Complexity in organisations means diversity in work groups and increasing reliance upon multi-disciplinary collaboration and coordination across functional boundaries within the organisation in order to produce effective integrated solutions. Focusing upon the extent and structure of diversity in work group composition, and the effects of diversity on processes such as communication and decision-making, represents an important point for analysis of human and organisational processes within a project-based organisation. The complexity and broad scope of systems engineering projects necessitates group decision-making processes in which multiple perspectives and stakeholder views are considered. In the aerospace and defence domains in particular, delivery of complex products requires a multiplicity of engineering expertise and disciplines to collaborate during all aspects of the product development process. At the macro level, overall project success represents performance criteria at an organisational level. At the micro-level however, project work-tasks are accomplished by individuals, whose performance and developing expertise is usually tracked by human resources-led performance appraisal processes. Due to the dominance of group-working practices in modern operations, a third, intermediary performance level is warranted: that of the work group as a basic functional, autonomous entity within the broader organisation.

There have been many attempts made to arrive at a satisfactory definition of what constitutes a 'work group' within an organisation (e.g. West, 1996b; Brown, 1988; Guzzo and Dickson, 1996; Guzzo et al, 1995) from which several specific themes emerge as important. A 'work group' may be broadly defined as any identifiable group within the organisation in which members share a common work objective and interact to achieve that objective. Work groups may be formal in that they have an assigned identity, function and specified roles, or 'ad hoc' groupings that self-organise through necessity to achieve specific objectives. The presence of role structures is a defining characteristic of work groups, such structures being either formally pre-assigned or rapidly emerging through group developmental processes (e.g. Belbin, 1981). Work groups exist at all levels, from executive management to operations-end processes, and may be permanent or temporary. Work groups within the organisation need not be formally defined, but may also include informal social groups without direct responsibilities, such as peer groups. Tannenbaum et al (1996) employs a broad definition of what constitutes a 'work group':

...a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively and who share at least some common goals or purpose (Tannenbaum, Salas and Cannon-Bowers 1996, p504).
The presumed benefits of team-based working practices in an organisational setting are therefore closely linked to human interactive processes that allow cross-functional integration, from a work process perspective (Hammer, 1988), and utilisation of collective knowledge, from a knowledge management perspective (Ruggles & Holtshouse, 1999). Work group-based functioning is presumed to benefit from the pooling of skill sets and experience brought to bear on a task and higher objectivity in decision-making through the ability to incorporate a range of perspectives in the process. The introduction of group-working practices is largely a response to complexity in modern organisations, and provides a platform for convergence and processing of information across functional areas, integrating what may be diverse working processes, sub-cultures and operational perspectives to achieve unified goals.
4.3 Theoretical population of conceptual modelling framework

In order to outline the content of the conceptual human and organisational performance models constructed during the course of the soft metrics research project, this section gives an account of a theoretical exercise undertaken to demonstrate the application of the work group level conceptual modelling framework. Through an evolving series of diagrams representing specific 'soft' performance influences and processes the work group performance model framework is decomposed and the rationale for populating it with specific performance factors and influences identified from existing empirical research literature is described. As such, this exercise offers important evidence for the theoretical validity of the modelling approach, framework and implied method at an early stage of development, in order to gain insight into any anticipated issues or limitations based upon what may be considered to be a 'theoretical' case scenario.

It is hoped that the modular and sequential structure of this section offers a means of understanding complex interactive processes in the model of work group functioning. In reality, it is difficult to identify specific linear sequences of influence in what the research literature showed to be highly interdependent 'systems' of interacting variables. An accurate picture of the systemic nature of human and organisational factors can therefore only be gained from viewing the model as a whole. Although the 'contingency factors', 'activities' and 'outcomes' distinctions may imply a linear sequence of causality, it should be noted that the general framework allows bi-directional arrows or reciprocal interactions to be mapped between elements. This is an important conceptual point, as the variables that interact in order to influence work group performance, behave as a complex adaptive system involving feedback or cyclical processes that represent learning and development.

The figures in the sub-sections that follow depict a sequential 'construction' of the model, with each successive figure adding specific variables and influences that are discussed in the text. For the sake of convenience, the factors and interactions that are of current interest within each successive model are highlighted in red. The variables included within these models relate specifically to the groupings of factors identifiable in the work group performance model depicted within figure 4.2.4d. The performance processes discussed are grouped under logical headings that form the titles of sections 4.3.1 to 4.3.10 below. Accordingly, specific performance issues considered may be associated with work group outcomes, contextual factors, decision-making processes, group composition, level of autonomy, motivational processes and learning.
4.3.1 Global preconditions for work group functioning

Figure 4.3.1a below depicts the influence of several important 'contingency factor' or 'precondition' variables that were identified as having a global influence upon all behavioural variables. In accordance with the general effects of these variables, they are depicted in the figure as influencing the entire class of work group behaviour variables, rather than specific factors within the behaviour class.

Research into the structure of human activity in the work place has highlighted many features of goal directed behaviour that influence performance, which are loosely structured into two main categories here: features of the work group’s task or group task characteristics and group goal characteristics referring to the nature of the goals set for activities. Regarding work group tasks, prominent performance-influencing characteristics include how group tasks are decomposed for assignment of sub-tasks to individual members (task decomposition), how inherently complex the task is and the subsequent degree of co-ordination required to perform it (task co-ordination; task complexity) and how rewarding or appealing the task may be to the work group as a whole (task significance; task variety; task afforded autonomy; task completeness).
The inclusion of goal characteristics reflects the fact that much human behaviour in the work place is overtly goal-directed, and as such pervasive features of goals and objectives set for work groups can be analysed for their impact upon performance. The effectiveness of work group behaviour may therefore be influenced by factors such as goal clarity and goal achievability, whereas other features such as the presence of goal conflict may inhibit work group effectiveness.

Other important influences upon all activities in the work group centre on people's ability and willingness to perform well. The collective ability of work groups to successfully carry out their activities is largely a function of the aggregated skills and knowledge available to the group, through pooling of knowledge and experience between the group's members. The willingness of the group to successfully accomplish its activities relies upon motivational input and cultural factors; the shared attitudes and shared values that exert covert influence over behaviour, and the shared norms for the performance of activities which develop over time within the group.

If the work group's task environment dictates performance to a certain degree, then the adequacy of the group's means of coping with that environment, in the form of formalised and socially accepted group-working practices and procedures, is also important. Finally, temporal modification as a factor, must itself be considered. One of the defining characteristics of work group processes is that they take place in time and group tasks change over time, especially where project teams may be required to perform a sequence of related tasks in order to achieve a specific overall objective. At different periodic instances of measurement, the exact value of other variables associated with behaviour and activities required to elicit appropriate outcomes in specific situations will change. The temporal dimension for the outcomes of work group performance is also important, as teams need to be adaptive and capable of delivering valued output in the future through learning and being cognisant of changing situational conditions.

4.3.2 Primary valued outcomes of work group functioning

Figure 4.3.2a below specifies two important groups of outcome variables that may be considered to be results of group functioning: group productive output and innovation or new knowledge. Achieving valuable results for the organisation invariably involves the accomplishment of the goals set for work group activity. The resulting output is often tangible and quantifiable in terms of conventional measurement variables such as quality, quantity, cost, time and error. Less obvious outcomes refer to the temporal aspect of performance: the
ability of an organisation to continually renew itself and its competitive position, through continuing to create valuable output into the future. Essential to this process is new knowledge as outcomes of human endeavour within the organisation, included here on the work group level because it is normally project-focused multi-disciplinary work groups that are tasked with the responsibility of renewing organisational structures, processes and capabilities to create value in the future.

4.3.3 Work group decision-making processes

Figure 4.3.3a below summarises important performance variables for decision-making processes in work group functioning. Effective decision-making in work groups can be generally said to involve several collective and sequential sub-processes. Problem definition involves the collation and construction of information describing the nature and requirements placed upon the group task. Solution generation normally begins with a preliminary ‘brainstorming’ phase that will benefit from the diversity of skills, experience and knowledge inherent in an effective work group. Solution analysis and prioritisation is an essential part of decision-making that actually results in the group agreeing upon a direction in which to proceed, before solution implementation processes can be performed.
As social interactions, collaborative processes are subject to inevitable social psychological processes that may result in bias or deficiency in work group objectivity. Various social interactive processes are implicated in considering the quality of work group decision-making, most derived from the study of interpersonal or group dynamics. Interaction, orientation, conflict and norm emergence are all important aspects of collaboration in the work place setting. Norm emergence occurs naturally as groups develop and individuals work together, and is an essential process for the effective dissemination of understanding about how the group functions, what appropriate behaviours are and how the group responds to specific tasks and situations. Developed norms for group-working practices and procedures decrease the amount of time the work group needs to spend organising itself and allocating sub-tasks within itself, allowing productive effort to be concentrated upon ‘actual’ work, as opposed to ‘organising’ work. Conflict, or rather conflict management, is another process emerging from collaboration and interaction between individuals. When managed constructively, the presence of conflict in a group can exert a positive influence upon the quality of group decision-making, by encouraging members to reconsider assumptions and justify their approaches to a problem.

Group task characteristics and group-working procedures are implicated in figure 4.3.3a by considering the effects of group-interactive processes upon performance. Various 'process
losses' are known to occur in terms of individual group member productivity, due to increased communication demands placed upon individuals by the group situation. Appropriate procedures and group-working practices can minimise the negative effects of collaborative working upon performance. Features inherent in the task environment, such as the level of inherent performance feedback or availability of information, can influence the objectivity of group interactive processes. In groups where cohesion is valued highly, as well as successful task accomplishment, poor informational input from outside the group makes it easier for group members to mask or down-play contradictory information to current opinion in the group, either unconsciously or deliberately.

In flatter-structured organisations, work groups are expected to integrate with their broader organisational environment in order to define more accurately their task problems and generate an optimal range of potential solutions. These aims are largely achieved through several processes. Environmental scanning involves appraising the broader organisational and external environment for the potential means to achieve the work group task, such as the identification of potentially useful technology or relevant academic research or institutions that may be drawn upon as a source of specific knowledge and expertise. Information probing and stakeholder identification involves identifying specific individuals with an interest or 'stake' in the subject of the work group's current activities and through so doing, gather together the relevant information to aid the group in defining its task, methods and potential solutions. These categories may also include requirements analysis aimed at the 'customer' for the work group's output. In work groups convened to develop internal organisational structures or processes, the end-customer or 'user' for the output of innovative efforts may not always be apparent from the outset, placing emphasis upon the stakeholder identification process to elicit as much relevant information as possible, for subsequent decision-making.

4.3.4 Work group composition

Figure 4.3.4a illustrates the important influence of variables associated with group composition. In modern organisations the need to integrate and co-ordinate efforts across functional boundaries, through the use of multi-disciplinary work groups, exploits diversity in group composition to functional advantage. Functional integration and co-ordination is therefore an important process or aspect of work group activity for effective functioning. Often group goal accomplishment requires the successful co-ordination of diverse, and occasionally less than compatible, functional or disciplinary sub-sections within the organisation. This is particularly the case with regards to capability and new process development, in which an integrated process requires understanding perspectives from several different areas of the organisational system, simultaneously.
There are three general dimensions upon which group composition can vary: **group size**, **group composition structure** and **group member characteristics**. The **group composition structure** variable refers to the level of heterogeneity and homogeneity amongst individuals comprising the group. For cross-functional collaboration a degree of heterogeneity in skills, knowledge and experience is required in order to benefit work group performance. Conceivably, other task requirements exist in which a more homogeneous group composition structure will be favoured. The **group size** variable is presumed to influence organisational requirements for coordinating, convening and communicating in groups, which are exacerbated by larger groups of people.

Variance in **group member characteristics** is an important group composition variable. Various work related individual variables may be utilised to indicate diversity in skill, knowledge and experience resources available to the group, including department membership, training, past work-experience and association with other projects, amongst others. In terms of personal variables, groups composed of individuals that are diverse in attributes such as language and cultural background, may experience performance problems due to poor communication processes and lack of intragroup cohesion. With computer supported collaborative working systems enabling personnel to collaborate across
geographical and even national boundaries, it becomes important to understand how diverse perspectives upon working practices and attitudes to performance may influence the overall effectiveness of these work groups.

4.3.5 Work group autonomy

Figure 4.3.5a depicts performance factors relevant to an important activity, from a systems point of view. Self-organisation activities represent 'systemic' feedback processes and hence a major objection to the linearity inherent in so-called input-process-output models of factors influencing work group performance. Complex, flatter-structured organisations employing multi-disciplinary autonomous work groups to perform projects have resulted in teams that possess a degree of control over their task and situational environments. In this sense, work group activities are capable of exerting reciprocal influences upon their determinants or contingency factors.

![Figure 4.3.5a: Work group level performance model - group autonomy](image)

Self-organising activities such as goal setting, target setting, temporal planning and task co-ordination are able to influence important contingency factors influencing the effectiveness of work group functioning, such as those relating to the characteristics of work group tasks (such
as task complexity and task organisation) and work group goal characteristics (such as goal clarity and goal achievability). Generated future targets can themselves be considered an important outcome of work group activities relating to the temporal planning and organisation of future behaviour to meet scheduled deadlines and specific objectives.

Perhaps the most important feedback interaction influencing work group performance is that in which the outcomes of work group functioning act as input for work group activities which are carried out to appraise the value of current performance. Performance evaluation behaviour is essential for work groups to refine their performance strategies and develop capability for the future. Variables such as the timeliness, quality, quantity and relevance of performance feedback available to work groups will therefore play an important role in influencing their future or subsequent performance. The autonomy level of the work group, partly afforded by the nature of the work group task, acts as an important mediating variable between the work group and its broader environment. The more autonomy a group has over its own functioning, the less the outcomes of work group activities can be attributable to the operation of external situational factors, as opposed to being the result of actual behaviour and efforts on the part of the team.

### 4.3.6 Development of work group capability and knowledge

Figure 4.3.6a addresses key learning and knowledge generation processes, essential for maintaining the organisation's future viability. Knowledge is one of the most important outcomes of organisational functioning, and a prime example of human or intellectual performance variables that are largely 'intangible' in nature. Knowledge is valuable to the organisation because it is a reusable resource for future innovation and adaptive capability, made all the more important by the high demand for flexibility in organisational structures and the unpredictability of future operating environments that influence contemporary organisations. Although the quality of technical knowledge and procedural knowledge present in a work group is an important determinant of the ability of the group to accomplish its goals, the generation of knowledge itself as an outcome, is one of the key purposes of implementing group-working practices in organisations.

Several work group activities are associated with the generation of knowledge as a performance criterion. Work groups provide a structured platform for individuals within an organisation to socially interact (represented by the factor: social interactive processes) and share information and experience. In this sense group learning can be said to occur and best practices emerge. Through the group development that occurs naturally as a result of continued day-to-day interaction over time, specific skills and expertise brought to the group
by individual members gradually becomes disseminated and 'owned' by the entire group. This process allows groups to display a collective or collaborative 'memory', and group-working practices is therefore one of the primary methods an organisation can employ to retain its 'intellectual capital', which will benefit future organisational performance even though the people in which the knowledge resides are mobile within the organisation, and may even leave the organisation altogether.

![Figure 4.3.6a: Work group level performance model - group capability development](image)

Knowledge as an outcome of work group activity is a key resource, which feeds back into the contingency factors influencing future work group performance over time. The most obvious interaction here is the one with group-working practices and procedures, in which methodological lessons learnt during day-to-day work group functioning are used to inform the way future activities and tasks are carried out. In this sense the organisational learning that originates at the work group level is cumulative over time.
4.3.7 Motivational processes

Figure 4.3.7a depicts the influence of motivational processes and associated factors on work group performance. The factors that influence the motivation of work groups to perform optimally are difficult to identify, but features of the task structure are known to influence well-being of group members and therefore must influence the motivation of groups. Factors important to psychological well-being include task variety, task significance and task afforded autonomy.

![Motivational Processes Diagram](image)

Cultural influences in the form of shared attitudes and shared values will dictate the general ‘climate’ within the group, influencing group member’s willingness to work and collaborate. Motivational processes largely operate through influencing the quality and quantity of communication behaviour within work groups, resulting in notable differences in performance between groups that communicate sufficiently to ‘get the job done’ and more cohesive, interactive groups in which knowledge and experience is readily disseminated amongst group members.
Group cohesion may be said to exert an important motivational influence, and the preoccupation of modern organisations with attempting to foster cohesive groups through 'team-building' initiatives is testimony to this. Research indicates, however, that the outcomes of performance have a feed-back effect upon group cohesion in that successful, task-accomplished work groups become more cohesive as a result of their effective functioning, in addition to the reverse: that cohesive groups high in interpersonal liking between group members achieve higher levels of performance. It is likely that group cohesion does influence outcomes of organisational functioning through removing barriers to effective communication processes. There are also examples in which high group cohesion results in poor performance, through causing group members to value cohesion and agreement within the group above objective decision-making, as is the case in the 'Groupthink' phenomena.

4.3.8 Individual level group member factors

Figure 4.3.8a below incorporates interactions between the work group level and performance factors that may be described as residing within the individual level of analysis within the overall organisational system. As these factors are not part of the work group level they are colour coded in blue. Factors associated with the individual in the organisation aggregate to influence performance upon the work group level and the work group provides a situational influence upon performance processes at the individual level of analysis.

Group motivation is a function of the motivation levels of individuals that comprise the work group members (hence individual motivation impacts upon group motivation). The work group's task environment also provides a contextual input to the task characteristics of the individual's sub-tasks. In this sense, the nature of work group organising behaviour that involves the decomposition of group tasks and allocation to specific individual members within the group ultimately influences how the features of those tasks affect the performance of the individual.

In considering group member characteristics as variables resulting in diversity in group composition, it becomes important to identify what exactly the person-related attributes that distinguish one person from another, at the individual level, are. Personal characteristics therefore include age, educational level, personality and ethnicity, to name a few variables that have been found to affect work group processes such as communication and decision-making. The work-related characteristics of individuals (status, geographical location, training, professional background and functional discipline) are important variables that influence the diversity of organisational perspectives brought to bear upon group tasks and decision-making processes.
Consideration of the outcomes of work group functioning is incomplete without accounting for personal experience and outcomes that group members achieve on the individual level, through involvement in group activities. Such personal outcomes include: well-being, job-satisfaction, motivation and personal growth and development, all thought to exert a reciprocal influence upon the individual’s ability and willingness to perform effectively in the future. Knowledge generated at the work group level can be thought of as ‘stored’ in, or belonging to, people and as such must be considered as an outcome on the individual level. In this sense, the individual gains new task knowledge and new task skills and abilities through involvement in the group working process.

4.3.9 Organisational level contextual factors

Figure 4.3.9 depicts interactions between performance factors at the work group level and those on the higher organisational level (identified in green). From a systems point of view, it is essential to consider the contextual influence of the broader environment beyond the control of the work group. Organisational level factors therefore interact with work group functioning by influencing specific contingencies, behaviour and outcomes at the work group level.
**Figure 4.3.9a: Work group level performance model – organisational level factors**

*Group motivation* is influenced from the organisational level by *incentive provision* or reward allocation processes. The broader *organisational cultural context* provides a motivational context for all human endeavours within the organisation, and therefore plays a part in influencing the pervasive climate within any one particular work group. Specific cultural attitudes and values, such as the *individualism-collectivism* and *task-social orientation* of an organisation as a whole holds specific implications for the likelihood of successful group-working practice.

*Strategic planning* and *high-level coordination* activities such as *temporal planning*, *deadline imposition* and *task scheduling*, represent the strategic input of efforts at the broader organisation-wide level to coordinate and organise activities through mandatory operating procedures to ensure that it maintains its ability to perform effectively and competitively into the future. Such higher-level planning dictates the task and goal contexts in which work groups function, to a certain extent, and any autonomy the work group exerts over its own functioning is therefore strategically afforded by higher-level allocation of responsibility.

An important outcome for the organisation as a whole is the stockpiling of *codified knowledge* through an *organisational learning* process. In this sense, knowledge that is generated as outcomes from group functioning at the work group level aggregates across groups to form a
knowledge repository of documented process knowledge. Due to the non-permanence of the human elements of an organisational system and the organisation's inability to 'own' knowledge that exists wholly within people, the organisation must develop knowledge management processes and systems capable of capturing knowledge, codifying it into a tangible form that can be stored and distributed, and disseminating it when needed. The efficacy of information systems is therefore implicated by this important aspect of long-term organisational performance. Organisations can also facilitate group development through training and development processes, an activity which also builds knowledge and expertise in work groups.

The effectiveness and efficacy of information and communications technology at the organisation-wide level is an important variable influencing performance, specifically through facilitating communication within work groups whose members may be separated by geographical distance, or large groups that find it difficult to convene. In terms of financial performance, computer-supported co-operative working systems have already been demonstrated to generate savings in travel expenses and wasted travel time, when implemented under the right conditions.

Finally, the resource allocation processes employed by the organisation may be considered to have several effects upon performance at the work group level. The allocation and configuration of human resources into various work groups and organisational sub-units impacts upon the dissemination of knowledge and skills within those groups, by dictating the diversity of group members brought together to interact. In this sense resource allocation can have a direct impact upon group learning processes within work groups. Another important influence of resource allocation is its direct impact upon the quality of innovations produced by a work group. As innovation is a speculative, creative and often spontaneous activity, which is not necessarily bounded by clear requirements as are other outcomes of work group functioning, the degree of freedom the organisation affords work groups in terms of allocating enough finances to allow experimentation, providing the informational resources and training to support R&D activities and allowing adequate temporal resources in terms of the allocation of time for trial and error is important.

4.3.10 Key conclusions

Having applied the conceptual modelling framework to work group functioning in order to map influences between human and organisational performance factors based upon review of empirical research literature, several key conclusions may be drawn. A conceptual modelling framework was developed in order to impose structure upon what are largely highly complex
interactive processes or causal chains linking specific human and organisational performance variables. This approach classifies variables according to type: either 'contingency factors' representing contextual factors that impact upon work group functioning, 'activities' representing behavioural processes or 'outcomes' of functioning. This typology may be successfully applied to classify research-based performance factors and in so doing represent the human aspects of functioning in the work environment.

The result of deconstructing complex interactive processes in the preceding sections of this thesis is a comprehensive theoretical or research model of human and organisational factors affecting work group functioning, an overview of which is depicted in figure 4.3.10a below.

<table>
<thead>
<tr>
<th>Contingency factors</th>
<th>Individual motivation</th>
<th>Work-related characteristics</th>
<th>Incentive provision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task characteristics</td>
<td></td>
<td>Work-related characteristics</td>
<td></td>
</tr>
<tr>
<td>Group composition</td>
<td></td>
<td>Work-related characteristics</td>
<td></td>
</tr>
<tr>
<td>Aggregated skills and knowledge available</td>
<td>Strategic planning</td>
<td>Work-related characteristics</td>
<td></td>
</tr>
<tr>
<td>Group goal characteristics</td>
<td>Temporal modification</td>
<td>Work-related characteristics</td>
<td></td>
</tr>
<tr>
<td>Training and development</td>
<td>Personal characteristics</td>
<td>Work-related characteristics</td>
<td></td>
</tr>
<tr>
<td>Personal characteristics</td>
<td></td>
<td>Work-related characteristics</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behaviour and activities</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation</td>
<td>Decision-making</td>
</tr>
<tr>
<td>Social interactive processes</td>
<td>Group learning</td>
</tr>
<tr>
<td>Communication</td>
<td>Self-organization</td>
</tr>
<tr>
<td>Performance evaluation</td>
<td>Functional integration and co-ordination</td>
</tr>
<tr>
<td>Group climate</td>
<td>Group cohesion</td>
</tr>
<tr>
<td>Organisational cultural context</td>
<td>High-level co-ordination</td>
</tr>
<tr>
<td>Autonomous level</td>
<td>Group-working practices and procedures</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Innovations</td>
</tr>
</tbody>
</table>

**Figure 4.3.10a: Complete work group level performance model**

Based upon this framework and factors, subsequent soft metrics research efforts were able to implement the concepts and performance variables identified in an applied model and framework for analysis of soft issues in operational industry projects. Development work undertaken to specify an applied human and organisational performance (HOP) model for project management work groups, with linked metrics, forms the subject of the next section of this thesis (section 5).
Section 5
APPLIED HUMAN AND ORGANISATIONAL PERFORMANCE MODEL AND METRICS

Drawing upon findings from development of a conceptual performance model for work group
effectiveness and practical experience of soft performance issues in an industry project
management team, this section of the thesis outlines the development of the applied soft
metrics tools that formed the main output from the soft metrics research project. The tools
outlined within this section were later implemented in a series of project case studies to
evaluate their effectiveness (the results of which are reported in section 7 of this thesis). The
tools comprise several integrated components including:

1) A Human and Organisational Performance (HOP) modelling framework.
2) A detailed list of potential soft performance factors broken down into sub-
factors that can be used to populate the model.
3) An inventory of ‘soft metrics’ and measurement methods linked to key
performance factors.
4) A detailed application process with defined activities for implementing the
model, factors and metrics in operational projects and validating the utility
of these tools (from the research and development perspective).

The sub-sections below give consideration to how the HOP modelling framework,
performance factors and inventory of soft metrics were developed for application within an
applied project management environment and were integrated within a process for analysis
and measurement of soft issues in projects. An overview of the resulting process itself may
be found in section 6 of this thesis, which forms a methodological overview to the analysis of
results from the validation case studies reported within section 7 of the thesis.
5.1 Development of applied HOP model for projects

An important finding from undertaking iterative development of the conceptual models, outlined in section 4.2 of this thesis, was the high complexity in interactions between 'soft' factors identified from research and their high interdependency in influence upon specific outcome factors. The broad scope of identifiable research-based human and organisational performance factors indicates the potentially broad range of soft issues that may be encountered in human work systems. The aim in development of an applied model was therefore to reduce this complexity to an intuitively plausible level that would enable the model to serve as a useful and practical explanatory tool for causal processes in applied project environments, without losing the descriptive capability of the model to represent what might prove to be highly idiosyncratic and context-specific performance processes in a particular application. An applied HOP modelling framework was therefore developed and deliberately specified at the level of a generic modelling framework, based upon a classificatory scheme for soft performance factors developed through conceptual modelling efforts. This framework could then be populated with specific performance factors and influences representing an 'instantiation' of the model to describe performance processes within a specific context, resulting in benefits in terms of applicability and level of analysis achieved over more prescriptive models with limited, predefined factors and influences.

Several development issues became apparent through attempts made to implement knowledge gained from the conceptual modelling exercises in an applied framework that was capable of being put into use in a project management context with conceivable benefits for existing performance analysis and control processes. The issues encountered in translating what had hitherto been largely conceptual research efforts into a practical tool included ensuring that:

- The model addressed the appropriate functional level within the organisation: that of the project work group or management team.
- The model was structured towards describing the impact of soft factors upon contractually-related operational effectiveness criteria, representing 'bottom-line' performance outcomes associated with cost, quality and time dimensions.
- Human functioning and behavioural factors within the model adequately represented project management activities in the industrial context of application.
- Human and organisational variables defined within the model were appropriate for the systems engineering project environment of interest.
The sections that follow describe the key features of the developed HOP modelling framework for application in analysis of soft performance issues in operational industrial projects and the results of early analysis of performance processes using the framework within the industry context represented by CAP1.

5.1.1 Key features of the model

Experience with the industry context of application shows that as operational performance within BAE SYSTEMS is largely a result of project-level functioning, it is appropriate to address performance factors at the level of, or which impact upon, the project management work group as the primary organisational unit responsible for operational performance outcomes. In this sense the HOP model needed to describe what were principally project work group or management team functional performance processes, with individual level and organisational level variables considered to the extent that they impacted upon work group functioning. Figure 5.1.1a below depicts the applied human and organisational performance model for the analysis of project work group performance and interpretation of resulting metrical data. Two earlier versions of the applied model are depicted in appendix F, illustrating refinement in factors and structure through intermediary stages of development.
The gap that exists within the current project management toolset is for methods that enable the visualisation of relevant soft performance factors and identification of appropriate metrics indicators for upstream process factors that impact upon operational performance during the execution of the project work plan. Accordingly, on a high level the model depicts a simple linear sequence of influence beginning with 'preconditions' in the project and working environment, which eventually impact upon operational project performance criteria relating to the interdependent quality, cost and time dimensions. In this sense, mapping specific causal chains in the model in the manner undertaken in conceptual research-based models illustrates how 'hard' project management data relating to currently monitored project outcome variables can be practically understood in terms of the operation of 'softer', less visible human and organisational processes within the human work system.

The structure employed within the model is designed to allow the direction of causal influence between specific performance factors to be represented according to any applied instance of the model to represent a specific industrial project context. The broad modelling framework groups variables into three separate classes: preconditions, behaviour and outcomes, in which 'preconditions' are directly related to what have been previously referred to as 'contingency factors' in conceptual modelling efforts. The impetus behind this approach is the need to not only measure key project parameters, but to trace their causal determinants back to the contextual conditions which influence 'soft' human functioning, through mapping the relationship of performance precondition factors (the 'enablers') to specific human work activities that represent human performance (or 'behaviour'). Outcome measures representing factors identified as dependent in these causal chains may then be analysed as indicators of the effectiveness of human functioning within the project and provide a retrospective input to performance control processes. Conversely, linked preconditions within causal chains provide important proactive indicators that may be monitored and controlled, either during project planning or during execution of the project work plan, to support enhancement in human work performance. The key functional characteristics of the applied HOP model's framework are summarised in figure 5.1.1b below.

Precondition factors within the model represent a broad class of contextual variables for human performance that encompass sociotechnical characteristics of the entire human and organisational system. Within this class, project preconditions including the type of project, characteristics of the project work group and features associated with the structure or organisation of project work are considered. The broader situational factors represented by the organisational context in which the project operates is also represented within the preconditions class, including variables associated with cultural factors, core competencies, IT support, authority and resource provision.
Within the preconditions class, factors at all levels of the organisational system are represented, including individual level factors referring to the characteristics of team members that comprise the project work group and broader organisational contextual influences. The preconditions therefore represent a holistic 'systems-level' perspective and measurement of the level of variables included within this class provides a static 'snapshot' view of the state of the system in which the project work group operates at any one point in time. The two primary classes of precondition factors within the HOP model are distinguished in terms of the practical issue of control. Project preconditions are amenable to control during pre-implementation planning phases and during performance reviews at intermediary stages of the project. Pervasive organisational preconditions are external to the project and not under the direct control of the project management team, yet must still be considered as potential performance factors that may interact with human functioning.

The 'behaviour' class of performance factors within the HOP modelling framework represents actual human work activities and is critical to the framework's capability to address the 'soft' aspects of the functioning of work systems. Several generic human activities are included here based upon processes identified within the conceptual models, including human task performance and coordination, along with general human communications and decision-making processes. In specification of an applied model, however, it became apparent from experience within the industry context that more specific project management activities could be represented here in order to link outcomes and preconditions to definable management
processes undertaken in the project work group's operating environment. Consequently risk management, performance control, process improvement and change integration activities, amongst others, are included within this class of the HOP model.

Whereas precondition and outcome factors are static in the sense that their level may be measured at any one point in time to provide an assessment of the state of inputs and outputs associated with the work system, human performance activities are more dynamic and represent behaviour or functioning of the human elements of the work system. These activities therefore represent processes that occur in time and from a performance control perspective the effectiveness of work activities undertaken is determinable through proactive monitoring of precondition indicators that represent facilitatory/inhibitory influences in the working environment, or through retrospective measurement of the outcomes of work activities.

As a representation of the 'soft system' that underpins human and organisational behaviour in the project, the applied HOP model also includes intermediary human outcomes of project activity. These outcomes represent the acquisition of human capital for the organisation and include knowledge, motivational and cultural development, which feeds back into future human and organisational activities and represents the process of learning or development. From a human perspective, these outcomes are also the mechanisms through which formal performance criteria for the project are achieved and represent the challenge for contemporary performance monitoring and control systems that must address the intangible as well as material value of work processes.

The performance factors specified within the HOP model framework form the basis for a set of soft metrics developed over the course of the research project and which were refined through in depth review of the human factors and project operations literature, as well as through case-based investigation of soft issues within the CAP1 study and the associated industry context of application. The factors specified within the HOP model itself represent aggregated classes of potentially important soft performance factors. As such they represent groups of important sub-factors that are specified at a lower level of abstraction and which are omitted from the HOP model overview in figure 5.1.1a for the sake of simplification. Variables within the model may therefore be decomposed into sub-criteria representing a finer-grained analysis of human system characteristics and behaviour for the practical purpose of identification of specific traits and soft issues within operational projects. The detailed performance factors list that relates directly to the individual broad factors specified within the HOP model is depicted within figure 5.1.1c below.
### Project Preconditions (P)

**P1 Project profile**
- P1.1 Size
- P1.2 Type
- P1.3 Complexity
- P1.4 Scope

**P2 Project work group characteristics**
- P2.1 Group size
- P2.2 Collaborative history
- P2.3 Groupworking climate
- P2.4 Group morale
- P2.5 Groupworking processes
  - P2.6.1 Knowledge/skills/experience
  - P2.6.2 Location
  - P2.6.3 Functional origin

**P3 Project work organisation characteristics**
- P3.1 Role/responsibilities clarity
- P3.2 Workgroup autonomy
- P3.3 Task characteristics
  - P3.3.1 Task interdependency
  - P3.3.2 Task concurrency
  - P3.3.3 Task feasibility
  - P3.3.4 Task completeness
  - P3.3.5 Task size
  - P3.3.6 Task significance
  - P3.3.7 Task complexity
  - P3.3.8 Task variety
  - P3.3.9 Inherent feedback
  - P3.3.10 Inherent autonomy

**P4 Organisational context**
- P4.1 Organisational culture
  - P4.1.1 Trust
  - P4.1.2 Collaborative culture
  - P4.1.3 Performance expectations
  - P4.1.4 Accountability
  - P4.1.5 Support for change
  - P4.1.6 Attitude towards innovation
  - P4.1.7 Communication barriers
  - P4.1.8 Functional barriers
  - P4.1.9 Shared mental models
  - P4.1.10 Social climate/support for networking
  - P4.1.11 Intergroup climate
- P4.2 Stakeholder characteristics
  - P4.2.1 Availability
  - P4.2.2 Issue involvement
  - P4.2.3 Position/authority
  - P4.2.4 Criticality
- P4.3 Core engineering/process knowledge
  - P4.3.1 Formal policies/operating procedures
  - P4.3.2 Established working methods/best practices
- P4.4 Staff development and training
- P4.5 Reward and recognition/performance appraisal
- P4.6 Information technology adequacy
  - P4.6.1 Support for collaborative work
  - P4.6.2 Accessibility of information
  - P4.6.3 Dissemination of knowledge
- P4.7 Resource provision
  - P4.7.1 Budgetary
  - P4.7.2 Temporal
  - P4.7.3 Human
  - P4.7.4 Technological
  - P4.7.5 Informational

### Human performance activities (A)

#### A1 Generic human work activities
- A1.1 Task performance
- A1.2.1 Productivity
- A1.2.2 Human error
- A1.2.3 Innovation
- A1.2 Communication
- A1.2.1 Stakeholder
- A1.2.2 Senior management
- A1.2.3 Intergroup/interproject
- A1.2.4 Internal project
- A1.2.5 Knowledge dissemination
- A1.2.6 Networking
- A1.2.7 Reporting (written)
- A1.2.8 Collaborative working
- A1.3 Task coordination
- A1.3.1 Planning and scheduling
- A1.3.2 Integration
- A1.4 Decision processes
  - A1.4.1 Situational appraisal/Problem definition
  - A1.4.2 Analysis/Generation of alternatives
  - A1.4.3 Solution formulation/Conflict resolution
  - A1.4.4 Implementation
  - A1.4.5 Evaluation

#### A2 Project management activities
- A2.1 Risk/contingency
- A2.1.1 Identification
- A2.1.2 Mitigation
- A2.2 Performance control
- A2.2.1 Monitoring/tracking
- A2.2.2 Evaluation and feedback
- A2.2.3 Target setting
- A2.3 Motivation and leadership
- A2.4 Training and group development
- A2.5 Work process improvement
- A2.6 Change integration

### Human and organisational outcomes (H)

#### H1 New knowledge
- H1.1 Work processes/best practices
- H1.2 Technical knowledge/capability
- H1.3 Organisational knowledge/capability
- H1.4 Individual KSA /Human capability
- H1.5 New performance targets

#### H2 Motivation and commitment
- H2.1 Job-satisfaction
- H2.2 Employee well-being
- H2.3 Absenteeism
- H2.4 Turnover
- H2.5 Work group viability/cohesion

#### H3 Organisational culture
- H3.1 Attitudes and beliefs
- H3.2 Evolving norms
- H3.3 Trust

### Project level outcomes (O)

#### O1 Project performance criteria
- O1.1 Schedule performance
- O1.2 Budget performance
- O1.3 Product quality
- O1.4 Work quantity

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Figure 5.1.1c: Expanded list of potential human and organisational performance factors for population of the HOP modelling framework (listed by code)
Each variable within the list in figure 5.1.1c is assigned a reference code that expresses the embedded sub level of analysis and can be used to identify the higher-level classes to which it belongs. The letter codes that precede these reference numbers correspond to the appropriate parent classes of variables within the HOP model: ‘P’ for preconditions, ‘A’ for human performance activities, ‘H’ for human and organisational outcomes and ‘O’ for operational project performance criteria. These codes become an important reference in later sections of the thesis, as they link specific metrics and measurement methods detailed in the inventory of soft metrics (included within appendix H of this thesis) with specific performance factors within the HOP model. The codes are also employed within the analysis of the results of ‘influence mapping’ exercises undertaken in the validation case studies described in section 7.

To summarise, the HOP modelling framework provides a means for applying human factors knowledge to the interpretation of variance in key project outcome parameters; linking project and organisational preconditions to performance results through human behaviour and general project management activities. The applied HOP model was developed as an integrating framework for the analysis of soft issues through population of the modelling framework with factors and interactions according to processes observed within an applied context. Through a process of mapping the relationship between key sociotechnical parameters, the HOP model provides an integrating framework for interpretation of measurement data to support the selection of appropriate ‘upstream’ performance indicators and explanation of variance in observed outcome parameters from a soft systems perspective. From a practical performance measurement systems perspective, identification of the conceptual links between various performance constructs that underlie a ‘theory’ of system functioning allows project control efforts to reason about the relative strengths of proposed performance indicators, the relevance of sub-metrics and whether they may possibly tap extraneous variation in addition to the construct of interest.

5.1.2 Case-based population of modelling framework

In development of the applied HOP model, an early version of the framework was applied in the CAP1 case project to determine its utility and identify potential soft factors in the industrial systems engineering context at an intermediary stage of development. This section reports the results from an exercise undertaken in the context of the CAP1 case study (reported in section 4.1 of this thesis) to populate the emerging HOP modelling framework with factors and interactions based upon the CAP1 project environment. Two instances of the modelling framework will be presented here with example soft factors and causal processes identified from qualitative analysis of CAP1 interview data and materials. Where possible, objective
criteria and project parameters that were identified within the applied industrial context are linked to factors identified within each model, to provide a means of quantification. Potential measures identified within the CAP1 project environment fed into the development of a comprehensive set of soft metrics that is detailed in the following section of this thesis (section 5.2). The commentary describes performance processes observed in the CAP1 scenario in more detail.

The soft performance processes considered below centre around two critical elements of human functioning in the CAP1 scenario: human decision-making and stakeholder management or communications activities, the effectiveness of each being identified as key prerequisites for successful operational performance. Elaborated figures with links to potential metrics and supporting qualitative evidence from the CAP1 case study are included within appendix G of this thesis. Figure 5.1.2a below provides an overview of the key performance processes identified within the CAP1 scenario from interviews with project management personnel and qualitative analysis of relevant project documentation.

![Figure 5.1.2a: Overview of key performance issues encountered in CAP1 project scenario](image)

A number of precondition variables that influence the effectiveness of stakeholder management activities within CAP1 were identified and are depicted within figure 5.1.2b below along with implicated outcome factors. Project complexity and project size are important factors that provide an indication of the level of stakeholder management activity
that is required for successful performance. Various indicators exist for the quantification of product complexity in software systems engineering environments, yet from considering a human behavioural viewpoint, organisational complexity in the project was implicated as a key factor. The actual complexity inherent in the project organisation could be measured based upon, for example, number of individual customers with differing functional requirements or level of required authority that is located externally to the project management work group, within the CAP1 project environment.

<table>
<thead>
<tr>
<th>Preconditions</th>
<th>Behaviour</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project complexity</td>
<td>Stakeholder management activity</td>
<td>Meeting attendance</td>
</tr>
<tr>
<td>Project size</td>
<td></td>
<td>Goal clarity</td>
</tr>
<tr>
<td>Communication adequacy</td>
<td></td>
<td>Project performance: Cost/time</td>
</tr>
<tr>
<td>Adequacy of stakeholder management plan</td>
<td></td>
<td>Trust</td>
</tr>
<tr>
<td>Level of stakeholders involved</td>
<td></td>
<td>Stakeholder knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work group viability</td>
</tr>
</tbody>
</table>

*Figure 5.1.2b: HOP model for stakeholder management effectiveness based upon CAP1*

The level of stakeholder management activity required can be quantified at project onset by considering the number and dispersion of stakeholders per interest (level of stakeholders involved). Individual stakeholder roles can also be considered in order to provide a finer grained level of analysis and to prioritise targeted communications, for example: number of senior management sponsors, number of stakeholders responsibility for authorising project work units, number of stakeholders whose input is required for project-critical decisions and number of stakeholders who may be considered to be non-critical to project progress, yet who need to be kept informed.

Continuous tracking of the state of stakeholder knowledge was identified as a means of monitoring the outcome or effectiveness of stakeholder management and communication activities during development. This factor was found to be an important pre-requisite for the rate at which input from key stakeholders could be sounded for prompt and timely decision-making. The necessity to take individuals through the release rationale before they could become more closely involved with the project was identified as a source of schedule delay,
especially where key stakeholders were busy working on other projects and were generally unavailable. With these aims in mind, the proportion of stakeholders informed as to current project requirements and issues (and also the release rationale in early phases) at any one point in time was identified as a useful source of stakeholder communications effectiveness data. The application of 'product awareness' type indicators that may be found in market research instruments was also identified as potentially useful here to assess the degree of awareness of project issues and release rationale relating to CAP1 throughout the broader organisation. The proportion of authorised to unauthorised work currently undertaken within the project was identified as an indicator of the success of stakeholder management activities and the degree of availability of key senior management sponsors responsible for the authorisation of work.

Figure 5.1.2b above also incorporates two soft outcomes of productive project working: trust and work group viability, in addition to the conventional project outcome parameters that may be tracked by established methods implemented in CAP1, such as the Earned Value Management (EVM) technique. Work group sustainability, as an outcome of shared work experience, was stated as an important determinant of repeatability for change projects. Objective measurement in the CAP1 context was considered problematic, however, and would probably involve reliance upon subjective ratings and perceptions of 'work group cohesion' at project close.

Regarding the measurement of trust, two specific dimensions were highlighted: trust in technology or systems and trust between organisational entities such as between integrated projects or dependent operational programmes that represented the application environment for the CAP1 work product. Within the industrial context studied, trust in technology may be indicated by the number of query notes reported against items or number of risks raised related specifically to a product or sub-component. More indirect indicators must be found for the measurement of trust between organisational entities based upon social theory, which holds that trust develops through repeated experience of successful interaction between actors and is often a function of the anticipated requirement for future contact. Possible measures identified as applicable to CAP1 therefore include: number of previous successful/unsuccesful collaborations, number of future anticipated collaborations (for example: number of scheduled collaborative review meetings), level of information exchange and communication and other subjective ratings, such as the perceived reliability, integrity, communication openness and goal compatibility of a collaborating partner.

Figure 5.1.2c below depicts the influence of a number of critical soft variables for decision-making effectiveness identified within the CAP1 scenario. In considering stakeholder availability a number of parameters associated with attendance at review meetings were
identified as appropriate for monitoring throughout development. These included: proportion of key stakeholders present at review meetings compared to specification within the stakeholder management plan, proportion of empowered to unempowered decision-makers, number of delegates and proportion of project interests represented. The level of empowerment was found to be an important factor for effective decision-making: 'delegates' may be unempowered and can't represent the customer project's position with the high degree of certainty and authority required to make immediate decisions upon CAP1 issues.

It was commented that stakeholder attendance at project reviews in change projects is often dependent upon local project events. Critical project periods or dealing with crisis situations take priority and the need exists to anticipate these in advance. By using more proactive indicators based upon anticipating periods of high project activity and periods of criticality, limitations in stakeholder attendance and involvement may be accommodated. One such indicator was proposed based upon considering a work organisation measure associated with the integrated project schedule: number of critical project activity periods that clash with those of parallel projects.

**Figure 5.1.2c: HOP model for decision-making effectiveness based upon CAP1**
In measuring the effectiveness of decision-making processes within the project environment, two key dimensions were identified as important: decision effectiveness relating to the quality of the decision made and decision timeliness relating to the efficiency with which the decision is made. Both factors are important for project success, impacting upon product qualities and adherence to schedule. It should be noted that certain negative effects of communications problems, such as the lack of availability of suitably empowered stakeholders may only be detectable within the time dimension of decision-making, and not be represented within actual effectiveness of the decision made.

Other contextual constraints that acted to influence decision-making effectiveness are also depicted in figure 5.1.2c. These included: information adequacy (level and quality of information availability upon which to base a decision), level of stakeholder involvement, complexity (degree of certainty or confidence in the viability of a proposed solution), decision autonomy (level of decision-making autonomy possessed by the work group) and decision criticality (the predicted level of criticality of a decision to project success). Specifying exact criteria for these factors is difficult due to their idiosyncratic nature and would need to be established on a case-by-case basis.

In summary, early experience in application of an applied HOP modelling framework within the CAP1 case scenario showed that the modelling approach provided a feasible means of analysing influences that represent human and organisational performance processes in projects. Figure 5.1.2d below provides a summary of the case-based human and organisational performance variables identified within the CAP1 case study. These factors were used to refine a comprehensive list of potential performance factors for systems engineering projects derived from the soft metrics project literature review.

<table>
<thead>
<tr>
<th>Preconditions</th>
<th>Behaviour</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust</td>
<td>Decision-making</td>
<td>Group viability</td>
</tr>
<tr>
<td>Level of authorisation</td>
<td>Communication</td>
<td>Product functionality (quality)</td>
</tr>
<tr>
<td>Level of work group</td>
<td>Coordination</td>
<td>Project cost</td>
</tr>
<tr>
<td>autonomy</td>
<td></td>
<td>Adherence to schedule</td>
</tr>
<tr>
<td>Level of delegation</td>
<td>Stakeholder management</td>
<td>Motivation</td>
</tr>
<tr>
<td>Goal compatibility</td>
<td></td>
<td>Stakeholder project knowledge</td>
</tr>
<tr>
<td>Available time</td>
<td></td>
<td>Stakeholder buy-in</td>
</tr>
<tr>
<td>Available funds</td>
<td></td>
<td>Customer satisfaction</td>
</tr>
<tr>
<td>Stakeholder availability</td>
<td></td>
<td>Decision effectiveness</td>
</tr>
<tr>
<td>Project complexity</td>
<td></td>
<td>Decision timeliness</td>
</tr>
<tr>
<td>Information characteristics</td>
<td></td>
<td>Networked knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Developed working processes</td>
</tr>
</tbody>
</table>

*Figure 5.1.2d: Key human and organisational performance factors identified in CAP1 scenario*
The HOP model offers a viable framework for relating multiple 'soft' project conditions to human performance and dependent operational outcomes. It therefore represents a systemic view of performance processes within human work systems. The proportion of key stakeholders that attend project phase review meetings may not have a large impact upon eventual project outcome, but through mapping influences within the modelling framework it may be implemented as an indicator of broader communication problems that in turn are likely to impact upon the effectiveness of key decisions and the provision of critical project resources by management sponsors; factors which in turn will affect achieved operational outcome criteria for the project.

5.2 Development of applied metrics

In operationalising conceptual performance factors and constructs for applied project management and control, efforts were undertaken to identify and develop a series of practical 'soft metrics' from best practices in this area identified through the literature review and analysis of the need for such measures in the intended industry context. This section outlines general development of soft metrics within the research project. From review of literature relevant to the soft metrics research project, the term "metrics" may be considered synonymous with "measures" and refers to a group of defined items against which data may be collected to quantify some variable or state at any one point in time. As opposed to simple measurement items, a practical project management metric may be considered to incorporate the necessary contextual information and measurement processes that define the scope and application of the measure for a specific purpose.

The term "metrics" is commonly utilised in the project management domain to describe data items that are used to parameterise some aspect of the project for enhanced visibility, understanding and ultimately control, to support improvement in project performance. The measures used therefore translate variance in key project parameters (events, resources and system conditions) into numerical values. A key assumption and part of the definition of a metric is that definable processes make this "snap-shot" measurement repeatable, allowing data to be tracked over time and compared with historical values to yield information regarding trends. The description of a metric's purpose and measurement process also allows it to be applied across instances; for example, comparison between data yielded from separate yet comparable projects, or so-called "benchmarking", in which data is compared with ideal instances that represent high performance or industry standards. Review of existing measures and performance factors (reported in sections 3.5 and 3.3, respectively) highlights the need for a clear conceptual integrating framework that establishes cause and
effect relationships, especially where the performance factors embodied in the measure are ‘upstream’ process factors that are indirectly associated with system outcomes.

In order to track the development of the ‘soft’ measures toolset and associated approaches applicable to the systems engineering problem domain, a working document comprising an inventory of evolving measures and methods was established early on in the soft metrics project. This database comprised the measures collected from review of research and operations literature, tracked their subsequent development and adaptation where appropriate, and provided a useful database for the documentation of new measures that were developed in response to specific requirements identified during the course of the project. The structure of the metrics inventory allowed each individual metric to be documented, including the performance factor in the HOP modelling framework with which it was linked, sub-factors and measurement scales, principal sources and references, and evaluative assessment of fitness for purpose. The metrics inventory itself is reproduced in appendix H of this thesis. Many of the measures identified through the literature review were subsequently adapted for application within a systems engineering project management environment and linked to key performance factors within the HOP model’s list of potential performance factors.

In total, approximately 60 individual metrics were compiled and developed during the course of the project and mapped onto key human and organisational performance factors. Each individual measure possessed varying numbers of sub-items against which specific values could be captured, making the total number of individual data items defined for application in performance monitoring and control of systems engineering projects well in excess of 100. The general development process for specification of appropriate measures of human and organisational performance factors involved linking factors defined within the HOP modelling framework with appropriate (or adapted) existing measures that were considered applicable to the industry environment. Where new measures were required, the performance factor was broken down into sub-factors that in turn were linked to objective indicators based upon tangible parameters within the project operations environment, or were specified as data items against which values could be generated based upon expert judgement. To the extent that the development of measures involved decomposition of higher-level factors into lower-level sub-criteria, the resulting data items may be considered to represent individual ‘facets’ of broader constructs.

In terms of the descriptive, analytical and evaluative criteria with which each identified measure or approach was treated, several individual points were considered. To the extent that this analytical process considered potential measures identified from in-depth review of relevant literature from a human factors perspective, it may be considered to be an expert
evaluation of existing methods and practices for knowledge and content specifically relevant to an emerging 'soft metrics' domain. Regarding the refinement of new measures, the criteria considered here served as key analysis points for consideration in development processes and potential application of the metrics. The major points of analysis for evaluation of potential soft metrics may be summarised as follows:

- **Suitability for systems engineering domain:** Applicability to a project-structured, systems engineering industrial environment that employs work groups or IPTs as the dominant functional and accountable unit within the organisation. Where applicable assumptions made within the measures content and method regarding the presence of specific work activities and structures are considered. As the aim for the soft metrics research was to develop measures for systems engineering project management, several assumptions were made regarding the presence of existing measures, tools and techniques associated with conventional project management, as were identified within the application domain using an industry-based scoping study (reported in section 4.1 of this thesis). For further background information the reader is referred to Burke (2003), Slack (2001) and Blanchard (1990), all of which are standard texts on relevant project and engineering operations management techniques.

- **Links to key performance factors:** Comprising analysis of the key performance factors directly quantified by the measures or to which the metric may be applied in order to support measurement of the variable in question. This point includes implied links to presumed antecedent and dependent factors and details of how authors consider the measure adds value to work functions through its relevance to key performance criteria.

- **Soft focus:** The degree to which the metrics focus upon human and organisational factors in content. The measures were predominantly selected according to their relevance to human and organisational performance issues, but the degree to which each measure is applicable to human work activities as opposed to technical process parameters varies.

- **Validity:** The degree to which the measure may be considered adequate and sufficient in generating numerical values that represent the construct or performance factor that the measure is proposed to quantify. Consideration of this issue involves assessment of the degree to which the overall measure's content is comprehensive enough to tap variance in all known sub-factors associated with the construct (criterion sufficiency), using knowledge and perspective from the human sciences domain. Where the measure taps variance that may be considered superfluous or outlying the target construct (contamination), this will also be considered.

- **Level of objectivity:** Assessment of the level of objectivity inherent within the metric and measurement method, according to its reliance upon objectively indisputable parameters or subjective opinions, perceptions and individual-level expert knowledge. Objectivity is
considered desirable in management metrics, but this does not always ensure validity of
the measure for the target factor, especially in the case of human factors that may be
subjective in nature. Often, insisting upon objective criteria means sacrificing direct
measures for indirect 'indicators' of experiential factors such as motivation or culture, the
presence of which is indirectly indicated by quantifiable behaviours and preconditions, yet
only directly assessed by sounding people's perceptions of the presence or level of these
factors directly.

- **Content and practicality of measurement method:** Where obtainable, the specific data
  items within a measure are described, along with consideration of the adequacy and level
  of detail regarding the measurement and data compilation methods specified in literature
  accompanying the measures, including sub-items and scales where appropriate. Where
  possible, the implications for level of effort involved and resulting feasibility of specific
  measurement methods is considered. In considering the measurement methods inherent
  in each metrics case, potential applications within the target industrial domain are
  outlined.

In accordance with development issues identified through consideration of the above criteria,
the following subsections outline the key measures that were developed during the course of
the project, their links to key human and organisational performance factors, the
corresponding design rationale and need for development based upon industry findings and
consider the envisaged use of each metric, in anticipation of subsequent application in
specific industry case projects to validate the emerging soft metrics toolset. Where
consideration of content and fitness for purpose led to the adaptation of the measure in some
way (e.g. removal, addition or rewording of specific items or changes to the measurement
methods employed), these changes are outlined in the sub-sections that follow, where
appropriate, along with the envisaged application and purpose of the measure. For a
complete summary of all the metrics collected and developed for application within the HOP
modelling framework, the reader is referred to appendix H the soft metrics inventory. The
inventory outlines specific measures including sub-factors and scale items, their principle
sources, and concise analysis of focus, level of objectivity and level of application within
operations management. The inventory metrics are also linked to key performance factors
within the HOP modelling framework and are structured according to the sequence and factor
reference numbers embodied in the performance factors list included in figure 5.1.1c that
may be found in section 5.1.1 of the thesis.

Metrics developed during the course of the soft metrics generally fall into one of several broad
categories: communication measures, measures for project stakeholder analysis, indicators of
trust and collaborative culture, measures of human workload, project task and role analytic
measures, human capability assessment for project work, project work group characteristics
and measures of project complexity and scope. In the sections that follow, specific references are made to the relevant metrics' titles in the inventory included in appendix H, along with the code for the soft performance factor with which the measure may be associated.

5.2.1 Measures of project complexity and scope

For the 'project uncertainty profile' measure (P1.3), the indices from De Meyer's (2002) uncertainty scale, which specified progressive levels of project uncertainty ranging from 'variation' (low) to 'chaos' (high), were developed based upon De Meyer's discussion of the nature of uncertainty and implications for appropriate project management methods. In order to reduce variation in interpretation of the scale's indices, further descriptive text was provided for each item, in order to provide more detailed profiling information. General recommendations for project management and control techniques were also specified according to each level of uncertainty. In the elaborative text which accompanied each scale item, efforts were made to ensure that the content was applicable to a systems engineering R&D project environment, through the provision of examples and reference made to tools which had been identified within the soft metrics research scoping study as being mandatory control techniques within the applied industrial context.

In order to aid managers in consideration of the potential performance influences of complexity and uncertainty levels within a particular project, specific performance factors within the HOP modelling framework were identified as likely to be dependent upon project uncertainty levels. A summary of the critical factors implicated and mechanisms of influence are outlined below:

- **Risk/crisis management**: High uncertainty may result in an inability to plan effective mitigation strategies due to unforeseeable nature of potential problems arising during project execution.
- **Planning and scheduling**: High uncertainty may result in an inability to define necessary project tasks, identify critical tasks and predict accurate task dependencies and durations. This may mean that conventional task planning methods (e.g. project planning, project work breakdown structures and critical path methods) are more appropriate for lower uncertainty projects.
- **Performance control**: High uncertainty may result in instability in the project plan due to the necessity to redefine task definitions, schedules, budgets, roles/responsibilities and deliverables. Consequently it becomes more difficult to set accurate and achievable targets and to appraise performance against those targets where planned goals, methods and structures change.
In addition to the project uncertainty profile, two additional measures were proposed as indicators of the level of organisational complexity inherent within the project work environment: 'level of ongoing concurrent tasks' (P1.3) and 'dependency of integrated project schedules' (P1.3). Both measures were developed in response to critical performance issues associated with organisational complexity identified within the soft metrics industry scoping study and take advantage of existing planning and control techniques identified as mandatory within the applied domain.

The number of tasks scheduled to run concurrently within the project work breakdown structure (WBS) over time is proposed as an ongoing indicator of project organisational complexity that influences required project management effort. This indicator can be used to identify critical periods when project management resources are likely to be strained in their ability to deal with issues arising from a number of separate work packages being executed simultaneously and ensuing problems in coordinating the output from these activities. The basic rationale behind this measure is that high organisational complexity, as indicated by peak task activity within the project plan, results in increased requirements for communications and coordination effort, increased likelihood of unanticipated interactions between tasks (resulting in heightened risk-logging activities) and increased level of uncertainty in planned project parameters (i.e. these periods are likely to be critical to the accuracy of the projected project schedule, costs and resource utilisation plan, as well as achievement of the required functionality). The potential for 'process loss' due to increased communication and coordination requirements as indicated by high level of concurrent tasks may be validated by monitoring the frequency of project management meetings and communications between project personnel. Dependent performance factors within the HOP modelling framework therefore include: communication activities and task coordination activities.

Data gathered against this metric can be represented as an X-t plot depicting number of concurrent tasks over time or by project phase. Peaks in the graph represent periods of high volume of activity as indicated by high frequency of concurrent tasks and indicate predicted periods of high project management activity with associated implications for the level of communication and coordination activity necessary to ensure all task performance criteria are met without deviation from the planned budget or schedule. Data should be modified according to the level of interdependent tasks present at any point in the project task breakdown structure, as indicated by task interdependency indicators such as number of separate output workflows from an individual task within critical path network diagrams (e.g. Burke, 2003). In order to get an aggregate measure of overall project complexity based upon level of concurrent tasks, peak level for each phase in the projects development lifecycle can
be aggregated. This data is then comparable against other projects that follow the same lifecycle sequence.

A key finding from the metrics scoping study was that where two or more separate projects were interdependent, i.e. one feeds output into the other as is the case in tool and capability development projects, high organisational complexity can result from the requirement to logically coordinate tasks between the two project schedules. The level of interdependency between parallel, ongoing project schedules was therefore proposed as a project complexity metric, based upon the presumption that where two interdependent projects experience simultaneous periods of high and critical activity, organisational complexity results posing a risk to the integrity of the project schedule. This complexity may manifest itself in the degree to which personnel are available to collaborate between projects, a decrease in schedule flexibility and may ultimately influence schedule performance for one or both projects. As an example: if a capability development project is required to deliver its product into an operational engineering project, schedules for deployment and testing for the capability project may be subject to when the engineering project can safely accommodate modification to its systems as determined by its own schedule. Accordingly, the number of critical project activity periods that clash with those of related or dependent projects can be recorded at project planning or following alterations to the schedule as an indicator of likely organisational complexity issues.

Experience with the industry case project studied during the scoping exercise identified project scope issues as important performance determinants that affected the level of organisational complexity and intensity of project management activity required within the project. The specific requirement inherent within capability development projects to develop tools and techniques for application within the organisation results in multiple ‘internal’ customers, each requiring discrete deployment, integration and testing phases for what may be individually customised work products. The necessity to engage in separate deployment or ‘roll-out’ activities leads to increased concurrency of work tasks and critical schedule dependencies linked to performance processes within other, external projects and programs. The ‘scope of technical objectives’ (P1.4) within the project requirements specification was therefore identified as valid indicators of these trends, including the number of separate existing systems (and sub-systems) that would be influenced by the project work effort, the number of discreet deployment activities to separate customers or organisational entities and the number of customer entities requiring variant solutions.
5.2.2 Project work group characteristics

'Project work group size' (P2.1) was identified as an important potential performance variable from a human and social factors perspective. Various classes of project-relevant personnel were identified to form a project work group breakdown against which an indication of number of specific types of personnel could be measured. The various classes included: the core project management team, the broader project work group and project stakeholders. Although a simple quantitative measure, several potential performance factors influenced by group size were identified, to assist project managers in analysis of soft issues associated with this parameter.

- **Communication**: The size of project work group influences effort required in communicating effectively between project personnel within the project as well as between the project and its stakeholders. Work group size influences the amount of non-directly productive work that is involved in managing the project (i.e. larger groups require more coordination and effort in contacting members, communicating information, and are more susceptible to unavailability of members for project steering meetings at any one time.

- **Task coordination**: The size of the project workgroup influences the complexity involved and effort required to effectively coordinate task efforts and plan integration of task efforts between different project personnel.

- **Decision processes**: The number of individuals within the project management work group may influence the effectiveness of decision processes as larger groups are subject to various social factors, such as conformity effects (groupthink), and increased demands to satisfy differing perspectives in solutions formed to problems.

- **Group-working climate**: Group size can influence the extent to which project members experience a sense of 'team spirit' or close collaboration. Smaller teams tend to be closer with more interpersonal knowledge and informal communications shared between individuals, due to a smaller social group available for interaction.

Based upon knowledge gained from the soft metrics literature review concerning the importance of informal working practices, interpersonal knowledge and shared mental models and values for work group effectiveness, a 'team collaborative history scale' (P2.2) was developed to quantify the level to which an established group working environment may be present in a project. The team collaborative history scale indicates the extent of past collaborative experience for the personnel that comprise the current project's management team, and comprises four levels representing increasing indices of collaborative history and proven effectiveness in functioning.
An important characteristic of a project management team or work group is the degree to which the working or collaborative climate inherent within the group and its environment supports effective functioning and high performance. In project management teams the 'climate for decision-making' (P2.3) may be regarded as of significant importance, as decisions made by the group may influence the success of the entire project. Accordingly, a group working climate measure was developed in order to quantify the degree to which individuals perceived the group-working climate as supportive and facilitative to effective decision-making processes. Sub items incorporated in the measure refer to the groups technical and social environment, equality in discussion processes, communication of decision issues and style of decision-making. In addition, a measure that addresses the effectiveness of evolving group-working practices was developed, incorporating measures indicating the extent to which effective informal group-working practices have developed within the team and includes items relating to the groups approach to achieving its objectives, interactions, style of risk management and degree to which 'process losses' occurred.

5.2.3 Human capability assessment for project work

The adequacy of human knowledge relevant to the nature of the project work was identified during the literature review and scoping study as a key factor for consideration when defining high performance project work groups. The presence of specific task-relevant knowledge, skills and experience on the level of the individuals that comprise the project team is a key factor in ensuring the adequacy of group-level knowledge for successful execution of the whole project. During the course of the soft metrics research project, a number of measures and techniques, with varying levels of analysis, were developed or adapted from existing methods to quantify human capability in a systems engineering project environment.

Based upon two measurement scales proposed in Nagy's (1999) Critical Task Method, a single measurement scale comprising ten incremental levels was refined as an indicator of 'project task-specific experience' (P2.6.1). The task-specific experience metric is a measure of the adequacy of the individual's current experience for performing a specified or planned task, as indicated by ratings of similarity between current task conditions or characteristics and those of previously completed tasks in the individual's work history. The metric is therefore applied at the level of the individual within the project and may be productively applied during the project work allocation phase of project planning. The individual rates the similarity of current task conditions with those in his or her previous experience. This process is performed for each task. The metric is a subjective, self-reported measure of experience as the data actually represents the individual's recalled experience of encountering similar task characteristics in previous work history. A higher score indicates a higher degree of fit.
between the task characteristics and the individual's experience. The level of fit is taken as an indicator of likely reliability and success in task performance and can be used to identify potential problem issues arising from knowledge gaps during project planning and resource allocation phases, when tasks identified as critical may be supported through allocation of increased time or modified human resources.

In an attempt to specify a more comprehensive and objective method of human capability assessment, a 'person-task fit index' (P2.6.1) was developed as an approach which relied less upon subjective personal judgements through providing project managers with the opportunity to quantify the adequacy of individual's knowledge against weighted, definable criteria representing desired skill areas within the project. Where objective data based upon certification and training experience is not available, more subjective judgements of knowledge adequacy must be relied upon. Asking individuals to consider the adequacy of their knowledge for a specific project work task is a valid activity, however, as data obtained represents the psychological reality of knowledge levels for those charged with executing specific tasks. In this sense, personnel's perceived opinions regarding knowledge adequacy for their project role are likely to influence task performance as are more objective, formal qualifications.

The method involved in assessing person-task fit involves recording ratings of knowledge adequacy against key skill areas for each project task or sub-task. The measure may be applied on any task level within the project work breakdown structure and may even be applied for skills possessed by the project management team for the entire project task. This measure will be useful in the analysis of problem issues associated with human capability for a project and may be used to identify critical tasks from a human systems perspective. In order to explain the developed method further, specific process steps are summarised in figure 5.2.3a below.

| Step 1 | Identify and list general and specific skills or knowledge for optimal execution of the target task. It is recommended that this process be undertaken through group discussion in the project management team during project planning in order to ensure broad inclusion of all possible relevant skills implicated by a specific task. Alternatively, skill and knowledge requirements can be standardised (for the general skills categories) to allow skills/knowledge profiles to be generated for each project task. |
| Step 2 | Rank skills in order of criticality to successful execution of the project task. These rankings will provide weightings for later analysis of skills/knowledge adequacy of individual personnel for performing the target task. The following ten-point 'level of criticality' scale may be used, anchored by:
  1 - skill is minimally involved in successful task execution (task may still succeed if skill/knowledge is absent),
  10 - skill is highly critical to successful task execution (task is likely to fail if skill is absent). |
| Step 3 | Rate candidate individuals against each skill/knowledge criteria identified for the task. This process can be based upon subjective self-report ratings in which individual's rate their own level of a particular skill/knowledge item on the following ten-point scale, or may employ objective training and certification data:
  1 - Individual possesses this skill to a very limited degree,
  10 - Individual is highly proficient in this skill. |
Step 4 Calculate overall skill/knowledge adequacy factor for each individual, by multiplying knowledge rating on a specific skill/knowledge item by the criticality level associated with the item, then summing the resulting scores across all items for a specific task.

Step 5 Compare results across individuals and across project work tasks and: a) re-allocate project work tasks according to knowledge adequacy of specific individuals, or b) use data to identify skills-critical tasks and implement appropriate training, modified human resource support for the task or modified time allowed for the task, as appropriate.

Figure 5.2.3a: Detailed process steps for human capability assessment of person-task fit

An example of the type of output from analysis of task-knowledge adequacy is indicated below in figure 5.2.3b. The table represents the analysis of a single hypothetical task ('Task 4.2') within the project work breakdown structure and incorporates the identified knowledge areas that specifically apply to that task. In the example, generic categories of knowledge areas are used to indicate the areas which could be included — in a real application, these categories would comprise detailed sub-items specific to the task and would therefore provide a more fine-grained level of analysis. The table also depicts the relative criticality rating of each skill for optimal task performance and the individual competency ratings against each knowledge item. In this case competency ratings made by three potential candidates (individuals A, B and C) for ownership of the project task are compared on the same table.

<table>
<thead>
<tr>
<th>Task 4.2</th>
<th>Task knowledge/skills items</th>
<th>Criticality rating</th>
<th>Individual competency rating</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Individual A</td>
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<tr>
<td>Technical skills item</td>
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<tr>
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<td>Planning and organisational skills item</td>
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<tr>
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<td>4</td>
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<td>Task knowledge adequacy score</td>
<td>179</td>
<td>378</td>
<td>292</td>
</tr>
</tbody>
</table>

Figure 5.2.3b: Example output from assessment of task-knowledge adequacy

Examples of two possible applications for the data based upon this example include analysis of task allocation effectiveness during project resource planning and identification of risks associated with knowledge-critical tasks within the project work plan. In the comparison, individual C is found to be most suitable for task 4.2, as the individual possesses the highest task-specific knowledge adequacy score, indicating that the individual is highly competent in
the knowledge areas that are most important for successful execution of the task. Individual A has high competencies in some knowledge areas, but crucially only in those that are likely to have a marginal influence on task performance and not those that are critical to the successful performance of the task. Individual C achieves a moderate score somewhere between the other two hypothetical employees.

Where task mappings onto human resources are fixed, tasks can be compared on the basis of the person-task fit index to provide an indicator of which tasks in a project are likely to be critical due to excessive or unsatisfied knowledge requirements. The Person-task fit index therefore represents the degree to which the individual's knowledge and skills match the requirements of the task and can be calculated as the percentage of competency attainment achieved against maximum possible competency rating. Low results then indicate potential problem tasks that may overrun, experience technical difficulties or achieve low quality output. For the example above, the person-task fit index scores for individuals A, B and C are 37%, 79% and 61% respectively. If individual A owned task 4.2 within the human resource allocation plan and all other person-task fit index scores for other tasks within the plan were high, then this would identify task 4.2 for prioritisation of support and monitoring activities. Accordingly, task 4.2 is therefore likely to be more resource-intensive, require more time, require specific training be undertaken, require more support and result in higher workload/stress for individuals charged with executing the task due to the increased challenge. In this way, the data collected may be used to modify critical path-based estimates during project planning and scheduling. This process should allow the project management team to identify which tasks are most likely to consume project resources and project management effort due to human-related factors such as task feasibility, task complexity and workload issues.

5.2.4 Project task and role-analytic measures

Based upon factors specified within Hackman and Oldham's (1974) Job Diagnostic Survey, several measurement items were adapted to apply to a systems engineering project work environment, through refinement of specific measurement items and scales to apply to project work tasks and work roles. The key performance factors identified for this treatment included:

- **Task completeness (P3.3.4)**: referring to the degree to which the role involves the completion of a whole and identifiable piece of work with clear onset, cessation and success conditions. Sometimes referred to as 'task identity'.
- **Task significance (P3.3.6)**: whether the project role is perceived as having an impact upon others and their lives within the organisation or broader society.
- **Task variety (P3.3.8):** assesses the degree to which the individual has the opportunity to apply a variety of skills and knowledge in the project role and whether that role involves a variety of tasks, i.e. is non-repetitive.

- **Task-Inherent feedback (P3.3.9):** the extent to which the task intrinsically provides information regarding the effectiveness of performance efforts.

- **Task-Inherent autonomy (P3.3.10):** the degree of discretion a project role possesses for exercising control over personal work processes and outcome.

There are two specific applications for task analytic measures relevant to the area of soft metrics for project performance control. The measures can be implemented when project performance anomalies are observed as a means of identifying if motivational or other soft factors associated with task characteristics are causing deficiencies in performance and productivity within the project. The other potential application is as an analysis or requirements specification during project planning phases in which the project workload is distributed, to ensure there are no un-workable role specifications from a human factors perspective.

In terms of possible links to other performance factors, the performance variable ‘task significance’ is conceptually related to task and objective clarity and influences motivation through task-determined characteristics such as the degree of inherent performance feedback (i.e. tasks with clear onset, cessation and success conditions are likely to provide clearer and more timely performance feedback allowing individuals the opportunity for personal learning/development and satisfaction through closure/achievement). Task significance or level of criticality to the project is also a contributing factor to workload/stress: the higher the criticality of a project work task to overall project success, the higher the pressure for successful performance. It is important to note here that in this instance subjective self-report items are essential, as the critical factor is perceived pressure experienced by the individual. The task significance measure also includes items that refer to the visibility of the individual’s contribution to the overall project. The performance feedback variable holds close conceptual links with the degree of uncertainty of outcome in task performance. Uncertainty along with complexity and clarity in task conditions may be considered to be a stressor in workload considerations. Feedback should not only be present but also timely and constructive if the individual is to perform optimally and learn from past experiences.

The measurement items specified quantify individual’s subjective perceptions of project task and other role/work characteristics. There exists a convincing argument that objectively testable data aside, from a human performance perspective it is only the individual’s subjective experience of work characteristics that influences performance and as such measurement of these perceptions is not only valid but also desirable. The project role and
task analytic measures requires instructions to respondents to define the project role under consideration, as the aim is not to measure global job characteristics but to assess the efficacy of job and task design within a specific project role or relevant to the characteristics of a specific project work task. This defines the range of applicability of the measure in order that data collected can be applied to predict performance in the project under consideration. It also allows measurement data to be applied in the evaluation of current project work breakdown structures and associated role designs.

5.2.5 Measurement of human workload

Following discussion of workload issues in operational systems engineering projects with project personnel, a simple equation for measurement of expected workload (P3.4) was specified: work time available divided by expected/ideal time required. Resulting values below 1 indicate workload-critical tasks, the smaller the value the higher the experienced workload. Values above 1 represent acceptable workload levels or even inefficient allocation of human resources for scheduled project work tasks. The indicator may be applied at the level of the individual, or by aggregating man-hours onto the project work group level and calculating required man-hours for the project work task. The critical component of the measure is the identified time required for tasks, which should consider the technical requirements of the task itself in the context of the capability of the people responsible for executing the task. This latter factor will be variable depending upon task-specific knowledge, skills and motivation, which accounts for the human factor in workload-related performance issues. The measure itself may be regarded as a robust, objective indicator of likely workload, providing the required time for tasks can be clearly established. The measure may therefore be usefully applied at project resource planning phases. Although effective project scheduling and resource planning at project onset should control for high workload situations arising, where the project plan changes during periods of unexpected variation in project conditions, the result might be work overload if the schedule is not flexible enough to accommodate. Workload assessment may therefore be effective in change management situations.

In terms of the influences of the workload variable on other performance factors identified through experience with applied systems engineering projects, task feasibility is implicated, as tasks that introduce high workload to an individual or work group may be regarded as less feasible. Cost, quality and time outcomes are influenced through either more resources being allocated to high workload projects to achieve them within specified schedule and quality parameters, or quality of the work task product is compromised to cope with the unworkable schedule constraints that result from high workload. The level of workload experienced by an
individual is also partly dependent upon their level of competency in the skill and knowledge requirements for successful execution of the task. Challenging tasks, relative to the individual, result in higher experienced workload as the individual will, in addition to performing the technical requirements of the task, be expected to acquire new skills and knowledge, or seek support during execution of the task.

### 5.2.6 Indicators of trust and collaborative culture

Various indicators of trust were developed that were based upon conclusions from social theory that indicates increased trust is dependent upon history of previous positive experiences. Trust develops over time as a result of experience, interaction and collaborative functioning between projects, individuals and organisational entities. It is also an important pre-requisite for effective progress in instances where there is a lack of effectiveness or degree of uncertainty in formal work systems, as highlighted by findings from the soft metrics scoping study. Regarding the measurement of trust (P4.1.1), two specific dimensions were considered in development efforts: ‘trust in technology’ or systems and ‘trust between organisational entities’, such as may be present in parallel, integrated projects. The Indicators of trust between organisational entities comprise various subjective and objective criteria, associated with factors such as level of previous successful collaborative experience between partners and perceptions of reliability and integrity. Trust in technology is inferred from objective data gathered from project query logging and risk management processes.

Issues identified within operational systems engineering projects concerning cultural compatibility between project and customer or sponsor organisations, led to the development of several measurement items against which indicators of the presence of an effective collaborative culture could be quantified. Separate sets of measures were developed to address both internal collaborative culture within the project and external collaborative culture within the project’s broader organisational setting. In accordance with Kaplan and Norton’s (1996a) conclusions, the extent to which team-working practices were valued in the project’s broader organisational environment was taken as the dominant predictor of the presence of a ‘collaborative culture’ in the organisation.

### 5.2.7 Communication measures

Despite a lack of practically applicable project management metrics to test communication effectiveness (A1.2), ‘communication problems’ are often blamed for performance deficiencies, without supporting data. In order to develop a measure that incorporated sub-dimensions of communication relevant to a systems engineering project context, several
items from the Penley and Hawkins measure (2000) were adapted and complemented with additional items to measure 'internal project communication'.

The measure offered by Penley and Hawkins taps only aspects of the dimensions proposed to account for the 'communication' performance variable in a project management environment. 'Task communication' measures resemble Prices (1997) 'instrumental' communication dimension, and 'expressive' communication is partly represented by aspects of 'personal' communication. There is doubt as to the importance of career communication as a sub-measure of overall communication and 'communication responsiveness' relates to vertical communication but horizontal communication is not represented as the focus is upon supervisor-subordinate communication. The 'supervisor' role in an engineering project management context would also require further definition. In response to these concerns a measure to quantify effectiveness of peer-to-peer communication in a project work group environment was developed to test peer-peer communication in the capability/engineering project context, as a response to the flatter structured, more autonomous roles that exist in a development environment. A new 'process loss' dimension was added to the measure, to quantify the degree to which project personnel feel that non-productive communication takes place during project operations.

5.2.8 Measures for project stakeholder analysis

Project stakeholders, especially customers, were found to be important to the success of systems engineering projects that employ intensive cross-functional collaboration and seek to satisfy multiple criteria from varying independent perspectives. Stakeholders are therefore required to be involved in the project throughout all stages of its lifecycle and their availability and relevance (P4.2) form key performance factors that may influence project success.

In considering stakeholder availability a number of parameters associated with attendance at review meetings were identified as suitable indicators to be monitored throughout development in order to quantify stakeholder availability. The level of empowerment of available project stakeholders was also found to be an important performance determinant in the operational system engineering project environments studied. This factor had a critical influence upon the effectiveness of decision-making processes: 'delegates' may be unempowered and can't represent the customer project's position with the high degree of certainty and authority required to make immediate decisions. Stakeholder attendance at project reviews in change projects was found to be dependent upon local project events. Critical project periods or dealing with crisis situations in a stakeholder's own project often took priority over responsibilities to other projects and the need therefore exists to anticipate
decision-intensive events and track the availability of stakeholders over the project's course. By using more proactive indicators based upon anticipating periods of high project activity and periods of criticality, limitations in stakeholder attendance and involvement may be accommodated. Schedule performance outcomes are therefore implicated as dependent factors for stakeholder characteristics as project work may be delayed in response to unavailability of suitable personnel to authorise activities, release budgets or contribute key knowledge to development work.

The degree to which stakeholder's interests are synonymous with issues within the project was identified as another key factor in consideration of stakeholder issues related to project performance. This factor represents political processes that may occur where separate projects run in parallel yet are expected to collaborate or integrate to a degree. Stakeholders may have a detrimental effect upon the current project due to circumstances within their own project. An example would be where deployment schedules are compromised due to critical periods or overruns within the customer project. This issue is associated with trust and goal compatibility. The perceived quality of stakeholders in terms of whether or not they satisfy targeted project-relevant knowledge areas is an important factor when assessing the impact of stakeholders on product quality. The percentage coverage of key knowledge areas in the stakeholder group identified within the stakeholder management plan was therefore specified as a valid measure.

Achieving the alignment of stakeholder values and knowledge with the scope, objectives and methods employed within the project was also identified as a key concern, together with the power of specific stakeholders to have a facilitative or inhibitory effect upon the course of project work. More objective criteria for assessing stakeholder characteristics may be based upon the stakeholder management plan and communications network diagrams for the project. The number and type of information flows may be used as an indicator of how stakeholder-intensive the project is, representing communicative complexity.

5.2.9 Measures for support of human decision processes

Experience in a systems engineering project management environment revealed the complexity of issues that were subject to the decision-making process, both in terms of practical project management issues and technical systems development issues. Decisions in a collaborative engineering environment are characterised by human processes representing multiple perspectives and interests that result in multiple success criteria and complex trade-offs between opposing design variables.
In order to support decision-making processes in project efforts involving complex systems a number of criteria were identified for measurement, associated with both the type of decision (A1.4.1) and the human communication processes that form the context for decision-making (A1.4). The measurement criteria and data items developed focused upon factors such as the bounded/unbounded nature of the decision issue, complexity of the problem as a result of systemic issues, criticality to project success, stakeholder involvement requirements, diversity in interests represented by the decision issue and quantity and quality of relevant information available, amongst others.

It is impossible to identify specific decision success criteria in general measures to support decision-making processes without anticipating a specific scenario or events that would limit the scope of applicability of the measure. Examples of criteria for evaluation of specific decision issues, such as the allocation of functions between humans and machines in the design process, are already available (e.g. Grote et al, 1995; 2000). Accordingly, efforts were made to ensure the criteria specified were as non-context specific as possible, and the measures rely upon subjective judgement of complex factors rather than objective parameters. This approach is appropriate as human decision making processes are characterised by human judgement and experiences, with evaluation of success in outcomes determined according to perspectives, which may be more or less divergent depending upon the range of interests and people affected by the decision.

5.3 An integrated soft metrics tool and application process

Having considered the development of an applied HOP model, potential soft performance factors and metrics in the preceding sections of this thesis, this current section addresses how these components were integrated into a cohesive tool for analysis and measurement of soft issues in operational systems engineering projects. This was largely achieved through the specification of a detailed application and validation process for implementing the approach outlined in this thesis within several operational project case studies. The exact details and method of this application process and the results gained from implementation in the case studies are reported in the subsequent sections of this thesis (sections 6 and 7, respectively). The current section is therefore confined to consideration of how the various aspects of the emerging tool are integrated and how the HOP modelling framework may be logically populated by project management teams to represent soft performance processes within a specific applied context. This latter concern is important as it forms the basis of the whole approach and allows appropriate soft metrics to be selected and applied to quantify key parameters within the causal chains identified within the model.
Figure 5.3a below depicts the breakdown of the emerging applied metrics tool into its interrelated components. The HOP modelling framework provides a structured framework within which specific performance factors and sub-factors can be used to populate causal sequences of influence representing the links between work system conditions and human functioning upon operational performance attainment.

**Integrated soft metrics tool and approach**

- **HOP Model**
- **Performance sub-factors**
- **Soft Metrics Inventory**

1. Structured framework for representation of soft performance processes using......
2. Expanded list of potential performance factors with sub-factors linked to......
3. Detailed database of specific soft metrics and measurement methods.

**Process for analysis of soft performance issues and selection of appropriate metrics in operational projects**

**Figure 5.3a: Relationship between components within the integrated soft metrics tool**

In order to provide a broad enough scope of coverage and applicability to a range of soft issues that may be encountered in differing operating environments, the general factors within the HOP model may be expanded into detailed sub-factors, derived from applied human sciences research, using a comprehensive list of potential performance factors. Upon the basis of strength of influences identified between implicated project preconditions and general aspects of human functioning, critical factors may be identified for proactive monitoring through the application of specific metrics and measures in the project work environment. These are identified within the metrics inventory and grouped according to specific factors within the model.

In development of the applied HOP model it was envisaged that the capability to specify the interactions between variables within the model was critical to the delivery of soft performance management capabilities in project analysis and control processes. **Figure 5.3b** below depicts the key logic inherent within the structure of the model that will allow project work...
groups to reason about soft causal processes in their operating environments. Creating a ‘causal chain’ of performance factors allows desirable project outcomes, such as the ability to deliver the required product functionality within cost and time constraints, to be traced back to preconditions inherent in the work system that are known to impact upon human performance. This implies a backwards-chaining process from achieved or desirable project outcomes, through the HOP model to root precondition factors.

Figure 5.3b: ‘Backwards’ and ‘forwards’ reasoning within the HOP modelling framework

Through tracing a specific path of influence back through the model from outcome variables, project management will be able to retrospectively analyse instances of project work to diagnose problem conditions involving soft issues. Conversely, by tracing influence forwards through the model, project management will be able to proactively reason about project conditions with a view towards achieving specific outcome objectives or remediating negative or undesirable conditions that may become apparent at project planning or onset phases. The framework therefore allows project managers to reason about whether or not a project will deliver within cost, quality and time constraints, based upon a human and organisational systems perspective that factors-in human functioning in the assessment of conditions for optimal project performance.

Having established an applied human and organisational performance model and corresponding metrics, research efforts moved on to development of a practical application process with supporting measures to implement the concepts developed within this work in an applied project environment and evaluate the results from doing so. Within the application
process, the practical issues discussed above fed into refinement of an 'influence mapping exercise' in which the HOP modelling framework could be populated with factors specific to an applied project case. Further details of the application and validation process employed within the soft metrics research project are outlined in section 6 of this thesis, which follows.
Section 6
DEVELOPMENT OF APPLICATION AND VALIDATION PROCESS

This section outlines the process employed for validation of the current metrics set and integrating model through case-based analysis of operational projects. To the extent that the validation process involved implementing the soft metrics approach outlined in this thesis, it also represents development of a prototype application process for analysis of soft issues in operational projects. As stated in section 2.1 it should be noted here that the broad term “validation”, as employed to describe the evaluation of the soft metrics work, answers an industrial concern to assess the extent to which the capability developed by the research effort is applicable and hence “valid” within the context of the sponsoring organisation’s operations. When the soft metrics project entered its validation phase, development work on the HOP model, its performance factors and metrics set ceased in order to provide a stable version that could be repeatedly applied in a series of case studies, allowing data across separate cases to be combined effectively. For the sake of simplicity, these components of the metrics framework were referred to in the validation studies and method outlined to participants collectively as the ‘soft metrics tool’.

The actual case studies involved taking project personnel through an analysis of potential/existing soft issues within their project in order to familiarise participants with the features of the emerging soft metrics tool, its proposed manner of application, envisaged benefits and to generate data using specific case project scenarios against soft metrics in order to assess their utility and feasibility. It also included evaluative items for both the model and metrics to assess the usability, feasibility and effectiveness of the developing tool. As an exercise that incorporated a proposed sequence of activities that would allow project management teams to utilise the modelling framework and metrics set, the validation process may be considered to be user-centred in content.

In order to assess the utility and usability of the individual measures that comprise the soft metrics tool, set evaluative questions were employed in the project case-studies. These questions employed both quantitative items and qualitative items as well as specific items
designed to rank variables in terms of criticality or weight of influence. The items comprised various response methods including semantic differential scales, Likert-type scales and dichotomous 'yes/no' questions. An influence mapping exercise was also included in the process to assess feasibility and usefulness of the HOP model. Throughout the exercise, participant's rationale for making specific responses was elicited and recorded by the researcher who acted as group facilitator for the exercise.

6.1 Purpose and aims

The validation process undertaken as part of the soft metrics research effort serves two broad purposes: 1) to satisfy industrial requirements placed upon the soft metrics project to demonstrate utility and feasibility of the emerging soft metrics tool, and 2) to increase knowledge regarding practical application of the HOP modelling framework and associated soft metrics to inform future research and development. The specific aims of the validation process are discussed below.

In terms of the specific aims of the validation exercise, the principal aim was to apply the modelling framework and metrics in specific case project scenarios to generate example output and evaluative data. The evaluation exercise was designed to allow a case project to undergo a detailed analysis of the impact of human and organisational factors upon its performance and overall outcome, and where possible to employ appropriate soft metrics to quantify critical factors. This was achieved through using the performance factors provided within the model and its overall framework to identify structured causal chains of factors that describe the sequence, direction and extent of influence of specific project preconditions on human activity and overall performance. Based upon perceived criticality, appropriate soft metrics were selected from a database of compiled candidate measures, applied to the specific case scenario, and then rated in terms of efficacy and utility.

From the research and development perspective, the evaluative aims centred upon informing the development of the HOP modelling framework. The validation process was designed to elicit information regarding the feasibility of the general modelling approach and framework, the efficacy of the proposed method to elicit, analyse and describe soft issues in the case project and the comprehensiveness and applicability of the performance factors definitions that accompany the model for specific operational project environments. The principal rationale from the research and development perspective for undertaking these activities was to ensure that the modelling framework and associated metrics set was comprehensive enough to be useful in a range of projects, whilst not too broad in scope as to be unwieldy or impractical for use by project management personnel.
The soft metrics tool including the applied human and organisational performance model, as outlined in section 5.1.1 of this thesis, was implemented in the validation process to address important performance process issues for each case project studied. Figure 6.1a below outlines important questions that application of the HOP model would allow each case project to address; relating specifically to analysis of human and organisational performance processes. For the purposes of simplifying the level of potential interactions within the model during the validation studies, both human and operational outcomes are condensed into one class of variables representing overall outcomes from project functioning.

![BASIC HOP MODEL FRAMEWORK](image)

Figure 6.1a: Key points of analysis in application of the HOP modelling framework

The structure of the validation process and content of the validation instrument aim to address the key questions stated in the figure above, and in so doing populate the modelling framework with factors specific to the case project scenario and specify the critical paths of influence between the resulting variables within the model. The aim in the development of the validation exercise was that after performing the process, the project management team would have populated the generic model through a process which: 1) identified key project outcomes or success criteria that were influenced by human and organisational factors, 2) specified which areas of general human performance in the organisational setting were critical to achieving these outcomes, and 3) analysed the project environment and preconditions for factors which influenced these critical aspects of human functioning. The project management team would also have had the opportunity to consider and map the influences...
between the three categories of variables specified in the modelling framework within the guidelines of a structured and supported process that imposed a logical sequence to the routing of causal chains through the model to desired outcomes. This process therefore considers how existing or future project conditions may impact upon human performance within the project organisation and what the implications of those effects might be on specific outcome criteria.

6.2 Individual and group level data collection

The validation process was designed to elicit expert knowledge from experienced project personnel currently engaged in operational projects. To this end, the process employed a group-based discussion format utilising established project management teams. During the validation process, participants were asked to respond to the sections of the evaluation instrument both individually and collaboratively. These two response methods were employed in order to elicit as much in-depth information and relevant knowledge as possible. The initial two sections of the validation exercise, sections A and B, and aspects of section C required the project management teams to give consensual responses, whereas the remaining sections were administered first as individual response items and then opened to group discussion.

Individual responses made on standardised response sheets that were distributed during the exercise allowed data to be collected representing personal perspectives that could then be aggregated or combined based upon arithmetic averaging. Asking participants to qualify individual responses on their response sheets also elicited a wealth of qualitative data, in the form of comments and feedback. In addition to the individual responses, certain sections of the validation process were designed to capture group responses and evoke discussion within the group. Single scores representing the group’s opinion were therefore recorded against the evaluative items based upon group consensus following debate on the issues raised by the facilitator in the introductory and explanatory preamble to each relevant section.

For the individual response sections, once participants had had the opportunity to consider and respond to the items on their response sheets, the issues raised were opened for group discussion in order to share views and provide an opportunity to gain further insight into participants rationale for their considered responses. During this process, no personal responses were disclosed, however. Although it is acknowledged that the possibility of conformity effects and acquiescence to social majority in group-response situations may have been present, the opportunity to capture qualitative data derived from open discussions was considered paramount to the depth of evaluation, and the inclusion of individual response
items negates any methodological drawbacks inherent in focus-group based workshops of this type. The group-based format also allowed the researcher to give a concise introduction and overview of the validation exercise, ensuring that participants understood the purpose and content of the activities and removed the necessity for lengthy, standardised written instructions.

For the purpose of capturing as much in-depth qualitative information as possible from the exercise, a semi-structured discussion process was employed, based upon the structure and sequence of sections in the validation process plan. The researcher and assistant recorded important comments, issues and themes that emerged during the exercise, for later qualitative analysis. The intangible nature of soft issues, their human, social and political origin and sensitivity in some cases meant that a facilitator-led group-discussion format for the validation exercise was both necessary and desirable in order to provide an informal environment in which subjective opinions and perceptions could be elicited and voiced. Participants were therefore encouraged to discuss and elaborate upon their statements throughout the validation exercise.

6.3 Pilot-based development of the validation process

Before the validation process activities and method is presented in the subsequent sections of this thesis, a brief account of a piloting activity that took place to inform the development of the evaluative instrument and process is given here in this current section. The pilot study involved a test run-through of the validation process and measures, using a locally available systems engineering project as a case example. A preliminary version of the validation process and associated resources was produced for this purpose and following the completion of each section, participant's comments regarding the adequacy and effectiveness of the methodology were recorded. A brief summary of key findings relevant to the development of the validation process, evaluative instrument and associated methodology is given below.

Prior to execution of the validation process using BAE SYSTEMS case projects, work was undertaken including development of the process and preparation of supporting materials for the evaluations, to incorporate issues raised during the pilot study. Following the pilot evaluation and feedback, a coherent introductory presentation with explanation regarding the structure of the exercise was produced for use during the validation exercise. Standardised response sheets to support each section of the exercise with example responses and spaces for comment were also produced. Available soft metrics to date were gathered within a single document, which was presented as an emerging 'soft metrics guide' at the validation
sessions. The performance factors themselves were finalised for the evaluation process and tagged with an identification number that could be used to link to specific measures and methods within the soft metrics guide. The appropriate content from the soft metrics guide could then be pulled up on screen to illustrate methods for measurement of specific factors and when they were identified by project management as being relevant to current project conditions.

In terms of an introduction and overall structure for the validation process, the pilot study highlighted the need for separate sections within the exercise to be clearly delineated, to ease understanding of where in the evaluative process participants were currently, what purpose the current activity served and what was to subsequently follow. In this sense, clear links and feed-ins for each section were outlined and the logic behind the sequence of sections within the exercise was defined in the introductory presentation. Presentation of two versions of the HOP model, a simplified version and a detailed version, within the introductory material was considered unnecessary for the purposes of the exercise, too time consuming and likely to lead to confusion. Accordingly, a simplified overview of the model only was incorporated in subsequent versions of the presentation material. To aid clarity during the description of aim and content of each stage of the validation process, it was considered important to give tangible examples of the expected output for each stage, particularly during the causal modelling exercises. Explaining the rationale behind influences depicted in some of the example models would also help to prime individuals for analysis of soft issues as opposed to hard, technical factors.

The pilot study also highlighted the need for participants to be provided with a reference document containing detailed definitions of performance factors on all sub-levels of the model for use in the influence mapping exercise, in order to prime individuals to focus upon human, organisational and non-technical issues for project success. In order to confine the scope of the exercise and target the most critical soft issues for a particular project, it was recommended that selection of critical precondition factors be confined to a maximum number. Accordingly a limit of six critical precondition factors, identified from the HOP model template provided, was implemented.

The length of the evaluative measures sections for validation of both the performance factors and associated soft metrics in early versions of the evaluative instrument was considered to be too involved, especially where the items would have to be repeated for each performance factor that the participants identified as important to their project. Certain evaluative items were therefore subsumed within a single measure to reduce the number of responses participants were required to make. It was commented that in addition to reducing the time required to complete the whole exercise, shortening the evaluative items would also increase
the integrity of the data through reducing fatigue effects that might impair the accuracy of the participant's responses.

In response to issues raised in the pilot study, several evaluative items were altered. This included mainly the division of a single item or section into sub-items due to opinions expressed that the item encompassed two or more separate factors that participants might usefully make separate responses to. Conversely, certain items were subsumed under a single item where it was considered that they were too lengthy or redundant. The wording of several evaluative items was modified to increase clarity of focus and so as not to exclude either currently ongoing or historic (completed) projects from analysis should the opportunity arise to use both classes of projects as potential cases for evaluation of the soft metrics tool. Some items were also reworded so as to prime participants to respond with reference to their specific case project, rather than to rely upon more general project management knowledge. In the first version of the evaluative items, certain measures were classed as either project-specific or project non-specific. It was decided that due to time constraints and the importance of case-based data, the evaluation would be based upon specific project cases only and not rely upon individual's general project management experience.

The validation process incorporated an in-depth analysis of soft performance processes within the case projects based upon an influence mapping exercise that employed a template of the HOP model upon which respondents could map specific influences within their projects. The sequence of activities designed to achieve this is outlined in section 6.4 below and is largely a result of experience within the pilot study. It was recommended during the pilot study that either colours or separate response sheets be used to map the influences of each individual precondition factor. This precaution ensures that the influence of a single precondition is traceable: 1) to a human performance item, and 2) from a human performance item to an outcome, otherwise the possibility exists for multiple links between a single human performance factor and various project outcome variables with no means of tracing the precondition responsible for each influence arrow.

It was also recommended that the direction of influence or correlation should be specified by respondents for each precondition-outcome relationship identified: 'positive' (indicated by a plus character) for instances of positive correlation (e.g. increase in the precondition resulted in increase in the dependent outcome, or the negative case: decrease in the precondition resulted in decrease in the dependent outcome) and 'negative' (indicated by a minus character) for instances of negative correlation (e.g. increase in the precondition resulted in decrease in the dependent outcome, or vice-versa: decrease in the precondition resulted in increase in the dependent outcome). These recommendations were all implemented in subsequent versions of the validation process, with the type of correlation indicated upon the
influence map by assigning the appropriate character, plus or minus, above the influence arrow, or following the specified outcome variable according to the colour chosen for that particular precondition. In this way the effect of specific variance in the precondition factors was assignable as 'inhibitory' or 'facilitative' of successful project performance. A further conclusion drawn from the pilot study was that within the influence mapping exercise, imposing an intermediary 'human performance' category of factors within the model template, rather than allowing direct links between preconditions and outcomes to be made, was thought to be valid and essential in establishing the relationship between tangible project parameters and 'soft' issues within the case projects.

Finally, in order to take advantage of the availability of multiple respondents from each of the case projects selected, sections of the evaluation exercise were classified as 'group' exercises, in which each research team was asked to come up with an agreed response, and 'individual' exercises, in which each individual was asked to respond on a separate response sheet and then results were fed back and discussed within the group. This provided more representative evaluative data for validation of the metrics and overall method, as well as recording personal views and rationale regarding the influence of specific preconditions upon project performance.

6.4 Overview of activities within the validation process

This section outlines the steps within the evaluative process in detail. The actual evaluative instruments used are included for reference purposes within the appendices of this document. The evaluation response sheets, incorporating a series of response items structured by section of the validation process, appear in appendix I and the template containing sample performance factors for the influence mapping exercise within the validation process may be found within appendix J. Figure 6.4a below provides a unifying overview of the whole validation process and depicts the sequence of five separate sub-sections, labelled A to E. Figure 6.4a shows exactly at which sections the main components of the emerging soft metrics tool were applied and the main feedback channels designed to capture knowledge elicited during the exercise, along with evaluative data.

Sections A to E in the overview correspond to the separate process steps that will be outlined in more detail in the following sub-sections. By way of a summary, following introduction to the exercise, section A establishes the key characteristics of the project, its aims, duration, size, etc. Section B then asks project personnel to express opinions concerning the overall performance of the project to date, against specific criteria that encompass both formal requirements outcome and human and organisational outcomes associated with quality
aspects of the work process and organisational context. Section C employs a series of response items in conjunction with an influence mapping exercise that utilises a template framework based upon the HOP model and a set of example soft performance factors which participants can use to create an influence diagram for their project. The response items in section C are applied to each critical performance precondition identified and assess level of criticality and impact upon human work. Based upon the influence maps created in section C, example soft metrics are selected from a database of possible measures and the items within section D are then repeated for each measure to evaluate the usefulness and potential application of the measures. Section E concludes the exercise by providing an opportunity for respondents to rate the overall methodology and evaluation exercise, providing key data for assessment of the soft metrics framework and development of its application processes.

Figure 6.4a: Overview of soft metrics tool application and validation process for systems engineering project cases

Figure 6.4b below provides a concise description of purpose of the individual evaluative items within each section of the validation process. The items included here are summarised with factor headings. For the exact measures and details of the scales used to elicit responses against each heading, the reader is referred to the evaluative instrument response sheets included within appendix 1. For the sake of convenience, future reference to individual items will be made according to an ID number based upon the appropriate section of the validation
exercise and number of the individual item within that section: e.g. A3, B12, etc. and the reader may find it convenient to refer back to either the figure below or the original evaluative instrument in the appendices during report and analysis of the results of the study.

<table>
<thead>
<tr>
<th>Section</th>
<th>Items</th>
<th>Description and purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Project case profile</td>
<td>1) Project aim</td>
<td>Establishes project 'type' or profile. Gathers necessary background information for analysis of trends across projects according to type.</td>
</tr>
<tr>
<td></td>
<td>2) Project duration</td>
<td></td>
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<td></td>
<td>3) Project budget</td>
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<tr>
<td></td>
<td>4) Work group size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5) Work process outline</td>
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<tr>
<td></td>
<td>6) Current status</td>
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<tr>
<td></td>
<td>1) Budget performance</td>
<td>Items 1-3 allow experienced project managers to express 'expert' opinions upon how the project is performing in terms of its formal criteria.</td>
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<tr>
<td></td>
<td>2) Schedule performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Functional performance</td>
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<tr>
<td></td>
<td>4) Motivating environment</td>
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<tr>
<td></td>
<td>5) Formal training</td>
<td></td>
</tr>
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<td></td>
<td>6) Experience</td>
<td></td>
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<tr>
<td></td>
<td>7) Collaboration/work group climate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8) Knowledge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9) Work process improvement</td>
<td></td>
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<td></td>
<td>10) Exceeding formal requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11) Innovation</td>
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<td></td>
<td>12) Commitment and persistence</td>
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<td></td>
<td>13) Novelty</td>
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<td></td>
<td>14) Customer satisfaction</td>
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<td></td>
<td>15) World class quality</td>
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<td></td>
<td>16) Organisational asset</td>
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<td></td>
<td>17) Project management effectiveness</td>
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<tr>
<td></td>
<td>18) Fulfilment of potential</td>
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<tr>
<td></td>
<td>19) Overall success</td>
<td>Item 19 asks project managers to rate overall success of the project and its criteria-independent. The previous sub-items can be used to calculate an alternative 'overall performance' score for comparison, based upon the formal and informal criteria scores.</td>
</tr>
<tr>
<td></td>
<td>20) Soft versus hard issues</td>
<td>Item 20 provides important data regarding the degree to which managers feel the project's performance was influenced by soft, non-technical, relative to hard issues.</td>
</tr>
<tr>
<td>B: Project performance outcomes</td>
<td>1) Criticality</td>
<td>Items 1 and 2 give overall indicators of 'importance' of an identified performance precondition, which can be used to assess risk.</td>
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<tr>
<td></td>
<td>2) Frequency</td>
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<td>3) Task performance</td>
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<td></td>
<td>4) Communication</td>
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<td></td>
<td>5) Task coordination</td>
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<td></td>
<td>6) Decision processes</td>
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<td></td>
<td>7) Risk management</td>
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<td>8) Performance control</td>
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<td></td>
<td>9) Motivation and leadership</td>
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<td></td>
<td>10) Training and development</td>
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<td></td>
<td>11) Work process improvement</td>
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<td></td>
<td>12) Change management</td>
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<td></td>
<td>13) Additional mechanisms</td>
<td>Items 3 to 12 assess the influence of the precondition on specific 'behaviour' or human work activities, and relate directly to the corresponding category of factors within the model. This provides a 'sensitivity analysis' and basis for weighting factors within the model.</td>
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<td></td>
<td>14) Existing measures</td>
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<td></td>
<td>15) Method effectiveness</td>
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</tr>
<tr>
<td>C: Impact of preconditions</td>
<td>1) Metric effectiveness</td>
<td>Items 13, 14 and 15 are qualitative and quantitative and ask respondents if they can think of any additional important influences and existing measures for the precondition.</td>
</tr>
<tr>
<td></td>
<td>2) Metric feasibility</td>
<td>Following link to soft metrics guide to identify relevant measures for the precondition, respondents get to try out the measures and complete section D, which rates the effectiveness and practicality of each measure.</td>
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<tr>
<td></td>
<td>3) Metric application</td>
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<td></td>
<td>4) Metric benefits</td>
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<tr>
<td>D: Metric examples and evaluation</td>
<td>1) Case-specific usefulness</td>
<td>Items 1-4 assess the effectiveness of the emerging soft metrics tool, as presented to respondents during the exercise.</td>
</tr>
<tr>
<td></td>
<td>2) Scope and comprehensiveness</td>
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<tr>
<td></td>
<td>3) Practicality and feasibility</td>
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<td></td>
<td>4) Overall effectiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5) Communication of aims</td>
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<td></td>
<td>6) Plan clarity</td>
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<td></td>
<td>7) Language accessibility</td>
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<td></td>
<td>8) Level of detail</td>
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<tr>
<td>E: Evaluation of exercise and methodology</td>
<td>Item 5-8 assess the adequacy of the validation process from the respondent's viewpoint.</td>
<td></td>
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</tbody>
</table>

Figure 6.4b: Description and purpose of evaluative items employed in validation studies
Presentation of the results from the validation exercises and discussion of the key issues raised are reported in the subsequent sections of this thesis (Sections 7 and 8, respectively). The results are reported by section of the validation process (A to E) in sections 7.1 to 7.5. For the sake of clarity, these sections bear direct correspondence to the activities outlined in sections 6.4.2 to 6.4.6 below, which provide the necessary methodological steps employed to collect the data and which provide a preamble to outline and analysis of the results in section 7.

6.4.1 Validation process preliminary preparation, introduction and orientation

In preparation for the project case-studies, suitable participants were contacted to outline the plan, negotiate time required to complete the exercise and request background materials providing contextual information for the project. Information requested included project control documentation including project planning and requirements specification (e.g. Gantt chart of scheduled activities, work package breakdown structure, etc.) and records of any systematically tracked data (e.g. Earned Value Management EVM output).

In assembling representatives and stakeholders for the case project in question, certain requirements and priorities were considered in terms of the composition of the focus group that would undertake the validation process. The content of the validation process and nature of some of the items required specific knowledge of project management information pertinent to the project. In practical terms, the exercise required the involvement of certain project roles and management levels in order to be successful. The following characteristics were therefore considered desirable in selection of appropriate personnel:

- Operation at the project management level; in a position to detect and address problem issues arising within the project.
- Fulfils a role that involves direct monitoring of project progress and current performance status.
- Possesses awareness and knowledge of the project work structure and plan.
- Possesses awareness and knowledge of the rationale and aims for the project.
- Is involved across all or a high proportion of project work activities.
- Is in close collaboration or is networked to the project management team, project work group and other relevant project personnel.
- Is a key stakeholder for and is committed to achievement of the project aims.
In order to introduce the participants to the validation process and orient them towards consideration of non-technical issues in their project, an overview presentation was made at the start of the validation exercise by the researcher in order to prime participants to the focus and purpose of the exercise and to outline the nature and functioning of the emerging soft metrics tool. The soft metrics topic was introduced along with the focus of the research work, a brief outline of current progress and where the present validation activity fitted in to the overall plan for the work. The soft metrics tool was outlined including rationale and structure of the HOP modelling framework. An overview of the day's activities and associated exercises was provided, along with example responses and output from each section. The provision of example models and influence maps ensured that participants were primed to consider soft performance issues as opposed to technical parameters and to adopt an analytical approach to the consideration of what influence these factors exerted on various aspects of productivity within the project. Finally, the presumed benefits of the approach were stated, along with what the participants might expect to get out of the exercise; namely, a structured process for analysing, representing and reasoning about soft issues within their project, an opportunity to gain insight into current/future soft metrics and potential applications, and an opportunity to provide feedback that would inform the course of development in this area.

6.4.2 Validation process section A: Project case profile

The main purpose of the initial section of the validation process was to gather contextual and background information regarding each specific case project. The information collected in section A provides a context for analysis and interpretation of data collected in subsequent sections of the validation process and allows association of subsequently emerging soft issues with 'project type' characteristics.

In this section, items A1 to A6 gather information about the type of project, its size, aims, work processes and current operational status. The items in section A did not employ scales but were qualitative response items. In order to gain an accurate description of the project, the principal and sub-aims of the work activities were recorded along with conceptual vision and rationale for why the work was being performed. Next, an indication of the scheduled duration of the project was taken according to funding periods or dates for key deliverables. Where possible, the total budget for the project work was recorded as an indication of project size and work effort. From the human systems perspective, it was important to identify the boundary for the project work group, which was achieved through specifying the size of what may be considered to be the 'core' project management team and arriving at an overall figure that subsumed all personnel involved in executing any part of the project work package.
Having established the manpower resources involved, participants were then asked to give a brief overview of the project work process, including key stages or phases in the project development sequence, key work activities and deliverables. Finally, details of the current stage reached in the project work process were recorded, including progress in separate work packages and overall development phase reached.

6.4.3 Validation process section B: Project performance outcomes

Section B serves to quantify both formal and informal outcomes of the project in order to give an indication of the projects achieved success to date. It also serves to establish performance in preparation for later analysis of the mechanisms that influenced the achieved outcomes. The measures rely upon subjective opinions of project personnel and may be applied retrospectively, to completed projects, or to ongoing, non-completed projects to assess to what extent the project is achieving key outcome criteria at its current stage of development. Section B employed a variety of anchored scales to quantify each item (see appendix I), including Likert-type scales anchored ‘strongly disagree’ to ‘strongly agree’ and score rating scales anchored ‘low achievement’ to ‘high achievement’.

There are currently formal measurement systems available to project managers to track cost, quality and time criteria. The subjective response items B1-B3 therefore allow project managers to voice their opinions as to how the project has performed and allows for consideration of the extent to which the project fulfilled non-specified or broad requirements such as may exist in proof of concept or pure research projects, or requirements that emerged during the course of project development. Items B1-B3 are also designed to elicit further contextual data relevant to the project case under consideration, i.e. by providing a concise indication of the degree of success achieved by the project. Participants were asked to respond using a percentage of overall requirements met in each of the three categories. Guidance was given in how to respond by providing anchoring conditions for 0 and 100%, and by providing a qualifying statement that limited the maximum attainable rating if the project experienced specific conditions.

The remaining items B4-17 rely upon the experience of project managers to give an indication of the relative degree of success they think the project achieved based upon how effectively the project satisfied formal and more informal, human and organisational success criteria and to what degree the project represented best practice within its domain. The factors tested within items B4-17 are adapted largely from the outcome category in the HOP model framework (depicted previously in figure 5.1.1a), and reflect what may be considered to be ‘quality of process’, organisational learning and creation of intangible assets. Discussion of
rationale behind why the project achieved certain outcomes forms a useful primer for the following influence mapping exercise in section C, in which specific antecedent performance factors are identified. As a group-based exercise, section B is designed to provoke discussion of performance-related processes in the project and the researcher documented any causal influences discussed at this stage, in order to be considered in more detail in later sections of the validation exercise that sought to trace causal origin of project performance outcomes. Item B18 was qualitative in nature, asking respondents to respond positively or negatively to whether they thought the project had achieved its potential and qualify their response.

Finally, having considered all the criteria inherent in items B1-18, Item B19 asks participants to give an overall rating of effectiveness for the project. This judgement-based measure in particular, and the rest of the items in section B in general, is designed to sound the 'expert' opinions of experienced project managers who are familiar with the operational functioning of the project and who are in a position to formulate a comparison with other projects they have had experience with, in order to gain a 'feel' for the project's level of achievement. In addition, item B20 asks respondents to consider the degree to which 'soft' issues influenced the success of the project, compared with 'hard' issues. Definition of 'hard' and 'soft' issues was stated clearly to participants in the introductory orientation section of the validation process, but it is reiterated in discussion here under item B20, where respondents are asked to consider the relative influence of 'hard', technical issues against 'soft', human and organisational or non-technical issues.

**6.4.4 Validation process section C: Influence mapping exercise**

Section C of the validation process comprised a semi-structured 'influence mapping' exercise, supported by set measurement items in the evaluative instrument, that sought to capture the mechanisms by which specific 'upstream' soft factors, identified within section B and from a sample set of performance factors presented within section C, influenced project performance outcomes. For the actual evaluative items used within section C and a reproduction of the sample performance factors template used in the study, the reader is referred to appendices I and J respectively.

Section C of the validation process was intended to be the central activity in the application of the HOP modelling framework within the case projects and aimed to provide sample data regarding how the model, framework and factors could be applied to make the key links between 'intangible' antecedent factors and the more tangible operational or customer-oriented project outcomes relating to the project work product. As such, the output from
section C: example causal chains of factors specific to 'real-world' operational case project scenarios and data concerning the nature and strength of influences within those chains, was intended to support an important part of the argument for the emerging soft metrics tool – its utility and effectiveness. As a semi-structured, discussion-based process, the influence mapping exercise forms a means of capturing knowledge that is largely qualitative and discourse-based in nature, in a reproducible, structured format for project planning, control and risk analysis capabilities relating to human and organisational performance factors.

The sample factors presented within the influence map template and performance factors set were derived from the soft factors literature review and represent known human and organisational factors that have the potential to impact upon project performance. They also represent factors which existing project management and support tools do not address directly and as such are parameters that are characterised by a high degree of opacity in nature and influence, and about which it is currently difficult to objectively reason for the purposes of project planning, risk analysis and performance control.

The influence mapping exercise formed the basis of detailed analysis of soft issues within the case projects. A list of precondition factors, human performance activities and project outcomes according to the framework of the HOP model were presented to the participants who were asked to map the influences between these factors according to their own observations of project issues within their specific case project scenario. The actual sequence of steps employed in this undertaking is outlined later in this current section of the thesis. Issues identified and recorded by the researcher during discussions elicited by section E3 of the validation process were summarised at this point in order to remind individuals of important issues to consider. As the exercises within section C were constructed to allow the identification of key soft performance factors and investigation of the mechanisms through which these factors influence performance outcomes, they provide the basis for selection of appropriate soft metrics for the specific case scenario in question during the subsequent section D of the validation process.

During the influence mapping exercise in section C of the validation process, all categories of variables and relationships inherent within the HOP model were addressed, but in varying levels of detail according to certain research priorities. Two conditions for analysis were therefore identified and embedded within the methodology employed during section C of the validation process. In condition A, in order to relate soft, 'upstream' factors to operational performance outcomes, respondents were asked to trace full causal chains of influence through the entire model, encompassing project preconditions, human performance activities, operational project outcome factors and the specific interactions between these three classes of variable applicable to the project case scenario in question. Full causal influence maps
based upon qualitative information elicited during the validation process were therefore constructed, in order to provide examples of the utility of the model in analysis of antecedent factors for overall project outcome performance. In condition B, response sheets from the evaluative instrument containing several items designed to focus in-depth upon what may be regarded as ‘soft’ performance processes within the project, were presented to respondents. This latter, more detailed, quantitative analysis was directed towards the relationship between what may be considered to be generic human work activities and contextual or input ‘preconditions’ that were inherent features of the project work environment. Figure 6.4.4a illustrates the aspects of the HOP model that formed the focus of analysis under each of the two conditions, A and B, outlined above.

The in-depth focus upon human performance processes under condition B was employed in accordance with a number of considerations. The principal reason from a research perspective was because the ‘soft’ or human work processes and influences that occur within a project are represented primarily by interactions between the first two classes of factors within the HOP modelling framework; in the relationship between human and organisational preconditions within the project work environment and the human-centred activities, or actual human behaviours, that they influence. These human-centred activities therefore represent non-technical, human performance on the project and include knowledge-intensive processes such as decision-making, task planning, risk analysis and change management, all of which are information-critical and require accurate projective and analytical reasoning. In addition they address processes partly determined by social climate and quality of interpersonal networks, such as communications, motivation and leadership, and as such represent the
human work aspects of project operations, which form the critical focus of interest for the soft metrics research effort.

Another reason for adopting an in-depth, quantitative approach to limited aspects of the HOP model was practical in origin. Access to project personnel for the validation exercise from ongoing BAE SYSTEMS operations was limited and subject to time-constraints. From refinement of the validation process in a pilot study performed for that principal purpose (reported in section 6.3 of this thesis), it was considered practical to confine the scope of activities within section C of the validation process to those outlined above, in order to lesson the necessary resources required to exercise what was already a multi-phase validation process.

The results from application of the methodology for section C of the validation process are reported in results section 7.3 of this thesis. The remainder of this current section provides an outline of the methodological aspects of the influence mapping exercise, namely sequence of activities and explanation of content and purpose of the evaluative items C1-C15 that were employed to analyse project performance preconditions in detail.

**Figure 6.4.4b** below provides an overview representation of the major points of analysis within the influence mapping exercise, classified as either quantitative or qualitative in nature. Within the influence mapping exercise of the validation process, qualitative knowledge and information elicited was used extensively to identify issues that could be ‘flagged-up’ for quantitative analysis using set evaluative items and scales, and was also used to qualify and further explore the results of quantification of influences and interactions.

**Figure 6.4.4b:** Quantitative and qualitative analysis within the HOP model influencing mapping exercise
Qualitative analyses of soft performance issues within the case project centred around application of the HOP modelling framework and sample performance factors identified from the soft metrics literature review and industry-based scoping study findings. For the specific case project context in question, project personnel were asked to identify relevant factors within each of the three classes of variables within the HOP model, and map the specific influences between these factors in a manner reminiscent of the theoretical modelling exercises outlined in section 4.3 of this thesis. To aid in this process, set definitions from the literature review regarding each identified performance factor were given where necessary by the researcher. In addition to representing complex soft performance processes using the HOP modelling framework, further qualitative analysis included the specification of direction of influence between critical preconditions and dependent project outcomes, in order to provide evidence for whether specific variances in project preconditions were likely to have a facilitatory or inhibitory effect upon overall project performance. In terms of the quantitative analyses conducted within the influence-mapping exercise, respondents used set evaluative items from within section C of the evaluative instrument (see appendix I) to achieve values representing overall criticality of a specific precondition for effective project performance, and values representing the estimated impact of a precondition on each of the generic human performance activities inherent within the central category of the HOP model. This latter analysis formed a detailed sensitivity analysis for how project preconditions influenced human performance within the project and was designed to provide data to support risk analysis and prioritisation activities during project planning and performance projections.

The critical points for analysis outlined above were embodied in a practical methodology for the influence mapping exercise, as illustrated in figure 6.4.4c below. Figure 6.4.4c comprises a table of sequential activities for the influence mapping exercise with details of the exact method employed within each step, including: resources used, nature of data elicited and results output. During all the separate steps undertaken, the researcher recorded important issues raised and rationale which qualified and elaborated upon participants responses.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Identify critical precondition factors.</td>
<td>Having considered broad human and operational performance outcome dimensions in section B of the validation process, respondents were asked to identify the critical precondition factors that influenced reported performance attainment and that best represented the origin of any ‘soft’ issues encountered during the course of the project. Critical preconditions were limited to six in total due to time constraints placed upon the exercise. This activity was qualitative in nature and employed the ‘precondition’ category of the HOP model template (reproduced in appendix J). The output from this activity was a series of ‘critical’ preconditions for the specific case project scenario.</td>
</tr>
<tr>
<td>2) Identify dependent project outcomes.</td>
<td>Taking each critical precondition in turn, respondents were asked to identify which specific project performance outcomes the factor had an influence upon. This activity was qualitative in nature and employed the ‘outcome’ category of the HOP model template (reproduced in appendix J). The output from this activity was a series of ‘dependent’ outcomes for the specific case project scenario.</td>
</tr>
<tr>
<td>3) Specify the direction of influence.</td>
<td>Considering each dependent project outcome for a specific precondition factor, respondents were asked to discuss and state the nature of influence of the precondition. The researcher presented the question verbally in the format: &quot;if [precondition X] increases, is the level of [project outcome Y] likely to increase or decrease?&quot; If the answer was &quot;increase&quot;, the precondition-outcome pairing was recorded as being positively associated. If the answer was &quot;decrease&quot;, a negative association was recorded. This activity elicited qualitative data that could be used to classify preconditions, relative to a specific performance outcome, as either facilitatory or inhibitory.</td>
</tr>
<tr>
<td>4) Identify mediating human performance activities</td>
<td>Respondents were asked to consider how each critical precondition influenced dependent outcomes by tracing causal paths between the precondition and outcome, through specific human performance activities. In this manner, detailed ‘soft’ performance mechanisms that operated within the case project were identified, incorporating full causal chains that linked project preconditions to the human work activities they influenced and the dependent operational outcomes that were affected by variance in the ability of project personnel to effectively execute project work. This activity was qualitative in nature and employed the full HOP model template (reproduced in appendix J). The output from this activity was a series of influence maps depicting full causal chains of influence through the entire HOP model, linking project outcome with upstream preconditions and soft factors.</td>
</tr>
<tr>
<td>5) Rate criticality of preconditions</td>
<td>Using the set response items in section C of the evaluative instrument (reproduced in appendix J) for each critical precondition factor identified, respondents estimated the impact of each precondition in terms of severity and frequency of occurrence of related issues for project performance. The level of influence of the precondition on each of the generic human performance activities within the HOP model was then assessed using set scale items. This activity was quantitative in nature and the output formed a sensitivity analysis of project performance processes based upon soft, human-centred project preconditions.</td>
</tr>
</tbody>
</table>

**Figure 6.4.4c: Process steps for mapping influences between performance factors using the HOP modelling framework**

The evaluative items employed to support the influence mapping exercise were first administered individually to all project personnel and then discussed in the group. Overall influences for specification of weightings within the influence maps were later calculated based upon aggregated scores for each performance precondition in each case project scenario. The content and purpose of the evaluative items used at this stage of the validation process is briefly described below.

Items C1 and C2 were designed to gain an overall reaction to the criticality of a precondition to the success of a project. The perceived level of influence or ‘importance’ of the precondition is measured (item C1), followed by the expected frequency of occurrence of
precondition-related performance issues (item C2). The logic behind this two-factor approach is that a highly critical factor that occurs relatively infrequently may not be as important from a project planning and performance monitoring perspective as a less critical factor that arises commonly. Seven-point scales were used for these items anchored by '0 – factor is irrelevant' to '6 – Factor is highly critical' in the case of overall criticality (item C1), and '0 – Never' to '6 – Constantly' for frequency of occurrence (item C2).

Following on from C1 and C2, items C3 to C12 offer a finer-grained level of analysis of the impact of preconditions on specific human work activities, by addressing the mechanisms by which preconditions influenced project performance. These items correspond to the 'human performance' items in the HOP model, in order to gain an understanding of the relative importance of a precondition for a specific human performance activity and allows sensitivity analysis of human work activities to contextual factors. In terms of the seven-point criticality scale used for items C3 to C12, it is important to note that the lowest index '0', does not represent 'low' influence but 'no' influence whatsoever. In compilation of the resulting influence maps, no influence is therefore represented by the absence of a connecting arrow between the precondition factor and human activity factor.

Item C13 is qualitative in nature and gives an indication of the comprehensiveness of the human performance factors specified within the HOP model sample set by asking respondents if there are any additional mechanisms through which the precondition in question influences project performance. Finally, the remaining two items were designed to give an indication of the existence and effectiveness (items C14 and C15, respectively) of current methods for measuring the precondition in question. Example causal chains from the influence mapping exercise with factor-weightings derived from items C3 to C12, in addition to other qualitative and quantitative results gained from section C of the validation process are outlined and discussed within section 7.3 of this thesis.

6.4.5 Validation process section D: Sample metrics

Section D of the evaluative process was designed to generate evaluative data for the soft metrics that were developed from the literature review and associated with individual performance factors within the model. The soft metrics used during the validation studies are outlined in the metrics inventory document included within appendix H. The evaluative items within section D of the evaluative instrument (included within appendix I of this thesis) were completed for each sample metric presented to respondents during the validation exercise, and formed the means of evaluating the effectiveness, feasibility, scope of application and potential benefits of each individual measure. Due to the recursive nature of section D of the
validation process, the evaluative items were limited to four in total and two or three metrics representing key factors identified during the influence mapping exercise in the preceding section C of the validation process, were selected by the researcher for validation. Items within section D of the evaluative instrument were administered first to individuals, and then discussed within the group.

Following selection of the metrics for validation, the researcher explained the purpose and content of the measure, including sub-items or factors where appropriate, data collection and analysis methods. The scales used to quantify each measure were described including the rationale for the semantic anchors employed, if applicable. Where practical in terms of the time available and presence of necessary resources, respondents were given the opportunity to generate data against the measure for their particular case project, in order to gain better insight and understanding of how the measure could be applied. The researcher also benefited from this process in that application of the measure could be observed and any problems associated with understanding or interpretation of the measure's purpose or content was recorded.

Item D1 of the set evaluative items was quantitative in nature and employed a ten-point rating scale to assess how effective respondents thought the measure was in quantifying the performance factor with which it was associated. The scale was anchored: '1 - Virtually ineffective' to '10 - highly effective'. This item was designed to elicit discussion of the suitability of the specific metric in question for testing a particular performance factor within the project and assessed the adequacy of the measure. The need for quantification of the performance factor that the soft metric was proposed to test had already been established in the preceding section of the validation process for each specific case project; the output from section C comprises a series of 'performance critical' factors.

Items D2 to D4 within the evaluative instrument were qualitative in nature. Item D2 asks respondents if they would have used the measure to quantify the performance factor within their project and prompts respondents to consider the practicality and effort involved in generating the necessary data. Considered with the preceding evaluative measure, items D1 and D2 give an indication of the potential usefulness of a specific soft metric, based upon the potential effectiveness-effort trade-off. Item D3 of the evaluative instrument asked respondents to consider when in the project lifecycle the measure should be employed. Instances in the course of the project to consider were listed as: at project planning, after changes to the plan, at periodic reviews or in more frequent, continual performance monitoring activities. Finally, item D4 asked respondents to consider the potential benefits to their projects that would have arisen if the measure had been available and employed.
Information gained in response to this specific item would be used to support the feasibility case made for the soft metrics associated with the emerging metrics tool.

6.4.6 Validation process section E: Overall evaluation

Following independent evaluation activities within the validation process, section E of the evaluative instrument provided respondents with an opportunity to discuss and rate the overall usefulness of the soft metrics tool and provide feedback concerning the practicality and effectiveness of the methodology employed within the validation process. Section E of the evaluative instrument containing items E1-8 (see appendix f) was distributed to all individual respondents before the items were discussed amongst the group.

In terms of the individual evaluative items employed in section E of the validation process, items E1-4 referred specifically to the usefulness of the soft metrics tool; its applicability, scope, practicality and effectiveness in achieving the aims set out for it in the introduction to the validation exercise. Items E5-8 focused upon the effectiveness of different aspects of the method employed within the validation process, to elicit data that could be used to refine future applications of the process. Items E1-4 employed a ten-point rating scale indexed ‘1 – Low’ to ‘10 – High’. Items E5-8 employed Likert-type agreement scales anchored ‘1 – Strongly disagree’ to ‘10 – strongly agree’. An even number of indices was present in these latter scales to force agreement or disagreement with the statements included within items E5-8.

Evaluative item E1 assessed case-specific usefulness and asked respondents to rate how useful the exercise had been in analysing soft issues within their specific project, giving an indication of applicability and utility of the soft metrics tool and analysis process for individual project case scenarios. Subsequent items E2-4 were not project-case specific and asked respondents to consider general usefulness and applicability of the tool for project management efforts against three dimensions: scope and comprehensiveness (item E2), practicality and feasibility (item E3), and overall effectiveness (item E4).

Within items E5-8 used to evaluate the validation methodology, item E5 addressed the extent to which respondents felt the aims and purpose of the exercise were clearly communicated and item E6 how logical and clear respondents thought the plan and process were. Item E7 assessed the perceived accessibility of the language and terminology used within the performance factors template and accompanying documentation, whilst item E8 asked respondents whether they considered the level of detail and analysis incorporated within the exercise's resources was appropriate for the purposes specified.
Section 7
RESULTS AND ANALYSIS

This section of the thesis is primarily concerned with presentation and analysis of results from application of the validation process in three BAE SYSTEMS engineering research and development projects. Key conclusions and issues arising from the data collected during the validation process for the emerging soft metrics tool are summarised within the subsequent section of this thesis (section 8), including discussion of the feasibility and utility case for the developed approach. In terms of the presentation format for the data and results of the validation exercises, some consideration of issues of confidentiality and ethical research practice are pertinent. Much of the data collected during the validation exercises was sensitive in nature, either due to its representation of personal viewpoints and opinions, its relevance to commercial and political issues associated with project performance reports or its relevance to security and defence interests.

In the interests of preserving commercial confidentiality and anonymity for participants, efforts have been made within this section to ensure data collected within the various sections of the validation process is not directly attributable to a specifically identifiable project. Where it becomes necessary to separate data according to the case project to which it refers for comparison, the projects are coded SEP (Systems Engineering Project) 1, 2 or 3. Most notably, the initial section of the validation process (section A: project case profile) collects project-specific data that could be used to identify a particular project origin. For this reason, results reported from section A are confined to an overview of the context and main features of each project according to project focus or development area, and no project-specific reference is given. In the subsequent treatment of qualitative data gleaned from the validation study and arising largely from discussions centred around the influence mapping exercise in section C of the validation process, again no project identifiable reference will be made and the discussion and analyses will be structured according to the performance factor of interest, rather than the project in which the issue was raised.

Sections 7.1 to 7.5 below provide a descriptive account and analysis of qualitative and quantitative data obtained within sections A to E of the validation process. For explanation of
the methodology used to elicit the following data within each section of the validation process, the reader is referred to the preceding section 6 of this thesis. Although the validation process employed multiple, integrated phases in order to allow participant project personnel to apply and validate the emerging soft metrics tool, sections C and D of the validation process are specifically relevant to results concerning the application of the HOP modelling framework and associated soft metrics.

7.1 Validation results section A: Project case profile

This section reports a summary of information regarding the type and focus, amongst other characteristics, of the case projects used to validate the soft metrics tool and some demographic characteristics of the individuals that participated in the validation exercises. The information recorded in this section is derived from responses made by project personnel during the validation exercises, in response to section A of the process (see previous figures 6.4a and 6.4b for an overview of the validation process and evaluative instrument). Responses for this section were discussed and made on the basis of group consensus during the actual validation exercise. As an overview of the key characteristics shared by the case projects used for the soft metrics work validation study, it is anticipated that this section will provide useful background and contextual information for the results sections that follow.

In total, three operational systems engineering research and development projects were made available to the soft metrics research effort through the BAE SYSTEMS sponsored Systems Integration Consortium research network. All the projects involved were industry-academic partnership projects, led by project management teams that comprised individuals representing varied academic and industrial interests. Each project was focused upon the development of a key technological or process capability to enhance operational performance in systems engineering activities and for direct application in BAE SYSTEMS future operations.

In terms of the numbers and roles of participants involved in the three evaluation sessions, figure 7.1a below provides a concise overview of the overall size of each project's core team and the levels of participation in the soft metrics evaluation process for each team, classed by seniority of project role. In total, nine individuals participated in the validation exercises of which five represented senior or lead project personnel, with each individual project being represented in this latter sub-group as per the requirements detailed in the plan for the validation process concerning role requirements for participating personnel (see section 6.4.1).
The project leads/senior personnel group comprised five individuals (four male, one female), all of whom were aged above 30 and possessed a broad range of relevant project management experience and domain-specific knowledge pertaining to the management and focus of the systems engineering projects that they headed. The responsibilities of this group included overall planning for delivery and integration of high-level project work tasks, performance review, budgeting, management of sub-projects and liaising with industrial sponsors at periodic steering groups that functioned at a strategic level. The project work/research personnel group comprised four individuals (all male) of varying ages and with widely varying experience and expertise. This group of personnel is distinguished from the lead personnel by the absence of strategic project steering responsibilities and high-level project management responsibilities. Personnel within this group were however responsible for the planning and execution of significant sub-tasks within the overall project work plan and represented their own areas of expertise in contributions to decision-making processes within the project management teams.

As future capability-oriented projects, each participating case project focused upon a novel area of research with the aim of developing knowledge and demonstrators to prove the feasibility of the concepts that formed the objectives for the research work. The main focus in the three development areas represented by the case projects and given in response to item A1 in the evaluation instrument (see appendix I) may be summarised as follows:

- Development of tools to support an Integrated Modelling Environment and assess the dependability of integrated models.
- Development of object-oriented and autocode technologies to improve productivity in software engineering.
In terms of project duration (item A2), all three projects began in 1999 or 2000 with the establishment of the Systems Integration Consortium and were currently ongoing at the time of the validation study (November 2003), with work packages scheduled as due for delivery in 2006 in some cases. The response to A3 'project budget' is considered confidential, but each project received a third of the overall budget for the Systems Integration Consortium, ensuring that the projects are comparable in terms of size as defined by available financial resources.

The principle or core work group size (item A4), defined as the team directly responsible for executing the separate work packages that comprised each project, varied between 5 and 9 individuals, including research associates and PhD students conducting research in sub-areas of the overall projects. When extended to include industry sponsors, directly associated industry personnel and research network members, all of whom contributed in some way to the project work, estimates for the total project stakeholder groups reached as high as 30. Although membership of the core project management teams had remained relatively stable, there had been changes in personnel responsible for executing sub- and peripheral tasks in the projects.

Although overviews of the project work process employed (Item A5) varied in each case according to the exact nature and technical requirements of each specific project, several points of commonality emerged. All work packages defined at project start-up underwent a scoping study in the early stages of the project in order to identify potential need and applications for the work. During this phase project stakeholders and those that would be influenced by the research work were identified. Following the scoping study, detailed literature search and exploration of the capabilities of existing tools and technologies generally followed. Another early activity was detailed planning and sub-project specification in which itemised work-plans were produced with set milestones and targets.

The general course of project development phase work provided the largest source of variation, as each project pursued specific and unique technical objectives. Following background research, solutions and demonstrators were developed and applied in the industrial context through case studies, as many as 8 separate applications in some instances, to generate validation data. Other activities considered important included the management and integration of sub-projects and the revision and updating of initial requirements and objectives in light of new developments. Each project reported a period of what has been termed "intensive" iteration in the project lifecycle, based upon successive case applications and subsequent development work based upon research findings. Estimates of general progress or stage reached (item A6) by each of the projects varied, though the initial stages of the vast majority of work packages were considered to be completed and undergoing validation in preparation for integration and deployment. Some
work packages and industry deliverables were reported as having been finalised by this stage, whilst others were at a much earlier developmental stage.

The project management teams from two of the three projects studied commented during discussion of responses to the items within section A that the project requirements and aims had been modified since the initial project definition, resulting in the necessity to re-plan work schedules, work package specifications and resulting in various ongoing sub-projects being at different stages of completion. A similar occurrence was reported in cases where the focus of the research effort had shifted during the course of the project to accommodate new areas, as a result of technological advancement. These unpredicted deviations from the original plan were attributed to the nature of 'proof of concept' or research projects which operated within new knowledge areas.

7.2 Validation results section B: Project performance outcomes

Section B of the validation process collected group-rated data regarding various dimensions of project outcome performance, including formal requirements and informal human and organisational criteria. Data within this section is presented according to the actual case project within which it originated. The actual quantitative responses made by the three case projects against each of the items within section B are included in appendix L.

Figure 7.2a below compares ratings made by all three projects against the three formal outcome criteria items (B1-3). The percentage scores show respondents opinions of the degree to which the project in question had achieved all budgetary, schedule and functional performance targets, representing the customer or contractually determined parameters: quality, cost and time.

Scores for formal performance criteria varied across the projects between 60% and 100% of objectives met. SEP3 recorded the highest scores with all (100%) set objectives met for both the budgetary and functional dimensions, and only occasional, minor schedule overruns in the temporal dimension (95%). SEP1 and SEP2's scores varied, with generally high performance (90-100%) on the budgetary dimension and the lowest scores occurring in the schedule and functional categories (SEP2 70% and SEP1 60%, respectively).
During discussions regarding items B1-3, several important issues were raised including causal factors in each project's history that respondents used to justify low or high ratings on the scales. These issues were recorded for consideration in later sections of the validation process, but served to demonstrate the utility of considering the exact level of outcomes of project performance criteria first in any process aimed at identifying and analysing 'upstream' performance factors. An important theme that emerged from consideration in all three projects was the interrelated nature of the three formal outcome criteria related to cost, quality and time. In this sense, it was suggested that "overall cost effectiveness" might be a suitable single measure that subsumes all three separate outcome criteria, in that an effective project delivers all key functional requirements quickly and with as little spend as possible.

Another common theme was the impact that instability in factors that were external to the project, and hence beyond project management control, had upon formal performance criteria. Changing or unstable customer requirements during the course of the project was offered by two of the three projects as important determinants of overall performance, impacting upon schedule performance (causing overruns for work packages) and functional performance (shifting technical goals and decreasing ability to appraise functional attainment at any specific point in time). The impact of changing technologies was also highlighted as a key external factor, that necessitated revisions to the project work plan mid-project to embrace advancements made by other research organisations and involved acquisition of a large amount of new knowledge by the project work group. In the words of one project manager, collaboration with an external research organisation in order to acquire necessary technical knowledge resulted in a "vast under-estimate" in the schedule, regarding the length of time necessary to complete specific work packages.
The uncertainty inherent in 'proof of concept' and research-intensive projects was stated as making functional performance monitoring and control difficult, highlighting a possible discrepancy in views between industrial and research interests concerning what level of parameterised control was appropriate for this type of project. Doubts were expressed during consideration of functional performance outcomes as to the accuracy with which it was possible to specify clear functional and technical objectives and milestones at the start of a research project.

Items B4-17 contained other human and organisational, as well as work process quality and organisational learning dimensions of project outcome performance. Collectively, items B4-17 represent informal, 'softer' outcome criteria by which a project's success and degree of achievement may be rated. Responses made to these items by each of the three case projects are depicted within figures 7.2b (items B4-10) and 7.2c (items B11-17) below.

![Figure 7.2b: Management team perceptions of performance against human and organisational outcome criteria (Items B4-10)](image)

Items B4-17 used the anchored 10-point scales provided in the evaluative instrument and responses varied considerably between the three case projects as a result of differing project work environments and performance factors. Within each project, ratings also varied considerably across different items. No responses were recorded in instances where time constraints meant that discussions on a particular item had to be curtailed, or where respondents couldn't collectively agree on a single score. Overall, consistently high scores were recorded across all three case projects for items B4 (Motivating environment), B8 (Knowledge), B9 (Work process improvement), B13 (Novelty) and B15 (World class quality).
All three projects therefore considered their respective project work environments to be adequately stimulating and motivating and that each project had made a significant knowledge contribution in terms of both the technical domain that the project was researching and in procedural knowledge or work processes employed within the project. The general consensus across all three projects was that in each case the work product had been novel and project work executed to a ‘world class’ quality level.

![Management team perceptions of performance against human and organisational outcome criteria (Items B11-17)](image)

In terms of individual project’s scores for the human and organisational outcomes, SEP1 scored highest in terms of its achievements in areas of work process improvements (item B9, score: 9), novelty in research product (item B13, score: 9) and as an asset to its organisation (item B16, score: 9). Lower scores were achieved in the provision of formal training opportunities for project personnel (item B5, score 4.5), achievement of a collaborative climate for project work (item B7, score: 5.5) and in the effectiveness of project management practices (item B17, score: 5). SEP2 project personnel were generally more conservative across all items, with the highest score in the achievement of a motivating work environment (item B4, score: 8). Low scores included satisfaction of stakeholder interests (item B14, score: 2) and exceeding formal requirements (item B10, score: 4). Finally, SEP3 scored highest in novelty of work product (item B13, score: 9), knowledge contribution (item B8, score: 9) and provision of a motivating environment (item B4, score: 9). SEP3 recorded no particularly low scores with the exception of achievement of a collaborative climate for project work (item B7, score: 6), relative to scores on the other dimensions in this section.

Mean scores across items B4-17 and B1-3 were calculated to give an overall inferred performance score for: 1) human and organisational outcome criteria, and 2) formal outcome...
criteria, respectively, for each project. These scores were then compared with project managers overall ratings of the project's performance as elicited by item B19 'overall success'. The results from this comparison are presented in figure 7.2d below. Only in SEP1 did the project management group’s estimate of overall performance closely match the inferred performance outcome values for both formal and informal criteria. In the other two projects, group estimates closely matched the human and organisational performance criteria but these scores fell short of the inferred formal criteria scores that incorporated the cost, quality and time parameters. One interpretation of this trend is that it is an artefact of the number of items within the formal requirements section compared with the human and organisational criteria, yet if the evaluative instrument is robust, there exists the possibility of a tendency to over-estimate performance against formal project outcome criteria. This may be due to the political sensitivity of customer or contractually defined budgetary, functional and schedule success criteria for operational projects. Conversely, the lower group-estimated scores might represent a human tendency to give conservative judgements in making complex judgements that involve multiple factors. That inferred performance ratings remained in the region of overall estimated project performance is an indication of some validity and internal consistency within the items of section B of the evaluative instrument, as sub-dimensions of overall project success.

Figure 7.2d: Comparison of inferred formal and informal outcome performance values with management team estimates

In terms of the qualitative responses recorded from discussion of human, organisational and quality dimensions of project performance (items B4-20), several issues were raised and causal influences identified. In consideration of item B4, several motivational influences and issues were raised affecting the degree to which the projects working environment was
considered 'stimulating' or 'motivating'. A range of factors that influenced commitment and persistence to achieve high standards of project work on the individual level were documented, representing personal views and a diversity of personality profiles within each project team. General opinions were expressed that projects of the 'proof of concept' type incorporated a high proportion of novel research activities that afforded individuals a level of autonomy that was itself stimulating and motivating. It was also commented upon that the research activity required considerable self-motivation and it may therefore be concluded that the nature of this work pre-selects certain personality types that respond well to these conditions.

Another factor identified as relating to the nature of the project work had the opposite effect, decreasing general motivation levels for some individuals. It was reported that in a research project environment, work groups tended to comprise a small number of functionally specialised individuals, each charged with executing sub-tasks with different technical focuses requiring differing skills and knowledge. Although unifying collaborative or common goals and objectives governed the specification of sub-tasks, it was largely individuals rather than teams that handled different aspects of the research project. The resulting experience of some project personnel was that the day-to-day working environment could at times be socially isolating. This phenomenon was independently reported within two of the three case projects studied, giving rise to the conclusion that whilst autonomous functioning is important for morale, there is a comfortable level of autonomy beyond which increasing levels give rise to a sense of over-independence, social isolation and negative affective states that influence personal well-being.

Other factors that influenced level of motivation included the degree of feedback information attainable, relevant to personal work products and activities, as a function of the collaborative environment that surrounds the project. It was commented that it was sometimes difficult to get industry sponsors, stakeholders and possible users "on-board" and involved, in order to provide access to environments in which prototype tools and methods could be applied and tested, and that this generally had a negative impact upon morale within the project work group. The effects of this factor were likened to "working in a vacuum", with a limited sense that goals and values within the project were shared by its collaborating partners.

Items B5 and B6 tested perceptions of the degree of beneficial formal training and positive informal experience received by project personnel through involvement within the project to quantify the level of human knowledge and competency gain as an outcome of the project. Responses encompassed conferences and safety courses mainly, with some structured personal development, but the point was made that as project work involved novel research, it was not possible to train specifically for the task, as the purpose of the research was to
develop new knowledge. The project work was described as "self-teaching", and as such was generally rated low in formal training (item B5) but high in positive personal experiences (item B6). As one individual stated: "Research tasks are non-repetitive, every phase is different with a multitude of different aspects involved, meaning that a wide breadth of personal experience is gained".

In considering the effectiveness of the work group climate and sense of productive collaboration that developed during project work (item B7), it was reported that general willingness to collaborate was high within the project team, but that only limited direct collaborative working on specific work activities took place due to the nature of the research task. In addition, reports of a lack of unification in overall goals within certain project work groups, representing a divergence in personal interests and perspectives that negatively influenced project performance, further contributed to lower than might be desirable scores. Accordingly, just above mid-range scores were recorded against this item.

In discussions of where knowledge was contributed by the project and the value of that knowledge, in consideration of item B8, a general consensus across all three projects was that knowledge gain had been a successful outcome of project work activities, with papers and publications benefiting associated academic institutions and proof of concept data benefiting industrial sponsors. Criteria that emerged for the estimation of the degree of work process improvement that had been performed during the course of the project (item B9) centred round recall of instances of adaptation in working and communication methods in areas that had been identified as needing improvement. These included planning processes for external communications made through conferences and journal publications, modifications to how the project was managed and frequency and format of technical review meetings designed to assess progress. For item B10 that assessed the degree to which the project was seen as exceeding formal requirements, criteria offered in support of ratings made included the level of innovation and flexibility in work processes and the extent to which developed tools could generalise and be applied outside of the domain in which they were originally intended. In the context of these discussions, ‘flexibility’ in working processes and project management was suggested as an additional outcome item for section B of the validation process, as it was not addressed directly by any of the other items.

It was commented upon during the course of section B of the validation process that considerable overlap existed between certain items within the evaluative instrument. Two such overlapping items were B11 ‘innovation’ and B13 ‘novelty’, the latter being largely a sub-item or contributing factor to the former. In consideration of these items, a common conclusion was that research is, by its nature, a creative process; the areas that are targeted for research being new and unpredictable, so research products are by definition ‘innovative’
In the sense that they are novel and experimental. Another possible area of overlap was highlighted in responses to item B12 'commitment and persistence', under which qualitative responses and criteria closely resembled responses given under item B4 which addressed motivational factors. Responses to item B12 were justified in terms of instances of committed, persistent work such as response to major setbacks, continued development and finding hypothetical 'workarounds' in the face of a lack of customer feedback. Coping with resource limitations including strained human resources and overloading resulting from time-pressure were also reported as key factors influencing commitment and persistence.

In response to item B13 regarding the level of novelty of the research product, general opinions were expressed that the 'proof of concept' or R&D nature of the projects meant that, by definition, the research products would rate highly in terms of novelty. This was largely found to be the case. It was pointed out that the objectives for the projects were derived from an identification of 'need' or gaps in existing knowledge that formed the targets of research effort. At project start-up, the outcome of the research effort was unknown and therefore must be considered 'novel'. Sub-factors or criteria raised in discussion of item B13 included the extent to which scoping analyses showed that hypothesised methods and tools had not been used before and assessment of how many other R&D organisations were working in the domain area. If the envisaged tools and development methods had not been used before, and few other R&D organisations were identified as working in the same area, the project focus and outcome was deemed to be 'novel'. Little or no objective criteria for the degree to which 'creativity' within the project work group contributed to the effectiveness of the work product was identified, however.

When considering the level of customer satisfaction reported for the project (item B14), the provision of continued funding was commonly cited as evidence of customer satisfaction. Qualitative criteria considered under item B15 supporting ratings of the extent to which the project could be considered to be 'world class' included number of accepted research publications, and invitations to present work, prestige of publications and conferences and breakthrough into foreign and world-renowned research consortiums. Ratings of the level of project management effectiveness (item B17) within the projects elicited several qualitative criteria to justify the scores given. Criteria included the level of subsequent changes to the project objectives following initial planning, and the effectiveness of identifying key research sponsors within the customer organisation. Where it was considered there existed room for improvement in project management effectiveness, areas to address included pressing for increased collaboration with project stakeholders and increasing the degree of integration between separate strands of work.
In response to qualitative item B18 'fulfilment of potential', only one of the three projects studied responded positively, stating that the diversification of project focus during the course of development had, in effect, allowed the project to deliver key knowledge in two areas, as opposed to the single area envisaged at the start of the project. The other two projects responded negatively, with reasons given including: work overload and high time pressure placed upon project leads, time taken for researchers upon the project to acquire the necessary background knowledge, lack of sponsorship and hampered access to information within the customer organisation, and changing targets during project phases leading to inability to objectively evaluate progress.

The last item in section B (item B20) asked respondents to give an overall estimate of the relative influence of soft, non-technical performance issues to hard, technical performance issues that had been experienced within the project. Figure 7.2e below depicts the proportional estimates given, which ranged from a slight bias (60%) to hard, technical issues to 75% dominance of soft issues. In an attempt to generalise across all three projects, an aggregated proportional influence was calculated and expressed as a percentage. Across the three case projects studied, on average 55% of the problem or performance issues experienced were considered to be 'soft' in origin, as opposed to 45% hard, technical issues. Examples of technical issues given in consideration of item B20 included integration of research product with existing technological tools and the nature of the technical research domain. An example of a clear, soft issue identified at this stage was lack of unification within the project work group. It was also commented that R&D efforts aimed at the development of process support tools, as was the case for each project studied, was likely to give rise to a strongly sociotechnical focus.

What was perhaps surprising about the responses given to item B20 was the approximately equal prominence given to human and organisational, or non-technical factors, in determining performance outcomes within the projects, in comparison with technical issues. At this stage in the validation process, it still remained to be seen as to whether or not an equal proportion of project management effort was aimed at assessment and monitoring of soft performance factors within the project. Key findings from the soft metrics literature review and exploration of existing methods would suggest that a lack of process and tool support for soft, human and organisational issues, in comparison with technical issues, would make this unlikely.
"In your opinion, what proportion of the project’s performance was influenced by ‘soft’, non-technical factors, relative to ‘hard’, technical factors?"

![Pie charts showing the influence of 'soft' and 'hard' factors](image)

**Figure 7.2e: Estimated relative impact of 'hard' and 'soft' issues on case project performance**

### 7.3 Validation results section C: Influence mapping exercise

Qualitative and quantitative data from section C of the validation process, which incorporated the influence mapping exercise based upon the HOP modelling framework, is reported in this section. Two sample influence maps from the actual validation exercise are reproduced within *appendix K* to illustrate participants' actual responses on the HOP model template provided during the exercise. The actual data collected against items within section C of the evaluative instrument is included within *appendix L*. Throughout the influence mapping activity, it was critical to capture the rationale and logic behind the performance links that were being made within the model by respondents. This qualitative information is presented below in explanation of the figures that depict the resulting causal chains and influence weightings that describe soft performance processes within the case projects. Where information gleaned from the evaluative process explicitly identified or could be reasonably associated with a specific performance factor from the sample set provided, the corresponding identification number will be included within the text for ease of reference. The full sample performance factors set complete with reference numbers may be found in *figure 5.1.1c* of this thesis.
The influence maps described below are structured according to critical performance preconditions identified within one or more of the case projects studied. Although identification of critical preconditions within each project for the purpose of calculating specific weightings for the resulting influences was limited to a maximum of six, during the free causal chaining elements of the exercise that allowed respondents to experiment with linking performance factors identified from the HOP model template to project performance outcomes, no such limit was imposed resulting in a multitude of factors being identified and commented upon.

Across all three case projects studied, a total of seven critical preconditions were quantitatively analysed in depth using the set items within section C of the evaluative instrument (see appendix I for evaluative instrument). The critical preconditions identified for this treatment were: P1.3 'Project complexity', P2.6.1 'Group knowledge, skills and abilities', P3.4 'Workload', P3.5.4 'Goal conflict', P4.1.2 'Collaborative culture', P4.2 'Stakeholder characteristics' and P4.8.5 'Accessibility of senior sponsors'. Of these critical preconditions, P2.6.1 'Group knowledge, skills and abilities' was identified by two projects as a critical factor in influencing performance outcomes within those particular scenarios. It should also be noted that factor P4.2 'Stakeholder characteristics' was identified at this higher level of abstraction to subsume all sub-factors, in particular: P4.2.1 'Stakeholder availability' and P4.2.2 'Stakeholder issue involvement'.

Figure 7.3a below depicts the full causal influence chain for precondition factor P1.3 'Project complexity', which may be described as the perceived complexity inherent in executing the overall project work task resulting in uncertainty in project planning and control. Project complexity, as a performance factor, was identified as influencing several project performance outcomes. Increased levels of project complexity were described as impacting negatively on the quantity of work produced (O1.4) and on schedule performance (O1.1). It was stated that high project complexity resulted in increased workload per hour and necessitated a generally higher level of intensity of work, to achieve the same level of productivity experienced on less complex projects. In contrast increased levels of complexity in the project work task had a facilitatory effect upon knowledge gain (H1) as an outcome of the project, in particular technical knowledge concerning the work product or system (H1.2), organisational knowledge (H1.3) and the knowledge and skills of individuals working on the project (H1.4).
In terms of the human performance mechanisms that mediated the relationship between project complexity and project outcome, three activities were identified upon which all specified outcomes were highly dependent. Innovation in task performance (A1.1.3) necessitated by complex and uncertain project processes resulted in high levels of knowledge output from project work activities, but was not considered to be a critical activity for schedule performance. Project complexity was also considered to affect two human decision-making processes: analysis (A1.4.2) and formulation of effective solutions (A1.4.3). These decision-making activities in turn impacted upon each of the specific project outcomes identified. The influence of complexity on decision making processes was described as resulting in continual re-analysis and shifting of understanding of key decision issues within the project.

In figure 7.3b below, the causal performance processes for the precondition P4.2 'Stakeholder characteristics' is depicted. For the particular case project scenario that identified this performance issue, it was considered necessary to subsume both P4.2.1 'Stakeholder availability' and P4.2.2 'Stakeholder involvement' within the same single category, as represented in the diagram by factor P4.2.
The availability and involvement in relevant project issues of key stakeholders was considered to have two primary influences upon dimensions of project success, namely schedule performance (O1.1) and the quality of the product achieved (O1.3). The nature of these influences was considered to be facilitatory in both cases; increased availability and involvement of stakeholders led to better schedule performance and enhanced product quality. This relationship was mediated by three human performance activities, including the coordination of project work tasks (A1.3), decision-making processes (A1.4) and the acquisition of evaluative information and feedback (A2.2.2). The ability to coordinate project work tasks effectively as a result of high stakeholder involvement was considered to enhance the quality of the end product and reduce the likelihood of schedule overruns. Stakeholder availability and involvement was also considered central to all decision processes executed within the project management team, contributing to more effective decisions as a result of increased information availability and more timely decisions. The importance of stakeholder availability to effective schedule performance was emphasised as a key contributor to project delays resulting from postponement of key decisions regarding problem issues that had arisen until key stakeholders were available. Finally, the importance of evaluative information and feedback provided by involved stakeholders for the project was stated as having a direct impact upon the quality of the end product.

The presence and level of P4.1.2 ‘Collaborative culture’ was identified as having an important influence on project performance, especially where close collaboration between project personnel and the customer organisation was required. The nature of the collaborative
culture present was linked to expectations for project work, and some minor cultural incompatibilities were reported between collaborating partners with respect to this issue. The influence map in figure 7.3c below illustrates the main sequence of influences involved, with two cultural outcomes implicated: H3.2 ‘Evolving norms’ for operational functioning and H3.3 ‘Trust’ between collaborative partners. In both cases, where the project was undertaken in the context of a collaborative climate for cooperative working, this had a positive influence upon the dissemination of shared norms for working practices and level of trust between organisational entities.

![Figure 7.3c: Influence of collaborative culture on human work and project performance outcomes](image)

The main mechanisms that were proposed to account for the effects of a collaborative culture on project outcomes involved several human activities including risk or crisis management (A2.1), the formulation of effective solutions to problems (A1.4.3), collaborative working (A1.2.8) and communication with project stakeholders (A1.2.1). In terms of trust between organisational entities as a desirable outcome of project operations, the experience of effective collaborative working, achievement of successful, mutual decisions and experience of extensive communications was regarded as important. These same activities also led to the establishment of shared norms and mental models between collaborating partners.

Two further critical preconditions: P4.8.5 accessibility of project sponsorship in senior management and P4.3 maturity of core engineering or process knowledge, were identified as important performance determinants which exerted their influence through people’s ability to
communicate effectively within and outside of the project. *Figures 7.3d* and *7.3e* below correspond to the influence of preconditions P4.8.5 and P4.3 respectively.

**Figure 7.3d: Influence of accessibility of senior sponsors on human work and project performance outcomes**

Increased accessibility of senior management sponsors was considered to have a facilitatory effect upon several project outcome variables, including: schedule performance (O1.1), product quality (O1.3), quantity of work produced (O1.4) and job satisfaction (H2.1). The relationship between accessibility of senior sponsors and the performance outcomes was mediated in each case by the effectiveness of communication activities, subsuming various sub-factors representing internal project communications between personnel within the project work group and external communications with project stakeholders and sponsors. Enhanced communication with senior sponsors was therefore considered to enhance the project's operational achievements and contributed to increased levels of satisfaction experienced by members of the project team.

The influence of precondition P4.3 core engineering or process knowledge (see *figure 7.3e* below) was primarily on knowledge outcomes and product quality, with a positive association in each case. Again, the relationship was mediated by communication activities (A1.2), highlighting the importance of shared mental models regarding systems and working practices for the ability to effectively communicate project issues and other relevant information within networks of project personnel and stakeholders.
Through influencing human communication processes, the level of core engineering and process knowledge that the project can draw upon was reported to have an effect upon project outcomes O1.3 'Product quality', H1.2 'Technical knowledge', H1.3 'Organisational knowledge', H1.4 the individual's knowledge and skills, and H1.1 development of work-process knowledge.

The final causal influence map is depicted in figure 7.3f below and focuses upon the impact and performance processes associated with the level of goal conflict within the project work group (P3.5.4). Four specific project outcome factors were linked to the level of goal conflict within the project work group, all negatively associated with increased goal conflict. Accordingly, decrements in product quality (O1.3), level of trust (H3.3), experienced job satisfaction (H2.1) and continued work group viability and cohesion (H2.5) were identified as likely outcomes. Effects upon job satisfaction were associated with motivational processes within the workgroup (A2.3), which were negatively influenced by the presence of conflicting goals and objectives. The negative impact of conflict upon the ability to motivate personnel was also reported as having a detrimental effect upon product quality, the general working climate and the likelihood that the work group would be able to function at optimal effectiveness in the future. The presence of goal conflict influenced communication processes (A1.2) and decision-making processes (A1.4) within the project work group, which in turn were linked to quality, trust and work group viability outcomes.
Quantitative sensitivity analysis of human performance processes within the projects yielded a multitude of data concerning the relative impact of critical project preconditions upon the human capacity to successfully engage in generic work activities. This impact was quantified as perceived influence, based upon experience within the project management environment, upon each of the following generic performance activities: task performance (A1.1), communication (A1.2), task coordination (A1.3), decision processes (A1.4), risk or crisis management (A2.1), performance control (A2.2), motivation and leadership (A2.3), training and group development (A2.4), work process improvement (A2.5) and change integration (A2.6). The influence rating in each case was made on a seven-point scale ranging from 0 (no influence) to 6 (high influence). The figures that follow (figures 7.3g to 7.3i, inclusive) illustrate the considered impact of each precondition identified within the case studies as critical to project performance upon human performance activities. Within the figures, the absence of a connecting arrow between preconditions and activities indicates a '0' or 'no reported influence' response, and implies that the two factors in question are not related.

Figure 7.3g below depicts the results from sensitivity analysis of the influence of preconditions P4.1.2 ‘Collaborative culture’, P4.2 ‘Stakeholder availability’ and involvement, and P4.8.5 ‘Accessibility of senior sponsors’, on human performance activities.
From the results it is apparent that in the case project scenarios studied, the level of collaborative culture present exerted the greatest influence upon communication and work process improvement activities. No specific influence was identified for task coordination, performance control or motivation and leadership activities, and only a moderate influence was reported upon the remaining activities. Stakeholder availability and involvement gave rise to five influences out of a possible ten, with high criticality scores for the relationships with performance control, decision processes, task coordination and communication. Accessibility of senior sponsors only influenced four of the human performance activities with the highest criticality rating achieved for communication activities.

Figure 7.3h below presents sensitivity analysis of preconditions P1.3 'Project complexity', P2.6.1 'Work group knowledge, skills and abilities', and P3.4 'Workload'. Responses here show that project complexity achieved the maximum criticality rating for its influence upon task performance and decision process activities with moderate scores for performance control and risk management. No association was reported between project complexity and motivational or training processes.
The level of project-relevant skills and knowledge within the project work group was rated as having the maximum possible impact upon people's ability to execute tasks effectively, with moderate to high influences upon communication and decision processes within the project. Other influence ratings were relatively low with no reported association with performance control activities. The level of workload experienced by project personnel was rated as maximally impacting upon task performance capability and also had a relatively large impact upon performance control activities. No influence was reported for the workload precondition upon training and group development activities.

The final sensitivity analysis diagram (figure 7.3i, below) depicts influence weightings for the second instance of precondition P2.6.1 'Work group knowledge skills and abilities', which occurred within analysis of performance processes within the case projects, as well as the influence of P3.5.4 'Goal conflict'. As in the previous instance, work group knowledge and skills was rated as highly critical to successful task performance and decision-making processes, giving an indication of some consistency in effect across two of the three case projects studied. The level of goal conflict within a project was rated as having a strong influence upon communication activities, decision processes and work process improvement, with little effect upon task performance or training and group development activities.
The data obtained in the sensitivity analysis performed in section C of the validation process may be employed to inform risk analysis activities within broader project planning and control activities. Application of the HOP modelling framework in this way allows project management to consider the impact of soft issues and human or organisational factors in scheduling and resource-allocation processes.

In the table in figure 7.3j below, the data obtained in the sensitivity analysis of the impact of critical preconditions on human performance activities is compiled against each of the ten generic activities within the model. The work activities within the table are ordered by the sum or overall strength of incoming influences identified within the case project scenarios, to prioritise which activities are likely to give rise to soft performance problem issues within the project (expressed as ‘dependency level’, within the table). The high priority work activities may therefore require additional resource support (i.e. allocation of additional time or additional human/technical/financial support) and should be flagged for close monitoring by project management and performance control processes. Each of the human work activities within the table is also assigned a number relating to the number of identified incoming influences from the sensitivity analysis reported above. This figure represents the extent of dependency of the specific work activity under consideration upon precondition and
contextual factors, and may be taken as an indicator of how complex any performance issues arising within that activity are likely to be in terms of causal origin.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Human performance activity</th>
<th>Dependency level</th>
<th>Number of dependencies</th>
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</thead>
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<tr>
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<td>7</td>
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<td>A1.2 Communication</td>
<td>30.3</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>A1.4 Decision processes</td>
<td>30.3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>A2.1 Risk/crisis management</td>
<td>20.6</td>
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</tr>
<tr>
<td>5</td>
<td>A2.2 Performance control</td>
<td>19.3</td>
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<td>6</td>
<td>A1.3 Task coordination</td>
<td>17.3</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>A2.3 Motivation and leadership</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>A2.6 Change integration</td>
<td>12.7</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>A2.5 Work process improvement</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>A2.4 Training and group development</td>
<td>10.3</td>
<td>4</td>
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*Figure 7.3j: High dependency human performance activities in case project scenarios*

As can be seen from the table, for the case project environments studied, the three human performance activities that are most dependent upon conditions within the project work environment are task performance, communication and decision processes, each with dependency levels in excess of 30 (out of a possible 48). These three activities also show high complexity in causal origin, with either 7 or 8 critical dependencies (out of a maximum of 8 possible dependent preconditions). Low priority human performance activities include those concerned with training or development, and work process improvement. In this manner, analysis of risk associated with likely soft human performance issues is achieved and the specific human activities associated with project work that are likely to be critically dependent upon conditions and contextual factors within the project work environment are identified.

Further risk analysis may be made to aid in project planning and control based upon data collected against items C1 and C2 of the evaluative instrument, for each critical precondition factor identified. This approach embodies a two-factor theory of risk based upon estimated criticality of project precondition for successful project performance (item C1) and estimated frequency of occurrence of issues associated with a precondition. Preconditions can therefore be spatially related to one another according to scores against these two dimensions in the framework provided in *figure 7.3k* below.
The four quadrants labelled A to D within figure 7.3k represent differing levels and types of risk associated with potential conditions in the project that are known to give rise to soft performance issues. Quadrant A represents high risk factors, which have the potential to exert a large influence upon project performance outcomes and which are likely to occur frequently. Quadrants B and C represent medium risk conditions, with quadrant B factors being high in potential impact, but low in likelihood of occurrence, and quadrant C factors being highly likely to occur, but low in potential impact. Quadrant D within the figure represents the lowest risk condition and performance issues associated with factors located here are both unlikely to occur very often and will have limited impact upon performance when they do occur.

As can be seen from figure 7.3k, the seven separate preconditions identified within the case projects studied are all located within or close to the high-risk quadrant A of the figure. This result is to be expected as respondents during the validation process were asked to identify the most performance-critical preconditions relevant to their project for sensitivity analysis. If project management were forced to address a pre-defined set of performance precondition factors in this way, the likely result would be a much more even distribution of precondition factors across the entire figure. The priority precondition factors can, however, still be...
identified within the figure, by comparing distance from the upper right corner of quadrant A; the shorter the distance, the greater the risk of performance issues within the project associated with the precondition. Accordingly, priority order assigned to the preconditions identified within the case studies is as follows: 1) P4.2 'Stakeholder availability and involvement', 2) P2.6.1 'Work group knowledge, skills and abilities', 3) P1.3 'Project complexity', 4) P3.4 'Workload', 5) P4.8.5 'Accessibility of senior sponsors', 6) P3.5.4 'Goal conflict', and 7) P4.1.2 'Collaborative culture'.

Finally, although time constraints during the validation process meant that only a limited number of performance factors could be identified and undergo in-depth sensitivity analysis, the influence mapping exercise yielded a wealth of qualitative information, which was recorded by the researcher, during discussions elicited by consideration of potential performance processes within the HOP model template. This information was later analysed for themes and relationships to specific factors within the sample performance factors set, in order to gain an indication of how comprehensive the generic model was and how applicable its factors were to the specific case scenarios studied. Figure 7.31 below presents the complete performance factors set, with factors that were identified either directly or indirectly during the case studies as performance influences highlighted in red. As can be seen from the figure, approximately three quarters of the factors specified (71 of 109 possible factors; 77%) may be considered relevant and applicable to the specific case scenarios encountered. On the basis of this result, the nature and focus of the performance factors specified within the HOP model may be regarded as relevant to the application domain for which it was intended, and contains sufficient redundancy to usefully accommodate a broad range of soft issues that may occur in potential project scenarios encountered.
### Project Preconditions (P)

<table>
<thead>
<tr>
<th>P1 Project profile</th>
<th>P1.1 Size</th>
<th>P1.2 Type</th>
<th>P1.3 Complexity</th>
<th>P1.4 Scope</th>
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<table>
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<tr>
<th>P2 Project work group characteristics</th>
<th>P2.1 Group size</th>
<th>P2.2 Collaborative history</th>
<th>P2.3 Group working climate</th>
<th>P2.4 Group morale</th>
<th>P2.5 Group working processes</th>
<th>P2.6 Group composition factors</th>
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<td>P2.6.1 Knowledge/skills/experience</td>
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<td>P2.6.2 Location</td>
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<td>P2.6.3 Functional origin</td>
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<td>P2.6.4 Motivation level</td>
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<table>
<thead>
<tr>
<th>P3 Project work organisation characteristics</th>
<th>P3.1 Role/responsibilities clarity</th>
<th>P3.2 Workgroup autonomy</th>
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<tbody>
<tr>
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<td>P3.3 Task characteristics</td>
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<td>P3.3.5 Task size</td>
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<td>P3.3.6 Task significance</td>
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<td>P3.3.7 Task complexity</td>
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<td>P3.3.8 Task variety</td>
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<td></td>
<td>P3.3.9 Inherent feedback</td>
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<td></td>
<td>P3.3.10 Inherent autonomy</td>
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<td>P3.5.1 Adequacy</td>
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<td>P4.1.5 Support for change</td>
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<td>P4.1.6 Attitude towards innovation</td>
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<td>P4.1.7 Communication barriers</td>
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<td>P4.1.8 Functional barriers</td>
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<td>P4.1.9 Shared mental models</td>
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<td></td>
<td>P4.1.10 Social climate/supply for networking</td>
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<td></td>
<td>P4.1.11 Intergroup climate</td>
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<th>P4.2 Stakeholder characteristics</th>
<th>P4.2.1 Availability</th>
<th>P4.2.2 Issue involvement</th>
<th>P4.2.3 Position/authority</th>
<th>P4.2.4 Criticality</th>
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<table>
<thead>
<tr>
<th>P4.3 Core engineering/process knowledge</th>
<th>P4.3.1 Formal policies/operating procedures</th>
<th>P4.3.2 Established working methods/best practices</th>
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</table>

<table>
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<tr>
<th>P4.4 Staff development and training</th>
<th>P4.5 Reward and recognition/performance appraisal</th>
<th>P4.6 Information technology adequacy</th>
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<td>P4.7 Resource provision</td>
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<td>P4.7.3 Human</td>
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<table>
<thead>
<tr>
<th>P4.8 Organisational structure/authority</th>
<th>P4.8.1 Hierarchical distance/proximity</th>
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<tr>
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<td>P4.8.3 Empowerment/devolution of decision-making</td>
<td>P4.8.4 Autonomy allocated to project workgroup</td>
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<td>P4.8.5 Accessibility of senior sponsors</td>
<td>P4.8.6 Formal structure</td>
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### Human performance activities (A)

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<td>A1.1.3 Innovation</td>
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<td>A1.2.7 Reporting (written)</td>
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<td>A1.2.8 Collaborative working</td>
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<td>A1.4.2 Analysis/Generation of alternatives</td>
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<td>A2.5 Work process improvement</td>
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<td>A2.6 Change integration</td>
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### Human and organisational outcomes (H)

<table>
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<th>H1 New knowledge</th>
<th>H1.1 Work processes/best practices</th>
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<td>H2.5 Work group viability/cohesion</td>
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### Project level outcomes (O)

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<th>O1.1 Schedule performance</th>
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<td>O1.2 Budget performance</td>
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<td>O1.4 Work quantity</td>
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**Figure 7.31: HOP model performance factors implicated through qualitative analysis of systems engineering project case studies**

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7.4 Validation results section D: Sample metrics

The results for items within section D of the validation process are recursive in nature; applied to each soft metric that was presented to respondents in order to illustrate how key critical precondition variables identified in the preceding section for each case project could be quantified in actual project operations. In total, seven specific soft metrics and associated measurement methods were outlined to participants across all three case projects. The critical preconditions with which these measures were associated included: P1.3 ‘Project complexity’, P2.6.1 ‘Knowledge, skills and experience’, P3.4 ‘Workload’, P4.1.2 ‘Collaborative culture’, P4.2 ‘Stakeholder availability and involvement’, P4.8.5 ‘Accessibility of senior sponsors’, P4.1.1 ‘Trust between organisational entities’.

In order to measure the level of project complexity, the project uncertainty profile scale (see metrics inventory in appendix H; sub-factor P1.3) was implemented, comprising detailed descriptions of four ascending levels or types of uncertainty present within a project. Participants then rate the degree to which each class of uncertainty is present within their project based upon the descriptions provided. For knowledge, skills and experience within the project work group, the task specific skills and knowledge measures (sub-factor P2.6.1) were applied, comprising a technique based upon weighted averages which allowed project management to prioritise specific skill or knowledge areas in their selection of individual project work group members, in addition to various scales for quantifying adequacy, depth and redundancy of knowledge within the work group. Workload was assessed using a simple equation (sub-factor P3.4), which divided time required for a specific task by time available. The resulting index indicated acceptable workload where the value achieved was above 1, and increasing levels of unacceptable workload present where values fell increasingly below 1.

The collaborative culture variable was operationalised in a measure that employed several sub-items against which project managers and relevant personnel could rate the presence or absence of specific sub-factors presumed to be effective indicators the degree to which a collaborative culture existed within the project environment (sub-factor P4.1.2). The measure implemented to quantify trust between organisational entities (sub-factor P4.1.1) was also of this type. The measure of stakeholder availability and issue involvement outlined to respondents during the validation process (sub-factor P4.2) included a list of parameters that could be quantified based upon presence of stakeholders in key project communications, coverage of key project issues within stakeholder group and perceived degree of shared values or interests relative to project objectives. Accessibility of senior sponsors (sub-factor P4.8.5) was assessed by comparison of time available of target sponsor against time requested by project team and subjective assessment of quality or adequacy of involvement.
Only item D1 of section D in the evaluative instrument was quantitative in nature and asked respondents to rate the effectiveness of each measure presented. Figure 7.4a below presents the aggregated results across all three case projects against each of the measures that were suggested to project personnel as suitable for quantifying the critical preconditions in question. As can be seen from the figure, the most favourable effectiveness ratings were achieved for work group knowledge, workload, stakeholder availability and accessibility of senior sponsors metrics, which each scored 8 out of a possible 10. The project complexity measure also scored highly (7/10). Effectiveness scores against the metrics proposed for collaborative culture and trust between organisational entities achieved only mid-range scores.

![Figure 7.4a: Effectiveness ratings of specific soft metrics in project case scenarios](image)

Scoring of the effectiveness of the project complexity scale was generally high (7/10) and respondents stated that level of uncertainty was a valid indicator of the presence of complexity within the project. It was commented that the case project in question did indeed exhibit uncertainty of more than one type according to the classification within the scale and that high technological variation and changing objectives as the project developed meant that there was some risk associated with uncertainty, and that the scale provided a useful indicator for risk analysis purposes. It was also considered that had the overall method embodied in the metric included clearer control and remedial strategies, the effectiveness ratings achieved would have been even higher.
In response to items D2 to D4, which considered the feasibility and benefits of using the measure, as well as where in the project lifecycle the metric could be applied, respondents unanimously reported that had it been available they would have used the complexity measure in practice. Application early in the project lifecycle was reported as being envisaged as useful to predict complex aspects in advance, although it was acknowledged that the case project currently had the benefit of hindsight in rating uncertainty in project management and control processes. It was generally considered important to apply the measure to assess the impact of and in response to changes in project conditions. Other respondents viewed the measure as applicable during early planning and at project reviews, and predicted the measure's usefulness in supporting prediction of schedule parameters for the project work plan, highlighting this metric as a possible indicator of schedule performance. In terms of potential benefits, the measure was considered important in understanding the need for certain review sessions and would have contributed to the accurate assessment of risk associated with project complexity. Specific applications reported included in project applications for resources and as evidence of problem issues arising in the project at reviews. The applicability of the measure was considered to be dependent upon project size and respondents considered it even more applicable in large-scale projects with large, complicated work breakdown structures.

The metric proposed to quantify task relevant knowledge, skills and experience achieved a high rating (8/10) in terms of its foreseen effectiveness in application. In terms of qualitative comments elicited by this measure, it was considered adequate in content for assessing existing knowledge, but lacked content concerning assessment of individual's ability to develop new knowledge, as was normally achieved during the interview process for candidates. For research and development projects, this characteristic was considered important. Despite this shortcoming, respondents largely considered the measure useful and would have employed it at project planning phases, as no other more adequate measures could be identified. The measure could also have been used in response to problem issues arising within the project as a result of a knowledge gap and in human resource planning, particularly in response to changes in the human resource configuration. It was considered that the measure may have facilitated the formulation of staff succession strategies and would decrease risk associated with loss of key staff within the project, through monitoring the knowledge available to the project work effort throughout the lifecycle.

The workload measure was also considered highly effective (8/10) and respondents within one of the case projects reported using a similar technique routinely to quantify workload. The metric was reported as applicable to project and resource planning phases, and would have been useful to detect the human impact of changes in the project environment that occurred due to resource availability. It was pointed out that this measure could be related to
assessments of skill adequacy, as workload and knowledge adequacy were related: low knowledge adequacy resulting in higher workload. To the extent that the measure does not specify direct links to knowledge adequacy assessment, this may be considered to be a limitation of the metric. In terms of the benefits of using this measure, it was reported that measuring workload made it easier to predict human resource problems within the project, but that workload as a performance factor was difficult to control. Two possible responses to application of the measure in the case project environment were reported, including: identification of necessity to revise the work plan when workload levels reached impractical proportions, and data gathered could have been used to support negotiation of schedule parameters with the project customer.

The collaborative culture measure scored a mid-range 5 out of 10, in terms of envisaged effectiveness. The content of the sub-factors and individual items was considered to be strong in some areas and weaker in others, particularly regarding the assessment of compatibility in performance expectations between collaborating partners. The measure was considered applicable at project onset and in retrospective application, to look back over project history. As with the complexity measure, this metric was considered to be dependent upon project scale and hence more applicable in larger projects with multiple collaborating partners.

Both the accessibility of senior sponsors and stakeholder availability and involvement metrics were rated as highly useful (8/10), and respondents reported that they would have used both measures had they been available to their projects. The metrics could have been applied at project onset to assess the adequacy of the stakeholder communications plan and senior management sponsorship, or in response to communication issues that arose during the course of the project. Potential benefits from using the measures included application at periodic reviews to assess the ongoing adequacy of stakeholder and senior management input for key project issues and it was thought that tracking data associated with the measures would ensure project interests were represented and sponsored throughout the course of the project at varying levels within the organisation.

The measure of trust between organisational entities received the lowest overall score in terms of predicted effectiveness (4/10). Respondents commented that the measure on a whole was useful in raising an issue that wasn't normally assessed directly, but that in the absence of historical evidence of past collaborations it was difficult to objectively assess the degree of trust present between organisational entities. One criticism levelled at the measure was that its sub-factors seemed to exclude contextual factors such as high workload and unclear role definitions that might erode openness and trust between collaborating entities. In terms of application, reservations were expressed as to the practicality of the measure due to
its subjective status, although it was acknowledged that trust as a performance factor was very dynamic and a product of social context. It was reported that the measure could have been applied at project onset and in response to collaboration problems that arose, but would probably be more suited to very large-scale enterprises in which many organisations collaborated. Limited benefits were reported for this measure, including the ability to analyse projects retrospectively by comparing data gathered at project onset and project close, and the possibility of establishing the potential for resulting communication conflicts early on in the project as a result of trust and information disclosure issues.

7.5 Validation results section E: Overall evaluation

Section E of the validation process elicited qualitative and quantitative data concerning the overall usefulness of the soft metrics tool: the HOP modelling framework, sample performance factors, soft metrics and application process. Section E also incorporated items designed to assess the suitability of the methodology and resources employed during the validation process itself. The evaluative items used during section E of the validation process are reproduced within appendix I of this thesis and the actual data collected during section E may be found in appendix L.

A summary of the combined results across all case projects for section E of the validation process is presented below in figure 7.5a. As can be seen from the figure, the majority of scores for items E1-4, which assessed various dimensions of usefulness for the soft metrics tool, were in the region of 7 out of a possible 10. Item E1 case specific usefulness scored 7.1, item E2 scope and comprehensiveness scored 6.9 and item E4 overall effectiveness also scored 6.9, with the score for practicality and feasibility (item E3) falling to 5.7. Within items E5-8, which addressed the adequacy of the methodology, high scores were achieved for item E5 communication of aims (8.6), item E6 plan clarity (8) and item E8 detail level (8). Accessibility of language and terminology used (item E7) was rated slightly lower with a score of 6.9.

Qualitative responses to item E1 were positive, with several respondents commenting that the exercise uncovered issues within their projects that weren't normally addressed during conventional project review processes. The exercise was generally considered useful in its ability to provoke discussion regarding soft performance issues and in providing a structured approach to uncovering performance processes that weren't normally "out in the open", within the project management environment. In terms of the scope and comprehensiveness of the soft metrics tool (item E2), comments included recognition of the fact that specifying a set of performance factors that could be applied to all possible projects was a difficult task, but
generally the human and organisational factors included within the sample performance factors list was comprehensive and accounted for a broad range of conceivable soft issues. The actual definitions employed within the performance factors list was highlighted as a potential problem area, conceivably provoking disagreement over exact description of specific factors, but it was acknowledged that in this case the sample factors specified did provide a useful frame of reference.

![Evaluative ratings of integrated soft metrics tool and application process](image)

**Figure 7.5a: Evaluative ratings of integrated soft metrics tool and application process**

Item E3 practicality and feasibility elicited the lowest ratings of all the items within section E of the validation process, but still achieved above mid-point scores. The time-intensive nature of the soft factors analysis and influence mapping activities were highlighted as a determining factor here. It was commented that the current business environment considered project management activities “operational overheads”, and as such the additional work involved in incorporating processes to analyse soft factors may be viewed unfavourably. As an early pilot process for analysing important performance factors within project environments and exploring critical influences, however, the exercise was considered useful and effective. It was also considered that the inclusion of clear decision-making and improvement processes linked to the activities in the analysis process would increase the feasibility of introducing the proposed solution into applied project management practices.

In consideration of overall effectiveness, respondents were prompted to consider both the practicality and potential benefits of the approach in combination before making their responses. Despite the time intensive nature of the process in its current form, responses to item E4 of the evaluative instrument were relatively high, due largely to consideration of the
potential benefits of a tool that supported analysis and measurement of soft issues within operational projects. Some respondents "weren't entirely convinced", but acknowledged that the process and outcome was "interesting" from a project management perspective. Others stated that the process had the potential to lead to "great improvements", once it had been properly integrated within the project lifecycle. In considering the benefits of the approach, under item E4, the general consensus was that the approach was progressive in that it provided a structured process for the analysis and measurement of broad soft issues inherent in operational project environments, reducing the reliance upon "heated debate of specific issues" to address less visible and objective performance parameters.

In terms of the adequacy of the methodology employed during the validation exercise, as tested by items E5-E6, favourable results were achieved for most measures. The communication of aims (item E5) was considered well explained and clear, with an effective discussion of issues relevant to soft factors and the HOP model. In terms of the clarity of the plan (item E6), it was acknowledged that the activities formed a complex process but overall the purpose and content of each step was clear. The limited time allocated to each activity was highlighted as a potential problem issue and it was suggested that this problem could be further alleviated by the distribution of more documentation and preparatory material prior to undertaking the actual exercises. Overall, the language and terminology (item E7) used within the process and associated materials was considered clear, well explained and appropriate for a project management level audience and the level of detail (item E8) was considered adequate.
Section 8
DISCUSSION OF KEY RESEARCH FINDINGS AND ISSUES

This section includes detailed consideration of conclusions drawn during the course of the soft metrics research project, relevant to development and evaluation of the proposed soft metrics tools and approach outlined in this thesis. Research findings are discussed in the context of the research objectives identified in section 2.4 of this thesis. Analysis of the results of the validation process is included within section 7 of the thesis and the sections that follow below discuss broad development issues and draw together research findings that emerged throughout the course of the soft metrics project.

Consideration is first given to the outcome of the research effort in terms of the original assumptions and values inherent in the engineering project management culture encountered within BAE SYSTEMS, which influenced the original project brief. The following topic areas representing development issues for soft performance measurement systems arising from the outcome of the research effort are then discussed in depth: definition and classification of soft factors, human outcomes of work systems, modelling soft performance processes and measuring human and organisational factors. This section culminates in discussion of the feasibility and utility of the developed metrics tool and modelling framework for application in the industrial context based upon research findings, before key research conclusions from this project and implications for future work are summarised in section 9.

8.1 Development of research assumptions

As a preamble to detailed consideration of development issues for soft performance measurement systems in light of the findings of the soft metrics research, this current section will address broad issues concerning the development of perspective on the soft metrics research problem from the original conception and assumptions of an engineering project management culture. Departure from the original conceptualisation of the research problem, as inevitably occurs in response to new experience and enhanced understanding of the
problem gained as the research progressed, impacted upon the course the research work took and the eventual form of the research output.

As has been outlined in an earlier section of this thesis (section 2), the terminology and culturally-determined assumptions of the industrial context for this research work have had a profound influence upon this human factors enquiry, through definition of the project's principal focus and imposition of certain industrial requirements upon what might otherwise have been a wholly academic piece of research employing methods more traditional in the human sciences domain. The industrial requirement to validate the developed approach in terms of applicability in systems engineering project operations is one such important influence that shaped the final phases of the research plan. More importantly, however, as the research progressed it became necessary to move away from a solely ‘engineering metrics’ based solution to one that relied upon an analytical, model-driven approach to act as an integrative high-level framework for lower-level measurement efforts.

In terms of the objectives for the research project, the term "soft metrics" is itself born of an engineering project management mindset that embodies a number of assumptions concerning the inherent ‘definability’ and ‘measurability’ of soft factors that might form a bounded and clearly understood set of project parameters for repeated measurement at performance reviews. Issues raised through the experience of attempting to develop such a metrics program, as discussed in depth in the following sections, highlights the limitations of a conventional ‘engineering management metrics’ approach to the issue of controlling human performance in organisational systems. The broadening of scope of the soft metrics research project that occurred gradually through refinement of the objectives for the metrics work to encompass a framework or model-driven approach to performance analysis, in addition to defining ‘metrics’, reflects this departure from the original assumptions regarding the project. Some incompatibility between the aims of defining a finite set of simple, repeatable data items to provide process indicators of the likely outcome of human work, for the ‘soft factors’ identified in this research work, is also evident from the complexity of many of the ‘soft metrics’ developed. In view of the evolution of assumptions inherent in the original soft metrics project definition, the research appropriately sought to develop a more constructive approach to soft performance issues in providing an analytical process and tools for investigation of ‘soft issues’ within project work groups and selection of appropriate measures based upon the output of this process, rather than application of a limited and prescriptive metrics set that is in danger of addressing soft performance issues on a superficial level.
8.2 Definition and classification of soft performance factors

The sheer volume of separate constructs that have been proposed in relevant literatures as human and organisational performance determinants indicates high complexity in antecedent process factors and conditions that may conspire to affect human system output. Experience within conceptual modelling of performance processes undertaken during the course of the soft metrics research project suggests that complexity in sociotechnical factors not only challenges the researcher to establish the exact nature of what are highly interactive processes, but also hampers clear definition and conceptualisation of factors that may be classed according to varying taxonomies. Accordingly, the operational definition of 'soft' human and organisational factors employed in this project encompasses several conceivable classes of variables, according to perspective and purpose of classification. Examples of non-mutually exclusive classes that describe the range of soft factors considered within this project alone included: individual-level factors that vary at the personal level, team or unit level characteristics that describe social groups, organisational-level characteristics, external environmental characteristics, controlled and uncontrolled or contextual variables, objectively determinable criteria and subjective perception-based factors, tangible and intangible factors, result/dependent or determinant/independent variables, activities and behavioural variables as opposed to 'state' variables, and system 'preconditions'.

In terms of defining the focus and purpose of the project performance factors that a soft metrics system must address, the soft metrics research effort implicates 'process' variables as opposed to 'outcome' variables in purpose and 'human and organisational' factors as opposed to 'technical' factors in focus. Review of relevant literature reveals that complexity in systems engineering products, the work processes that are implemented to achieve them and the broader organisational environment means that the challenge for performance measurement systems lies in the provision of proactive process measures that indicate the 'health' of work systems at intermediary periods in the work-flow, rather than retrospective outcome measures of characteristics of the work product. Application of the HOP modelling framework to analyse performance influences in operational systems engineering projects shows that human and organisational variables, including knowledge-based assets and so-called 'intangibles', represent an important sub-class of these 'upstream' performance determinants, the effects of which need to be better understood to support enhanced organisational effectiveness and improve the quality of work processes.

In answer to requirement 1a: 'define possible human and organisational performance factors and key mechanisms of influence', this research project has identified a number of specific human and organisational factors (reported in section 3.3) that research literature links to dimensions of operational performance and organisational effectiveness, including: team
composition, human knowledge and experience, work group climate and cohesion, leadership, level of functional autonomy, task and goal characteristics, workload, conflict, motivation, communication, and decision-making processes, amongst others. In terms of specifying outcome factors that represent key performance dimensions or success criteria from the operational viewpoint, characteristics related to delivery of the product, such as cost, time and quality were identified as the dependent variables of interest. Research literature derived performance factors were complemented and refined according to findings from an industry scoping study (reported in section 4.1 of this thesis) and three validating case studies (reported in section 7) for the emerging soft metrics tool and approach. These applied studies contribute the practical evidence for the relevance of the human and organisational performance factors that define the focus of this thesis, in response to requirement 1b to 'investigate the presence and impact of human and organisational factors in operational industrial projects'.

Within the specific project management environment reported in the scoping study, the project management team highlighted the potential impact of 'soft' factors such as trust between organisational entities, stakeholder communication and availability, the organisational and inter-group environment, the level of autonomy assigned to management teams, team composition and cohesion, and human motivation, on the overall performance of the project and its ability to achieve specific cost, time and quality-related commitments. The projects in the validation studies commented upon the influence of many human and organisational factors upon overall performance and selected several for in-depth analysis according to their considered prominence, including: the complexity inherent in the project, work group knowledge and skills, individually experienced workload, goal conflict, collaborative culture, stakeholder characteristics and accessibility of senior management sponsors. A key finding from the project case studies used to validate the soft metrics tool was that over half of the performance issues project management encountered in executing the projects were related to soft, non-technical as opposed to technical factors. This finding echoes that of Dinsmore (1990), who reports a similar proportion of project performance issues that are attributable to 'behavioural', people factors. An important conclusion from this research project is therefore that 'soft issues' is a valid topic for project performance management efforts and that knowledge of the potential impacts of softer issues upon project performance is available to research which provides a structured approach to eliciting knowledge from experienced project managers and personnel.

The preconditions identified within the case projects outlined above were found to influence all operational success criteria for the project and a variety of 'softer' outcomes, including: job satisfaction, trust, work group viability and cohesion, knowledge contribution, evolved working practices and team capabilities. The performance processes characterised by the causal
sequences identified between these critical preconditions and outcome factors were found to represent 'soft' performance issues within the projects studied, as was evident from the impact of project conditions upon several aspects of human functioning within the project work environment, including predominantly: task performance, decision processes and communication, to identify the most commonly occurring behavioural factors. In view of these findings, it must be concluded that the soft metrics research project was successful in identifying soft performance factors and their potential influences upon project success within the four applied industrial scenarios studied.

As this project dealt with 'human systems', the variables identified during its course represented factors that operate across all levels of an organisation, including human characteristics, group level characteristics and organisational level characteristics. Motivation level, for example, may be a personality-determined factor that is experienced by the individual. It may also be considered to be a characteristic of a work group or organisational unit (i.e. general morale). Knowledge and skills may also be treated in the same way, as traits inherent at the individual level or as an aggregated skills profile that describes a work group, or even networked knowledge and core human competencies at the organisation-wide level. The key issue in the development of a practical representational framework within which to classify potential performance factors is the issue of control and boundaries. The identified users for the output of this work, 'project managers', require the ability to navigate through the soft performance factors set and identify specific aspects of the project environment and characteristics of the project work group for manipulation in order to practically support process improvement. Accordingly, in specification and classification of the performance factors set which fed into the development of the HOP modelling framework, the boundary representing the 'system of interest' was established as the 'project', with system output being that of the 'project management team'.

Having established this guiding knowledge from an early scoping study of industrial operations, the performance factors identified from the literature review and applied studies are classifiable according to boundary and control issues. In this sense, 'preconditions' represent system state, both within and surrounding the project sub-organisation, with the 'project' preconditions including characteristics of the work group and the way the project work was organised being, in theory, available for manipulation in order to achieve facilitatory performance effects. 'Outcomes' represent criteria for detection of the expected results of this manipulation within the project organisation, and 'human performance activities' represent behavioural factors that describe the actual functioning of people at work in the industrial project environment. The soft metrics research study therefore shows that providing a structured framework for classification of key performance variables is an important step in achieving proactive control of soft systems to support performance improvement efforts.
Through conceptual classification, performance control activities can identify important systemic factors at project planning phases and relate them to potential effects upon human functioning that will impact upon execution of the project plan.

8.3 Human outcomes of functioning in work systems

The CAP1 industry scoping study reported in section 4.1 of this thesis revealed that central to the interests of engineering organisations is the core knowledge of how to manage technical issues and technical dependencies in operations activities. This need arises from the high level of complexity in systems engineering products and demands high levels of technical competency. The ability to integrate across functional boundaries in order to fulfil complex technical and functional requirements is, however, a ‘soft’ organisational issue that demands competency in the management and execution of work processes. The characteristics of work processes and other contextual factors influence how effectively humans can function within their work environment. From a soft systems perspective, it is the effectiveness of this human functioning within the work process that is partly responsible for technical achievement in the qualities of the project work products.

A key conclusion that may be drawn from experiences within the soft metrics research project is the need for broader outcome or success criteria for the evaluation of effectiveness in work group-based functioning, that expands the scope of performance measurement beyond formal cost, quality and time dimensions to encompass ‘softer’ outcomes that represent human capability development. From reviewing variables classed as ‘outcomes’, in a number of models, it becomes apparent that any attempt to measure and manage human and organisational factors influencing performance must not consider the productive output dimensions related to cost, quality and time in isolation. Recent research into workgroup performance factors, for example, tends to employ a broader definition of ‘effectiveness’ in the consideration of outcomes from work group functioning (e.g. Guzzo and Dickson, 1996; Unsworth and West, 2000). A work group’s effectiveness may be indicated by team-produced outcomes, the consequences a work group has for its members or the enhancement of a work group’s capability to perform effectively in the future. Brodbeck (1996) distinguishes a sub-class of performance outcome: ‘productive output’, and also includes ‘social criteria’ such as willingness to work together and ‘personal criteria’ such as group member personal development. Investigation of soft performance issues arising in the case projects studied within this current research supports the need for inclusion of ‘softer’ performance outcome criteria in performance measurement systems, as is implied by these authors.
Other authors have emphasised task completion as the sole or dominant indicator of work group effectiveness, being the most important outcome of employing group-working practices from the organisation's perspective. This approach, however, represents a predominantly 'top-down' oriented view, in which work groups are largely dehumanised sub-units of an organisation, with the sole purpose of serving predefined organisational or customer-focused goals. It ignores the view that organisational systems are comprised of human elements and that organisational effectiveness is in part a function of the capability that exists within the human system, and that this capability develops in practice with the acquisition of new skills, knowledge and experiences on both the group and individual level.

The task-oriented approach to success criteria ignores the fact that work groups rely upon human interactive processes that can influence and are themselves influenced by the outcomes of work group functioning. This is evident from the successful application of the HOP modelling framework to analyse soft issues in operational projects and the finding that outcomes such as new knowledge, work group cohesion and cultural norms were regarded as important performance factors. Social interactive factors such as intra-group conflict was found to facilitate the creation of valued work group output, or may result in the breakdown of group cohesion and subsequent loss of productivity. The findings from this research study therefore lend support to the work of authors such as Tannenbaum, Salas and Cannon-Bowers (1996), who not only define work group effectiveness in terms of how well the team accomplishes its goal or mission (usually in terms of the quantity and quality of productive output), but also in terms of its ability to develop and regenerate itself, allowing it to sustain its performance and accomplish its mission over a period of time. Considering human-related output from functioning in organisational systems, such as new knowledge, evolving working practices and cultural norms therefore adds an important temporal dimension to effectiveness criteria, in that it emphasises longevity or continued high-performance functioning as a key effectiveness variable and indicator of human capability within the organisation.

8.4 Modelling human and organisational performance processes

In response to research requirements 2a: 'identify and evaluate suitable performance models' and 3b: 'develop an appropriate performance modelling framework for projects', a number of relevant performance models were identified (outlined in section 3.2) and conceptual modelling efforts were undertaken culminating in the development of an applied human and organisational performance model (outlined in section 5.1.1 of this thesis). Subsequent validation case studies have shown that the modelling framework was applicable in the case projects of interest and successfully elicited performance-critical information regarding human and organisational processes within each operational project. Several research findings and
development issues drawn from activities within the soft metrics research project may be used
to support modelling efforts that address human and organisational performance processes
and validate the utility of capabilities inherent within the HOP modelling framework.

From review of currently available performance models it becomes apparent that any model
or integrative framework that seeks to adequately represent performance processes must
complement outcome criteria with 'upstream' or process factors that represent system
characteristics and functioning. In order for a performance model to be maximally useful in
application it requires: 1) factors specified in detail, 2) specific interactions that represent
mechanisms of influence, and 3) quantitative weightings for comparative analysis of the
impact of specific factors. The HOP modelling framework and application process reported in
this thesis embodies all of these functional attributes and as such may be considered to be
theoretically valid. As the application of the model to represent work group performance
processes shows (see section 4.3), the model and classificatory framework is applicable to
soft factors identifiable from research-based studies. Subsequent application of the HOP
modelling framework demonstrates that through this approach important sociotechnical
system preconditions could be linked to key aspects of human functioning that represent the
contribution of human factors to operational performance.

From evaluation of the key limitations of currently available human and organisational
performance models, an important conclusion for the practical application of performance
models is their inability to depict specific links between determinant process factors and
specific operational outcome criteria. This is a practical draw-back in terms of the applicability
of human and organisational performance models in actual operations to diagnose and
identify specific antecedent factors for attention when, for example, a decrement in schedule
performance, or increased human error is observed in the work product. Two possible
reasons are plausible for this observed trait in human and organisational performance
models. The specific interactions between factors are likely to be very situation-dependent,
and as 'generic' representations a certain level of abstraction across specific instances is
necessary to develop a broadly applicable model, with an associated loss of descriptive detail.
Secondly, the centrality of human system characteristics to all work processes may mean that
they do indeed have a general non-specific effect upon all work product-related outcomes.

Accordingly, the soft metrics research undertaken within this project highlights the validity of
the second explanation: that human and organisational processes exert a pervasive influence
upon all operational activities that are carried out by people in the work setting. This general
conclusion is apparent from the high level of influences found to impact upon operational
effectiveness criteria both in the developed conceptual human and organisational
performance model and in the applied models that represent specific project cases. Analysis
of specific performance processes within operational projects undertaken within the soft metrics validation studies, however, reinforces a fundamental assertion that it is important to analyse the differential influences of specific human or organisational factors, in order to determine the relative strength of influences, scope of influences and nature or direction of effect, upon operational performance criteria.

Whilst in other work-related areas of research such as work psychology and social sciences, dependent outcome factors such as job-satisfaction, work-related stress, cultural norms and knowledge may be considered the object of causal modelling efforts, the applied nature of operational process research means that systems models may be streamlined to represent interactive processes that contribute to variance in performance outcome or effectiveness criteria only. In this sense imposing a purpose upon a model in accordance with improvement objectives can constrain the level of complexity that needs to be represented within the model, by representing only those factors and influences that are associated with the targeted outcomes. Issues raised during the course of development of the HOP modelling framework, however, show that soft systems factors and other parameters that demonstrate high interdependency and interactive complexity do not prove so amenable to outcome-defined bottlenecks.

Within performance models that seek to specify sociotechnical and human processes, recursive influences or 'interactions' abound with 'feedback' processes occurring over varying time-scales. Accordingly, outcome criteria that may be considered to be the human and social results of an organisation's continued functioning, such as individual knowledge, personal well-being and unit-level working climate, may be considered to be only intermediary outcome criteria, that themselves affect operational performance dimensions such as product quality or work quantity. When soft performance processes within a model are considered from the perspective of an added temporal dimension, what are sometimes complex feedback influences must be considered within the human system, due to the nature of many human factors. For example, through a process of collaborative functioning and exposure to other members within the group, team-based operations may result in non-directly productive, incidental outcomes including evolved norms and working practices, increased interpersonal knowledge, varying levels of cohesion and conflict, and enhanced available process knowledge, to name but a few. These outcomes feed back to modify the state of the social system and over time will exert an accumulating influence upon operational performance. Put simply, this recursive process may be referred to as 'organisational learning' (Senge, 1990) and represents the evolution of shared mental models, vision and team-based learning.

The experience of repeated high performance attainment by a unit or work group will have complex feedback effects upon factors such as motivational processes and level of group
cohesiveness (e.g. Mullen and Copper, 1994), giving rise to circular reasoning within models that seek to establish the relationship between these precursors and performance: highly cohesive groups perform better, yet over time high performance increases the level of group cohesiveness. These complex processes and issues represent a real challenge for attempts to model soft performance processes and functioning in human work systems. In terms of the HOP model detailed in this thesis, consideration of the aforementioned issues resulted in inclusion of a 'human and organisational outcome' category to accommodate learning and cultural evolution aspects of functioning that impact upon operational performance over time, and the inclusion of potential cultural, motivational and knowledge-related variables in both 'outcome' and 'precondition' classes, to allow the model to represent recursive loops in performance processes. These apparent idiosyncrasies may be considered direct artefacts of the need to impose a classificatory structure to the framework, in order to allow project managers to populate the model according to specific scenarios and employ a logical, sequential process of analytical reasoning in doing so, to what are essentially complex, non-linear interactive processes.

One of the most important considerations arising from work undertaken to provide an adequate modelling framework for human and organisational influences, is the importance of relating process factors to clearly defined outcomes in a performance model. Review of conceptual literature reveals a multitude of human and organisational performance models and frameworks, yet if these models are to prove useful in supporting performance improvement efforts in an applied context, they require two critical functional elements: 1) specification of tangible, definable outcome criteria that represent 'bottom line' operational objectives in addition to human and organisational factors, and 2) specification of clearly linked process factors or performance determinants.

Firstly, whether an organisation produces tangible products or supplies services to clients, the key objective or purpose in the organisation's functioning is to produce an effective work product, efficiently. The work product must therefore possess certain valued qualities or characteristics that make it effective or desirable, and must be delivered within a finite period of time having consumed an acceptable level of cost or effort in its production. The operational outcome parameters: cost, quality and time, are therefore universals that represent the ultimate focus of all performance control activities undertaken in any enterprise. Any human and organisational systems model that claims to model performance processes must therefore incorporate operational outcome factors within its framework in order to have practical value in application. Human and organisational processes may more readily suggest other outcomes that may be soft in nature, yet from the perspective of industrial application, any variable is superfluous to requirements unless it can be linked, however indirectly, to an operational outcome.
The second criteria follows logically from this last. Any generic performance model is of limited use unless the factors it contains can be clearly defined within and related to the operational environments that it seeks to represent. Industry therefore requires operational measures of the factors within the model, that are capable of generating values that represent the level of certain 'performance indicators' within a specific context. In order to select appropriate measures or indicators to capture data for performance control processes, any useful and analytical human and organisational performance model must define the exact influences between specific operational outcomes and specific soft factors. In this way the purpose of measurement is clear, as are the assumptions regarding overall performance that may be made on the basis of a selected 'indicator'. The utility of human and organisational performance models for metrication processes is demonstrated in this last point; as integrative frameworks capable of serving as relational maps for the selection of appropriate 'upstream' or 'lead' indicators, according to defined 'downstream' objectives that are monitored by 'lag' measures. Application of the HOP modelling framework to analyse performance processes in the case projects studied during the course of this research project proves the utility of the approach as a criterion selection tool for measurement of performance-critical soft factors.

8.5 Measurement of human and organisational factors

A practical conclusion drawn from review of existing human and organisational performance models and measures concerns the ease with which the variables specified translate into feasible and useful project management metrics. From a practical or operational viewpoint, this point serves to highlight one of the biggest challenges for application of soft measurement systems in practice to support performance control and process improvement. Although in the interests of offering a complete explanation for observable processes any comprehensive performance framework must account for all known and theorised variables, in practice it becomes difficult to 'operationalise' many of these soft factors in feasible metrics within performance control systems. For this reason, a key challenge for human and organisational performance analysis is the capability to objectively parameterise factors that represent 'personal preferences', 'shared values and beliefs', 'alignment in perspectives' and other cultural elements, to quote examples from one specific model (Castka et al, 2000).

During the phase of the soft metrics project that addressed requirement 2b: identification and evaluation of existing measures from relevant literatures (reported in section 3.5 of this thesis), it was found that only limited coverage of a sub-set of potential performance factors was present in established metrics and methods. The measures identified from the literature...
fell largely into two categories: subjective judgement-based measures and objective parameter-based measures. The former class of measures was favoured by research literature that employed survey-type measures to quantify soft human and organisational factors. Objective measures were favoured in the management sciences literature for the quantification of more tangible variables and parameters in the project environment, at the exclusion of many important soft issues.

It remains debatable as to whether an instrument for project parameter metrciation should employ solely objective 'management metrics' type criteria or should also draw upon subjective self-report survey measures, especially where the focus of such a tool is the quantification of intangible human and organisational factors. Several considerations relating to the benefits and drawbacks of each type of measure are important in selection of an appropriate approach to measurement of soft issues in applied contexts. Though conventional management metrciation methods favour objective criteria for measures, many soft variables are only directly quantifiable through judgement-based scales. 'Level of innovation' is one example and may be considered to be only directly assessable through sounding the opinions of experienced personnel capable of evaluating the degree to which a work product might be considered 'innovative'. Other soft factors, such as 'level of trust', are subjectively experienced phenomena and as such are not directly quantifiable through objective means.

By their very nature, 'soft' human factors include subjective and experience-based phenomena such as motivational and affective responses to the environmental context in which the individual is expected to function. Subjective measures that rely upon the opinions and perceptions of individuals are therefore appropriate, as only they can directly measure the individual's experience of, and attitudes towards, the workplace. In addition, there exists a convincing argument for the use of subjective measures to quantify environmental variables and other project parameters or conditions that fall outside the category of subjective human variables. As primary interest lies in the performance of people or the work group, it is not the environmental and situational conditions that influence human performance so much as the work group's experience or subjective perception of them. For this reason using subjective experiential measures must be valid. In certain circumstances, the use of subjective measures allows expert opinion or knowledge to be brought to bear upon factors involved in decisions or complex processes that are too complex for other methods to accurately quantify.

The drawbacks of subjective criteria measures are that they are open to bias and interpretation, especially in situations where measurement takes place to indicate performance and may be politically sensitive in support and justification of performance and
contract-critical decisions. Subjective responses therefore offer the respondent the opportunity to manipulate the response in order to achieve specific effect. The possibility also exists of the occurrence of the so-called 'Hawthorne effect', in which individuals' responses and behaviour are modified due to awareness of being measured or observed (Ballantyne, 2000). Such an effect may cause individuals to report an 'ideal' that may more or less represent reality. Another important factor to consider is practical in origin. Subjective survey-type measures may be simply too time-consuming, due to the fact that they require direct attention by each responding individual. Normal procedure for improving accuracy, predictability and reducing the distortion effects of bias and 'outlier' responses is to measure a series of individuals and adopt a measure of central tendency for the group. This, however, necessitates a number of individuals completing the measurement survey. One alternative is for the work group to make time during open discussion to consider and come to an agreement upon the level of individual measures through group discussion. Needless to say, a balance or compromise will need to be struck between the accuracy of the subjective survey measure and valuable work-time occupied in order to complete the measure, especially if that measure is to be repeated periodically. Where individuals respond to measures repeatedly, other undesirable effects can occur associated with learning how to manipulate the measure, or so called serial order effects in which experience of one measure primes an individual to respond in a certain way on another.

In contrast, objective measurement criteria require less effort to administer as only one individual need be involved in the collection of data (the indicator is objectively quantifiable and in theory, indisputable; the result should always be the same, regardless of who performs the measurement). There are other possibilities for the reduction of project management workload through the use of objective criteria metrics. In certain cases measurement and data production may be automated as part of the operation of support and IT systems. One example of this would be the automated counting of electronic communications between project group members through the IT system, as an indicator of the level of communication activity. Objective criteria may not be prone to bias effects, as are subjective indicators, yet they do have limitations particularly in their ability to cope with human and organisational variables. They can only provide causal 'indicators' of these factors, which are often less tangible, complex social and human factors. A distinction should therefore be made between direct measures and 'indicators', the latter being based upon reasoned links or chains of cause and effect: for example, taking the level of email communications as an indicator of high or effective communication ignores the fact that in some circumstances a high level of communication may not actually benefit performance, or that the number of emails may increase yet the actual communicative content remain the same, as would occur if, for example, an individual repeatedly emailed someone who was not available. Here, no communication has effectively taken place, yet the indicator reports (inaccurately) otherwise,
due to a high volume of electronic transmissions. Objective criteria-based measures are therefore only as good as the causal model or theory upon which they are based. This is a limiting factor of this type of measure and also emphasises the need for a coherent and accurate integrating model or performance framework to aid in the selection and interpretation of measurement criteria for a given situation.

Under research requirement 3a: development of appropriate soft metrics, a variety of potential measures were developed within the soft metrics research project employing a facet-based approach in which broad constructs or performance factors were decomposed into sub-factors and individual measurement items against which values could be elicited in the project management environment. In response to issues raised regarding the appropriate type of metrics for this project, development efforts focused upon a combination of both subjective and more objective indicators, with the latter type being favoured where it was considered that objectively specifiable criteria could be identified for a given factor. Several key conclusions regarding the status of the metrics developed during the course of the project may therefore be drawn based upon experience in development and application of potential soft metrics.

Project type indicators associated with size and technical complexity may be indicated by objectively observable criteria and key project parameters. The level of complexity in the organisation of project work and scope of project aims are issues associated with more inherent uncertainty, and these require more expert-judgement based measurement methods. This was evident from case study findings that highlighted the R&D nature of the projects studied as a key determining factor for the level of early project planning and applicable management control methods available to projects that need to be flexible in scope and accommodate evolving customer requirements.

Measures of work group characteristics may rely upon objective criteria to the extent that the metrics address tangible characteristics of a team such as size and length of time established, but ‘softer’ performance issues such as group morale and team climate must be assessed using subjective means, as these are factors closely tied to subjective human experience of working conditions. Quantification processes developed for the measurement of human capability within the project team are objective where evidence of formal certification and training is available. More in-depth analysis of suitability for specific project work tasks must be based upon the judgements of peer-review panels and the self-ratings of individuals, to quantify more subjective issues such as the relevance of work experience and perceived motivational potential of work tasks. This latter issue is subjective in nature as it is partly a function of personality factors (e.g. Hackman and Oldham, 1976) and this conclusion is supported by evidence from the comments of project personnel interviewed during the soft metrics project, which revealed the motivating potential of experienced working conditions and
inherent features of project work tasks such as the level of social contact afforded by the task structure. This was an important factor for the type of project represented by the validation case studies, and was reported on more than one occasion, across different project instances.

Objective indicators may be derived for the workload variable based upon comparison of available man-hours with schedule parameters within the project work breakdown plan. As with many human issues, however, workload also incorporates a softer component associated with human factors and evidence from the project cases studied as part of this research revealed the dependency of experienced workload upon other factors such as the level of human capability within the team and level of complexity in work tasks. Difficult tasks for which the individual has limited relevant knowledge therefore increases experienced workload, and these facets of workload are only testable through more subjective indicators based upon perceptions.

The issue of trust between groups within the project work setting is an inherently soft variable that is influenced by a variety of social processes and individual human experience. Trust between organisational entities such as interdependent project work groups was highlighted as an important factor in industrial capability acquisition projects and allows informal agreements to support project work efforts where formal protocols are inadequate. The issue of internal work group conflict reported in one project case study arising from diversity in goals within the team also implicates trust as an important performance factor for quantification. Objective indicators based upon past collaborative experience may be used to quantify facets of trust indirectly, but as an inherently subjective factor, direct measurement involves personal and group judgements of integrity and compatibility in objectives between collaborating partners.

Project stakeholder characteristics were identified as critical to project success across all case projects studied within the scope of the soft metrics research project. In particular, the availability of key stakeholders for decision-making processes, relevance of stakeholder knowledge and involvement of potential end-users in the development process were all highlighted as important performance determinants. Again, stakeholder characteristics may be considered to vary in level of objectivity and this research project serves to emphasise balancing objective retrospective indicators such as attendance at review meetings with human judgements of stakeholder adequacy.

Many of the metrics developed during the course of this project involve data items that represent established objectively quantifiable parameters associated with the project work environment, such as task concurrencies, interdependencies and work group characteristics.
The factors that these parameters represent are shaped either deliberately or incidentally during the course of conventional project management planning processes. The value of the contribution the soft metrics research has made is in providing expert human sciences knowledge for the interpretation and analysis of the implications of variance in these parameters, from the perspective of soft issues and performance processes, to complement existing technical engineering knowledge. This was achieved through detailed analysis of potential performance factors, measurement and causal modelling approaches in order to specify the potential impact of incidental organisational characteristics upon the functioning of the human system that underlies all operational activities. In doing so, the groundwork is laid for proactive control of human and organisational conditions for enhanced operational performance.

8.6 Feasibility and benefits of the soft metrics approach

In response to soft metrics project requirement 4: 'make a utility and feasibility case for the soft metrics tool and concept', this section discusses the implications of key findings from the validation process regarding the potential benefits and limitations of the approach. Detailed presentation and analysis of the results from the validation studies is presented in the preceding section (section 7) of this thesis. The discussion of issues in this section is therefore confined in scope to research findings that represent evidence for the level of feasibility and utility achieved in development of a soft metrics solution.

From the results of the validation process, it is clear that the key benefit of the soft metrics approach to support project performance control activities lies in its ability to provide a structured process for the analysis and measurement of performance factors for which there is currently limited tool support, due to complexity in nature and uncertainty in influence of human and organisational parameters. The application method provides a logical and sequential method of analysing soft factors in projects, as indicated by respondent's positive appraisal of the clarity of the process plan and aims. In each project case, key performance issues were identified according to definable criteria, their influences analysed and their impact upon project performance outcomes specified, effectively raising the level of visibility and objective consideration of soft issues from informal topics of conversation to definable parameters that can be proactively monitored and controlled.

As was evident from the extent and focus of discussions provoked during activities undertaken within the validation studies, project managers are aware of the nature and presence of soft issues and their effects upon project functioning. Project personnel were able to identify important preconditions within the modelling framework that applied to their
projects and could comment upon various mechanisms by which these factors influenced the quality of the project work produced. The relative inability of participants within the validation study to suggest existing measures or established methods of control for soft factors, indicates that the 'softer' aspects of project and organisational functioning tend to be identified and mitigated through personal initiative, improvisation, informal networks or structures and ad hoc efforts that are not defined or scheduled activities anticipated by current project management methods and frameworks. Information gained during informal interviews conducted within the CAP1 industry scoping study (reported in section 4.1 of this thesis) tends to support this assertion. Interviewees stated that a large proportion of project management effort was expended in 'hidden' activities that did not appear within the project work plan. Such activities were not directly associated with project work tasks and production of scheduled deliverables and products, but were more closely associated with peripheral issues involved in overseeing and facilitating the smooth running of the project work process. Communicating key project information, status and immediate issues, as well as coordinating formal and informal meetings and activities both within and between the project work group, stakeholders, other organisational entities and dependent projects, were stated as being the informal activities inherent within the project management role. Research findings achieved within this project therefore support 'coordinational process losses' (e.g. Steiner, 1972; Stroebe and Frey, 1982) as important human and social interactive issues that can influence achieved productivity in work systems. The soft metrics methods developed in this project make an important step towards more formal control of these human work process issues, the nature and outcomes of which are currently difficult to predict, parameterise and evaluate.

The utility of the soft metrics tool and method is demonstrated by its ability to analyse 'softer' issues in the industrial case projects that were studied. The case projects studied were all industry-academic partnership projects that were heavily research and development or 'proof of concept' focused. Analysis of performance processes within these projects using the soft metrics approach was successful in identifying key performance issues and describing the involved mechanisms of influence through identifying critical preconditions, relating them to human functioning and their broader performance implications. Upon the basis of these findings, it is possible to outline the likely types of soft issues that projects of a similar size, type and focus, will encounter and draw recommendations for remedial strategies directly from the output of the tool application process. Figure 8.5a below summarises key conclusions and recommendations resulting from application of the soft metrics tool to analyse soft performance issues in the validation case projects. The findings offered in the figure support the case made for the soft metrics tool's effectiveness, usefulness and fitness for purpose in the applied context for which it was intended.
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<th>Research finding based upon application of tool in case projects</th>
<th>Recommendation based upon research finding</th>
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<td>1) Changing and unstable customer requirements in pure R&amp;D projects due to lack of clear functional definition for output at project onset can have a significant impact upon overall project performance outcomes, affecting the project schedule and functional qualities of the work product.</td>
<td>Regular periodic reviews of broad aims and functional requirements are therefore warranted in these projects, with full consideration of the potential impact of changes to the work plan that might occur mid-project. This finding highlights the importance of intensive collaboration with the customer for the work product, at project planning phases in particular, and throughout the course of the project.</td>
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<td>2) Tight coupling of technologies that represent the target of project work to external technological development efforts can make the project's work plan and knowledge requirements within the team highly sensitive to external factors beyond the control of the project work group.</td>
<td>Situational appraisal of the external environment outside of the project work group and organisation is therefore essential in technology-driven enterprises, as is networking and the establishment of both formal and informal communications channels between development teams that focus upon similar technological areas. Where practical, the organisation should provide the temporal and financial resources to make this possible.</td>
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<td>3) Proof of concept projects are inherently uncertain in terms of planning and scheduling making parameterised performance tracking against set milestones difficult. Industry-standard techniques that rely upon detailed product and work breakdown structures divided into definable, scheduled sub-tasks, and intermediary cost or 'Earned Value' estimation may therefore not be appropriate methods of performance control in these projects. The acquisition of new knowledge was reported as an important outcome of R&amp;D projects, especially, as this represented the novelty of the work and indicated contribution to existing disciplines.</td>
<td>Achieved knowledge output and targets may therefore represent important intermediary indicators of how well projects of this type are performing, rather than parameterised tracking methods based upon spend and task duration. Other potential outcome indicators for the assessment of project effectiveness include peer and customer reviews of maturity of new knowledge gained, and the degree to which knowledge output is accepted and circulated in appropriate industry publications.</td>
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<td>4) Motivation on the individual level was identified as an important human outcome of involvement in the project that influenced task performance. High desirability and significance of work tasks were reported as having an important motivating effect, whilst lack of stakeholder involvement and limited opportunity for social contact was reported as having a demotivating effect.</td>
<td>Steps therefore need to be taken to ensure appropriate allocation of tasks to personnel with reference to personal preferences and that task performance is supported with appropriate feedback information from key stakeholders for key areas of the work. The structure of the work plan and working conditions need to be considered in terms of to what degree they provide opportunity for face-to-face collaborative work.</td>
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<td>5) Conflicting goals and interests within the project work group were reported as having a negative impact upon product quality in terms of the extent that separate areas of the work were integrated to provide a unified output. Goal conflict was reported as influencing operational outcomes through reduced communications, unresolved decision processes and demotivating effects.</td>
<td>As a potential measure to negate the adverse consequences of these factors, group composition needs to be considered in more detail at project onset, including potential conflicts of interest that may arise. The compatibility of partners in strategic alliances formed between organisations within an enterprise is also implicated.</td>
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<td>6) High complexity in work products and the resulting influence upon project organisation had a detrimental impact upon schedule performance and quantity of work produced, through the influence of environmental complexity on human decision-making processes and personal workload, affecting task performance.</td>
<td>Complexity in systems and work processes needs to be monitored in order to identify instances where management decision-processes may require additional support. The impact of varying complexity in work tasks on personal workload needs also to be considered in scheduling activities, with allocation of an increased schedule buffer implied for projects and tasks identified as high in technical complexity.</td>
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Research finding based upon application of tool in case projects

7) Limited stakeholder involvement and availability decreases product quality and schedule performance through impacting upon the ability of the work group to coordinate and schedule tasks effectively, make timely decisions on key issues and obtain useful and timely performance feedback information regarding ongoing processes.

Recommendation based upon research finding

This finding supports an argument for enhanced stakeholder management activities and tool support throughout the course of the project, especially in instances where multiple stakeholders and partners exist and where some authority for the execution of specific work tasks within the project lies outside of the project management team. Accordingly, the broader organisation must recognise the importance of allowing key personnel time to fulfil important roles on other projects, in addition to their own project commitments and provide necessary communications support through ensuring project personnel and stakeholders are sufficiently networked through IT infrastructures.

Figure 8.5a: Summary of research findings and recommendations derived from application of soft metrics tool in case projects

Overall, experience in application of the metrics tool within the case projects showed that the performance factors set employed within the HOP modelling framework was valid and comprehensive enough to accommodate a broad range of possible soft issues and performance processes within industrial projects. In terms of the sub-set of metrics applied to the projects within the validation studies, the majority were rated as mid-high in terms of effectiveness as valid measures of the factors they were proposed to quantify. Overall effectiveness and usefulness ratings for the utility of the tool as applied to each specific scenario ranked as generally mid-high, with lower overall scores achieved for the practicality and feasibility dimension.

In terms of evaluation of the perceived feasibility of the HOP modelling framework and approach, mixed results were achieved during the validation studies. As a demonstrator version of a 'proof of concept' tool, the application process represented a pilot demonstrator version rather than a complete deployable solution. The evident resource load in terms of involvement of project personnel (level and time allocation) and the availability of focus group facilitators may therefore be considered to be exaggerated in the 'proof of concept' demonstration, due to issues associated with the tool's prototype status. Such issues would be removed in a deployable solution, leading to a more efficient application that is beyond the scope of this project's work. In its current form, the process was considered during the validation exercise to be time-intensive in a current business environment that already considered project management activities to be operational overheads. It was also considered that the inclusion of clear decision-making and improvement processes, linked to the activities in the analysis process, would increase the feasibility of introducing the proposed solution into applied project management practices.

Another important consideration for assessing feasibility of the soft metrics approach in current engineering environments regards knowledge requirements and perspective
necessary to successfully execute the process. The application process itself required the presence of a trained facilitator with knowledge of processes that operate within human and organisational systems, in addition to being conversant with up-to-date project management approaches, potential issues and the specific operating environment in which the soft metrics tool is being applied. This factor may well limit the current tool's application and the ease with which it is incorporated into standard working practices.

The actual level of effort involved in implementing the approach outlined in this thesis within an operational project management environment, depends upon a number of factors including the extent of 'soft' performance problem issues inherent within the specific project in question, which in turn dictates the perceived requirement to employ analysis and measurement techniques periodically within the project's lifecycle. As a 'one-time-only' analysis exercise that may be implemented in response to performance issues raised during review meetings or risk analysis activities, the soft metrics analysis process in its current form requires a one-day focus group in which it is recommended that the majority of the project management team and representatives of the broader project work group are involved. Although human-resource intensive, this level of effort will ensure that all human perspectives are brought to bear upon the analysis task allowing comprehensive review of potential and existing human and organisational performance issues.

It is anticipated that implementation of elements of the soft metrics analysis process to support repeated risk and performance control activities subsequent to an initial focus-group exercise will be considerably less resource-intensive, due to increased familiarity with the tools and approach that will develop through repeated application. Rather than an in-depth, comprehensive analysis using the model and sample factors, the HOP framework may be employed periodically at project management reviews to visualise and select appropriate metrics for specific soft issues that have been raised within current project phases, with minimal additional effort. The HOP model framework and the 'preconditions' class in particular, may also be usefully employed during project start-up or planning phases to ensure that the design of project work organisation, roles, responsibilities, team composition and other controllable characteristics that might arise from project planning activities are conducive with optimal human work performance. In terms of administration of the actual metrics selected for quantification of specific soft factors, the level of effort involved will depend upon: 1) the number of measures identified as critical for acceptable performance control, 2) the type of measure selected, with objective project work plan parameters requiring little or no effort with regards to data collection and personnel survey measures requiring considerably more effort, and 3) the frequency of measurement, with periodic repeated measures requiring more effort than 'one-time-only' diagnostic measures, the values of which will not be expected to vary over the course of the project. Data collection responsibilities
may be added to the role definitions of project management personnel tasked with the compilation of budgetary and scheduling performance information in preparation for project phase reviews.

A broader issue regarding feasibility concerns acceptance of human and organisational systems perspectives in an engineering community dominated by a focus upon technological development and a 'performance culture' geared towards achievement of contractual commitments. The relative importance of soft issues to technical issues reported in the validation studies highlights the need for the inclusion of input from the human factors and ergonomics disciplines in a broad range of industrial operations and engineering training programmes. Whilst specific technical disciplines equip organisations with the technical competency to successfully execute project operations, it should be recognised that human work processes are the universal mechanisms that deliver technical achievements. The broadening of systems engineering core disciplines to encompass human work systems provides a useful basis for the development of practical knowledge for the control of human and organisational factors that will enable similar analysis processes to be undertaken in industry projects in the future. It is anticipated that much of the knowledge developed within the soft metrics research project regarding human and organisational performance processes could be usefully applied in future personnel training and development initiatives.

The critical utility of the approach lies in its ability to develop proactive performance indicators for operations management through establishing definable causal influence sequences between soft 'upstream' factors and outcome criteria. Review of existing metrication practices reveals the dominance of work product-related metrics that measure outcome criteria associated with contractual commitments to specific cost, quality and time objectives. In the customer-focused project management domain, there is a general lack of practical knowledge regarding how 'softer' upstream conditions impact upon operational performance criteria, limiting the potential benefits of measurement of non-product focused human and organisational factors. Through a defined causal mapping process that employs the structured HOP modelling framework, managers using the soft metrics tool can apply proactive indicators to measure the key soft performance determinants upon which operational success is dependent. The tool therefore supports analysis and capture of key work process knowledge and information regarding the effectiveness of organisational design. This knowledge may then be used to support performance improvement efforts through proactive application of metrics to effect changes in key cost, schedule and quality achievements.

Application of the prototype soft metrics tool and approach has shown it to be of key benefit to operations management, through the delivery of soft metrics capabilities that were previously
lacking. The soft metrics approach developed in this project may be summarised as having the following specific benefits for project work groups and management teams using the technique:

- Complex and opaque project performance issues may be identified and defined from a comprehensive list of potential 'soft' factors representing expert knowledge in this area.
- The exact nature of the relationship and influences between 'upstream' precondition factors and dependent operational success criteria may be established, clearly linking potential problem issues to expected results, for mitigation of associated risks.
- Information is captured regarding the expected effects of variation in precondition factors upon performance outcomes, providing a basis for reasoning about the overall effects of changing project organisational structures and human resource configurations during project planning and in response to imposed changes in the project work environment.
- Important work activities associated with human performance may be identified that are likely to impact upon project success and which may require additional support as a result of specific project conditions.
- Appropriate measures may be identified, linked to critical factors, for monitoring the level of a soft factor regarded as important for project success.
- Critical performance factors may be analysed in terms of their relative weight of influences upon operational processes and likelihood of occurrence within the project in order to prioritise risk mitigation activities.

To the extent that existing tools and methods do not provide a defined, structured approach to achieving these ends within the area of human and organisational performance factors, the soft metrics approach reported in this thesis may be considered to be a useful and important contribution to the project management toolset. In terms of overall utility, the soft metrics approach outlined in this thesis is potentially of great benefit in application to support project performance improvement efforts, pending further development to achieve a more practical, deployed solution.
Section 9
SUMMARY OF KEY CONCLUSIONS

The main achieved value of the soft metrics tools and approach that forms the subject of this thesis lies in its utility as a means of analysing human and organisational performance processes within projects. The approach allows the identification of soft performance issues, analyses their potential impact upon operational project success criteria and provides new metrics to measure the key human and organisational factors involved. As a practical tool, the soft metrics approach is limited in its current form due to its 'prototype' standing for application in an industrial context. Future research work needs to address these issues, building upon the preliminary work outlined in this thesis. To conclude the report of research activities undertaken within the soft metrics project outlined in this thesis, the sections below provide a concise summary of achievements against the original project requirements, lessons learnt and personal development, followed by consideration of the research in a broader context of possible future work.

9.1 Statement of achievements against research objectives

1) Identify soft issues impacting upon project performance

A broad range of human and management sciences literature was reviewed to identify potential 'upstream' human and organisational factors that impact upon operational performance outcomes relating to the achievement of cost, time and quality objectives. In total, over 100 potential factors were defined, with supporting evidence from research literature relating to known influences upon performance-related processes. A scoping study and a series of industrial project case studies were used to refine the focus of the performance factors set and explore their influences upon project performance in an applied context.

From the literature review, team composition, human knowledge and experience, work group climate and cohesion, leadership, level of functional autonomy, task and goal characteristics,
workload, conflict, motivation, communication, and decision-making processes were all identified as potential human and organisational performance factors. Findings from analysis of several operational case projects made available to the soft metrics research effort provided evidence of the presence of several soft performance issues which were associated with the following factors: trust, effective stakeholder communication, team composition and cohesion, human motivation, experienced workload, goal conflict, project uncertainty and broader organisational environment and cultural factors such as the climate for collaborative work.

2) Explore current best practices for analysis, measurement and control of human and organisational variables in projects

Various relevant human and organisational performance models and frameworks were identified from research and applied work that modelled key influences of soft factors upon performance outcomes and complex interactive processes within human and organisational systems. Existing project management metrics and research measures were reviewed to identify potential methods of quantifying human and organisational performance factors, along with existing research models and management frameworks that had been proposed to represent human and organisational performance processes.

As a general conclusion, current project management metrics fail to address soft performance factors within the project’s work environment and research measures of human and organisational factors tend to provide lengthy diagnostic instruments that are not best suited for practical, repeatable application in the project management domain. Conventional management metrics are limited to objectively quantifiable criteria and parameters, which may explain the apparent lack of coverage of more subjective, human factors that represent personal experience of the work environment.

A key requirement for integrative models of human and organisational performance processes is the ability to depict specific relationships between ‘upstream’ soft factors and operational performance outcome criteria, if the model is to be useful in application to support performance improvement processes. Existing models were found to vary in the degree to which they achieved this aim and in the level of analysis attempted in consideration of complex sociotechnical processes. Dependent variables within research models are not confined in scope to operational performance outcomes to the degree that practical management frameworks are, yet these latter models tend towards provision of broad dimensions of performance factors, rather than detailed definition of specific factors and interactions.
3) Develop practical approach and tools for analysis and measurement of soft issues in projects

Through an iterative process based upon development of concepts identified in relevant research literature and industry research findings, an integrated 'soft metrics tool' was developed. The tool comprised three interlinked components to deliver soft issues analysis and measurement capabilities for operational systems engineering projects and included: 1) a set of soft metrics for quantification of key performance variables, 2) an integrative modelling framework for causal analysis of operational performance from a soft factors perspective, and 3) a detailed application process with group-based activities for analysing soft issues in specific scenarios and selection of appropriate metrics using the model.

The Human and Organisational Performance (HOP) modelling framework was developed to allow the representation of complex performance processes within specific industrial scenarios and structured performance factors under three main classes: project 'preconditions' or contextual factors representing pervasive system conditions, 'human work activities' representing behaviour or functioning in human activity systems, and 'outcomes' representing operational performance or effectiveness criteria. The main focus of the soft performance factors specified within the model is on process or 'upstream' performance criteria that are human and organisational in nature, rather than technical factors and 'results' of work processes that are associated with product-related characteristics. Critical to the analysis of soft issues, the generic human performance activities specified within the HOP model mediate the relationships between precondition factors and outcomes; representing the impact of work environment and system factors on the aspects of human performance that deliver the work product.

The application process was designed to provide a structured approach to allow the population of the modelling framework with factors and interactions specifically applicable to any particular industry. Due to the intangible, human nature of many soft factors, the application process for analysis of soft issues in projects is largely qualitative in nature, to aid managers in identifying relevant factors and mapping their causal influences upon project success criteria. Quantitative scales are employed to weight influences within the model and prioritise human performance-critical preconditions for risk assessment and performance monitoring. Appropriate soft metrics for measuring relevant performance factors identified within the modelling framework were developed based upon existing measures and knowledge regarding potential human and organisational performance factors, where current methods were inadequate. The soft metrics complemented objective items with subjective, judgement-based items, in order to quantify human factor variables that represent the
experience of individuals and teams, and that were not amenable to other methods of quantification.

4) Make utility and feasibility case for soft metrics concept and tools

The concept of a soft factors approach to project performance was established as feasible and of potential benefit for performance improvement, with a clear knowledge gap and need for soft metrics capabilities identified within the industrial context. The practicality and effectiveness of the developed approach and tools was evaluated using a series of industrial case studies. Although considered a prototype implementation, the HOP modelling framework and metrics were successfully applied to analyse and prioritise soft issues within the operational projects studied, yielding a range of useful information concerning soft performance processes and potential risks associated with specific factors that were not currently controlled through existing available methods.

In terms of the development of specific new capabilities for analysis and control of soft issues in projects, the soft metrics tools and approach outlined in this thesis represent several benefits for integrated project management teams. These benefits include the capability to: 1) identify, analyse and define the softer, less visible process factors that influence operational performance, 2) prioritise system preconditions in terms of their relative impact upon human functioning for improved planning and organisational design, 3) support critical human work processes through risk analysis associated with soft issues, and 4) implement appropriate proactive metrics and measures for monitoring variance in key soft parameters for effective operations.

In its current status as a proof of concept demonstrator, the soft metrics tool is resource load intensive, requiring group-based involvement of a number of project personnel at a range of levels of responsibility in order to be effective. The tool also requires a trained facilitator to guide the group through the analysis process. In addition to any inherent limitations due to time and manpower resource consumption, it should be noted that within the context of BAE SYSTEMS' extended enterprises, the soft metrics tool is limited in its known utility to the extent that development efforts were constrained by available industry case studies. Application beyond the boundaries of BAE SYSTEMS' operations was not part of the project definition and as such the outcome of the work may be considered valid in a localised industrial rather than globally applicable context.
9.2 Lessons learnt and statement of personal development

The following statement, written in the first person, outlines the researcher's own personal learning and professional development outcomes resulting from experience gained in undertaking the soft metrics research project outlined in this thesis. With the benefit of hindsight, lessons learnt relating to how the soft metrics research project might have benefited from certain methodological changes are also considered, in the hope that these recommendations will inform future research efforts in related areas.

Building upon knowledge gained from an undergraduate psychology degree with some specialisation in social and work psychology, the soft metrics PhD research experience has provided me with the opportunity to pursue professional development in human factors research. Moving from a theoretical human sciences background to applied work in systems engineering at Loughborough University represented a broadening of my personal perspective upon the study of human performance to complement psychological knowledge regarding the characteristics of the human condition with a comprehensive 'systems' view that considers the ergonomic properties of the complex organisational or sociotechnical systems in which people work. Through experience of the systems engineering R&D environment and the development focus of this project, I have acquired much invaluable knowledge regarding methodology and approaches for the development of technical systems, which may be usefully applied to support the analysis and development of improved human and organisational systems. The experience of using research methods to not only develop knowledge but support systems development activities has also been beneficial to me from the practical perspective of pursuing customer-defined project requirements. Experience within the industrial environment has also greatly increased my knowledge of the practical requirements for human factors support in operations management.

Through a broad literature review and subsequent development of an applied solution I have had the opportunity to study a variety of existing practical approaches and theoretical research work relating to human performance in work systems. Through this project I have also gained experience in the issues associated with implementing theoretical research knowledge in the development of practical tools and intervention strategies to effect change in organisational systems. The key knowledge areas developed in this project include: empirical research findings relating to human and organisational factors in work systems, issues in the development of research measures and practical performance indicators (or 'metrics'), systems modelling approaches and practical project management processes, tools and techniques. Although the focus of the development efforts within the soft metrics research project, this latter category includes performance measurement systems, project planning and control methods, all of which are applicable to the research activity and research projects.
consider personal learning in all of these areas to be an important outcome of my involvement within the research project. Through experience within the soft metrics research project I have also developed several transferable skills, and have had the opportunity to:

- Engage in autonomous PhD-level research activities and present project progress at periodic reviews in a peer research group comprising industry and academic partners.
- Prepare periodic industry reports and deliverables, including documentation of the research development process, evaluation of existing operational procedures and associated costs/benefits analysis.
- Present research developments and findings at systems engineering conferences.
- Capture project requirements and coordinate work efforts with a 'client' organisation.
- Network with multiple industry and academic project stakeholders and secure interest in the outcome of the research.
- Plan and be responsible for the completion of research project work tasks and deliverables to meet project milestones.
- Develop and execute a comprehensive research methodology for the project including detailed qualitative and quantitative research methods.
- Facilitate focus group discussions and team-based exercises in key user groups represented by project management teams from operational industry projects.
- Perform structured interviews, data collection activities and analyse qualitative and quantitative data to support iterative development in the project.
- Coordinate and seek support for project work tasks with academic supervisors.

With the benefit of hindsight, a number of methodological changes to the soft metrics research project might have been implemented to enhance stakeholder involvement throughout the project and further support the development of a soft metrics solution. The following recommendations represent an ideal that might not be achievable in new development, proof of concept research projects for which there is inherent uncertainty regarding the exact project requirements and work plan at project onset. They also represent lessons learnt and the outcome of a process of personal learning and development for the researcher, as a direct result of experience within the soft metrics PhD research.

Applied research work benefits from in-depth knowledge of the applied operational environment in which it seeks to implement changes and experience in the soft metrics work shows that it is the acquisition of this knowledge, through undertaking the research activity and implementing a comprehensive research methodology, that is of primary importance in achieving applied research objectives. To this end, securing potential use-cases for the output of development efforts throughout the research project's lifecycle is of primary importance, both in scoping the boundaries for applied research and supporting an evidence-
based iterative development process. This conclusion echoes that drawn from analysis of the R&D systems engineering projects that formed the focus of this study: that close collaboration between developers and potential users at all stages of the research project is essential to the success of case-based development efforts.

Enhancing communication of project issues to industrial and academic stakeholders might have further supported development efforts. In collaborative projects of this nature, networking with both relevant industrial and academic entities is important in the acquisition of necessary knowledge to inform the design process. Setting up an email-based stakeholder interest group for regular project updates and bulletins early on in the project would have ensured stakeholder's knowledge of the project was up-to-date, supporting enhanced stakeholder involvement, more early input to the requirements specification and increased awareness of potential benefits of the approach. This in turn may have increased the degree to which stakeholders 'bought-in' to the project rationale and objectives, ensuring willingness to commit resources to case study exercises.

Other potentially beneficial changes to the research methodology concern the general approach taken to scoping and defining the boundaries for the size of the research effort. Due to the necessity to develop an approach that could accommodate a broad range of potential soft issues in projects it became difficult to narrow the research focus to specific soft factors that might then have been analysed and dealt with in more depth. Confining the scope of the project to a smaller number of human and organisational issues might have allowed focus upon further refinement and calibration of a more definitive, concise and ultimately more wieldy soft metrics set, although the comprehensiveness and applicability of the overall tool for varied project scenarios may have suffered as a result. The soft Issues identified through experience with the case projects reported in this study were dealt with in as much detail as time and human resource constraints permitted and it is debatable as to whether additional case projects would have negated or exacerbated the problem of scope within the soft metrics research project, due to the idiosyncratic and systemic nature of many human and organisational performance influences. Earlier access to the industrial environment in order to define the context for the development and application of the research product might arguably have made the literature review, early vision and conceptual development phases of the project more economical in terms of time and effort. This issue is problematic, however, in that from an industrial perspective, it is more practical to commit resources following completion of preliminary development phases and this might conflict with academic interests which seek to support the student's learning and grasp of a 'novel' application environment.
From consideration of the practical limitations of the soft metrics approach developed in this project and knowledge acquired regarding the current operational project management environment, an enhancement to the research project might have involved including objectives relating to the development of a software-based solution. Conceivably, software-based application of the modelling activities and administration of soft metrics might have resolved some of the practical issues associated with implementing the approach and it now remains for future research work to implement the framework and knowledge acquired within this project in an appropriate IT system, application package or decision support software. Implementation of the soft factors analysis and measurement approach in a formal software system may, however, reduce its utility in analysis of many soft issues that benefit from focus-group analysis methods due to their nature as subjective or social factors.

Due to the lack of existing practical knowledge in the soft metrics research area within commercial systems engineering operations, the industrial requirement to develop a practical approach was largely synonymous with the academic requirement to make a valid contribution to knowledge in the soft metrics research area. Experience within the project highlighted the important need for consideration of the compatibility of academic and business goals in collaborative projects of this nature early on in the project planning process, and attention must be given to ensuring that research objectives meet business needs and close mapping between industry deliverables and academic output is highly desirable. Within the soft metrics research project, one example of complementary industrial and academic requirements is found in the human and organisational performance modelling exercises, in which exploring systemic interactions between variables furthers academic knowledge regarding the functioning of sociotechnical systems and linking soft factors to tangible outcome parameters satisfies industrial requirements for operational performance control capabilities.

9.3 Soft metrics: an emerging capability and priority for future research

The fact that the literature review for the soft metrics research project necessitated analysis of several complementary yet distinct areas of knowledge, is evidence of the lack of a clearly definable knowledge area or discipline relating to the measurement and control of human and organisational factors for the applied industrial context. The management science literature relating to project management and control contributes knowledge, much of it embedded in existing models and tools, regarding practical application of metrics and task management systems that focus upon the technical and work-flow aspects of project organisation. The social and human sciences knowledge-base contributes information regarding the nature and mechanisms associated with human and organisational factors through several strands of
research including human factors, process ergonomics, work psychology and organisation theory. Where academic research efforts develop measures relevant to what operations managers have termed 'soft' factors, these tend to be involved diagnostic instruments that provide broad-scale organisational assessment, rather than the repeatable, practical metrics that the operational environment requires for effective project management and control. A clear requirement exists for the further establishment of soft metrics and associated methods as an operational capability in industry and a defined body of knowledge in research.

An industry-based scoping study that addressed soft performance processes in capability development projects reported in this thesis, shows that experienced project managers intuitively and routinely monitor and control perturbations in the human and organisational systems, which underpin the formal organisational structures that are implemented in accordance with the requirements inherent within the project work plan. Although evidence of the importance of soft factors for project success is readily available when the right questions are asked of individuals immersed in the operational environment, it is perhaps surprising that review of available literature can identify few practical methods and tools to assist project managers in 'parameterising' these important factors and quantifying their impact upon performance. This latter finding constitutes clear evidence of an existing 'knowledge gap' relating to a soft metrics capability within the engineering project management domain. The acquisition of such a capability would represent the transformation of what are largely informal, 'ad hoc' practices originating in the tacit knowledge of individuals, to formally defined systems and processes owned by the organisation and about which the organisation can build a knowledge-base of best practices in order to further develop the capability itself, and support performance improvement initiatives.

The future broad aims for soft metrics research and development must be to establish a clear discipline in this area that combines what is currently largely academic research knowledge regarding human and organisational performance processes in work settings with the practical knowledge and requirements of applied project management and control interests. This aim represents the distillation of theoretical knowledge into practical and applied tools, refining broad and complex research measures into concise and effective project management metrics. Essential to the achievement of this goal is the close collaboration of academic research efforts with industry and the securing of sufficient access to stakeholders, potential users and case projects, in particular.

Experience in the development of soft metrics tools and integrated approaches for the analysis of human and organisational performance processes in this project has resulted in the review of a multitude of research measures, management metrics and performance models representing varied perspectives on the functioning or organisational systems.
Clearly, there is great need for further research work that integrates technical and human perspectives on a system-wide level in order to further understanding of complex sociotechnical processes. Fulfilment of this aim begins with models that attempt to represent complex performance processes in 'soft' systems, such as the HOP modelling framework proposed in this thesis, and must ultimately result in the development of applied performance metrics and tools to support the design of more effective organisational systems.

Whilst empirical, quantitative research efforts must, through necessity, seek boundaries within systems in order to control experimental conditions, a reductionist approach that focuses only upon a sub-set of system variables, that represent the research focus of interest, is limiting in its ability to account for systems-level outcomes that may be the result of complex interactions between a multitude of potentially independent factors. Future comprehensive modelling efforts must therefore adopt a systems-level approach in which human and organisational processes are represented along with technical parameters and tangible infrastructures. The high level of complexity in interaction and unbounded nature of many 'soft' issues means that the challenge for modelling efforts lies in accommodating high levels of uncertainty in reasoning about human and organisational processes. Future applied research must therefore seek to support operations managers in analysis and control of soft human activity systems through the development of appropriate decision support and performance measurement systems, based upon conceptual understanding of systemic processes.

The modelling framework and measurement methods developed within this project have focused largely upon the analysis or diagnosis of soft issues in projects and the establishment of potential measurement techniques. In order to develop more mature project management tools and methods for support of soft performance processes, more research needs to be undertaken associated with control and remediation strategies to address potentially detrimental human and organisational issues in projects. Further research could productively focus upon calibration and standardisation of the soft metrics to enable broader cross-organisational and cross-industry comparisons. Incorporation of the measures into operational project management processes and standard operating procedures for industry, through further refinement of the tools and techniques outlined within this thesis, is of primary importance.

The research described in this thesis offers evidence for the applicability of the HOP modelling approach for both: i) a useful means of increasing awareness and reflection upon human and organisational issues in systems engineering projects, and ii) a framework for the selection and application of appropriate measures of aspects of human and organisational performance. This dual capability was deliberately engineered to satisfy the management requirement for specific metrics, whilst offering a viable analysis process that could
accommodate and generate insight into complex causal influences in human and organisational systems.

In the author's opinion, the developed tool and approach is more successful in the fulfilment of a diagnostic or analytical role for exploring the causal influences affecting 'soft' problem issues in operational projects than in providing what might be regarded as specifically a program of project management metrics. It is one of the central arguments of this thesis that the notable lack of existing soft metrics in industrial use is mainly due to inability in formalised performance measurement systems to cope with the inherent complexity within and intangible nature of these types of factors. In this sense, the output of this research effort: the HOP modelling framework, is appropriately aimed at diagnosis and increasing visibility of soft factors for performance control. The title given to this thesis may therefore be more appropriately regarded as being concerned with "...a framework for the analysis of human and organisational factors in projects", rather than the direct measurement of soft issues.

In identifying a duality of role for the soft metrics research output, some consideration of how future work might develop both the analytical/awareness-raising and measurement potential of the tool, is warranted. With the interests of developing more viable project management metrics in mind, research efforts should logically proceed towards the development of a more context-specific "balanced scorecard" of key performance indicators, to include 'soft metrics' in the form of a finite set of simple data items defined as important performance determinants for human and organisational processes. Such an outcome might conceivably be achieved through a more systematic and global application of the HOP model-based analysis process throughout BAE SYSTEMS' project operations, to establish and refine this 'definitive' metrics set. The resulting measures could then be fully integrated within BAE SYSTEMS' lifecycle management processes before being put to operational use in the performance review phases of active systems engineering projects.

In order to develop the analytic and educational aspects of the soft metrics research output, further work needs to be undertaken to refine the process aspects of applying a diagnostic model such as the HOP framework, with further attention paid to full integration with existing process knowledge and decision-support systems. In terms of future application of the HOP model, it is envisaged that such a framework would form a useful common language for data collection across the full range of BAE SYSTEMS project-based operations. This outcome would increase general awareness of soft issues whilst promoting a common understanding and basis for reasoning about soft performance issues and data-based organisational learning.
This study represented the Initial development of a demonstrator approach to prove the concept of soft metrics methods in project management control. The research conducted in this project represents in-depth analysis of requirements relating to specific industrial cases, as necessitated by the Industrial-academic partnership of which this project was a part. Having achieved promising results through application of the soft metrics concept in detailed qualitative case-studies, the next logical step is to use larger-scale case samples for a more general study to indicate to what extent the type of tools and methods outlined within this thesis are applicable in a broader context or are 'generic'. Although the HOP framework is proposed at a high level of abstraction applicable to all project-based operations in any context that involves human functioning, the performance factors may be limited to a systems engineering environment and it remains for cross-sectional, large sample quantitative research to establish if this is the case. Inferential statistical analysis techniques may then be employed where large enough samples are available to test the structure of research models based upon the interactions specified within the HOP model. Path analysis and structural equation modelling may prove to be useful techniques to address these aims (see: Millsap, 2002 or Norman and Streiner, 2000, for example).

The soft metrics tools and approach developed through this research to support control of human and organisational performance factors employ both quantitative measurement and qualitative inferential logic methods in order to analyse and monitor soft factors within operational projects. The qualitative, causal modelling approach complements established quantitative methods that are limited in their ability to describe subjective phenomena such as motivational and cultural processes. Qualitative analysis methods may therefore prove to be a valuable area of future development work, as numerical values against specific metrics alone cannot capture the full complexity of human and organisational processes that underlie variance in the outcomes of operational effort. It is therefore no surprise that very few existing project management metrics directly address the softer human issues, which this research has highlighted as important to operational performance.

An important implication of the research reported within this thesis for future work is that operations performance management practices may need a broader toolset for analysis and control of human and organisational issues that lie beyond the scope of objective management metrics. As one manager stated in response to being asked about the need for soft metrics research work: "it's not so much development of soft measures, as soft interpretation of hard measures that's important". Interpreting 'hard' measures as indicators of potential soft issues is a valid aim for future development efforts, but this requires linking tangible systemic parameters to their human and social implications. The causal modelling processes described in this thesis provide a viable preliminary framework for approaching this
problem and it is hoped that this conceptual approach will provide the basis for practical
development in the soft metrics area.
References


BAE SYSTEMS (B) Employee opinion survey. Internal industry document.

BAE SYSTEMS (C) Guide to earned value management. Internal industry document – Lifecycle management standard operational procedures.


Appendices
Appendix A: Detailed summary of research literature relating to human and organisational performance factors

This appendix contains a more elaborative account of research knowledge identified within the soft metrics project literature review, than that outlined in the thesis text of section 3.3. The sub-sections that follow represent human and organisational performance factors that existing research findings identify as relevant to organisational performance and effectiveness.

Work group composition

Work group composition refers to several variables including: homogeneity or heterogeneity in work group composition structure, work group size and demographic or person-characteristics of work group members such as age, gender, ethnicity, educational level, training, ability levels, personality, attitudes and values, professional background, status and geographical location (e.g. West, 1996a; Jackson, 1996; Unsworth & West, 2000). Various mechanisms have been proposed to explain the effects of work group diversity on performance.

West (1996a) in a review of the literature on work group effectiveness states that demographic homogeneity in terms of age, sex and educational level predicts group cohesiveness, similarity in attitudes and values and group stability or how long the group "sticks together", rather than influencing work group effectiveness directly.

Certain individual characteristics and personality factors are known to influence the effectiveness of group decision-making processes, though little clear evidence exists as to how the personality of individual group members affects work group performance directly (West, 1996a):

- Lack of communication skills makes individuals less able to present their views and knowledge successfully.
- Shyness may mean that not all members contribute optimally to the group's store of knowledge. Knowledge offered by such members may be done so hesitatingly and less assertively than that offered by more confident group members.
- Egocentricity can make individuals unwilling to consider opinions contrary to their own.
- Social conformity effects which influence group members to a greater or lesser degree can mean the withholding of opinions or information contrary to the majority view, especially if that is an organisationally dominant view (Brown, 1988).
Dominating individuals can occupy a disproportionate amount of 'airtime' and influence whose views prevail through disproportionately vigorous argument.

Status, gender and hierarchy effects lead individuals to attend disproportionately to specific individuals, for example: the views of senior managers, when present in the group, are likely to significantly influence decision-making outcomes.

Regarding the effects of group size, Stroebe and Frey (1982) state that 'coordination' process losses can occur due to the problems associated with arranging and integrating other people in group-working practices. Hence, the larger the team, the bigger the coordination problems. Several coordination issues have the potential to adversely influence work group effectiveness including arranging times for meetings, coordinating tasks, integrating information and passing on information.

Group size also influences the demand for having a 'facilitator' role at group meetings in order to coordinate interactions during group discussions (Unsworth & West, 2000). Group size therefore influences the efficacy of communication within the work group. The authors state that one of the reasons why this occurs is that the natural non-verbal communication cues present in ordinary dyadic interaction, such as eye-contact and gesture, are more difficult to direct and interpret in group interaction situations.

In terms of age and gender, Jackson et al (1991) report that staff turnover rates are higher in teams that are heterogeneous with respect to age. Age diversity has it's greatest effects when it reflects differences in attitudes, values and perspectives, e.g. both risk-taking propensity and problem-solving processes are related to age, and if diversity in age is present within the team, conflict over the acceptable degree of risk taken for a particular problem may arise. Unsworth and West's (2000) review of literature relating to team effectiveness concludes that the effects of gender diversity are complicated by conflicting research results, with some studies showing that same-sex teams perform better than mixed sex teams and some showing the opposite.

A study by Watson, Kumar and Michaelsen (1993) suggests that culturally heterogeneous groups of students interact and perform less effectively initially, but that this effect diminishes over time as members gain experience with each other. Group member's identities therefore change over time, from belonging to an ethnic in-group, to a team in-group. Ethnic diversity may influence work group performance by impacting upon the effectiveness of intra-group communication. Effective communication requires common understandings, meanings, language conventions and conventions in non-verbal communication. Different ethnicity may mean differences in linguistic traditions and norms, making it more likely that misunderstandings and misperceptions may occur. Contributions by ethnic minorities may
also be automatically downgraded because of stereotypes associated with their accents (Unsworth & West, 2000).

Smith and Noakes (1996) in a review of cultural differences in work group processes conclude that there is some evidence to suggest that work groups incorporating cultural diversity in group composition, exceed the performance of their monocultural counterparts, over longer time periods. The authors also offer several factors which may impede performance in culturally diverse groups, and which must be resolved over time before the work group can begin functioning optimally, hence the delay in achieving high-performance outcomes in culturally diverse work groups compared with monocultural groups:

- Culturally heterogeneous groups must initially overcome language problems, problems of access and differing understandings of how to form interpersonal relationships.
- Culturally diverse groups are likely to encounter conflict due to differing perspectives on time, on preferred leadership styles and on the functions served by group meetings.
- ‘In-groups’ of individuals that share similar cultural values are likely to form during the course of group development in culturally heterogeneous work groups, impeding effective decision-making.

Once group development succeeds negative performance factors associated with cultural heterogeneity, the work group can begin to exploit inherent advantages in integrating different perspectives within the group. Smith and Noakes comment that groupthink may be minimised by drawing upon the diversity of perspectives inherent in a culturally heterogeneous group.

In terms of ability level, group problem solving performance is generally a positive function of average group member ability level (West, 1996a), though this relationship is not simply linear and the extent to which a group members ability level influences group performance can be affected by factors such as status, popularity and political processes within the group.

Groups composed of people from diverse professional backgrounds produce more creative decisions of higher quality than professionally homogeneous groups (West, 1996a). Unsworth and West (2000) conclude that diversity of task-relevant skills and knowledge leads to greater team effectiveness. Heterogeneity of task-related characteristics implies that each team member will have relevant and distinct skills that he or she can contribute towards task accomplishment. Work groups that are diverse in task-related attributes, however, are also often diverse in terms of demographics relating to the attributes of the individual such as age, gender, and ethnicity. A study by Wiersema and Bantel (1992) examined the diversity of top
management teams of 100 of the largest manufacturing companies in the USA, finding that diversity in educational specialisations within the teams was related to a more adaptive organisation and more effective strategic change. Bantel (1993) reports that the management teams of banks that were heterogeneous in terms of education and functional background developed clearer corporate strategies.

In terms of knowledge requirements for composition of successful work groups for execution of a specific task, Siemieniuch, Sinclair and Fairclough (1999) propose a knowledge network structure in which a set of generic classes of knowledge relating to operational procedures, human resources, products, equipment, control processes, quality assurance and domain knowledge are defined. The knowledge requirements for specific functions or operations can therefore be defined in terms of specific patterns of these knowledge 'nodes' in the network. Additionally, the authors propose four levels of knowledge that may be possessed by the individual in any specific domain or grouping of knowledge classes. Task requirements placed upon the individual may therefore be described in terms of necessary thematic content of knowledge required and level of that knowledge required to perform the operation. The four levels of knowledge are:

1) 'Know about': the individual knows that the knowledge exists and what its purpose is, but not necessarily how to apply it.

2) 'Entry': the individual has sufficient knowledge to be able to execute the defined task securely under normal circumstances (assuming adequate training to carry out the task in a specific environment with specific tools).

3) 'Experienced': defined as for 'entry' level knowledge, but additionally the individual can cope with some abnormal environmental variation. The individual can make some constructive use of knowledge in the design processes. Wider and deeper knowledge is required, with some rule-based behaviour as opposed to merely procedure-based behaviour.

4) 'Expert': defined as for the 'experienced' level, with the addition of sufficient formal, technical knowledge and expertise to be able to meet almost any demand regarding the specific task. Knowledge at this level is largely heuristic and skills will be fairly automatic.

In terms of individual group member competency, Fletcher (2000) offers examples of behaviourally defined competencies for the assessment of work performance, utilised in HR staff appraisal processes. These represent outcome indicators of work performance on the individual level and are related to role skill requirements. The competencies outlined below comprise generic measures of work performance that are not tied to specific quantifiable outcome indicators or objective 'results'. These indicators can therefore be used to make
direct comparisons between individuals, regardless of the specific characteristics or objectives of work performed, but necessitate a degree of subjectivity in measurement. Efforts to define or exemplify both positive and negative performance in behavioural terms represent an attempt to reduce the possibility for subjective bias inherent in these measures. Behaviourally definable competencies include:

- **Problem analysis and judgement performance**: Degree to which the individual analyses problems logically, with a 'strategic' perspective that looks to possible long-term consequences as well as immediate effects. Focus is not narrowly confined to the immediate problem situation. Decisions are made on the basis of a balanced and adequate appraisal of the facts and a capacity for innovation in problem solving is demonstrated. Doesn't promise more than can be delivered or over-simplify a complex situation to 'black and white' terms.

- **Planning and organisational performance**: Organises days productively and actively plans ahead to meet schedules in the long as well as short term. Anticipates potential problems and proactively intervenes to ensure they are prevented from occurring or their effects minimised. Ensures cover for absences and follows up key events. Plans to anticipate and meet other's requirements for information on demand. Delegates routine work where possible and employs a structured approach to task performance. Where task conflicts or time pressure arises, is able to correctly assign priority to the more important aspects of the individual's tasks or role whilst not being 'captured' by less important elements.

- **Motivation of others**: Sets an example in speed of response, efficiency and dealing with customers. Provides feedback on results, involves staff and seeks their advice where appropriate. Delegates where possible and encourages initiative. Generates a team spirit and sets targets. Reinforces the important aspects of corporate culture for organisational success. Demonstrates personal commitment to objectives and does not work independently. Provides motivation through an appropriate style of leadership.

- **Achievement and energy**: Energetic and quick in dealing with work. Proactive rather than reactive. Willing to make sacrifices to achieve targets. Is constructively competitive. Not willing to settle for average but seeks to exceed targets. Actively pursues business rather than letting it come in of its own accord. Responds positively to challenges.

- **Tenacity and resilience**: Maintains morale in the face of setbacks and is not deterred by initially unpromising responses. Displays determination in the face of adversity and persistence in pursuing objectives. Does not take rejection personally. Not easily demotivated and deflected from pursuing objectives.
**Group cohesiveness**

Unsworth and West (2000) offer several research findings concerning group cohesiveness, which can be defined as the degree of liking or attraction between group members and their liking for the group itself.

- Members of socially integrated groups experience higher morale and job-satisfaction.
- Cohesiveness can influence work group effectiveness by increasing motivation and group members' helping behaviours.
- Cohesive groups tend to devote more time to planning and problem-solving behaviours.
- Highly cohesive work groups incur less coordination and communication costs and can therefore apply more attention to task-related activities such as problem solving.

Mullen and Copper (1994) reviewed evidence from forty-nine separate studies of the cohesiveness-performance effect and report that there is a statistically significant relationship between group cohesiveness and group task performance. The direction of influence, however, remains to be clarified and may be strongest from performance to cohesiveness, i.e. successful, high performance fosters greater intra-group cohesion.

**Leadership**

Bass (1990) proposes two types of leadership styles, transactional and transformational, which motivate and direct work groups towards the achievement of their performance goals:

1) Transactional leadership employs transactions, exchanges and contingent rewards and punishments to change team members' behaviour. This style focuses upon task-oriented behaviours, and interventions to reinforce required behaviour and deploy sanctions for negative performance. Unsworth and West (2000) state that the transactional leadership style comprises contingent reward and punishment, active management by exception (following team members performance and taking action when mistakes occur) and passive management by exception (waiting until mistakes become serious problems before taking action).

2) The transformational leadership style involves influencing and inspiring team members through charisma and visioning, and motivating individuals towards completing tasks as part of a team rather than just focusing upon group members individual objectives and performance. Unsworth and West (2000) outline charisma (displaying conviction and trust, and emphasising commitment, purpose and loyalty),
Inspirational motivation (by visioning an appealing future, challenging standards, encouraging the team and promoting enthusiasm), intellectual stimulation (questioning assumptions and beliefs, stimulating new perspectives and encouraging the expression of ideas) and individualised consideration (leaders deal with team members at an individual level, by developing, coaching, listening and teaching each person) as being the main characteristics of the transformational leadership style.

Markiewicz and West (1997) suggest three main functions in which group leaders must be competent:

- Group management: setting clear objectives, clarifying the roles of work group members, evaluating individual contributions and developing individual tasks, providing feedback on group performance and reviewing team processes, strategies and objectives.
- Coaching individuals: listening, recognising and revealing individuals' thoughts and opinions, giving feedback and agreeing goals.
- Leading the group: creating favourable performance conditions for the work group, building and maintaining the work group as a performing unit and coaching and supporting the group.

Work group functional autonomy

In a meta-analysis of 131 field studies of organisational change by Macy and Izumi (1993), the authors concluded that the creation of autonomous workgroups, with substantial responsibility for their own work, largely influenced financial measures of organisational performance. Cordery (1996) in a review of research into autonomous workgroups offers several reasons for improved work group performance as a result of self-management:

- Autonomous work teams make decisions more rapidly in response to changing and uncertain environments.
- Decisions that are made in open and trusting climates, such as those found in autonomous work groups are more likely to be creative and innovative.
- Being part of an autonomous work group creates opportunities for new learning, which aids performance, both because employees are able to see 'the big picture' owing to greater responsibility, and because their skills are more fully utilised.
- Self-managed teams increase the self-efficacy of team members. Research shows that people who feel they have control over their environments, perceive themselves to be more competent at their jobs.
Job characteristics of those in self-managed teams, including autonomy, feedback, task significance, task identity, and skill variety are related to job satisfaction, intrinsic motivation, lower absenteeism and better work performance.

Work group autonomy is linked to leadership by Gulowsen (1979) who states that type of leadership may influence the degree to which a work group can decide where, when and how to work, can decide how to sub-divide tasks and assign them to group members, can influence the formulation of its goals and can determine it's own group composition. Leadership style is also synonymous with cultural performance determinants and research has shown that the pervasive style of leadership evident in an organisation's culture may have a direct impact upon team level performance achievement (Chalmers, 2001).

**Resource availability and quality**

Peters and O'Connor (1980) highlight the importance of adequate resource provision for effective human performance within the organisation. Even though individuals may be knowledgeable or skilful and motivated enough to be able to successfully accomplish a task, they can be prevented from doing so by characteristics of the situational context beyond their control. The authors outline three categories of situational constraints that affect the relationship between individual ability, performance and effectiveness:

- Unavailability of resources needed.
- Inadequate quantity of resources needed.
- Inadequate quality of resources needed.

In team effectiveness research, the availability of resources such as people, money and equipment, as well as the appropriateness of the work technology used, affects the relationship between work group processes and effectiveness (West, 1996a). Tannenbaum, Salas and Cannon-Bowers (1996) claim that an important prerequisite of effective performance and team success is that a work group's resource needs are met. The work group's resource needs include time allowed for members to work on the group's tasks, access to information necessary to complete the tasks, necessary equipment and personnel made available, organisational policies which facilitate (or rather don't inhibit) work group effectiveness and commitment over the longer term to group-member development and skill-acquisition.
Group goal characteristics

Work groups greatly assist in the coordination of separate activities performed by individuals in organisations that may be large and structurally complex. In a review by Weldon & Weingart (1994) of more than thirty studies of group goals and group performance in various work settings, it was concluded that the introduction of group goals leads to better performance and productivity. Furthermore, specific and difficult goals were found to improve performance over more vague and easier-to-achieve goals. Group goal planning was also found to be important, as group members were characteristically slow to respond to changes in their tasks or environments that made their strategies ineffective or their goals obsolete. The authors therefore propose five directives to ensure effective group planning and functioning:

- Goals should be set for all dimensions of performance that contribute to the overall effectiveness of the group.
- Feedback should be provided on the group's progress towards its goal.
- The physical environment of the group should remove barriers to effective interaction.
- Group members should be encouraged to plan carefully how their contributions can be identified and co-ordinated to achieve the group goal.
- Group members should be helped to manage failure, which can damage the subsequent effectiveness of the group.

Pritchard et al (1988) reports research in which the incremental effects of introducing group feedback, goal setting, then incentives upon productivity were measured using organisational units from a military context. The reported average increases in productivity over established baseline performance were 50%, 75% and 76% respectively, indicating the importance of group feedback and goal setting for work group effectiveness. West's (1996a) review of the work group literature also highlights the importance of performance feedback, in addition to goal clarity, especially for autonomous work groups that constantly develop their own work tasks in order to improve performance.

Goal commitment on the part of group members is an important factor influencing goal attainment (Weldon & Weingart, 1994) and is largely a result of features inherent in group goal design. Goal commitment is influenced by:

- The attractiveness of goal attainment, which makes the group goal more compatible with the personal goals of group members.
- The degree to which the individual's desires are satisfied through group membership, by being a member of an attractive or successful group.
- How charismatic the group leader is.
- The perceived difficulty of goal attainment and group member's expectations that the group can successfully complete its task.
- The presence of competing goal demands such as conflict between reducing costs and increasing quality.
- The goal commitment of others in the group.

The Goal-setting theory of motivation (Locke, 1968) highlights several important variables associated with inherent characteristics of task-goals that influence performance through motivation:

- Goal difficulty: more difficult goals lead to higher performance than easier goals up to a point; if goals are perceived as impossible they will not be motivating but will have the opposite effect.
- Multiplicity/compatibility of goals: where multiple and conflicting goals exist, increasing goal difficulty may be consistently associated with detriments in performance.
- Remoteness of goal realisation: goals that are remote in time do not display performance benefits from increasing difficulty.
- Goal specificity: specific goals lead to higher performance than general ones.
- Goal performance feedback: feedback on performance is necessary if outcome benefits from challenging and specified goals are to be obtained.
- Goal acceptance: acknowledges interaction of goal characteristics with the psychological characteristics of the individual. Level of employee involvement or participation in goal-setting is thought to be important in assuring acceptance of task goals, especially where organisational change is involved.

**Task and role characteristics**

The degree of visibility of individual's performance to other team-members is particularly important if negative effects associated with social loafing are to be avoided (George, 1992). Task design within the group should therefore incorporate the facility to both identify and evaluate individual contributions. According to Guzzo and Shea (1992), group member's tasks and roles should be designed in such a way as to be unique, important and make a meaningful and visible contribution to the effectiveness of the work group, if individuals are to be motivated and work effectively with others towards achieving the groups objectives.

Work group task characteristics can be classified in terms of the cognitive requirements they place upon work group members. Kent and McGrath (1969) conclude that much of the
variance in work group performance can be accounted for by the nature of the task itself. Employing various work group outcome indicators such as issue involvement, originality and action orientation, Kent and McGrath found that differences in the inherent cognitive features of tasks affected group effectiveness outcomes. Production tasks tended to result in high originality but low issue involvement, whereas discussion tasks had the opposite effect. Work groups performing problem-solving tasks were most likely to perform highly on action-orientation.

Warr (1987; 1996) offers nine categories of work environment features that influence employee (or 'job-specific') well-being and experienced job-satisfaction. Warr makes an analogy with the effects of vitamins upon the human body to distinguish various characteristic patterns of influence that the individual factors exert upon well-being or mental health. Each environmental feature may therefore be described as having an AD (additional decrement) effect or a CE (constant) effect. Levels of AD environmental features have a positive influence upon mental health up to a certain point, but high levels of the feature may then begin to have a negative impact upon mental health, just as vitamins A and D may have a negative impact upon physical health at high levels. Vitamins C and E, and health, have a linear relationship in which the positive influence upon mental health of increasing the level of the environmental feature is constant, regardless of the level of that feature. Additionally, Warr emphasises interaction between the person and the environment in determining outcome variables such as well-being, by stating that various personal characteristics of the individual mediate the effects of environmental features upon experienced well-being. The nine groups of environmental features, associated research constructs, their 'vitamin' type and matching personal characteristics are outlined below (matching personal characteristics as outlined by Foster, 2000):

- Opportunity for personal control (AD): employee discretion, decision latitude, autonomy, absence of close supervision, self-determination, participation in decision making. Matching personal characteristics: High Growth Need Strength (GNS), High ability.
- Opportunity for skill use (AD): skill utilisation, utilisation of valued abilities, required skills. Matching personal characteristics: High GNS, relevant unused skills.
- Externally generated goals (AD): job demands, task demands, quantitative or qualitative workload, attentional demand, demands relative to resources, role responsibility, conflicting demands, role conflict, normative requirements. Matching personal characteristics: High GNS, high need for achievement (nAch).
- Variety (AD): variation in job content and location, non-repetitive work, skill variety. Matching personal characteristics: High GNS.
Environmental clarity (AD): a) Information about the consequences of behaviour, task feedback; b) information about the future, absence of job future ambiguity, absence of job insecurity; c) information about required behaviour, low role ambiguity. Matching personal characteristics: High GNS, external control beliefs.

Availability of money (CE): Income level, amount of pay, financial resources. Matching personal characteristics: High desire for money.

Physical security (CE): absence of danger, good working conditions, ergonomically adequate equipment, safe levels of temperature and noise. Matching personal characteristics: High desire for physical security.

Opportunity for Interpersonal contact (AD): a) quantity of Interaction, contact with others, social density, adequate privacy; b) quality of Interaction, good relationships with others, social support, good communications. Matching personal characteristics: High sociability.

Valued social position (CE): a) wider evaluations of status in society, social rank, occupational prestige; b) more localised evaluations of in-company status or job importance; c) personal evaluations of task significance, valued role incumbency, meaningfulness of job, self-respect from job. Matching personal characteristics: High desire for social esteem.

Hackman and Oldham (1975; 1976) propose five core job dimensions that interact with characteristics of the individual to influence work performance. These characteristics are linked to psychological states, the individual's level of which influences personal and work outcomes, not the job characteristics themselves. The psychological states include: experienced meaningfulness of work (linked to skill variety, task identity and task significance), experienced responsibility for outcome of the work (linked to autonomy) and knowledge of the actual results of the work activities (linked to task feedback). A 'potential motivating score' (MPS) can be calculated for any job by taking the mean of the jobs score on skill variety plus task identity plus task significance and multiplying that by its autonomy and then by its feedback scores. This means that if either autonomy or feedback has a value of zero, the MPS will also be zero. Outcome variables from the operation of job characteristics upon psychological states include: level of motivation, quality of performance, satisfaction and level of absenteeism and turnover. Experienced motivation is modified by the person variable Growth Need Strength (GNS). The core job dimensions incorporated in Hackman and Oldham's model are:

- Skill variety: the extent to which work activities utilise different skills and abilities of the individual.
- Task identity: the degree to which work task performance involves completion of a 'whole', identifiable and meaningful piece of work.
• Task significance: the degree to which the individual's work has a substantial impact on the lives or work of other people and broader society.

• Autonomy: inherent freedom, independence and discretion in the performance of the work task.

• Feedback: level to which relevant information regarding the individual's currently attained performance is available.

The characteristics of the required task may influence whether or not group-working is the optimally effective methodology. Tannenbaum, Salas and Cannon-Bowers (1996) state that there must be a logical reason for the use of work groups, as group-working places increased demands upon employees. There must be inherent interdependencies in the task and work situation to warrant the use of a collaborative group, rather than just individuals.

Interventions aimed at changing task processes through helping teams define objectives, improve group members understanding of each others roles and identify specific performance problems in order to devise action plans to deal with them, are generally more successful in improving team performance than interventions aimed at socio-emotional processes, such as team-building exercises (West, 1996a).

McGrath and O'Connor (1996) consider temporal issues relating to task synchronisation in work group functioning. Work group's task synchronisation behaviours involve dealing with issues such as task concurrency, succession and coordination. Several important points are made:

• The effectiveness of work group task synchronisation activity is influenced by the qualities of the work group's technology, especially communications technology.

• Temporal patterning of collective group action or task performance involves consideration of the frequency, duration, periodicity, sequences and temporal locations of interactive behavioural events.

• The level of mutual entrainment of behaviour and action patterns by interacting partners in the work place holds important implications for the effectiveness of interaction, the quality of interpersonal relationships, task performance, and group member satisfaction and well-being. Over time the behaviour of interacting individuals in a work group becomes mutually entrained to one-another.

• Temporal organisation of behaviour within the work group to meet externally imposed deadlines is a form of work group entrainment with the surrounding organisational environment.
Workload

Tattersall (2000) states that mental workload, which may be loosely defined as the costs that humans incur in performing tasks, is a multidimensional concept that is difficult to measure and which incorporates aspects such as time pressure, mental load and stress or frustration. Mental workload therefore represents the operation of factors associated with features of the work task, relative to the characteristics and experience of the Individual.

- Mental workload is important due to increasing cognitive demands in modern jobs. The complexity of the modern working environment leads to increased cognitive demands placed upon memory, attention, perception and communication skills.
- Implicates the characteristics of the operational tasks, which may lead to high mental workload through placing demands that are too high or too low.
- Implicates other antecedent factors, though, as human worker’s performance cannot be improved indefinitely simply through ‘working harder’. Humans must be motivated to sustain high mental effort through attention to task demands and awareness of the operating goals.
- Workload may be said to have both ‘acute’ and ‘chronic’ effects. The immediate acute effects are evident in the short-term and have a direct effect upon performance, e.g. poor task and job design may result in errors, slow response times or situations which promote the neglect of subsidiary tasks. Chronic effects manifest themselves over a longer time period and can influence performance indirectly through health and well-being.

Siemieniuch, Sinclair and Fairclough (1999) outline various constructs that can be used to classify workload level for individual operations in a process. Workload is defined as a multidimensional concept, covering both physical and mental variables that describe task demand or difficulty and the operator’s perceptions of task demands. Workload variables can be utilised to evaluate operations groupings in terms of whether they exceed the capacity of a single individual to perform. They are therefore useful in evaluating and informing the process of the assignment of functions or operations to roles within a process. Workload constructs include:

- Time ratio: the temporal demands of the operation as calculated by time available for performance divided by time required for successful performance.
- Operation criticality: the importance of the operation within the process, distinguishing critical operations from lower priority operations, the latter resulting in less perceived pressure on the part of the individual.
Operation uncertainty: the availability of relevant information to ensure successful performance of the operation, a decrease in available information corresponding to increase in workload.

Operation complexity: representing cognitive load and sensory modes required for performance, as expressed by a number of workload sub-components including mental complexity, visual demands, auditory demands and modes of required input/output.

Operation criteria: the degree of precision required to perform the operation, higher performance criteria in terms of required precision corresponding to higher workload.

Mental effort: the 'energy intensity' associated with cognitive activity required for successful performance of the operation.

Physical effort: the intensity of physical activity associated with task performance.

Inter-group conflict

Social identity theory (e.g. Tajfel & Turner, 1979; Hogg & Abrams, 1988) holds that as a result of habitual human tendencies to categorise things as an aid to understanding and efficient cognition, we assign people and their attitudes into classes in a group situation. People consider themselves to be members of the 'in-group', leading to discrimination against the 'out-group'. Unsworth and West (2000) comment upon several effects in group settings arising from the implications of social identity theory:

- In-group members evaluate their group on dimensions that maximally differentiate them from the out-group, and which also show the in-group in a more positive fashion.
- When the work group itself is the most salient categorising characteristic, the whole team becomes the in-group and there will be no out-group discrimination. The effects of diversity on effectiveness are therefore minimal.
- If an in-group and out-group develops within the work group, for example: if a person identifies with only those of the same gender within the team, a more pronounced effect of diversity upon the effectiveness of the team may follow.
- The effects of diversity on performance are dependent upon the specific type of diversity in question, e.g. task-related attributes or person-characteristics.

Organisational culture and groupworking climate

Many culturally determined aspects of organisations have been addressed by organisational culture and climate research, including organisational effectiveness (e.g. Denison, 1990) and
Research into the factors that influence innovation by West and colleagues (West, 1990; West & Anderson, 1993; 1996) proposes four factors that are required to create an effective climate for innovation:

- **Vision**: a clear, shared, negotiated, attainable and evolving ideal of the valued outcome needs to be present, giving the group focus and direction.
- **Participation or participative safety**: reduces resistance to change, encourages commitment and empowerment and allows all team members' opinions to be heard in a safe environment. Participation has been found to predict the number of innovations introduced by top management teams.
- **Support for innovation**: the principal predictor of innovation that helps to reduce threat; often present when forwarding new and original ideas to the rest of the group.
- **Task orientation**: required commitment to excellence and high-quality innovations. Task orientation has been found to predict the administrative effectiveness of introduced innovations.

Unsworth and West (2000), drawing upon the work of Reichers and Schneider (1990), define work group climate as shared perceptions, values and beliefs regarding formal and informal policies, procedures and practices, that can influence performance, productivity and innovation. Commenting upon research in the area, the authors state that climate can influence performance through stress and job-satisfaction, in that dimensions of climate such as support, respect for rules, goal-oriented information and innovation are related to variables such as level of role conflict, ambiguity, job tension, and overall satisfaction experienced by group members. An effective work group climate is therefore related to happy, unstressed, satisfied group members.

Successful team-based organisations require commitment to the skill development, well-being and support of employees. Where the climate is characterised by high control, low autonomy for employees, lack of concern for employee welfare and limited commitment to training, group-working effectiveness will suffer as a result (Markiewicz & West, 1997). Unsworth and West (2000) comment that competition and intrigue create an untrusting environment that undermines facilitative factors, such as shared objectives, participative safety, constructive controversy and support, which effective group-working relies upon.

Mohrman et al (1995) demonstrates that inter-team competition is a major threat for team-based working, as competing teams may develop more commitment to their own success than to that of the organisation on a whole, which may in turn lead to the withholding of vital information and support from other 'competing' teams. A competitive culture may, therefore,
promote individual work group goals above and without reference to the broader goals of the organisation.

In terms of what may be regarded as broader cultural influences, Erez and Earley (1987) demonstrate that cross-national differences in work group performance can be explained by differing values held by group members towards goal setting strategies. Hofstede (1980) conducted research using IBM employees in 40 countries and employed a classification system comprising originally four dimensions, later amended to include a fifth (Hofstede, 1991), to identify cultural variance in work related attitudes and values. For example, in terms of the following dimensions, the UK can be said to have low power distance, low uncertainty avoidance, be highly individualistic and possess a masculine culture:

- Individualism-collectivism: the degree to which people employees in a particular society define themselves as individuals or group members.
- Power distance: the extent to which employees in a society tend to maintain distance from their superiors, indicated by factors such as the degree of formality with supervisors and the extent of informal and equal relationships with superiors.
- Uncertainty avoidance: the degree of ambiguity about the future which can be tolerated amongst employees in a specific society, indicated by future planning and future anxiety.
- Masculinity-femininity: whether achievements and recognition (masculine) or the quality of interpersonal relationships (feminine) are valued highest in workplaces in a society.
- Long-term perspective: perceived permanency and commitment to long-term goals in the workplace.

Smith & Noakes (1996) review research into cultural differences in group working practices and draw several conclusions regarding cross-cultural disparities in the definitions of what constitutes a work group and the values that relate to it's performance:

- The meanings of work group behaviours, such as participation and the obligations of work group membership, vary by cultural location.
- Of the five dimensions proposed by Hofstede (1980; 1991), the individualism-collectivism distinction is most important for the effectiveness of collaborative efforts, such as work group practices, in organisations. Furthermore, high individualism correlates strongly with low power distance and collectivism with high power distance.
- Work group-based organisation is easier to implement in collectivist cultures.
- Compared with Western organisations, Japan is a collectivist society. The attributes of the Japanese work groups are high work involvement, long-term time perspective,
high organisational commitment, low differentiation of specialist roles, acceptance of hierarchy and collective decision-making.

- Definition of a work group is culturally relative and explicable in terms of specific concepts such as Hofstede's (1991) collectivism-individualism dimension. Individualist cultures view group members as individuals who each use their skills on a different part of a task and who will be dropped by the team if their contributions are judged inadequate. Collectivist cultures consider work groups to comprise employees varying in seniority, but who have a long-term commitment to the organisation and a shared responsibility for all aspects of its performance.

- Research into organisational development practices shows that group participation in the USA leads to more effective change programs, whereas more collectivist, high power distance cultures don't display benefits from group participation, which may actually have a detrimental influence upon effectiveness.

- The nature of lower power distance cultures means that the need for leadership is reduced and group participation is favoured, as a means of increasing individual employee control over work.

- Collectivist cultures enhance the social motivation to perform well and have been demonstrated to reduce social loafing and promote success in quality-circle teams, where this latter technique has experienced relative failure in countries high on individualism.

**Organisational context**

Unsworth & West (2000) argue that the organisational context in which work groups operate is a powerful determinant of work group effectiveness. The authors outline the main organisational contextual factors that impact upon work group effectiveness as:

- How people are rewarded in the team and the organisation.
- The technical assistance available to support the team in its work.
- Whether the organisational climate is supportive both of people and of team working.
- The extent of competition and political intrigue within the organisation.
- The level of environmental uncertainty in relation to the task, customers, suppliers, market share, etc.

Brodbeck (1996) gives the following examples of situational constraints imposed upon a work group's functioning:

- Material resources.
• Task complexity.
• Work flow interdependence.
• Environmental uncertainty.
• Market growth.
• Technology.

**IT Support**

The adequacy of information technology to facilitate human communication is an important factor that may influence operational performance. Information management systems influence work group performance by providing or withholding the necessary information to effectively plan and perform group tasks (Hackman, 1990). Unsworth and West (2000) comment upon the impact of communications technology upon work group performance by influencing communications between group members:

- A study by Rice and Shook (1990) examined the use of voice mail in organisations. The technology was found to overcome communications restraints such as the requirement for both individuals to be available at the same time. The authors conclude that voice mail is valuable for coordinated, collaborative tasks such as group-working, and has considerable potential.
- Teleconferencing: allows teams to work across large physical distances but still communicate as a group. There is, however, some suggestion in the research literature that teleconferencing is not a viable substitute for face-to-face meetings.

In an evaluation of the use of CSCW systems in the automotive industry, Siemieniuch and Sinclair (1999b) comment upon the role of information and communications technology in supporting information-handling and collaborative working of groups that are geographically distributed throughout the supply chain. Several technological issues are important for the performance of distributed work groups:

- Successful concurrent engineering processes require that virtual teams of individuals from different companies, who collaborate to achieve common goals, are supported and networked through technology.
- Different information management systems must be integrated to ensure adequate timeliness, security, ownership, integrity and awareness of the data transferred. Data must be shared and made available throughout the network, rather than sequentially transferred from station to station.
Organisational issues such as lack of trust between groups, procedural inadequacies, role and task inflexibility, lack of employee empowerment and incompatibility in organisational policies, cultures and languages, often compound the influence of technology on virtual team performance.

CSCW systems are required to provide project management tools that allow on-line, available, up-to-date and accurate temporal scheduling on a project-wide level. Technology should also facilitate the development and dissemination of technical knowledge regarding product design and engineering, through providing centralised stores of product-relevant information, or 'product libraries', that allow broad access to current data models and specifications.

Computer-conferencing requirements mean that CSCW systems should support voice and face-to-face communications and provide facility for shared access to applications.

Successful application of CSCW in the supply chain requires organisations to display several attributes: transparency in work goals, problems and methods, willingness to share benefits and trust partners with potentially sensitive information. Additionally, there must be clear policies governing supplier interfaces and clear processes for collaboration and data exchange. The efforts of people in cross-organisational or cross-functional collaborative group-working activities must be supported by appropriate role redefinition and training needs identification.

Davenport and Prusak (1998) report a case study of work groups using virtual team-working technology in British Petroleum, to collaborate across geographically different locations. The initiative incorporated hardware and software aimed at duplicating, as far as possible, the richness of face-to-face contact, accepting that individual expertise often resides in the subtleties, variety and 'human' aspects of this type of communication. With this aim in mind, desktop videoconferencing equipment, multimedia e-mail, application sharing, shared chalkboards, document scanners, tools to record video clips, groupware and a Web browser were all made available at Virtual Teamwork stations. The authors report the outcomes of the study as follows:

- Quantifiably measured productivity increases and savings in both money and time demonstrated the success of the project.
- Success was also demonstrated by qualitatively measured effects such as increasing volume of use and participant enthusiasm.
- The costs associated with travel and expenses required to bring experts to a site was significantly reduced.
There were measurable productivity improvements related to more efficient information searches, issue resolution and reductions in duplication and wasted travel time.

Virtual team-working was considered to be a key factor contributing to the project meeting its target date.

A successful example of how communications technology can be used to support knowledge sharing in an organisation, by bringing experts and the relevant situations requiring specific expertise, together.

Notably, though, face-to-face meetings were still required to establish mutual trust and understanding and to resolve issues requiring the collaboration of a large number of team members. Once established, however, trust was better maintained and more commitments honoured due to the introduction of subsequent face-to-face videoconferencing, than by telephone or mail correspondence.

Technology allowed the creation of work groups from widely scattered individuals, and individuals who would not normally easily collaborate due to departmental as well as geographical boundaries.

The technology was judged to contribute to a more collaborative culture of executive decision-making across the organisation.

According to McGrath and O'Connor (1996), technology and communications technology in particular, holds important implications for the temporal patterning of communication in work groups. Aside from the effects of introducing complex technology in the work place on temporal organisation of task performance sequences, there has been significant interest in the effects of computer-mediated communication in work groups. The authors summarise some of the main issues raised by comparing these groups with normal face-to-face interactive groups as follows:

- Different transmission and feedback times.
- Different speed of communication-related activities (e.g. typing is slower than talking).
- Different timing of components of the interaction process (e.g. in computer-conferences, composition, editing, transmission and reception times are longer and these activities don't take place concurrently, as they do in normal face-to-face communication).
- Different degrees of turbulence in the flow of information in the interaction.
- Different constraints on the possible range of modalities available to communication (e.g. non-verbal and paraverbal cues aren't as readily available in computer-mediated interactions).
- Information transmitted between interacting partners in computer-mediated group-working is less rich, which can make decision-making processes and reaching
consensus amongst group members with differing perspectives both slower and more problematic.

- The effects of communications technology on work group performance are mediated over time by the work group's experience.
- The effects of communications technology may also interact with other variables such as task type, complexity and degree to which the task requires consensus, group composition, group member socialisation in the group and group member experience with the technology in question.

One of the biggest challenges for information technology to support modern working practices lies in achieving functional socio-technical integration. CSCW systems must therefore adequately integrate with social processes within an organisation, if they are to be accepted and functional (Eason, 2002).

**Human motivation**

In a review of conceptual attempts to understand motivation, Foster (2000) states that motivation exerts three important influences upon human behaviour in the working environment: direction, effort and persistence.

- Theories that have been proposed to account for motivation tend to fall into one of three general categories: those that presume people are motivated by internal factors ('need' theories), those that presume people are rational (expectancy or goal setting theories) and those that presume people are motivated by external factors (equity theory).
- 'Process' theories which address the question of what influences people's persistence at work, rather than why do people work, tend to emphasise either motivation (e.g. goal-setting theory) or job-satisfaction (e.g. equity theory) and can be invoked to account for variance in human performance outcomes.

Buchanan and Huczynski (1997) define motivation as the internal psychological process of initiating, energising, directing and maintaining goal-directed behaviour. Motivation is a broad concept that encompasses individual preferences for specific forms of action, the strength of their response and persistence of behaviour. The authors also comment that organisational designers and developers still largely lack the ability to create organisations that consistently and predictably motivate their members.
Furnham (1997) reviews the 'expectancy' or VIE (valence, instrumentality and expectancy) theory of work motivation. The theory is multiplicative, in that motivation is highest when levels of all three variables are high, yet zero if any one of the three components falls to zero. The three factors that affect motivation according to this theory are:

- Valence of achieved outcomes (perceived desirability/value of rewards associated with outcomes to the individual). The outcomes themselves may be 'first level' or direct, such as payment for work performed, or 'second level'/indirect, e.g. promotion for consistent high standard of work performed over time.
- Instrumentality referring to the belief that ones performance will be rewarded. The degree to which the individual believes their performance will be instrumental in achieving the desired outcome and hence eliciting reward.
- Expectancy, or the 'action-outcome' association that productive effort will result in the achievement of the desired outcomes.

Locke (1968) holds that motivation is influenced by specific intrinsic characteristics of work tasks, namely features associated with the goals of work task activities. These include the difficulty of goals (increasing difficulty results in increased performance up to a point), the specificity of goals (highly specific goals tend to increase performance compared to more general ones) and the presence of feedback regarding the current level of goal attainment.

Locke and Latham (1990) propose an integrated theory of motivation that depicts motivation as a complex process, subject to various moderating factors. Job satisfaction, for example, does not influence motivation directly but acts through influencing commitment to the organisations goals in determining high performance. Well specified, high yet attainable goals, high expectancy on the part of the individual and high self-efficacy all influence performance through increasing the effort, persistence and sense of direction in people's approaches to work tasks. This effect is moderated by the individual's commitment to the organisations goals, their ability, task complexity and inherent feedback and broader situational constraints. The achievement of high performance outcomes leads to the delivery of rewards, subsequently affecting job satisfaction which in turn feeds back by influencing commitment to the organisations goals and future performance and goal level expectancies. The motivational process therefore forms a 'high performance cycle'.

Vroom (1964) proposes three important performance determinants that influence human performance through influencing motivation for effective activity in the work-place. The effects of the variables expectancy, instrumentality and valence on human performance are multiplicative, in that motivation is highest when levels of all three variables are high, yet zero if any one of the three components falls to zero:
Expectancy belief: an 'action-outcome' association belief that the individuals workplace activities will result in the achievement of specified outcomes. This variable represents the fact that the efficacy of work activities in achieving the objectives of production may vary.

Instrumentality belief: referring to the belief that ones performance will be rewarded. The degree to which the individual believes their performance will be instrumental in achieving the desired outcome and hence eliciting reward.

Desirability of outcomes of activity: the outcomes themselves may vary in terms of the desirability of the rewards they represent. Rewards not necessarily confined to external reward for objective attainment, e.g. pay incentives, but can incorporate intrinsically rewarding features of the task itself. To a large extent, personality factors can influence the perceived value of rewards.

Performance feedback

Fletcher (2000) comments upon the importance of performance feedback for the individual, stating that performance is improved by supplying information regarding the effectiveness of ongoing behaviour. Performance feedback is an essential psychological prerequisite for learning that allows individuals to acquire knowledge as to the value of results they are already achieving. The author also highlights the link between performance feedback and motivation, by stressing that the very act of giving feedback provides motivation as people have an inherent desire to know the efficacy of their actions and behaviour. Formalised performance feedback processes in the organisation, such as staff appraisal or evaluation procedures, also provide motivation by governing the allocation of rewards and reinforcing positive performance through offering incentives related to salary and personal development opportunities. Assessment practices that involve target-setting also have a motivating effect by directing the individual's efforts towards the achievement of specific goals.

Team performance is most effective when rewards are administered to the team as a whole and not to individuals, and when they provide incentives for collaborative rather than individualised work (Unsworth & West, 2000).

Fletcher (2000) highlights the importance of formalised performance evaluation and management processes in organisations. These processes have several important influences on performance and other performance-related factors:
Performance appraisals guide reward processes by ensuring the fair allocation of rewards to individuals and organisational sub-units on the basis of performance. Reward and reinforcement of positive performance is an important motivator.

Assessment practices allow performance target setting, motivating people towards achieving the organisations objectives. Participative target-setting activities also ensures cohesion and coordination between the goals and efforts of the individual's behaviour and the strategic objectives aimed at the creation of value on the part of the broader organisation.

Performance appraisals are one of the key processes which support human or workforce development, by allowing the evaluation of development needs in terms of training and skill acquisition or maintenance.

Performance evaluation processes allow the organisation to plan for the future, by aiding the identification of human potential and allowing the strategic manipulation of human capital within the organisation. One example of future planning is the formulation of staff succession strategies.

Formalised assessment procedures also allow the permanent recording or documentation of performance over time.

**Decision processes**

Group-working and decision-making processes are implicated by consideration of how performance loss due to social-interactive processes can be averted. Research indicates various instances of apparent negative performance effects resulting from the aggregation of individual's work efforts in group situations. Rogelberg et al (1992), for example, reports that whilst groups make better decisions than the average quality of individual's decisions when rated by experts, they consistently fail to exceed the quality of decisions made by the most capable group members when working as individuals.

Diehl and Stroebe (1987) in their study of 'brainstorming' groups, report that the quality and quantity of ideas produced by individuals working alone exceeds those produced when individuals work together. Effective group methodology and organisation of group-working processes should therefore aim at minimising performance losses. Rogelberg et al (1992) propose a structured decision-making methodology or procedure, based upon the idea that where group discussion and suggestion processes are delayed until after individuals have been allowed thinking time, and then all suggestions are discussed by the group, the resulting group decisions are at least of the quality of the most capable individual members.
West (1996a) after reviewing literature on group brainstorming concludes that group members should generate ideas individually before bringing them to the group, which should then give air-time to all the ideas of each individual, before evaluation and selection take place. Group-working processes can therefore be altered to counter so-called ‘production-blocking’ effects that occur in group situations. Rogelberg et al also report that in high performing groups, there is typically a stronger correlation between ‘airtime’ in group discussions and group member expertise than in groups that perform poorly, suggesting that group-discussion processes should take account of the distribution of expertise within the group. Tjosvold (1985) suggests that group-working procedures that involve fostering conflict in a structured way leads to more effective group decision-making. Multi-disciplinary work team literature suggests that group-working procedures aimed at functional integration convey performance benefits due to varied participation and combination of a broad range of experience and expertise brought to bear upon group tasks (e.g. Jackson, 1996).

Unsworth and West (2000) state that due to the increased demands of communication in groups of several individuals during decision-making processes, it is often necessary to have someone in the role of ‘facilitator’ to direct discussion at meetings. The assignment of the facilitator role can exert specific effects upon the nature and hence effectiveness of group interactive processes:

- Group leaders are capable of facilitating effective discussion, but this requires strong control.
- Sharing the facilitative role between group members or assigning it to a junior member of the work group can make meetings more participative and discussion more active, whilst still maintaining consensus and order.

Work group decision-making processes include several sub-elements (Unsworth and West, 2000):

- Problem recognition and definition: work groups must engage in extensive scanning and problem-discussion in order to formulate appropriate plans and actions.
- Solution generation: producing a variety of possible problem solutions increases the chances of obtaining high quality and innovative decisions. Group brainstorming is an often-employed approach to generating a range of possible solutions to a problem.
- Solution analysis and choice: analysis and evaluation of possible solutions must be based upon task-related criteria.
- Solution implementation: successfully implementing and maintaining the chosen decisions depends upon high participation levels within the work group.
Maier (1970) found that work groups which focus upon the problem as well as the solution, are more effective. Defining the problem through analysis improves work group decision-making and defining the problem from a variety of different perspectives produces a broader range of possible solutions.

Employees who have participated in decision-making have greater satisfaction with, commitment to and ownership of decisions than those who do not. Participants in the decision-making process will be less likely to let the implementation fail as a result of increased task ownership and shared responsibility for the outcome of a work group's efforts. Participation is therefore a key motivator for commitment to high standards of performance (Unsworth and West, 2000).

The absence of rational, task-related evaluation of proposed actions in a group decision-making situation is one of the key features of the 'groupthink' phenomenon (Janis, 1982), in which opportunities for reaching a high-quality decision are sacrificed in order to maintain cohesion within the group.

Unsworth and West (2000) offer minority dissent as another factor that can influence group decision-making processes, by bringing about sustained change in attitudes as a result of persistent task-related conflict.

There is some research evidence to suggest that cohesive groups tend to devote more time to planning and problem-solving behaviours than less cohesive groups, which incur more communication and coordination costs and therefore have less attention to devote to problem-solving under time pressure (Ouchi, 1980).

West (1990) proposes two successive processes involved in innovation in work groups. Idea generation or brainstorming is a result of interactive processes and the level of motivation, knowledge and skill within the work group, whereas idea implementation refers to the process by which innovative ideas are translated into new products, methods and services.

'Groupthink' is a group syndrome reported by Janis (1982, 1989) in which groups may make erroneous decisions due to a pre-occupation with maintaining internal agreement over consideration of the quality of group decision-making. Several issues are associated with groupthink:

- Groupthink is most likely to occur in groups with a dominant supervisor, implicating the training of supervisors to be more facilitative in group decision-making, rather than forcing their own opinion.
• Groupthink is most likely to occur in work groups that are high in internal cohesiveness.
• Conditions that foster isolation of the group from alternative perspectives and sources of information are conducive with groupthink.
• Organisations in which different departments feel in competition with one another promote 'in-group' favouritism and therefore a greater likelihood of groupthink.
• Groupthink is characterised by decision-making and group behaviour that is not based upon rational information and reality, but rather is motivated by group-consensus seeking.

It has been stated that groupthink may be minimised by exploiting the diversity of perspectives inherent in work groups comprising multi-national or culturally heterogeneous members (Smith & Noakes, 1996). The level of cohesiveness itself within a group does not appear to be a crucial factor for the occurrence of groupthink (McCaulay, 1989).

Conflict in the group decision-making process can have a positive effect upon group performance, by promoting the elaboration of views, the integration of opinions and the search for new information and ideas (Tjosvold, 1985; 1991). Constructive controversy in intra-group interactions has been found to be an important factor influencing the innovativeness of work groups (West & Anderson, 1993).

In minority influence theory (Moscovici, 1982; Moscovici, Mugny & Avermaet, 1985), minority dissent can have a sustained and powerful influence upon the attitudes and opinions of others in the group, through the cognitive and social conflict created by enduring task-related conflict. The minority's influence is a result of their consistent and coherent disagreement with the majority opinion, which forces other group members to examine the source of conflict more thoroughly and think more adaptively around the problem, often resulting in more effective decision-making.

West (1996a) highlights several important issues for work group performance from research into minority influence effects:

• Exposure to minority influence can cause marked internalised changes in attitudes in the direction of the deviant view as a result of the cognitive or social conflict generated by the minority's disagreement with the dominant view.
• Conformance to a majority view is often general public compliance without necessarily a change in private beliefs. Minorities, in contrast, appear to produce a shift in private views rather than mere public compliance.
- Minorities encourage greater diversity in thinking about the issues they raise even when they don't cause the majority to adopt their viewpoint.
- Minority influence in work groups can lead to very different patterns of group processes than majority influence, and that the conflict generated by minorities may lead to new orientations within groups towards group objectives and decisions.
- There is a general lack of research evidence concerning whether, in what circumstances and how minorities in work groups affect group performance.

Intra-group conflict has also been highlighted as an inherent stage in the developmental sequence of groups (Tuckman, 1965), involving a period of conflict and emotionality, as members become assertive, argue and seek to manipulate the group to satisfy their own needs.

Courtney (2001), in a consideration of the personal or individual perspective in organisational decision-making, identifies several important individual variables that influence decision-making style, including: individual experiences, training, intuition, values, ethics, personality factors and attitudes to risk. The author comments that for partially structured decision problems, such as are commonly encountered in an organisational context in which social, environmental and ethical concerns must be considered in addition to technical factors, identifying and incorporating as many diverse individual perspectives as possible in the decision-making process is important for overall decision-effectiveness and successful implementation of solutions. The different types of individual's decision-making strategies highlighted by Courtney are based upon propensity to use five different inquiry styles associated with philosophical traditions:

- The Hegelian Synthesist, who embraces conflict and integrates information from opposing views in order to formulate a synthesis incorporating those aspects of each opposing view the observer considers most plausible. This approach has been found to be effective in sounding opposing viewpoints and the assumptions upon which they are based, and may be particularly successful in strategic planning problem situations.
- The Kantian Idealist values both data and theory and employs multiple analytic views in search of an ideal solution. Based upon observations, the inquirer constructs various models in order to explain those observations; the model that best fits the data being eventually adopted whilst the others are discarded. This approach is both theoretical and empirical in its decision-making style and, it is suggested, is suitable for problems of moderate complexity.
- The Leibnizian Analyst uses models, mathematical and formal logic techniques to derive optimal solutions through inferring cause and effect relationships. This approach has been termed 'analytic-deductive' and represents a formal, inflexible
approach that relies upon well-established rules and procedures. It is suitable only to simple, well-structured problems such as those that arise in scientific technical domains.

- The Lockean Realist is an inductive reasoner who seeks concrete facts upon which to base decisions as opposed to generalised theories. Decision-making is therefore based upon interpretation of facts or observations. This style of decision-making is more effective where the problem situation is highly environmentally determined.

- The Singerlan Pragmatist is open to multiple perspectives that are employed as and when they are required according to the features of the problem situation. This decision-making style may therefore be considered most adaptive as it is capable of encompassing and may utilise the previous four styles as and when appropriate. It is also perhaps most appropriate for contemporary organisational environments involving complex socio-technical problem situations, the solutions of which may potentially influence multiple stakeholders. This style may be considered innovative and adaptive, and as such suitable for more complex situations. The decision-maker will make a point of sounding multiple perspectives and stakeholder groups involved in a problem situation and employs 'systemic thinking'; in appreciation of the interconnectivity of variables in complex problems.

Work group development and learning

The time dimension becomes important for work group effectiveness in the consideration of group developmental sequences and temporally determined factors, implying that over the course of time, different factors will become prominent in influencing work group effectiveness (e.g. Tuckman, 1965; Smith & Noakes, 1996; McGrath & O'Connor, 1996). Tannenbaum, Salas and Cannon-Bowers' review of efforts to promote work group effectiveness (1996) incorporates a temporal dimension in the definition of work group effectiveness, defining performance in terms of how well the team accomplishes it's goal or mission and its ability to develop and regenerate itself, allowing it to sustain its performance and accomplish its mission over a period of time. This consideration becomes important for the effectiveness of a work group's functioning, which may not reach optimum output until various factors associated with the novelty of the situation in a newly formed group are overcome. Tannenbaum et al also accept that a work groups needs may vary between different stages of group development, stating that different needs at different times require specific interventions. Possible needs may include role conflict, lack of technical skills and communication problems, amongst others.
From a review of over fifty studies of group-working, Tuckman (1965) proposes a theory of group development incorporating several stages. According to this developmental approach, groups progress through different stages of socio-emotional and task behaviour and activity, over time. Tuckman's original four group developmental stages were later amended by the author to incorporate a fifth developmental stage. The proposed stages of group development are:

- 'Forming' involves a period of orientation and dependence during which members are anxious about belonging to the group.
- 'Storming' involves conflict and emotionality as members become more assertive, argue and seek to manipulate the group to meet their own needs.
- 'Norming', in which negotiation about how to proceed reaches a conclusion and conflicts are resolved resulting in group cohesion.
- 'Performing' involves role-taking and problem-solving in order to achieve mutual goals.
- 'Adjourning', in which members begin disengaging from the group both socioemotionally and in terms of task performance, in anticipation of the end of the group.

Smith and Noakes (1996) state that there is some evidence to suggest that multinational work groups exceed the performance of their monocultural counterparts over longer time periods. The authors propose that the delay in achieving high-performance outcomes in culturally diverse work groups is due to extended maturation time required to overcome language problems, problems of access, differing understandings of how to form interpersonal relationships, differing perspectives on time, different preferred leadership styles, differing opinions as to the functions served by group meetings and the development of cultural 'in-groups', all of which have a detrimental effect upon work group performance in the initial stages of group development, but then dissipate over time. The value of the time factor at any specific point can therefore be said to modify the relationship between group composition (specifically cultural diversity) and work group effectiveness.

McGrath and O'Connor (1996) hold that groups are dynamic systems that develop and change over time. A work group's functioning is therefore affected by four key temporal processes during its lifecycle:

- The origins and subsequent development of a group as a socio-technical system.
- The processes by which the work group performs its tasks.
- Changes in the group as a function of its own developmental and task performance experience.
• Dynamic changes that occur in groups as a result of changes in their environments and constituent parts.

McGrath and O'Connor (1996) offer the concept of synchronisation or coordination of multiple activities in time as a factor that affects group task performance. Synchronisation involves issues such as task concurrency, succession and coordination, and is influenced by the work group's technology; especially communications technology. Important points made by the authors include:

• The important issue is to address the question: how is the flow of interaction in groups patterned over time?
• Temporal patterning of collective group action or task performance involves consideration of the frequency, duration, periodicity, sequences and temporal locations of interactive behavioural events.

Argote & McGrath (1993) propose four generic 'CORE' processes (Construction processes, Operations processes, Reconstruction processes and External Relations processes) as descriptive of activities that take place in the typical work group life-cycle.

The development of group norms, procedures and routines over time is a form of group learning (McGrath & O'Connor, 1996), representing the collective development of group member's knowledge and skills through experience of task performance. One approach to the study of development of group norms is 'adaptive structuration theory', which seeks to explain the patterns that groups develop in order to carry out their work. There is however a paucity of research on two important topics:

• How work group performance varies as a function of development and change in methods, structure and division of labour.
• How groups 'embed' their learning in new standard operating procedures, new norms and new project plans.

West (1996b) states that group-working practices enable organisations to maintain 'memories' of knowledge and lessons learnt relating to organisational functioning. Through group experience, shared knowledge and skills develop which are then retained, even if one member leaves the group. Information therefore continues to be maintained in group memory.

Mohrman, Cohen and Mohrman (1995) incorporate the fact that work groups enable organisations to learn and retain learning more effectively as one of the main reasons why
organisations implement group-based working approaches. McGrath and O'Connor (1996) state that if 'learning' is to occur, groups must have some way of embedding the knowledge gained from experience of performing tasks. Learning must therefore be embedded in members, projects, technology and combinations of all three, for example: member-technology pairings such as in habitual routines, member-project pairings such as in the division of labour or role networks, and as project-technology combinations such as in project templates, norms, standard operating procedures, etc. Several authors have adopted a group-information-processing approach to the study of factors such as group learning and transactive memory (a so-called 'socio-cognitive processing/factors approach), mimicking the human-information-processing approach dominant in cognitive psychology aimed at the individual. The authors also highlight several central issues for the study of group learning and performance over time:

- Where in the system does 'learning' reside?
- What conditions influence the retrievability of learning (for example, learning may be lost with group member turnover)?
- What interventions are necessary to maintain learning (for example, cross-training of work group members to increase redundancy of skills new knowledge, consequently minimising loss due to staff turnover)?
- How does the more tangible evidence of learning ('hard-copy' archival records, meeting minutes, correspondence, production and sales records, etc.) fit into a socio-cognitive model of group learning and memory activities?

West (1996a) comments that group effectiveness can be considered in relation to three types of outcome:

- Effectiveness of the group in meeting its organisational goals, including those for innovation.
- Effectiveness in terms of a group's long-term viability, i.e. how long they are able to continue functioning, influenced by factors such as: group member satisfaction, participation and willingness to continue working together, as well as by level of social support, effectiveness of conflict resolution methods, team social climate and support for team member growth and development.
- Group effectiveness in terms of the mental health and growth and development of team members, i.e. teams may be considered ineffective if pressure resulting from team functioning means that individuals are unable to achieve organisational goals satisfactorily.
Planning and scheduling

McGrath and O'Connor (1996) summarise the main challenges faced by work groups in the planning of the performance of complex tasks that require coordination and synchronisation. Their approach adopts a temporal perspective on complexity in group tasks which, it is proposed, can be overcome by temporal planning of collective action involving allocation, synchronisation and scheduling activities. Successfully functioning work groups must therefore plan to overcome three key temporal issues in order to perform effectively:

- Work groups must plan to allocate available resources, including temporal ones, in order to match resource availability with the demands of the task and situation.
- They must plan the coordination of both content and timing of the actions of multiple individuals with one another, synchronising actions within and between individual group members.
- They must plan the scheduling of task activities, by anticipating what actions and events will take place and when they will occur.

Gersick (1988) offers insight into how externally imposed deadlines influence the flow of work in groups. Project deadlines influence group work by shaping work flow into a "punctuated equilibrium" pattern, in which the amount of time remaining for the group to complete its tasks shapes the phases of a project, rather than the amount and type of work performed previously.

Kelly, Futoran and McGrath (1990) found that imposed deadlines or temporal markers on task performance sequences entrain factors such as rate of productivity and pattern of interaction, an effect that generalised to later instances of task performance. Two specific patterns of entrainment were noted:

- Response to problems of capacity (how much can the system do in a given time?). When initial task performance attempts raise problems of capacity, individuals and groups speed up their rate of production to compensate on subsequent tasks, even if time constraints have been relaxed.
- Response to problems of capability (how much task difficulty can the system handle?). When initial task performance attempts raise problems of capability, individuals and groups slow down their rate of production on subsequent attempts, presumably to accommodate the deeper cognitive processing necessary to understand the complexity inherent in the task.
McGrath and O'Connor (1996) propose that the relationship between imposed deadlines and performance goals is important to productivity. The authors advocate the expansion of the concept of goal setting beyond the dimension of quantity to include issues of quality and timing as well. McGrath and O'Connor (1996) defines organisational scheduling activities as the matching of specific periods of time to specific sets of activities and to specific social units (i.e. individuals and groups) that are to perform those activities. The authors comment that periods of time that are the same size are not necessarily interchangeable, nor are sets of activities or the units charged with the performance of tasks. Several other issues are raised:

- Some sets of activities are temporally inflexible in that they can only be done at certain specific times without incurring penalties in terms of efficiency.
- Some periods of time are not versatile in terms of what activities can be performed within them.
- Sets of activities vary in terms of their modularity; how easily they are grouped for performance in a specific period of time, or decomposed for performance over a number of separate time segments.
- Time periods set for the completion of activities are often elastic, or vary within certain parameters, depending upon the requirements of the task and whether they allow for compromise between outcome factors such as that between time to deliver and quality.

**Process loss and boundary issues**

Groups that engage in environmental scanning behaviour have a better chance of discovering a problem before it becomes unmanageable (Cowan, 1986). Brodbeck (1996) stresses the importance of considering the externally-oriented, environmental integration activities of work groups, for effective functioning. The author cites examples such as ‘boundary management’, in which the way a work group is integrated into a larger system through coordination with other stakeholder groups such as suppliers, peers and customers is an important dimension of work group performance, and therefore work groups which are shown to be actively managing these external demands are more effective.

The collective strategies that work groups and their leaders utilise to relate to their external environment have been the focus of research. Gladstein-Ancona (1990) concludes that work groups facing external demands and new unstructured tasks succeed best by employing a ‘probing’ strategy, involving emphasis upon interaction with outsiders to diagnose requirements and formulate solutions.
Social interactive processes refer to processes that occur as a result of interaction between people within a group and can exert both positive and negative influences upon work group effectiveness. Steiner (1972) uses the term 'process losses' to refer to the detrimental effects of certain social processes on the effectiveness of work group behaviours, such as group decision-making. These processes are a direct result of collective working methods and can result in work groups achieving performance outcomes that are less effective than the aggregate of individual's efforts. Process losses therefore mean that actual team productivity is less than potential productivity.

Stroebe and Frey (1982) specify 2 categories of process losses: coordinational and motivational. Coordination process losses occur due to the problems associated with arranging and integrating other people in group-working practices. Motivational process losses occur when individuals use less effort in performing a task in a group, than when performing the same task by themselves. A primary example of motivational process loss is the widely reported 'social loafing' phenomenon.

Innovation

In a study by West and Anderson (1993) designed to investigate which sub-set of indicators, out of a number of measured factors, best predicted innovation in work groups, it was found that group innovativeness was inversely related to the size of work group and the level of resources available to the work group. Additionally, several factors were found to be very effective predictors of work group effectiveness, including: goal commitment, level of group member interaction, level of information sharing, group member influence over decision-making, practical support for attempts at innovation and task orientation (this latter indicated by constructive controversy and group performance monitoring processes).

West (1990) divides team innovation into two successive components: idea generation and implementation, suggesting that innovation processes in work groups result in two distinct outcomes: the innovations themselves and their subsequent implementations or deployments in the organisation. Brodbeck (1996) makes the point that 'implemented innovations' are themselves performance outcome indicators of work group effectiveness and not easily subsumed under other headings such as productive output or personal/group criteria. The effectiveness of work group functioning is therefore partly expressed by how well innovative ideas are translated into new products, methods and services.
Well-being

Warr (1996) offers three dimensions for the measurement of employee well-being: 1) overall pleasure – displeasure (sometimes referred to as satisfaction – dissatisfaction), 2) anxiety – comfort and 3) depression – enthusiasm. Warr comments upon the relationship between employee well-being and job performance, stating that although it is often presumed that high well-being leads to increased performance, it is difficult to establish the direction of causality, e.g. high job-satisfaction could result in increased performance or may conversely be the result of successful (high) job performance. Alternatively, a third unspecified factor (such as some feature of the work environment or management practice) may be responsible for both high job performance and high satisfaction independently. Performance is known to be a result of a number of factors associated with the individual and the work environment and therefore job-satisfaction or well-being cannot account for all variance in performance measures. Specific research findings include:

- Multi-item measures of overall job-satisfaction are positively correlated with high performance (as rated by supervisors).
- Intrinsic satisfaction (derived from the intrinsic features of performing the actual work activities themselves) is more strongly associated with high performance than extrinsic satisfaction (resulting from ‘background’ features of the job that provide a context for work activities).
- The association of satisfaction with performance may be stronger for managerial and professional employees, than for others.
- On the organisation-wide level, academic performance outcomes have been found to be associated with teachers overall job satisfaction.
- Higher levels of job-related tension are associated with lower levels of supervisory performance ratings, offering support for the intuitively plausible assumption that high reported job-related anxiety and strain is an indication of inability to cope with job demands, which consequently results in detriments in effectiveness.
- There may be an optimal level of experienced challenge, specific to each individual, for high performance outcomes; deviation either side of this optimum resulting in decrements in performance. Moderate demands are therefore linked to raised but manageable tension and high performance, with extremity (low and high) levels of tension resulting in decrements to performance.
- Little direct evidence exists for the beneficial effects of high levels of the depression-enthusiasm dimension on performance, but the association is again intuitively plausible.
Overall job-satisfaction, level of job-related anxiety and enthusiasm (as indicated by active job engagement/voluntary involvement) all correlate to some degree with absenteeism, an organisational level indicator of employee performance.

Warr (1996) reviews some research into the influences upon the organisational performance indicator employee absenteeism. Absenteeism and its converse, employee attendance, are important employee performance indicators on the organisational level and are influenced by a number of different types of variables. On the individual level, sickness, social and family pressures can influence the decision to attend. On the organisational level, the presence and effectiveness of policies to encourage attendance, support from a supervisor and the corporate culture relative to attendance can all influence absenteeism. With regards to the latter, the presence of an 'absence culture' comprising specific norms, attitudes and beliefs regarding the acceptability of certain levels of absence and perceived consequences of absenteeism (including formal and informal sanctions) are also important. Conventional measures of absenteeism fall under two categories: the 'time-lost Index', an indicator of the total duration of absence for a specified period, and the 'frequency index', which measures the number of separate incidences of absence within a defined period, regardless of their duration. The former is thought to be a better indicator of involuntary absence and the latter of voluntary absence, due to the expectation that genuine sickness absences are likely to be longer in duration. Warr summarises various research findings related to performance as indicated by employee absenteeism:

- Job satisfaction correlates with both measures of absenteeism, but appears to account for more variance in the total time lost indicator than in the frequency index. The same can be said of the effects of job-related anxiety on absenteeism.
- Higher well-being as indicated by high level scores on the depression-enthusiasm dimension show a negative correlation with single-day absences, thought to indicate voluntary time off work.
- Measures of job involvement indicating active engagement in the activities associated with ones working role are negatively correlated with the frequency index of absenteeism, meaning that more enthusiastic and proactive individuals in the workplace demonstrate less incidences of absenteeism.

**Trust**

Goranson (1999) defines trust as "confidence through experience" and states that trust is important in the development of adaptive unofficial communication networks that often "take up the slack" where formal networks and systems are limited. In an example of the problem
quoted by the author, informal communication between nodes, based upon trust, was important in providing information support to the decision maker, through the sharing of local knowledge not captured by formal communication channels. Unofficial networks based upon trust are also highly personality-oriented and evolve through close collaboration. Accordingly, trust in both the nodes or agents and trust in the communication channels that connect them is important for successful enterprises.

Goranson offers a distinction between two types of trust: inductive trust and deductive trust. Inductive trust may be defined as "common confidence" that a specific outcome of interaction with the trusted entity will be achieved based upon historical experience of interaction with that entity. Deductive trust is not based upon reliability, however, but knowledge of circumstances surrounding the interaction. As such, deductive trust recognises that experience with an entity may change due to changing circumstances and contextual factors. Inductive trust is often subjective and based upon personal relationships, whereas deductive trust may be considered to be more objective, more essential for successful decision-making within enterprises and can be modelled, analysed and measured. Whereas inductive trust is based upon repeatability and works with static situations and known agents, according to Goranson, deductive trust is based upon insight and can accommodate unknown agents in dynamically changing situations. Deductive trust may also be partly based upon inductive experience.
Appendix B: Early multi-level conceptual model

The conceptual model depicted below consists of an early attempt to identify performance factors inherent in multiple levels of an organisational system, consisting of individuals, work groups and organisational units within the context of the broader environment. A key feature of this model is that it seeks to represent the interaction between factors on varying levels of an organisational system as was evident from review of theoretical and research literature that addressed performance in organisational systems.
Appendix C: Expanded embedded-level conceptual model

Developed from the simple model depicted in appendix B, the embedded-level model below represents overall organisational performance as a function of the operation of many human and organisational variables within embedded sub-levels of the organisational system. These performance factors may be decomposed into finer-grained criteria within each level of analysis. The model below represents an elaborated version of that depicted in figure 4.2.3a within the thesis text.
Appendix D: Early conceptual influence map depicting performance factors at three levels of the organisational system

The model below illustrates the complexity inherent in interactions between research-derived human and organisational performance factors. This model represents an early attempt to map specific influences between variables, which are classified as factors within the individual, work group or organisational levels of analysis. A further example of an early influence network map may be found in figure 4.2.3b within the text of the thesis.
Appendix E: Conceptual model of work group performance factors at intermediary stage of development

The work group performance factors model, depicted within the thesis text in figure 4.2.4d, is shown below at an intermediary stage of development to illustrate the analysis and refinement process involved. In this process, potential performance factors from an existing research knowledge base are identified, classified according to the modelling framework and grouped into logical classes of higher-level factors. Specific influences are mapped between individual variables to establish causal sequences or 'performance processes' operating within the human and organisational system.

The model below represents performance on the work group level of analysis within the organisational system and influences to or from other levels of the organisation are depicted as incoming or outgoing arrows at the boundaries of the diagram. The modelling exercises undertaken within the context of this research project serve to highlight the complexity and high interdependency inherent in the 'softer' factors that affect the functioning of human and organisational systems.
Appendix F: Developing applied Human and Organisational Performance model

This appendix provides an overview of two intermediary versions of the applied Human and Organisational Performance (HOP) model and framework that was developed to aid management teams in analysis and representation of soft performance issues in their projects. The final version of the HOP model that was implemented in a series of systems engineering case projects and that forms an important part of the product of the soft metrics research effort, is depicted within figure 5.1.1a in the thesis, along with detailed explanatory text.

Attempts to develop an applied HOP model were based upon knowledge gained from the literature review, from conceptual modelling exercises and from early experience in an industry scoping study. The key features of an initial applied HOP modelling framework with description of its broad classes of performance variables are depicted below.
Overview figures of two early versions of the applied HOP model, labelled version 'a' and version 'b', are depicted below to illustrate the initial format of representation adopted to define a clear, simplified performance framework that focused upon relationships between broad example classes of variables, rather than specific, complex interactions that would be highly idiosyncratic in any applied context. Evident from the figures is the refinement of performance factors that occurred as more information was gained regarding the industrial operating environment. It should also be noted that a key modification to the framework between these versions of the model and the eventual HOP model in figure 5.1.1a of the thesis, is the removal of a direct feed-forward influence arrow between the precondition class and outcome class. Although conceptual research promotes the ability of system conditions and external constraints to influence performance outcomes directly, this influence was not considered relevant from a 'soft', human performance perspective unless it affected outcomes through human behavioural variables.

![Applied HOP model (version A)](image-url)
Applied HOP model (version B)

**Precondition variables**
- Individual characteristics
- Work group characteristics
- Human resource configuration
- Task characteristics
- Information
- Organisational structure
- Project work organisation
- Functional autonomy
- Corporate culture

**Behaviour**
- Task performance
- Decision-making
- Communication
- Feedback evaluation
- Learning
- Organisation
- Leadership
- Collaboration
- Change accommodation

**Outcome variables**

**Intermediary**
- Engineering knowledge
- Skills and experience
- Decision effectiveness
- New work practices
- Process improvement
- Flexibility
- Performance goals
- Motivation level
- Comms. effectiveness

**Operational**
- Cost
- Quality
- Time

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Appendix G: Example qualitative analyses of soft performance processes in CAP1 industrial project scenario

The figures below depict example qualitative analyses of human and organisational performance processes based upon application of an early version of the HOP modelling framework in the CAP1 industrial project scenario. Within the figures, the main causal processes for each issue are defined through specification of individual precondition, behaviour or outcome performance factors (in the yellow boxes), linked by influence arrows. Associated with precondition and outcome factors, the blue boxes incorporate specific measurement criteria identified in the CAP1 scenario that might be used to quantify the performance factors. The 'callout' boxes contain qualitative evidence from experience of issues raised and commented upon by CAP1 project personnel. The performance processes and findings from this modelling exercise are discussed in more detail within the thesis text, in section 5.1.2.
**Preconditions**

- Subjective perceptions of reliability, integrity, communication openness and goal compatibility
- No. of previous successful/unsuccessful collaborations
- No. of future/anticipated collaborations

- Level of info. exchange/communication
- Anticipated contact - no. of scheduled collaborative review meetings

**Customer-supplier trust**

**Trust in system/project**

- No. query notes against item
- No. risks raised

**Behaviour**

- Instance of customer placing trust in supplier to deliver functionality in the product that was not officially required/authorised - not ideal situation but allows work to proceed

- Work-process/task performance

- Communication

- Schedule performance

- Deviation from schedule (EVM)

**Outcomes**

- Influence of this aspect of trust upon performance could not be inferred from PM case study

**Preconditions**

Successful project performance and collaborative experiences foster trust between organisational entities - trust is therefore an important outcome of project work

**Behaviour**

**Outcomes**

- Trust

- Project performance: Cost/time

- Work group viability

- Subjective ratings of group cohesion at end of project

The continued viability of a work group is another important outcome of project work depending upon experiences during the project
Effectiveness of communication and stakeholder management practices is reflected in how quickly and effectively the project requirements are established and baselined. This involves collaboration with stakeholders to establish expectations for what the change project will deliver into each project.
Appendix H: Inventory of soft metrics linked to human and organisational performance factors

The inventory of soft metrics reproduced below on the subsequent pages represents an important part of the toolset developed through this research and consists of a series of measures with sub-items linked to human and organisational performance factors. The soft metrics inventory was updated as a 'working document' throughout the course of the research project in response to new requirements and achievements in development.

The metrics comprise both subjective judgement based items and more objective criteria where appropriate and represent: 1) relevant measures identified within existing project management and research practices, 2) metrics adapted from existing measures to fit the systems engineering project context of application, and 3) new metrics developed where required. Where appropriate the source of an individual metric, or impetus for its development, is identified within the inventory. For ease of reference, the metrics are grouped according to their associated performance factors within the HOP model (detailed in section 5.1.1 of the thesis; see figure 5.1.1c for a complete list of performance factors with reference codes). Descriptive notes relating to key development issues such as focus upon soft factors, level of analysis and level of objectivity are included for each metric. The metrics toolset was implemented within several systems engineering case projects based upon the output from soft performance issues analysis activities that sought to identify critical performance factors for proactive monitoring during the phases of a project's lifecycle.
<table>
<thead>
<tr>
<th>HOP model variable</th>
<th>Metric description, method, sub-items and scales</th>
<th>Soft focus, level of analysis and objectivity</th>
<th>Source</th>
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</table>
| P1.1 Project Size  | **Budgetary size**  
A general indicator of project size representing commitment of resources to the project, effort involved, project duration and the importance of the project to the business. Costing data can be collected against the following categories:  
- Direct costs  
- Indirect costs  
- Time related costs  
- Labour costs  
- Material and equipment costs  
- Transport costs  
- Preliminary and general costs  
- Project office costs  
- Project team costs | ☐ Focuses upon technical parameters rather than human and organisational processes.  
☐ Measured at the project level.  
☐ Objective measure. | BAE SYSTEMS (1); Burke (2003) |
|                   | **Function points Analysis**  
Accepted sizing metric in software engineering and IT development projects for measurement of units of work based upon functional characteristics of the software deliverable. | ☐ Focuses upon technical parameters rather than human and organisational processes.  
☐ Measured at the project level.  
☐ Objective measure. | Garmus and Herron (2001) |
|                   | **Project work package size**  
Based upon size of individual system sub-components on the lowest level of the product breakdown structure, e.g. number of lines of code in software sub-systems. | ☐ Focuses upon technical parameters rather than human and organisational processes.  
☐ Measured at the project level.  
☐ Objective measure. | BAE SYSTEMS (1) |
|                   | **Required effort**  
The number of man-hours per work package (or cost of the man-hours) is measured and aggregated for the whole project or a single project phase. Man-hours are calculated on the basis of level of committed personnel and hours engaged on project tasks. | ☐ Focuses upon technical project parameters associated with time and resource requirements.  
☐ Measured at the project level.  
☐ Objective measure. | BAE SYSTEMS (1) |
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</table>
| P3.1 Project Complexity | Project uncertainty profile  
The uncertainty profile can be used to indicate the level and dominant type of uncertainty inherent within a specific project's operating environment or within a particular phase of a project and draw specific recommendations for appropriate project management and control methods. The project team rates the level of each of the following types of uncertainty in the project:  
 **Level 1: Variation**  
Project objectives are clearly defined, project sub-tasks and activities can be clearly identified in advance and a detailed, stable plan can be achieved. Budget and schedule parameters may vary according to minor events that are predictable and planned for and which cause minor deviations from the project work plan (e.g. resource/task reallocation due to unavailability of personnel).  
**Recommendations:** Performance can be tracked and monitored against set criteria. Project can be planned in detail using established methods (e.g. CPA, PERT, GANTT)  
 **Level 2: Foreseen uncertainty**  
Larger scale contingent events and foreseen uncertainties are identifiable and controllable through formal risk management activities that involve planning alternative courses of action (e.g. the effects of predictable design variations on product performance may not be known, but contingent alternative plans to achieve the desired outcome may be formulated, based upon existing knowledge and experience with previous projects).  
**Recommendations:** Comprehensive risk management and contingency planning activities must be included in the plan. Decision support systems are used to calculate efficacy of predefined alternative paths to project goals.  
 **Level 3: Unforeseen uncertainty:**  
Although the project may begin with reasonably stable goals and a plan, the nature of variations in the project cannot be anticipated during project planning and therefore specific contingent strategies cannot be prepared. Inferential decision tools cannot accommodate unforeseeable uncertainty. Unforeseeable uncertainty may arise from unanticipated interactions between many foreseeable events (e.g. in projects that seek to develop new technology, the plan may dramatically change mid-project in response to new knowledge or information regarding the feasibility of a system or the project’s aims).  
**Recommendations:** Unforeseen problems must be solved as they occur and targets/performance criteria (and the methods used to achieve them) modified accordingly.  
 **Level 4: Chaos**  
The project does not begin with stable assumptions or goals and therefore no structured project plan can be formulated in any real degree of detail. The end result may vary significantly from that intended and the ability to predict eventual outcomes based upon current trends is poor at any particular time (e.g. pure research projects in new areas that cannot rely upon existing knowledge, tools or techniques).  
**Recommendations:** Continual iterations including redefinition of project objectives and scope must occur. Project may be too unstable to make formal planning and control methods feasible. Flexibility and fast response to new learning is required.  
 | Focuses upon an 'intangible' project characteristic with implications for organisational performance factors.  
Measured at the project or project phase level.  
Due to the complexity of possible influences upon the construct: 'uncertainty', this may be regarded as a relatively subjective, judgement-based measure. | Developed based upon De Meyer (2002) in order to distinguish between different types of projects based upon uncertainty inherent in the project's objectives and predicted plan. |
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<tbody>
<tr>
<td>Level of ongoing concurrent tasks in project work activity plan</td>
<td>The number of tasks scheduled to run concurrently within the project work breakdown structure (WBS) over time is proposed as an ongoing indicator of project organisational complexity that influences required project management effort. This indicator can be used to identify critical periods when project management resources are likely to be strained in their ability to deal with issues arising from a number of separate work packages being executed simultaneously and ensuing problems in coordinating the output from these activities. Indicators include:</td>
<td>☐ Focuses upon organisational factors resulting from the way project work tasks are planned. ☐ Measured at the project or project sub-phase level. ☐ Objective indicator based upon parameters in the work plan and actual events.</td>
<td>Developed in order to predict high project management-intensive periods of activity resulting from organisational complexity in the project work plan.</td>
</tr>
<tr>
<td>Level of interdependency in parallel project schedules</td>
<td>Indicator of likelihood of issues arising associated with organisational complexity that are likely to impact upon project schedule performance, particularly in capability development projects with an ‘internal’ customer.</td>
<td>☐ Focuses upon organisational factors resulting from the way project work tasks are planned. ☐ Measured at the project level. ☐ Objective indicator based upon parameters in the work plan.</td>
<td>Developed in response to scoping study finding that capability development project schedules were highly sensitive to those of dependent projects.</td>
</tr>
<tr>
<td>P1.4 Project scope</td>
<td>Scope of technical objectives</td>
<td>The following indicators may be used to assess the scope of a project’s technical objectives, especially where a number of discrete deployments or customised work products are involved in project cases with multiple customers. These parameters are particularly relevant to capability development projects:</td>
<td>☐ Focuses upon organisational factors associated with technical objectives of the project ☐ Measured at the project level ☐ Objective indicators based upon project requirements documentation</td>
</tr>
<tr>
<td>P2.1 Project work group size</td>
<td>Project work group breakdown</td>
<td>Various indicators are applicable based upon classification of personnel related to the project. Increased levels mean higher effort involved in coordination, communication and possibly a more involved decision-making process for issues with high ambiguity.</td>
<td>☐ Focuses upon human resource configuration and factors that implicate human communication, decision processes and working climate ☐ Measured at the project work group level ☐ Based upon objectively observable parameters</td>
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<tr>
<td><strong>P2.2</strong> Project work group collaborative history</td>
<td><strong>Team collaborative history scale</strong> Indicates the extent of past collaborative experience for the personnel that comprise the current project’s management team, as an indicator of the likely presence of established informal working practices and a productive working climate. The following increasing scale may be used: Level 1: The project work group is a novel configuration of staff with no previous history of working together Level 2: Some members of the group have worked together before but the team is largely new Level 3: The work group is an established team with history of working together on a previous project Level 4: The work group is well-established with a proven track record and history of working closely together on several previous projects</td>
<td>Focuses upon human experiences of previous collaboration with other project personnel. Measured at the project work group or management team level. Based upon subjective judgements made by the group as to what level of the scale best describes the team</td>
<td>Developed based upon knowledge of the importance of informal working practices, interpersonal knowledge and shared mental models and values for work group performance.</td>
</tr>
<tr>
<td><strong>P2.3</strong> Group-working climate</td>
<td><strong>Working climate and interactive climate for decision-making</strong> Assesses the degree to which group members judge the working climate and decision-making processes within the work group to be productive and supportive of effective functioning. Several statements concerning the work group climate and environment are given, against which the individual responds on a likert-type scale anchored ‘strongly agree’ to ‘strongly disagree’. The following sub-items are used: Work group discussion-processes are dominated by the opinions of one or more individuals to the detriment of other’s opinions (reverse scored) The work group provides a stimulating and supportive technical environment to work in. The work group provides a stimulating and supportive social environment to work in. Relevant information is disseminated quickly and effectively within this work group. All relevant members of the work group are made immediately aware of problem issues that arise in the project. Individuals have the opportunity to express their views and opinions in this work group. Individual’s views and opinions are valued and respected in this work group. Adequate time is given to planning and problem solving. This work group makes timely, effective decisions.</td>
<td>Focuses upon social interactive processes within a workgroup and personal satisfaction with the team working environment Measured at the individual level to capture personal responses which can then be aggregated onto the project work group level or sub-group level for large-scale projects Incorporates subjective, survey-type items to capture perceptions and judgements</td>
<td>Developed to support evaluation of group-working and collaborative climate for functional effectiveness, as indicated by the groups unique style of approaching problem issues and conflict</td>
</tr>
<tr>
<td><strong>P2.5</strong> Group-working processes</td>
<td><strong>Effectiveness of group-working processes</strong> This measure indicates the extent to which effective informal group-working practices have developed within the team. The individual responds on a likert-type scale anchored ‘strongly agree’ to ‘strongly disagree’. The following sub-items are used: This work group has developed it’s own way of doing things. The way this group interacts, conducts meetings and approaches objectives is effective. The group always sets manageable and realistic objectives with clear targets and performance criteria/measures. The group was proactive rather than reactive in its anticipation and mitigation of risks. Much effort was expended in coordinating and communicating between individual group members, to the detriment of project tasks (reverse scored).</td>
<td>Focuses upon social interactive processes and informal working practices within a team Measured at the individual level to capture personal responses which can then be aggregated onto the project work group level or sub-group level for large-scale projects Incorporates subjective, survey-type items to capture perceptions and judgements</td>
<td>Developed to support measurement of the effectiveness of informal group-working processes that develop to achieve formally specified activities, as indicated by the team’s unique style of functioning.</td>
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| P2.6.1 Knowledge /skills/ experience | **Task-specific experience level**  
In order to assess adequacy of human capability for specific task requirements within the project work plan and allocate work to human resources more effectively, respondents indicate which level within the following scale best indicates their experience relative to the technical requirements of their current project task.  
Where scale items include three sub-levels representing varying difficulty of task conditions, increasing difficulty is indicated by: shorter time frames, less sophisticated tools and/or fewer support structures.  
- I have never attempted a technically similar task (Level 1)  
- I have successfully completed a technically similar task under:  
  - Easier conditions (Level 2)  
  - Similar conditions (Level 3)  
  - More difficult conditions (Level 4)  
- I have successfully completed a technically identical task under:  
  - Easier conditions (Level 5)  
  - Similar conditions (Level 6)  
  - More difficult conditions (Level 7)  
- I have successfully completed many technically identical tasks under:  
  - Easier conditions (Level 8)  
  - Similar conditions (Level 9) |  
- Focuses upon relevance of human experience  
- Measured at the individual level to quantify an individual's capability relevant to specific project work tasks, but may be aggregated onto the group level.  
- Responses are subjective and open to individual biases as they rely upon personal recall of past work experience | Based upon the 'Critical Task Method' developed by Nagy (1999). |
|  | **Task-specific knowledge and skill adequacy**  
Measures skills relevant to the individual's current work tasks and is indicated by subjective opinions of adequacy of skills/knowledge for completing a specified or planned task. For each task undertaken, the individual responds on the following 5-point scale:  
**Level 1:** I do not have the necessary skills and knowledge to complete this task within the conditions defined  
**Level 2:** I believe my skills and knowledge will definitely be challenged to complete this task within the conditions defined  
**Level 3:** I believe my skills and knowledge will possibly be challenged to complete this task within the conditions defined  
**Level 4:** I believe my skills and knowledge will not be challenged to complete this task within the conditions defined  
**Level 5:** I have the skills and knowledge to complete this task within the conditions defined |  
- Focuses upon human knowledge and skills  
- Measured at the individual level to quantify an individual's capability relevant to specific project work tasks, but may be aggregated onto the group level.  
- Responses are subjective based upon individual's personal judgement of knowledge adequacy. | Nagy (1999) |
|  | **Person-task fit index**  
This measure comprises a detailed method of assessing the adequacy of project work allocation practices from the perspective of knowledge sufficiency. The following steps are involved:  
**Step 1:** Identify key skill areas for specific project work tasks.  
**Step 2:** Rank identified skill areas according to criticality for successful execution of the project work task.  
**Step 3:** Rate candidate/assigned individuals for competency against each knowledge requirement.  
**Step 4:** Calculate overall task-competency level based upon weighting individual ratings using criticality of each knowledge area.  
**Step 5:** Compare results across candidate individuals to assist work allocation or compare percentage competency attainment across tasks to identify knowledge-critical tasks for increased project management support. |  
- Focuses upon task-specific human knowledge  
- Measured at the level of the individual, group or project work breakdown structure  
- Knowledge criteria are subjective where no objective data is available. Method of weighting key knowledge areas according to project requirements reduces negative effects of judgement-based subjectivity | Developed to provide fine-grained analysis for human resource allocation and risk management associated with critical and potential problem tasks within the project work breakdown structure. |
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<tr>
<td><strong>Work group level knowledge adequacy</strong></td>
<td>The following three dimensions require consideration to indicate required presence of project-critical knowledge and degree to which the required knowledge profile within the team can withstand changes to the human resource configuration as a result of loss of key project personnel. Three sub-scales that may be rated on a 1 (low) to 10 (high) basis were identified:</td>
<td></td>
<td>Developed in response to a finding within the scoping study in which the ready availability of project-specific knowledge within the work group was highlighted as an important factor for project success</td>
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<tr>
<td>- Are required skills present in project work group?</td>
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<td>- Is required knowledge covered in sufficient depth?</td>
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<td>- Is knowledge networked to provide adequate redundancy &amp; duplication to accommodate unexpected changes to the human resource configuration?</td>
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<tr>
<td><strong>Generic knowledge adequacy scale</strong></td>
<td>This measure relies upon there being an adequate map of required knowledge to execute the project at project onset/planning stages. A specific pattern of key knowledge areas can be identified for a specific role or project and the individual or project management team then makes a rating on the following scale:</td>
<td></td>
<td>Siemieniuch et al, 1999a; 1999b</td>
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<tr>
<td>Level 1: 'Know about': the individual knows that the knowledge exists and what its purpose is, but not necessarily how to apply it.</td>
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<td>Level 2: 'Entry level': the individual has sufficient knowledge to be able to execute the defined task securely under normal circumstances (assuming adequate training to carry out the task in a specific environment with specific tools).</td>
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<td>Level 3: 'Experienced': defined as for 'entry' level knowledge, but additionally the individual can cope with some abnormal environmental variation. The individual can make some constructive use of knowledge in the design processes. Wider and deeper knowledge is required, with some rule-based behaviour as opposed to merely procedure-based behaviour.</td>
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<td>Level 4: 'Expert': defined as for the 'experienced' level, with the addition of sufficient formal, technical knowledge and expertise to be able to meet almost any demand regarding the specific task. Knowledge at this level is largely heuristic and skills will be fairly automatic.</td>
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<tr>
<td><strong>P2.6.4 Work group motivation levels</strong></td>
<td>This method measures the individual's prediction of what level of motivation will be experienced during the execution of a specified task or project role. Measurement occurs during the project work allocation phase of project planning – prior to commencing task execution. A weighted average calculation is employed to determine the motivational level of an individual for the completion of a specified task or project role. The following five dimensions are presumed to represent the motivating characteristics of work tasks: 1) Acceptance/recognition, 2) Adventure/fun, 3) Ambition/accomplishments, 4) Comfort/security, and 5) Money/finances. Each dimension is rated on a 10-point scale of importance to represent variation in individual's personal and professional goals. Another 10 point rating scale is then used to determine the individual's motivation to complete the specified task against each dimension. The individual is asked the following question for each dimension:</td>
<td></td>
<td>Based upon technique suggested by Nagy (1999).</td>
</tr>
<tr>
<td>- &quot;Based upon your past experience and instinct, what affective outcome is more likely to be experienced while completing the assigned task?&quot;</td>
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<td></td>
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<tr>
<td>Response ratings: 1 (very negative experience), to 10 (very positive experience).</td>
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<tr>
<td>A total motivational score may then be calculated based upon the derived weighted averages. Individual responses may be aggregated onto the group level to arrive at an overall motivational level for the project work group in completing the assigned project (sub-) tasks.</td>
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<tr>
<td>P3.3.1 Task interdependency</td>
<td><strong>Level of dependent inputs in workflow plan</strong>&lt;br&gt;The higher the number of separate workflow inputs, the higher the level of interdependency of the task with preceding tasks and the higher the likelihood of performance issues arising associated with the task due to unexpected interactions and coordination issues.&lt;br&gt;- Number of separate input workflows to an individual task within the critical path network diagram.</td>
<td>- Focuses upon organisational factors: task characteristics&lt;br&gt;- Measured at the individual project work task level.&lt;br&gt;- Objective indicator based upon parameters in the work plan.</td>
<td>Developed based upon Critical Path Method output (e.g. Burke, 2003; Slack et al, 2001)</td>
</tr>
<tr>
<td>P3.3.2 Task concurrency</td>
<td><strong>Level of concurrently scheduled tasks</strong>&lt;br&gt;Indicates likelihood of high project management activity and limited availability of project management to deal with coordination and unexpected problem issues arising for a task with high concurrency.&lt;br&gt;- Number of separate parallel ongoing tasks in the project work plan</td>
<td>- Focuses upon organisational factors: task characteristics&lt;br&gt;- Measured at the individual project work task level.&lt;br&gt;- Objective indicator based upon parameters in the work plan.</td>
<td>Developed in order to predict likely availability of project management support for specific tasks</td>
</tr>
<tr>
<td>P3.3.4 Task completeness</td>
<td><strong>Task completeness characteristics</strong>&lt;br&gt;Task completeness or identity refers to the degree to which a role involves the completion of a whole and identifiable piece of work with clear onset, cessation and success conditions. The following survey items may be applied to quantify individual's opinions as to the completeness of their project role tasks:&lt;br&gt;- To what extent does the project role involve the completion of a &quot;whole&quot; and identifiable piece of work? (Scale: Very little – Very much)&lt;br&gt;- To what extent does the project role involve tasks with a clear beginning and end. (Scale: Very little – Very much)&lt;br&gt;- The objectives that mark successful completion of my project tasks are clearly defined. (Scale: Disagree – Agree)&lt;br&gt;- The project role involves tasks that do not visibly contribute to the finished product. (Scale: Disagree - Agree)&lt;br&gt;- The project role provides me with the chance to completely finish the pieces of work I begin. (Scale: Disagree - Agree)&lt;br&gt;- The project role is such that I can do a complete piece of work from beginning to end. (Scale: Disagree - Agree)</td>
<td>- Focuses upon human performance-relevant features of project work tasks and roles that influence motivation and ability to optimally execute project work&lt;br&gt;- Measured at the individual level.&lt;br&gt;- Subjective measures that quantify individual's perceived experience of characteristics in the project work environment.</td>
<td>Adapted from Job diagnostic survey (Hackman and Oldham, 1974 with revisions by Idaszak &amp; Drasgow, 1987) to apply to work roles and tasks in a project-based systems engineering environment.</td>
</tr>
<tr>
<td>P3.3.6 Task significance</td>
<td><strong>Task significance characteristics</strong>&lt;br&gt;Task significance determines whether the project role is perceived as having an impact upon others and their lives in the organisation and in general.&lt;br&gt;- In general, how important is your project role; to what extent is it likely to influence the lives and well-being of others? (Scale: Very little – Very much)&lt;br&gt;- My project role is one where a lot of other people can be affected by how well my tasks are performed. (Scale: Disagree – Agree)&lt;br&gt;- My project role is critical to overall successful project performance. (Scale: Disagree - Agree)&lt;br&gt;- To what extent does overall project success depend upon the performance of tasks for which your project role is responsible? (Scale: Very little – Very much: The performance of my project role is critical to overall project success)</td>
<td>- Focuses upon human performance-relevant features of project work tasks and roles that influence motivation and ability to optimally execute project work&lt;br&gt;- Measured at the individual level.&lt;br&gt;- Subjective measures that quantify individual's perceived experience of characteristics in the project working environment.</td>
<td>Adapted from Job diagnostic survey (Hackman and Oldham, 1974 with revisions by Idaszak &amp; Drasgow, 1987) to apply to work roles and tasks in a project-based systems engineering environment.</td>
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<td>P3.3.8 Task variety</td>
<td><strong>Task variety characteristics</strong>&lt;br&gt;Assesses the degree to which the individual has the opportunity to apply a variety of skills and knowledge in the project role and whether that role involves a variety of tasks i.e. is non-repetitive.&lt;br&gt;☐ To what extent does the project role require you to perform a variety of tasks? (Scale: 1 - Very little, to 10 Very much)&lt;br&gt;☐ To what extent does the project role utilise a range of your skills, talents and knowledge? (Scale: 1 - Very little, to 10 - Very much)&lt;br&gt;☐ The project role allows me to utilise a number of complex or high level skills. (Scale: 1 Strongly Disagree – 10 Strongly Agree)&lt;br&gt;☐ The project role is quite simple and repetitive. (Scale: 1 Strongly Disagree – 10 Strongly Agree; Reverse scored)</td>
<td>☐ Focuses upon human performance-relevant features of project tasks and roles that influence motivation and ability to optimally execute project work&lt;br&gt;☐ Measured at the individual level.&lt;br&gt;☐ Subjective measures that quantify individual’s perceived experience of characteristics in the project working environment.</td>
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<td>P3.3.9 Task inherent feedback</td>
<td><strong>Task-inherent feedback characteristics</strong>&lt;br&gt;The extent to which the task intrinsically provides information regarding the effectiveness of performance&lt;br&gt;☐ The tasks that I perform in my project role provide clear feedback as to how I am performing. (Scale: Agree – Disagree)&lt;br&gt;☐ It is clear during the performance of the project work task as to how successful current progress is likely to be in achieving the objectives set for the task. (Agree – Disagree)&lt;br&gt;☐ It will be clear after project task completion as to how successful I have been in achieving the objectives set for the task. (Agree – disagree)&lt;br&gt;☐ In my project role, performance feedback is available from managers, supervisors and co-workers. (Scale: Agree – disagree)&lt;br&gt;☐ In this project role, performance feedback is clear, timely and useful. (Scale: agree – disagree)&lt;br&gt;☐ In my project role I receive information that isn’t relevant to the performance of project tasks assigned to me.&lt;br&gt;☐ How much of the information you receive concerning project operations is actually useful in the performance of your project work. (Scale: Very little – All largely relevant)</td>
<td>☐ Focuses upon human performance-relevant features of project work tasks and roles that influence motivation and ability to optimally execute project work&lt;br&gt;☐ Measured at the individual level.&lt;br&gt;☐ Subjective measures that quantify individual’s perceived experience of characteristics in the project working environment.</td>
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<td>P3.3.10 Task inherent autonomy</td>
<td><strong>Task-inherent autonomy characteristics</strong>&lt;br&gt;The degree of discretion a project role possesses for exercising control over personal work processes and outcome.&lt;br&gt;☐ In your project role, to what extent do you have autonomy over how you complete project tasks? (Scale: Very little – Very much).&lt;br&gt;☐ In your project role, how much control do you exert over which tasks and responsibilities are allocated to you? (Scale: Very little – Very much)&lt;br&gt;☐ In your project role, to what extent do you have autonomy over choice of working methods used to complete project tasks? (Scale: Very little – Very much) OR: how much control do you have over how your project tasks are completed?&lt;br&gt;☐ In your project role, to what extent do you have autonomy over when project work allocated to you is performed? (Scale: Very little – Very much)&lt;br&gt;☐ My project role allows me to make decisions about how and when work is performed. (Scale: Agree – Disagree)&lt;br&gt;☐ My project role gives me considerable opportunity for freedom and independence in how the work is performed. (Scale: Agree – disagree)&lt;br&gt;☐ My project role allows me to use a high degree of personal initiative and judgement. (Scale: Agree – Disagree)</td>
<td>☐ Focuses upon human performance-relevant features of project work tasks and roles that influence motivation and ability to optimally execute project work&lt;br&gt;☐ Measured at the individual level.&lt;br&gt;☐ Subjective measures that quantify individual’s perceived experience of characteristics in the project working environment.</td>
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<td>P3.4 Workload</td>
<td><strong>Workload index</strong>&lt;br&gt;The following indicator may be applied at the level of the individual, or by aggregating man-hours onto the project work group level and calculating required man-hours for the project work task. The critical component of the measure is the identified time required for tasks, which should consider the technical requirements of the task itself in the context of the capability of the people responsible for executing the task. This latter factor will be variable depending upon task-specific knowledge, skills and motivation, which accounts for the human factor. Workload may therefore be quantified by the simple equation: &lt;br&gt; Time available divided by expected/ideal time required. Values below 1 indicate workload-critical tasks, the smaller the value the higher the experienced workload. Values above 1 represent acceptable workload levels or even inefficient allocation of human resources for scheduled project work tasks.</td>
<td>Focused upon experienced human workload, which incorporates a human capability and motivational dimension.&lt;br&gt; Measured at the individual level for specific tasks or aggregated onto the work group level.&lt;br&gt; Measure is reasonably objective providing required time for tasks can be clearly established.</td>
<td>Specified following discussion of workload issues in project case studies.</td>
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<td>P3.5.3 Goal attractiveness</td>
<td><strong>Desirability of project goals</strong>&lt;br&gt;The following measurement items may be used to quantify the level of intrinsic, non-financial reward experienced by project personnel through involvement with the project itself and experience working on its sub-tasks:&lt;br&gt; - Novelty of project goals (level of similarity with other projects in organisations history, similarity with individual's prior project experience, perceived novelty of contribution to society's science/knowledge/technology)&lt;br&gt; - Perceived desirability of project focus (interacts with individual characteristics - i.e. interests)&lt;br&gt; - Perceived rewards (skill/knowledge acquisition, career development opportunities, organisational networking, social contact (desirability of collaborators)&lt;br&gt; - Perceived value of project product, both internally (organisation/programs/business) and externally (customer/society)&lt;br&gt; - Perceived level of satisfaction resulting from involvement/successful completion of project.</td>
<td>Focused upon human motivational processes - level of perceived rewards&lt;br&gt; Measured at the individual level, may be aggregated onto the group level.&lt;br&gt; Subjective - based upon perceived rewards and intrinsic needs that will vary from person to person</td>
<td>Developed to quantify motivational aspects of project work associated with the desirability of technical and other objectives</td>
</tr>
<tr>
<td>P4.1.1 Trust between organisational entities</td>
<td><strong>Trust in technology</strong>&lt;br&gt;These measures are based upon social theory, which holds that trust develops through repeated experience of successful interaction between actors and is often a function of the anticipated requirement for future contact.&lt;br&gt; - Number of previous successful/unsuccessful collaborations between partners&lt;br&gt; - Number of future anticipated collaborations (for example: number of scheduled collaborative review meetings) between partners&lt;br&gt; - Level of information exchange and communication between collaborating partners&lt;br&gt; - Perception of reliability of collaborating partner&lt;br&gt; - Perception of integrity of collaborating partner&lt;br&gt; - Perception of communication openness between collaborating partners&lt;br&gt; - Perception of goal compatibility between collaborating partners.</td>
<td>Focused upon a soft cultural or social factor based upon perceived values and past collaborative experience&lt;br&gt; Measured at the project level to assess value of collaborative partners&lt;br&gt; Mainly subjective judgements-based, but also incorporates more objectively quantifiable parameters associated with collaborative history.</td>
<td>Developed in response to scoping study finding that trust between collaborating partners was an important performance factor.</td>
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**Trust in technology**<br>Valid indicators may be found in the project’s query log and risk management documentation:<br> - Number of query notes against items<br> - Number of risks raised related specifically to a system or sub-component. | Focused upon indicators of human trust in technical systems<br> Measured at the project level<br> Offers soft factors interpretation of objectively quantifiable project parameters | Developed according to experience in systems engineering projects that identified confidence in systems as an important human performance factor. |
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| P4.1.2 Collaborative culture | **External collaborative climate**  
- Perceived degree of trust existing between collaborative partners  
- Perceived degree of flexibility in customer organisations dealings with project  
- Level of autonomy for project execution decisions handed over to project from sponsoring organisation  
- Degree of shared objectives and compatibility of goals  
- Level of successful prior collaborations between partners  
- Perceived level of productive cooperative spirit  
- Level of open communication between partners  
- Degree to which collaborative partner made performance-critical information accessible to the project |  
- Focuses upon culturally determined value systems  
- May be measured at the organisational level  
- Addresses socially and culturally-determined values and beliefs, through specifying more or less subjective indicators cultural compatibility | Developed from case study finding that cultural compatibility between collaborating partners was an important performance factor |
| | **Internal collaborative climate**  
- People involved in this project are genuinely concerned about the needs and problems of others.  
- People involved in this project are sympathetic to the constraints under which others have to operate.  
- A team spirit pervades all areas of this project.  
- People in this project feel that project success depends upon the contributions of everyone.  
- People in this project view themselves as independent individuals who have to tolerate others around them. (Reverse scored)  
- To what extent are other project personnel considerate of others in their work and actions? |  
- Addresses human cultural factors concerning collaborative social environment within the project  
- Measured at the project level to assess effectiveness of internal culture  
- Measures perceptions of team-working environment | Developed from case study finding that cultural compatibility between collaborating partners was an important performance factor |
| | **Level of work group orientation**  
- Internal survey on teaming: survey of employees to determine if business units are supporting and creating opportunities for one another.  
- Gain-sharing level: tracks the degree to which the organisation is entering team-based relationships with other business units, organisations or customers.  
- Number of integrated engagements: the number of projects upon which more than one business unit participated.  
- Percentage of business plans developed by teams.  
- Percentage of teams with shared incentives: number of teams where team members share common incentives and objectives.  
- Percentage of all projects with customer gain-sharing.  
- Percentage of projects in which potential gains were achieved.  
- Percentage of projects with individual team incentives linked to project success. |  
- Addresses human cultural factors concerning collaborative working environment within the organisation  
- Measured at the organisational or organisational sub-unit level.  
- Objective, indirect indicators of a soft issue: level of team-working or collaborative culture within the organisation | Kaplan and Norton (1996a) |
| P4.1.3 Performance expectations | **Compatibility of performance expectations**  
These measures are designed to assess the compatibility of performance expectations between the project organisation and partner/customer entities as an indicator of cultural factors.  
- Degree of satisfaction with externally imposed workload  
- Perceived achievability or feasibility of externally imposed (i.e. customer) requirements  
- Compatibility of working methods and processes |  
- Addresses human cultural factors  
- Measured at the organisational level.  
- Subjective indicators based upon judged compatibility | Developed based upon case study finding that performance expectations of collaborating partners was an important performance factor |
| P4.1.11 Inter-group climate | **Inter-group climate indicators**  
Measures the effectiveness of the climate that exists between separate work groups within the project's organisation.  
- Level of inter-group competition (for objectives/resources)  
- Level of inter-group cooperation.  
- Level of inter-group conflict. |  
- Focuses upon organisational cultural factors  
- Measured at the organisational level  
- Involves subjective perceptions where no objective data is available | Developed to quantify the effectiveness of the inter-group working climate within the organisation |
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| P4.2 Stakeholder characteristics | **Key stakeholder performance factors** The following measures indicate the level of availability, relevance and suitable empowerment of key project stakeholders for effective development and decision-making:  
- Percentage coverage and representation of target project-related knowledge areas  
- Percentage time involvement against target time involvement in project  
- Degree to which stakeholder involvement achieved agreed targets in terms of benefits to the project  
- Proportion of key stakeholders present at review meetings compared to specification within the stakeholder management plan  
- Proportion of empowered to un-empowered decision-makers present at project review meetings  
- Proportion of empowered representatives available at key decision points compared with stakeholder management and communications plan  
- Number of delegates present at project review meetings  
- Perceived degree of flexibility in customer or partner organisation's stakeholders  
- Perceived extent to which stakeholders and collaborative partners are capable of acting within the best interests of the project. | □ Focuses upon availability of key knowledge for the project represented by project stakeholders  
□ Measured at the project level  
□ Incorporates some objective criteria and perceptions of project work group concerning relevance and interests of project stakeholders | Developed in response to findings from case studies that highlighted the importance of stakeholder knowledge, availability and involvement for project success. |
| P4.3 Core engineering/ process knowledge | **Competency development effort and effectiveness**  
- Amount of time spent in developing the knowledge, skills, and process abilities underlying the organisation's workforce competencies  
- Number of people and amount of effort involved in developing or delivering Competency Development activities  
- Amount of effort to define and document competency-based processes  
- Amount and types of communication within a competency community  
- Amount of effort spent on capturing and documenting competency-based information  
- Amount of process or competency-based experience and information available in repositories  
- Rate of progress in competency development activities  
- Individual ratings of the effectiveness of each competency development method  
- Level of knowledge, skill, or process ability developed in each workforce competency through different development methods  
- Performance-based evidence of increases in knowledge, skills, or process abilities in each workforce competency  
- Results of certification programs, where appropriate  
- Rate at which individual's request access to different training programs or methods | □ Measures effort involved in human resource competency development activities  
□ Measured at the project or organisational level  
□ Largely objectively definable criteria with some items that may usefully rely upon expert judgement | Curtis (2002) |
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| P4.8.3 Empowerment/Development of decision-making | **Effort and effectiveness in empowerment activities**  
- Rate at which workgroups can be developed into empowered workgroups  
- Amount of time spent in tailoring workforce activities to the organisation’s empowered workgroup-based practices  
- Rate or progress in tailoring the organisation’s workforce activities for empowered workgroup-building application  
- Indicators of the organisation’s increased efficiency in performing empowered workgroup-based workforce activities  
- Individual ratings of the effectiveness of empowered workgroup-based workforce practices  
- Improved empowered workgroup coordination and functioning  
- Increased level of motivation and retention resulting from empowered workgroup-based staffing, career planning, compensation, and reward practices  
- Improvements in empowered workgroup performance  
- Increased impact of empowered workgroup performance on unit and organisational performance | Focuses upon effectiveness of work group empowerment activities  
- Measured at project or organisational level  
- Includes subjective and more objective items | Curtis (2002) |
| P4.8.5 Availability of senior sponsors | **Availability of senior sponsors**  
- Speed of response to project queries raised  
- Percentage time available against time requested in project management plan | Focuses upon availability of human resources  
- Measured at the project level  
- Objective criteria based upon recordable parameters | Developed based upon finding that availability of senior management supported enhanced project performance |
| A1.2 Communication | **General communication level and effectiveness indicators**  
- Use of communication media  
- Number of people trained in communication skills  
- Number of people trained in meeting management and facilitation skills  
- Results from opinion surveys  
- Number of interpersonal conflicts handled through formal mechanisms  
- Number of concerns raised  
- Number of meetings requested for expressing concerns  
- Time and effort expended to resolve concerns, grievances, or issues  
- Number of dependencies documented  
- Percent of commitments completed on time  
- Time spent in meetings  
- Meeting measures, such as percent of meetings starting and ending on time, and percent of meetings with agendas and with agendas distributed in advance  
- Rate at which meeting action items are closed | Focuses upon human communication processes within the organisation  
- Measured at project or organisational level  
- Includes subjective and objective items | Based upon Curtis (2002) |
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<td>Vertical superordinate-subordinate communication</td>
<td>Five dimensions of vertical communication are distinguished and data collected for each using a series of questionnaire items for each of which a response is made on a ten-point Likert scale anchored by 10 - 'strongly agree' and 1 - 'strongly disagree'. Responses are summed and averaged within each dimension to arrive at a single value for each dimension.</td>
<td>- Focuses upon effectiveness of vertical communication in the project that may be considered evidence of strong leadership</td>
<td>Adapted from Penley and Hawkins (2000) to apply specifically to project communication.</td>
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**Dimension 1: Task communication** - extent to which project leaders convey instructions to project personnel as to what activities need to be performed, describe changes in the workplace and indicate policy.
- Project leaders clearly explain policy changes
- Project leaders let us know about forthcoming changes
- Project leaders let me know what work needs to be done
- Project leaders discuss how to handle problems in my work

**Dimension 2: Performance communication** - assesses the degree to which project leaders transmit information about the quality of the work of project personnel.
- Project leaders let me know which areas of my work are weak
- Project leaders let me know how I can do better in my work
- Project leaders let me know about the quality of my work

**Dimension 3: Career communication** - extent to which project leaders review training opportunities with project personnel and offer career advice
- Project leaders encourage me to develop my career
- Project leaders advise me how to get additional training
- Project leaders give me advice on developing my career
- Project leaders make me aware of the demands of future jobs in my career path
- Project leaders give me information on training opportunities

**Dimension 4: Communication responsiveness** - degree to which project leaders respond promptly and helpfully to issues raised within the project
- Project leaders are always responsive to issues raised within the project
- Project leaders responses are helpful in resolving problem issues
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| Internal project communication | - Changes in working practices and operating procedures are always clearly communicated to me  
- I am aware of forth-coming changes in advance  
- I am always aware of what work needs to be done  
- I can openly discuss problems in my work with other project members  
- Other project members are a useful resource supporting the completion of my tasks  
- Project steering meetings help me to determine which areas of my work are weak  
- Project steering meetings help me to determine how to improve quality in my work  
- Other project personnel are always willing to listen and respond to issues I raise concerning the project  
- Key project personnel are always available for communication regarding progress issues  
- If I make a request to a higher level within the organisation, I can depend upon getting a response  
- I spend a lot of time coordinating communications between project personnel  
- The communication that occurs between project personnel is often wasted effort  
- A high degree of agreed actions from group discussion get implemented  
- Progress in this project suffers as a result of requirements to communicate between many different stakeholders  
- Colleagues are willing to chat about non-work related issues  
- I feel that I can share my interests outside of work with others | - Focuses upon effectiveness of human communication within the project  
- Measured at the individual level and results can be aggregated onto the project or work group level  
- Incorporates subjective judgement based assessment | Adapted from Penley and Hawkins (2000) to apply specifically to project communication with additional items relating to process losses. |
| Effort and effectiveness in workforce planning activities | - Time spent in organisational and unit-level workforce planning  
- Number of people involved in Workforce Planning activities  
- Effectiveness of meeting milestones in workforce planning  
- Effectiveness of achieving the objectives of the strategic workforce plan  
- Effectiveness in performing workforce activities at the organisational and unit levels  
- Number of revisions made to workforce plans  
- Length of time between workforce planning cycles | - Focuses upon human resource management activities  
- Measurable at the organisational or project level  
- Includes subjective and objective items | Curtis (2002) |
| A1.2.4 Internal project communication activities | Frequency of project management group meetings  
Recorded over time to represent level of formal face-to-face communication scheduled in the project management plan and arising from problem issues encountered during the course of the project. | - Focuses upon soft factor: human communication.  
- Measured at the project or project sub-phase level.  
- Objective measure recording frequency of actual events. | Developed in response to ‘process losses’ reported in scoping study due to high volume of problem issues requiring discussion. |
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<td><strong>A1.4</strong>&lt;br&gt;Decision processes</td>
<td><strong>Decision-making process and effectiveness indicators</strong>&lt;br&gt;- PM workgroup attitude to risk&lt;br&gt;- Level of conflict/divergence of views in team/stakeholder group for specific decision-situation&lt;br&gt;- Conflict was facilitative to the effectiveness of the decision reached and not detrimental to work group climate or motivation.&lt;br&gt;- Adequacy of solution reached in satisfying all stakeholders&lt;br&gt;- All viewpoints on the problem were sounded and received adequate air-time during group discussions&lt;br&gt;- All relevant viewpoints were represented by suitably knowledgeable and empowered individuals&lt;br&gt;- All relevant information was available for the decision in question.&lt;br&gt;- Appropriate time and resources were allocated to gathering relevant information, analysing information, formulating alternatives and reaching an agreement on the best solution.&lt;br&gt;- Availability of key stakeholders for decision-processes&lt;br&gt;- Decision effectiveness – based upon success criteria&lt;br&gt;- Awareness of implications of decision amongst stakeholders</td>
<td>- Focuses upon the human decision-making process&lt;br&gt;- Measured at the project management workgroup level or level at which the decision is made&lt;br&gt;- Mainly subjective indicators as effectiveness and adequacy of decision processes is difficult to parameterise in such a way as to apply to all possible scenarios</td>
<td>Developed in order to quantify key parameters of human decision making processes in project management teams</td>
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<td><strong>A1.4.1</strong>&lt;br&gt;Situational appraisal/Problem definition</td>
<td><strong>Decision type indicators</strong>&lt;br&gt;- Perceived bounded/unbounded nature of problem&lt;br&gt;- Perceived complexity of problem&lt;br&gt;- Clarity of cause and effect relationships/potential for novel and unpredictable interactions&lt;br&gt;- Interconnectivity of variables involved in decision situation&lt;br&gt;- Availability of information regarding decision-adequacy (e.g. effectiveness of decision is/is not immediately observable&lt;br&gt;- Criticality of decision to project success&lt;br&gt;- Scope of decision – how many separate project processes it effects&lt;br&gt;- Level of stakeholders that must be involved&lt;br&gt;- Number of stakeholders that must be involved (level of effort involved in communication)&lt;br&gt;- Availability of previous relevant decision models – best practices&lt;br&gt;- Amenability to standard operating procedures, formal rules and established procedures&lt;br&gt;- Quantity of information available&lt;br&gt;- Reliability of information available&lt;br&gt;- Representativeness of information available (across all relevant perspectives)</td>
<td>- Focuses upon the human decision-making process&lt;br&gt;- Measured at the project management workgroup level or level at which the decision is made&lt;br&gt;- Mainly subjective indicators as effectiveness and adequacy of decision processes is difficult to parameterise in such a way as to apply to all possible scenarios</td>
<td>Developed as generic parameters for consideration regarding any potential decision issue</td>
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<td><strong>A2.1.1</strong>&lt;br&gt;Risk identification</td>
<td><strong>Effectiveness of risk analysis activities</strong>&lt;br&gt;- Number of unanticipated risks materialising during project phase, project history so far, or whole project&lt;br&gt;- Perception of degree of adequacy of planned contingent actions for mitigating the negative effects of specific risks&lt;br&gt;- Rate/cycle time of risk mitigation activity from identification and specification of risk on the risk register, until completion of contingency plan/effective mitigation.</td>
<td>- Focuses upon human risk analysis processes&lt;br&gt;- Measured at the project level&lt;br&gt;- Mainly subjective indicators due to perception of risk</td>
<td>Developed to quantify risk management activities</td>
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<td>A2.2 Performance control</td>
<td>Effectiveness of performance control activities</td>
<td>□ Focuses upon human and organisational feedback and project control activities</td>
<td>Curtis (2002)</td>
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<td>• Percent of accomplished performance objectives at unit and individual levels</td>
<td>□ Measured at the project level</td>
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<td></td>
<td>• Rate of change in performance objectives during the performance period at unit and individual levels</td>
<td>□ Mainly objectively identifiable criteria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Profile of performance across unit objectives</td>
<td></td>
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<tr>
<td></td>
<td>• Profile of performance across individual objectives</td>
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<td></td>
<td>• Trends in development needs identified in discussing performance</td>
<td></td>
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<tr>
<td></td>
<td>• Percent of the workforce with performance problems</td>
<td></td>
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<td></td>
<td>• Progress against performance improvement plans</td>
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<td></td>
<td>• Time spent on performance management activities</td>
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<td></td>
<td>• Number of individuals or groups whose outstanding performance was recognized</td>
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<td></td>
<td>• Number and size of rewards</td>
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<td></td>
<td>• Time from proposing a recognition or reward until it is received</td>
<td></td>
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</tr>
<tr>
<td>A2.3 Motivation and leadership</td>
<td>Personnel commitment and motivation indicators</td>
<td>□ Focuses upon human motivational processes and commitment to project objectives</td>
<td>Developed to quantify motivational variance in project work group</td>
</tr>
<tr>
<td></td>
<td>• People feel that their future is linked to that of this project.</td>
<td>□ Measured at the project work group level through administration of survey to individuals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Project personnel are happy to make sacrifices if it would increase the success of the project.</td>
<td>□ Necessarily subjective indicators that measure experience of motivation and commitment in the work place</td>
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</tr>
<tr>
<td></td>
<td>• Project personnel often go above and beyond the call of duty to ensure success.</td>
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<tr>
<td></td>
<td>• The bonds between the project and its personnel are weak.</td>
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<tr>
<td></td>
<td>• Employees are fond of this project.</td>
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<tr>
<td></td>
<td>• This project benefits from highly committed and dedicated personnel.</td>
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<tr>
<td></td>
<td>• To what extent are project personnel committed to attaining the overall objectives of the project.</td>
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<tr>
<td></td>
<td>• There is a high degree of awareness amongst project staff as to what the overall goals of the project are and how individual actions contribute to the overall success of the project.</td>
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</tr>
<tr>
<td>A2.4 Training and group development activities</td>
<td>Rate of strategic reskilling</td>
<td>□ Focuses upon human competency development process</td>
<td>Kaplan and Norton (1996)</td>
</tr>
<tr>
<td></td>
<td>• Time taken to develop/transform employees to required levels of competency</td>
<td>□ Measured at the work group or organisational unit level</td>
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<tr>
<td></td>
<td></td>
<td>□ Objective indicator based upon training certification processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strategic job coverage ratio</td>
<td>□ Focuses upon human competency development process</td>
<td>Kaplan and Norton (1996)</td>
</tr>
<tr>
<td></td>
<td>• Step 1: Derive strategic job families from analysis of critical processes and activities (this stage outlines the role capabilities that are required to successfully implement new capability).</td>
<td>□ Measured at the work group or organisational unit level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Step 2: Relate to broader market development strategy in order to identify timescale for development of strategic job coverage.</td>
<td>□ Objective indicator based upon training certification processes</td>
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<tr>
<td></td>
<td>• Step 3: Identify 'competency profile' for each job family (unique skill sets required by each role).</td>
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<td></td>
<td>• Step 4: Conduct inventory assessment to determine which employees are currently qualified or capable of being reskilled.</td>
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<td></td>
<td>• Step 5: Create 'competency development strategy' (with formalised levels of attainment).</td>
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<td></td>
<td>• Step 6: Measure strategic job coverage using the percentage of employees that meet required strategic competency levels over time.</td>
<td></td>
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</tr>
<tr>
<td>HOP model variable</td>
<td>Metric description, method, sub-items and scales</td>
<td>Soft focus, level of analysis and objectivity</td>
<td>Source</td>
</tr>
<tr>
<td>--------------------</td>
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</tr>
</tbody>
</table>
| Training and group development effectiveness indicators | - Amount of training provided  
- Rate of training against stated training needs  
- Timeliness of training  
- Cost of training  
- Retention of trained skills  
- Improvements in learned skills  
- Application of learned skills or behaviours in job performance  
- Quality of training as rated in student evaluations  
- Frequency of development discussions  
- Number and type of development opportunities arranged | - Measures human competency development processes and movement in human resources  
- Measured at the project level  
- Includes subjective judgements and more objective criteria | Curtis (2002) |
| A2.5 Work process improvement indicators | - Amount of time or number of people involved in analysing workforce competencies or in collecting competency information  
- Number of workforce competencies defined  
- Effectiveness of meeting milestones in analysing workforce competencies or collecting competency information  
- Amount of competency information collected  
- Period between updates of workforce competency analyses or competency information  
- Extent to which competency information is used in designing or tailoring workforce practices and performing workforce activities  
- Level of detail to which workforce competency descriptions are defined  
- Frequency and range of uses of workforce competency descriptions and competency information  
- Usability of workforce competency descriptions or competency information  
- Number of revisions made to workforce competency descriptions  
- Number of corrections made to competency information | - Focuses upon improvement processes for human work competency  
- Measured at the project or organisational unit level  
- Mainly objective criteria with some items that may need to be judgement based | Curtis (2002) |
| H1 New Knowledge | Knowledge development and capture  
- The rate and type of competency-based assets being captured  
- Progress in packaging knowledge, experience, and artefacts into forms fit for dissemination and reuse  
- The rate at which competency-based assets are disseminated through different sources  
- The rate at which different repositories of competency-based assets grow and are accessed  
- The rate at which competency-based assets are accessed  
- The rate at which competency-based assets are incorporated into competency-based processes  
- Their effect on improving the rate of developing workforce competencies at the individual, workgroup, or organisational levels  
- Improved performance results at the individual, workgroup, unit, or organisational levels  
- Improved performance capability at the individual, workgroup, unit, or organisational levels  
- Increased motivation or retention | - Focuses upon development of human knowledge  
- Measured at the project level  
- Mainly objective criteria with some items that may need to be judgement based | Curtis (2002) |
| H2.1 Job satisfaction | Job satisfaction survey  
- Degree of pay satisfaction  
- Opportunity for promotion satisfaction  
- Satisfaction level for supervision  
- Satisfaction with non-pay related benefits  
- Level of reward and recognition provided  
- Adequacy of operating procedures  
- Level of satisfaction with co-workers  
- Meaningfulness and enjoyment in role  
- Adequacy of communications | - Focuses upon human occupational well-being  
- Measured through survey of individuals  
- Measures the reported experience of individuals and therefore subjective judgements based | Dimensions from Spector (1985) |
<table>
<thead>
<tr>
<th>HOP model variable</th>
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<th>Soft focus, level of analysis and objectivity</th>
<th>Source</th>
</tr>
</thead>
</table>
| H2.2 Employee well-being | Employee opinion survey  
Standardised employee opinion questionnaire to survey workforce attitudes at periodic intervals | - Focusses upon employee well-being and job satisfaction  
- Measured at the organisational unit level  
- Subjective opinions | BAE SYSTEMS (B) |
| H2.5 Work group viability/ cohesion | Continued viability  
- I would like to continue working with this team on future projects.  
- I have gained important skills and career benefits through being a member of this work group.  
- Overall, I find working in this group a rewarding experience.  
- The team's working practices and performance have become increasingly effective during the course of the project.  
- The benefits and value that this group brings to the organisation will carry over onto future projects.  
- The performance of this work group is more determined by internal factors than external constraints.  
- This work group provides a motivating environment in which to work.  
- This group performs well and has met all performance targets and objectives | - Focusses upon human work group development  
- Measured at the work group or project management team level  
- Employs subjective judgement items | Developed to quantify social outcomes of work group functioning |
| Work group cohesion | Work group cohesion is defined as the degree of liking or attraction between group members and their liking for the group itself. Relationship between cohesion and performance is bi-directional, i.e. it may be a result of high performance.  
- This team is an effective and cohesive group.  
- Mutual respect for other group members exists within this group.  
- A real sense of 'team spirit' exists within this group. Morale within the group is generally high.  
- Other group members were helpful and supportive  
- I get a real sense of satisfaction from working in this group. | - Focusses upon human work group development  
- Measured at the work group or project management team level  
- Employs subjective judgement items | Developed to quantify social outcomes of work group functioning |
| Resilience | The work group displays determination in the face of adversity and persistence in pursuing objectives  
The work group maintains morale in the face of setbacks The work group utilises internal conflict productively to consider alternative courses of action  
The work group utilises negative responses productively and embraces the opportunity to learn from mishaps, error and negative experiences  
The work group takes proactive steps to mitigate risks before they become a serious threat.  
The work group is easily deflected from pursuing agreed objectives | - Focusses upon human work group development  
- Measured at the work group or project management team level  
- Employs subjective judgement items | Developed to quantify social outcomes of work group functioning |
<table>
<thead>
<tr>
<th>HOP model variable</th>
<th>Metric description, method, sub-items and scales</th>
<th>Soft focus, level of analysis and objectivity</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>H3.3 Trust</td>
<td>Trust between organisational entities&lt;br&gt;These measures are based upon social theory, which holds that trust develops through repeated experience of successful interaction between actors and is often a function of the anticipated requirement for future contact. Trust indicators are based upon history of previous positive experiences. Trust develops over time as a result of experience, interaction and collaborative functioning between projects, individuals and organisational entities.</td>
<td>Focuses upon human trust and confidence between organisational entities or groups&lt;br&gt;Measured at the work group level&lt;br&gt;Objective criteria and subjective judgement based rating of reliability</td>
<td>Developed to quantify confidence in collaborating partners</td>
</tr>
<tr>
<td></td>
<td>- Number of previous successful/unsuccessful collaborations between partners&lt;br&gt;- Number of future anticipated collaborations (for example: number of scheduled collaborative review meetings) between partners&lt;br&gt;- Level of information exchange and communication between collaborating partners&lt;br&gt;- Perception of reliability of collaborating partner&lt;br&gt;- Perception of integrity of collaborating partner&lt;br&gt;- Perception of communication openness between collaborating partners&lt;br&gt;- Perception of goal compatibility between collaborating partners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O1 Project performance criteria</td>
<td>Earned Value Management&lt;br&gt;Standard project management technique for project control which tracks 'earned value' over time. Measures key operational performance parameters associated with budget and schedule performance.</td>
<td>Focuses upon 'hard' technical parameters associated with cost, quality and time&lt;br&gt;Measured at the project level&lt;br&gt;Incorporates objective criteria such as elapsed time and spend</td>
<td>e.g. BAE SYSTEMS (C); Slack et al (2001).</td>
</tr>
</tbody>
</table>
Appendix I: Evaluative instrument response sheets

The quantitative and qualitative items employed within sections of the soft metrics tool application and validation process are reproduced below on the subsequent pages. Section 6 of the thesis provides a detailed methodological account of how this instrument may be applied in case project analysis and figure 6.4b in particular offers a concise summary of the purpose of each item within the instrument. For reference purposes, each measurement item within the sections of the evaluative instrument that follows are allocated an identification number and factor title. Where the items are quantitative in nature, the response scale is also included. Scales utilised in the evaluative instrument include Likert-type 'Agreement' scales and scales with continuous indices anchored by descriptive items at their poles.

The sections within the evaluative instrument vary in terms of whether they are applied at the level of the individual or work group. In application of the instrument a group facilitator was employed to explain and administer the validation process and much useful information was recorded from focus group discussions provoked by specific evaluative items. Throughout the process, respondents were encouraged to qualify their responses with more elaborative, qualitative comments. In terms of the content of the evaluative instrument, section A employs qualitative items to describe key features of the project case, before section B items quantify performance achieved against a variety of operational outcome and human and organisational development criteria. Section C is used in conjunction with an Influence mapping exercise that employs the HOP model framework and sample performance factors list, and is designed to assess the level of influence or 'criticality' of specific preconditions upon each of the main human work activities within the HOP model. Section D evaluates potential soft metrics that were identified to support specific performance issues and section E provides overall evaluative items for the integrated soft metrics tool and validation process.
### Section A: Project case profile (Group level responses)

<table>
<thead>
<tr>
<th>ID</th>
<th>Item</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Project aim</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What were/are the principle aims of the project?</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Project duration</td>
<td></td>
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<tr>
<td></td>
<td>What was/is the duration of the project?</td>
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<tr>
<td>A3</td>
<td>Project budget</td>
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</tr>
<tr>
<td></td>
<td>What was/is the project's total budget?</td>
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<tr>
<td>A4</td>
<td>Work group size</td>
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<tr>
<td></td>
<td>What was/is the size of the principle project work group?</td>
<td></td>
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<tr>
<td>A5</td>
<td>Work process outline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What was/is the general project work process?</td>
<td></td>
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<tr>
<td>A6</td>
<td>Current status</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What stage is the project currently at?</td>
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</tbody>
</table>

### Section B: Project performance outcomes (Group level responses)

<table>
<thead>
<tr>
<th>ID</th>
<th>Item</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Budget performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In your opinion, to what degree has the project met the formal objectives set out for it?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Budget performance scale:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0% (the project ran over the planned budget early in its life-cycle, did not recover, and closed with a significant over-spend)</td>
<td></td>
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<tr>
<td></td>
<td>100% (the project functioned within planned costs throughout its life-cycle and closed within initial budget estimates)</td>
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<tr>
<td></td>
<td>If the project ran over budget for a significant period of time during its lifecycle, yet closed within initial estimates, the highest score assignable should be 90%</td>
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<tr>
<td>B2</td>
<td>Schedule performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In your opinion, to what degree has the project met the formal objectives set out for it?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schedule performance scale:</td>
<td></td>
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<tr>
<td></td>
<td>0% (the project ran behind the planned schedule from early in its life-cycle, did not recover, and closed very late)</td>
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<tr>
<td></td>
<td>100% (the project remained within planned schedule parameters throughout and closed on time)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the project ran behind schedule for a significant period of time during its lifecycle, yet closed on time, the highest score assignable should be 90%</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>Functional performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In your opinion, to what degree has the project met the formal objectives set out for it?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Functional performance scale:</td>
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</tr>
<tr>
<td></td>
<td>0% (the project achieved none of its objectives as specified within the functional requirements definition)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100% (the project achieved all of its objectives as specified within the functional requirements definition)</td>
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</tr>
<tr>
<td>B4</td>
<td>Motivating environment</td>
<td></td>
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<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The project provided a stimulating and motivating work environment for project personnel.</td>
<td></td>
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<tr>
<td></td>
<td>Scale:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (Strongly disagree)</td>
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</tr>
<tr>
<td></td>
<td>10 (Strongly agree)</td>
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<tr>
<td><strong>B5</strong></td>
<td><strong>Formal training</strong></td>
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<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The project provided beneficial formal training for project personnel.</td>
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<tr>
<td></td>
<td>Scale: 1 (Strongly disagree) 10 (Strongly agree)</td>
<td></td>
</tr>
<tr>
<td><strong>B6</strong></td>
<td><strong>Experience</strong></td>
<td></td>
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<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The project provided beneficial experience for project personnel</td>
<td></td>
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<tr>
<td></td>
<td>Scale: 1 (Strongly disagree) 10 (Strongly agree)</td>
<td></td>
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<tr>
<td><strong>B7</strong></td>
<td><strong>Collaboration/work group climate</strong></td>
<td></td>
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<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
<td></td>
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<tr>
<td></td>
<td>The project developed a collaborative spirit and productive group-working climate</td>
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<tr>
<td></td>
<td>Scale: 1 (Strongly disagree) 10 (Strongly agree)</td>
<td></td>
</tr>
<tr>
<td><strong>B8</strong></td>
<td><strong>Knowledge</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The project contributed useful knowledge and competency to the organisation or its customers.</td>
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</tr>
<tr>
<td></td>
<td>Scale: 1 (Strongly disagree) 10 (Strongly agree)</td>
<td></td>
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<tr>
<td><strong>B9</strong></td>
<td><strong>Work process improvement</strong></td>
<td></td>
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<tr>
<td></td>
<td>In your opinion, to what degree was the project successful in contributing towards human and organisational development within the project team?</td>
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<tr>
<td></td>
<td>The project generated knowledge for/stimulated development in processes and working practices.</td>
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<td></td>
<td>Scale: 1 (Strongly disagree) 10 (Strongly agree)</td>
<td></td>
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<tr>
<td><strong>B10</strong></td>
<td><strong>Exceeding formal requirements</strong></td>
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<tr>
<td></td>
<td>To what extent do you think work performed in the project and the project's output/product was 'high quality' and 'innovative'?</td>
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<tr>
<td></td>
<td>The degree to which project work exceeded formal requirements set for it.</td>
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<td></td>
<td>Scale: 1 (Low achievement) 10 (High achievement)</td>
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<tr>
<td><strong>B11</strong></td>
<td><strong>Innovation</strong></td>
<td></td>
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<tr>
<td></td>
<td>To what extent do you think work performed in the project and the project's output/product was 'high quality' and 'innovative'?</td>
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<tr>
<td></td>
<td>The degree to which project work products represented innovative and creative solutions to difficult challenges.</td>
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</tr>
<tr>
<td></td>
<td>Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Description</td>
<td></td>
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<tr>
<td>----------</td>
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</tr>
<tr>
<td><strong>B12</strong> Commitment and persistence</td>
<td>To what extent do you think work performed in the project and the project output/product was 'high quality' and 'innovative'? The degree to which the project excelled in the face of overwhelming limitations and set-backs. Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td><strong>B13</strong> Novelty</td>
<td>To what extent do you think work performed in the project and the project output/product was 'high quality' and 'innovative'? The degree to which the project has achieved something that has not been achieved before. Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td><strong>B14</strong> Customer satisfaction</td>
<td>To what extent do you think work performed in the project and the project output/product was 'high quality' and 'innovative'? The degree to which project customers reported high satisfaction with the project's deliverable. Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td><strong>B15</strong> World class quality</td>
<td>To what extent do you think work performed in the project and the project output/product was 'high quality' and 'innovative'? The degree to which project work was of a 'world class' quality level. Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td><strong>B16</strong> Organisational asset</td>
<td>To what extent do you think work performed in the project and the project output/product was 'high quality' and 'innovative'? The degree to which the project was an asset to the organisation. Scale: 1 (Low achievement) 10 (High achievement)</td>
<td></td>
</tr>
<tr>
<td><strong>B17</strong> Project management effectiveness</td>
<td>Within externally imposed constraints, in your opinion could the project have been more effectively planned and executed? Scale: 1 (Most aspects of the project and the way it was conducted could have been improved) 10 (All aspects of the project and the way it was conducted were optimal and couldn't have been improved)</td>
<td></td>
</tr>
<tr>
<td><strong>B18</strong> Fulfilment of potential</td>
<td>Within the external constraints imposed upon the project (e.g., customer requirements, resources available), do you think the project achieved its full potential? Yes/No?</td>
<td></td>
</tr>
<tr>
<td><strong>B19</strong> Overall success</td>
<td>Overall and considering your responses to the above questions, how successful would you say the project was? Scale: 1 – Very unsuccessful 10 – Highly successful</td>
<td></td>
</tr>
</tbody>
</table>
### B20 Soft versus hard issues

In your opinion, what proportion of the project's performance was influenced by 'soft', non-technical factors, relative to 'hard', technical factors?

**Scale:**
Percentage rating for hard versus soft factors (totalling 100%)

---

### Section C: Impact of preconditions (Individual level responses)

Note: Items are used in conjunction with influence mapping exercise. Please complete one sheet for each identified precondition.

<table>
<thead>
<tr>
<th>Precondition</th>
<th>ID</th>
<th>Item</th>
<th>Response</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Criticality</td>
<td>C1</td>
<td>Criticality</td>
<td>How critical is [precondition] as a determinant of overall project performance outcomes?</td>
<td></td>
</tr>
</tbody>
</table>
| | | | Criticality scale:  
0 (Factor is irrelevant)  
6 (Factor is highly critical) | | |
| C2 Frequency | C2 | Frequency | How frequently do performance issues within the project arise due to [precondition]? | | |
| | | | Frequency scale:  
0 (Never)  
6 (Constantly) | | |
| C3 Task performance | C3 | Task performance | To what degree does [precondition] influence the project work group's ability to:  
Perform tasks effectively. | | |
| | | | Criticality scale:  
0 (Factor is irrelevant)  
6 (Factor is highly critical) | | |
| C4 Communication | C4 | Communication | To what degree does [precondition] influence the project work group's ability to:  
Communicate effectively. | | |
| | | | Criticality scale:  
0 (Factor is irrelevant)  
6 (Factor is highly critical) | | |
| C5 Task coordination | C5 | Task coordination | To what degree does [precondition] influence the project work group's ability to:  
Coordinate tasks effectively. | | |
| | | | Criticality scale:  
0 (Factor is irrelevant)  
6 (Factor is highly critical) | | |
| C6 Decision processes | C6 | Decision processes | To what degree does [precondition] influence the project work group's ability to:  
Make effective decisions. | | |
| | | | Criticality scale:  
0 (Factor is irrelevant)  
6 (Factor is highly critical) | | |
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Criticality Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7 Risk management</td>
<td>To what degree does [precondition] influence the project work group's ability to: Manage risks effectively.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C8 Performance control</td>
<td>To what degree does [precondition] influence the project work group's ability to: Monitor and control performance.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C9 Motivation and leadership</td>
<td>To what degree does [precondition] influence the project work group's ability to: Provide effective motivation and leadership.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C10 Training and development</td>
<td>To what degree does [precondition] influence the project work group's ability to: Support training needs and group development.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C11 Work process improvement</td>
<td>To what degree does [precondition] influence the project work group's ability to: Evaluate and improve work processes.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C12 Change management</td>
<td>To what degree does [precondition] influence the project work group's ability to: Effectively manage and integrate change.</td>
<td>0 (Factor is irrelevant) 6 (Factor is highly critical)</td>
</tr>
<tr>
<td>C13 Additional mechanisms</td>
<td>Are there any other mechanisms you can think of by which [precondition] influences project performance?</td>
<td>X</td>
</tr>
<tr>
<td>C14 Existing methods</td>
<td>In your general experience of project management, have you employed methods to measure [precondition] in project operations?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>C15 Method effectiveness</td>
<td>If response to C14 is 'yes', how effective would you say these tools/methods were in measuring and controlling [precondition]?</td>
<td>1 (Virtually ineffective) 10 (Highly effective)</td>
</tr>
</tbody>
</table>
### Section D: Metrics examples and evaluation (Individual level responses)

<table>
<thead>
<tr>
<th>Metric</th>
<th>ID</th>
<th>Items</th>
<th>Response</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 Metric effectiveness</td>
<td></td>
<td>How effective would you say this metric/method is in measuring and controlling [performance factor]?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effectiveness scale:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (Virtually ineffective)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 (Highly effective)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 Metric feasibility</td>
<td></td>
<td>Would you have used this measure? Please consider the practicality and effort involved.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes/No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3 Metric application</td>
<td></td>
<td>When in the project lifecycle do you think this measure should be employed?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Qualitative response: e.g. Project planning?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>After changes to the plan?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>At periodic reviews?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>More frequently/Continual tracking?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4 Metric benefits</td>
<td></td>
<td>If you had used this measure, what difference would it have made?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Qualitative response</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Section E: Evaluation of exercise and methodology (Individual level responses)

<table>
<thead>
<tr>
<th>ID</th>
<th>Item</th>
<th>Response</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Case-specific usefulness</td>
<td>How useful has this exercise been in analysing soft factors in your project?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (Not very useful)</td>
<td>10 (Very useful)</td>
</tr>
</tbody>
</table>

In general, how useful do you think the soft metrics tool (Model, Metrics and Method) is for analysis and control of soft performance issues in projects?

Please respond against the following dimensions:

<table>
<thead>
<tr>
<th>E2</th>
<th>Scope and comprehensiveness</th>
<th>1 (Low)</th>
<th>10 (High)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E3</td>
<td>Practicality and feasibility</td>
<td>1 (Low)</td>
<td>10 (High)</td>
</tr>
<tr>
<td>E4</td>
<td>Overall effectiveness</td>
<td>1 (Low)</td>
<td>10 (High)</td>
</tr>
</tbody>
</table>

To what extent do you agree with the following statements?
<table>
<thead>
<tr>
<th></th>
<th>Communication of aims</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E5</td>
<td>The aims and purpose of the exercise were clearly communicated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (Strongly disagree)</td>
<td>10 (Strongly agree)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E6</td>
<td>Plan clarity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The plan and process for the exercise was logical and clear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (Strongly disagree)</td>
<td>10 (Strongly agree)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E7</td>
<td>Language accessibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The language and terminology used within the model and documentation was accessible.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (Strongly disagree)</td>
<td>10 (Strongly agree)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E8</td>
<td>Level of detail</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The presentation material and resources were of adequate detail</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (Strongly disagree)</td>
<td>10 (Strongly agree)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix J: Influence map template

The figure on the following page comprises the actual HOP model Influence mapping template used in section C of the validation case studies to map dependencies between specific project preconditions and outcome factors. These dependencies are mediated by specific human behaviours in the work place and causal paths between preconditions and outcomes are therefore traced through key 'human performance activities'. To support the analysis of human and organisational influences upon project performance in the influence mapping exercise, two further analytical activities were undertaken: 1) Identification of direction of influence between precondition and outcome factors, i.e. whether the variables in question were positively or negatively associated, and 2) judgement-based rating of level of criticality of an identified precondition for effective human performance activities. More details regarding methodological considerations in the influence mapping exercise may be found in section 6.4.4, within the main text of this thesis.
<table>
<thead>
<tr>
<th>Project Preconditions</th>
<th>Human Performance</th>
<th>Project Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project profile</strong></td>
<td><strong>Organisational context</strong></td>
<td><strong>Generic human work activities</strong></td>
</tr>
<tr>
<td>· Size</td>
<td>· Organisational culture</td>
<td>· Task performance</td>
</tr>
<tr>
<td>· Type</td>
<td>· Trust</td>
<td>· Productivity</td>
</tr>
<tr>
<td>· Complexity</td>
<td>· Collaborative culture</td>
<td>· Human error</td>
</tr>
<tr>
<td>· Scope</td>
<td>· Performance expectations</td>
<td>· Innovation</td>
</tr>
<tr>
<td><strong>Project work group characteristics</strong></td>
<td><strong>Stakeholder characteristics</strong></td>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td>· Group size</td>
<td>· Availability</td>
<td>· Stakeholder</td>
</tr>
<tr>
<td>· Collaborative history</td>
<td>· Issue involvement</td>
<td></td>
</tr>
<tr>
<td>· Group working climate</td>
<td>· Position/authority</td>
<td>· Internal project</td>
</tr>
<tr>
<td>· Group morale</td>
<td>· Criticality</td>
<td>· Intergroup/Interproject</td>
</tr>
<tr>
<td>· Group composition</td>
<td>· Core engineering/process knowledge</td>
<td>· Informational process</td>
</tr>
<tr>
<td>· Knowledge/skills/ experience</td>
<td>· Formal policies/operating procedures</td>
<td>· Problem definition</td>
</tr>
<tr>
<td>· Location</td>
<td>· Established working methods/best practices</td>
<td>· Analysis/Generation of alternatives</td>
</tr>
<tr>
<td>· Functional origin</td>
<td>· Staff development &amp; training</td>
<td>· Solution formulation/Conflict resolution</td>
</tr>
<tr>
<td>· Motivation level</td>
<td>· Reward &amp; recognition/performance appraisal</td>
<td>· Implementation</td>
</tr>
<tr>
<td><strong>Project work organisation characteristics</strong></td>
<td>· Information technology adequacy</td>
<td>· Evaluation</td>
</tr>
<tr>
<td>· Role/responsibilities clarify</td>
<td>· Support for collaborative work</td>
<td>· PM activities</td>
</tr>
<tr>
<td>· Workgroup autonomy</td>
<td>· Accessibility of information</td>
<td>· Risk/crisis management</td>
</tr>
<tr>
<td>· Task characteristics</td>
<td>· Dissemination of knowledge</td>
<td>· Identification</td>
</tr>
<tr>
<td>· Task Interdependency</td>
<td>· Resource provision</td>
<td>· Mitigation</td>
</tr>
<tr>
<td>· Task Concurrence</td>
<td>· Budgetary</td>
<td>· Performance control</td>
</tr>
<tr>
<td>· Task Feasibility</td>
<td>· Temporal</td>
<td>· Monitoring/Tracking</td>
</tr>
<tr>
<td>· Task Completeness</td>
<td>· Human</td>
<td>· Evaluation &amp; feedback</td>
</tr>
<tr>
<td>· Task Size</td>
<td>· Technological</td>
<td>· Target setting</td>
</tr>
<tr>
<td>· Task Significance</td>
<td>· Informational</td>
<td>· Motivation &amp; leadership</td>
</tr>
<tr>
<td>· Task Complexity</td>
<td>· Organisational structure/authority</td>
<td>· Training &amp; group development</td>
</tr>
<tr>
<td>· Task Variety</td>
<td>· Hierarchical distance/proximity</td>
<td>· Work process improvement</td>
</tr>
<tr>
<td>· Inherent feedback</td>
<td>· Power distribution</td>
<td>· Change integration</td>
</tr>
<tr>
<td>· Inherent autonomy</td>
<td>· Empowerment/Devolution</td>
<td></td>
</tr>
</tbody>
</table>
Appendix K: Example output from HOP model influence mapping exercise

In the figures below, two influence maps from the validation studies are reproduced to illustrate the output from utilisation of the HOP modelling framework in section C of the validation process. Causal chains are traced through the three classes of variables within the model to describe specific performance issues inherent in an applied project context. This process allows ‘upstream’ preconditions to be linked to ‘downstream’ project performance outcomes through specific human performance activities. In the exercise, dependent influences for specific preconditions are colour-coded for ease of identification. Specific causal chains identified within the soft metrics project case studies are outlined in more detail in the thesis text (section 7.3). Evident from the influence maps depicted below is the high dependency of operational performance upon human behaviour in the work environment, as is indicated by the intensity of activity within the human performance class of variables. This high level of activity also suggests high sensitivity of human performance to characteristics inherent in the sociotechnical organisational system and working environment.
<table>
<thead>
<tr>
<th>Project Preconditions</th>
<th>Human Performance</th>
<th>Project Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisational context</strong></td>
<td><strong>Generic human work activities</strong></td>
<td><strong>Project performance criteria</strong></td>
</tr>
<tr>
<td>- Organisational culture</td>
<td>- Task performance</td>
<td>- Schedule performance</td>
</tr>
<tr>
<td>- Trust</td>
<td>- Productivity</td>
<td>- Budget performance</td>
</tr>
<tr>
<td>- Collaborative culture</td>
<td>- Human error</td>
<td>- Product quality</td>
</tr>
<tr>
<td>- Performance expectations</td>
<td>- Innovation</td>
<td>- Work quality</td>
</tr>
<tr>
<td>- Accountability</td>
<td>- Communication</td>
<td>- New knowledge</td>
</tr>
<tr>
<td>- Support for change</td>
<td>- Senior management</td>
<td>- Work processes/best practice</td>
</tr>
<tr>
<td>- Communication barriers</td>
<td>- Interproject</td>
<td>- Technical knowledge/ability</td>
</tr>
<tr>
<td>- Functional barriers</td>
<td>- Internal project</td>
<td>- Individual KSA/human capability</td>
</tr>
<tr>
<td>- Shared mental models</td>
<td>- Knowledge dissemination</td>
<td>- New performance targets</td>
</tr>
<tr>
<td>- Social climate</td>
<td>- Networking</td>
<td>- Motivation &amp; commitment</td>
</tr>
<tr>
<td>- Support for networking</td>
<td>- Reporting (written)</td>
<td>- Job-satisfaction</td>
</tr>
<tr>
<td>- Interproject climate</td>
<td>- Collaborative working</td>
<td>- Employee well-being</td>
</tr>
<tr>
<td>- Stakeholder characteristics</td>
<td>- Task coordination</td>
<td>- Absenteeism</td>
</tr>
<tr>
<td>- Availability (e.g., physical access)</td>
<td>- Planning &amp; scheduling</td>
<td>- Turnover</td>
</tr>
<tr>
<td>- Issue involvement</td>
<td>- Integration</td>
<td>- Work group viability/cohension</td>
</tr>
<tr>
<td>- Position/authority</td>
<td>- Decision processes</td>
<td>- Organisational culture</td>
</tr>
<tr>
<td>- Criticality</td>
<td>- Situational appraisal/Problem definition</td>
<td>- Attitudes &amp; beliefs</td>
</tr>
<tr>
<td>- Core engineering/process knowledge</td>
<td>- Analysis/Generation of alternatives</td>
<td>- Evolving norms</td>
</tr>
<tr>
<td>- Formal policies/operating procedures</td>
<td>- Solution formulation/Conflict resolution</td>
<td>- Trust</td>
</tr>
<tr>
<td>- Established working methods/best practices</td>
<td>- Implementation</td>
<td>-</td>
</tr>
</tbody>
</table>
Appendix L: Raw quantitative data from validation studies

The raw quantitative data from sections B, C and E of the validation case studies is included within the tables below. Within the tables, the evaluative items are summarised with an identification number and factor title linked to individual items within the evaluative instrument (see appendix I for further information regarding the evaluative items, including the measurement scales employed for quantification). Note that only quantitative data is reported here; the qualitative information gained from focus group discussion of the evaluative items is reported within section 7 of the thesis text. Within the validation process, sections A and D were predominantly qualitative in nature and the results for these exercises may be found in sections 7.1 and 7.4, respectively.

Within the tables, the three case systems engineering projects studied are coded: SEP1, SEP2 and SEP3. Section B recorded single scores against evaluative items in each project case study, based upon group discussion amongst respondents to arrive at a satisfactory overall score for each measure. Accordingly, the table of section B data shows the actual responses recorded in each project, by evaluative item. The table of data for section C of the case studies reports criticality ratings made by each respondent (R1, R2, etc.), for specific preconditions that were identified as important performance factors within each project. The critical preconditions identified by each project are coded and directly relate to the performance factors within the HOP modelling framework (see figure 5.1.1c for reference, in the thesis text). Responses made by individual respondents against evaluative criteria in section E of the validation process are reported in the table, with respondents grouped by project. Throughout the tables that follow, missing data against evaluative items is signified by the presence of an 'X' character.
### Section B data: Project performance outcomes

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>SEP1</th>
<th>SEP2</th>
<th>SEP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Budget performance</td>
<td>90%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>B2</td>
<td>Schedule performance</td>
<td>85%</td>
<td>70%</td>
<td>95%</td>
</tr>
<tr>
<td>B3</td>
<td>Functional performance</td>
<td>60%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>B4</td>
<td>Motivating environment</td>
<td>8</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>B5</td>
<td>Formal training</td>
<td>4.5</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>B6</td>
<td>Experience</td>
<td>8</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>B7</td>
<td>Collaboration/work group climate</td>
<td>5.5</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>B8</td>
<td>Knowledge</td>
<td>8</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>B9</td>
<td>Work process improvement</td>
<td>X</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>B10</td>
<td>Exceeding formal requirements</td>
<td>7.5</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>B11</td>
<td>Innovation</td>
<td>8</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>B12</td>
<td>Commitment and persistence</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>B13</td>
<td>Novelty</td>
<td>9</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>B14</td>
<td>Customer satisfaction</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>B15</td>
<td>World class quality</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>B16</td>
<td>Organisational asset</td>
<td>9</td>
<td>5</td>
<td>X</td>
</tr>
<tr>
<td>B17</td>
<td>Project management effectiveness</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>B18</td>
<td>Overall success</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>B20</td>
<td>Soft versus hard issues</td>
<td>50-50</td>
<td>75-25</td>
<td>40-60</td>
</tr>
</tbody>
</table>
### Section C data: Impact of preconditions

<table>
<thead>
<tr>
<th>Case Project:</th>
<th>SEP 1</th>
<th>SEP 2</th>
<th>SEP 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Critical Precondition:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual Respondent:</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
</tr>
<tr>
<td>C1 Criticality</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>C2 Frequency</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>C3 Task Performance</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
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### Section E data: Evaluation of exercise and methodology

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