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A Conceptual Methodology to Assist Employees and Employers
Design New Ways of Working in Lean Manufacturing

By

Avinash Jhugroo

A Doctoral Thesis, Submitted in Partial Fulfillment of the
Requirements for the Award of Doctor of Philosophy of
Loughborough University

June 2004

Supervisor: Prof N.D. Burns

The Wolfson School of Mechanical and Manufacturing Engineering

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Abstract

The opportunity to create more fulfilling and effective work in lean manufacturing is considerable, but so are the dangers of reducing its quality. Lean organisations are introducing new measures involving changes to people's jobs. However, the complex nature of work organisation in lean production environments are contributing to work related injuries in particular Repetitive Strain Injuries (RSI).

Previous research has evaluated work organisation changes in the workplace by aligning work practices within business operations rather than considering the working situation from the workers perspective. The issues of work related injuries in lean production environments lack a coherent theoretical framework. This research work in lean production environments, has addressed certain issues however doubt and scepticism from the perspective of a range of disciplines, have emerged from the literature.

In this research the possibility of identifying the levels of RSI risk has been through the development of the Lean Job Position Model. The proposal of this model has been to add and contribute to the aspects of work organisation in the lean production literature, not been previously considered. The model was applied in a lean manufacturing environment using direct observations, semi-structured interviews, and a questionnaire in an action research content. The testing of the Lean Job Position Model showed that the use of Situational Strength as a strategic management method showed the key relationships that assisted the process of identifying the level of RSI risk in a lean manufacturing setting.
Acknowledgements

Abstract

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Chapter 1
Introduction

The aim of this chapter is to provide the reader with the objectives of this research. The research background is introduced, setting the scene for the field of study. The research process is discussed outlining the methodology used followed by the organisation of the thesis.

1.1 Relevant Search Area for the Literature Review
The main sources of literature have involved a spectrum of topics including work related upper limb disorders, repetitive strain injuries (RSI), musculoskeletal disorders, work organisation, lean production, reflective production, musculoskeletal diseases, cumulated trauma disorders, musculoskeletal system disorders, assembly work, hand arm syndrome, and strategic management.
A review of these literature sources has been carried out involving a review of academic journals, conference papers and proceedings, reports and government publications, such as reports from the Department for the Health and Safety Executive, contract reports and, European publications, for the European Agency for Health and Safety at Work. Secondary sources have involved the review of textbooks, and newspaper articles. Specialised on line databases such as BIDS, ISI Web of Science, EBSCO and Emerald, have been frequently used.

1.2 Research Aims
The aims of this research are two fold:
Aim 1
To explore the nature of the job task situation in a lean environment in order to understand how the risks of RSI injury affect the worker

Aim 2
To understand in depth the level of RSI risk in a lean job by exploring the operator's job situation working in a lean environment.

1.3 Research Background
The critique of existing work practices in lean production creates intensified work pace and demands (Landsbergis et al., 1999). The changing compositions of the lean
workforce have resulted in changes in job characteristics over time. In Europe, surveys indicate increases in time constraints in workload demands between 1977 and 1996 (European Foundation, 1977). Similarly in the United States increases between 1977 and 1997 were reported for “working very fast”, (55% to 68%), and “never enough time to get everything done on my job”, (from 40% to 60%; Bond, Galinsky, & Swanberg, 1998). Fucini and Fucini (1990), reported that injured workers at Mazda had been ridiculed by managers and told they were “faking it”, and that injuries were “not related.” Berggren et al. (1991), in their study of Japanese owned plants in North America also reported the lack of early treatment because of peer pressure to “work pain” and not reporting injuries, and the denial of work relatedness to these injuries by management e.g. “There are strong people and there are weak people.” According to Graham (1995), at Subaru-Isuzu, an outbreak of hand and wrist injuries occurred after production officially began and line speed increased. A number of Canadian and US studies of lean production in auto manufacturing, reported significant heavier workloads and “too few people” than those in traditional companies (Lewchuk & Robertson, 1996).

Published literature by Kenney and Florida, (1998) Berggren, Bjorkman and Hollander (1991), mention how fragmented and demanding work in the lean environment is. Rinehart et al. (1997), reported levels of muscle fatigue, strains and frequent risks all resulting in RSI and job stress. On the other hand authors advocating lean production, for example Womack et al. (1990) believe re-balancing production efforts and adding to vertically integrated jobs enhances skill development. Although some authors see lean manufacture as being a flexible system providing both job enlargement, job rotation, and problem solving opportunities, considerably more than most traditional mass production, Parker and Slaughter (1988) use the term “management by stress”, to emphasise that in the lean system employees are subjected to intense pressure from the pace of work, and its team members as well as being “fragmented, repetitive work combined with piece rate leads to high rates of work related muscular disorders (WRMD) (Brisson, Vinet, Vezina, & Gingras, 1989; Punnett, Robins, Wegman, & Keyserling, 1985; Schibye, Skov, Ekner, Christiansen, & Sjogaard, 1995). Thus, work with physical ergonomic stressors such as in lean manufacturing intensification of labour may lead to increased rates of musculoskeletal disorders (Landsbergis et al., 1999).
This research explores how lean production can lead to occupational injuries such as RSI, (Repetitive Strain Injury), Musculoskeletal Disorders and Work Related Upper Limb Disorders (WRULDs).

The intention is to learn and understand the desired measures that can develop a new system of work that can enable employers and employees identify the likely levels of risks associated with their job task situation.

1.4 Research Process

The research process chosen is driven by the research aim. A constructivist position is taken, in the research methodology. The aim is to generate new knowledge using qualitative methods that aim to create a rich understanding of complex variables. Qualitative methods were chosen to be more appropriate for this research than quantitative. The research process is administered in form of action research carried out in a real world context. It involves the researcher immersing himself into the work environment where initiative, pro-activity and communication were essential to explore the risks of work organisation in a lean environment. Direct observation, semi structured interviews and a questionnaire was used within the action research process for the collection of data. The research design encompasses these methods of collecting data and is grounded in a real world context as a result of an interaction between the researcher, and researched, adding richness to the findings of this research. These findings are measured against the traditional measures of validity and reliability. The outcome of this thesis is to provide credible findings to both academics and industrialists alike.

1.5 Thesis Organisation

The thesis is divided into eight chapters:

Chapter 1 provides the research background for the research providing the reader with an overview of the theme of the research. The research aims are put forward along with a brief description of the research process.

Chapter 2 reviews the existing background literature surrounding the work content of the Lean Production System. The review is divided in four parts. The first part explains the emergence of Lean Production system and its outcome, the second part
reviews the work methods of working in lean, the third part discusses the consequences of working in Lean Production with respect to Repetitive Strain Injury (RSI) in its context and the fourth part reviews situational strength as a strategic management tool applicable to the work organisation in the lean environment.

Chapter 3 provides a conceptual framework for the research. A management game is simulated using the results from a pilot study questionnaire to characterise jobs in a lean environment. Situational strength is applied as a strategic management tool to identify repetitive work patterns in a lean environment. An initial framework is then developed formulating a conceptual model for which a set of research hypotheses are generated for testing in a lean manufacturing setting.

Chapter 4 positions the research in the context of its philosophical stance and links this to the research approach. The research approach is discussed and identified along with its limitations through comparisons with alternative approaches. The research process is then presented explaining the administration of the research problem to be explored.

Chapter 5 in the form of a case study describes the main study conducted in a Lean Manufacturing company. The main study discusses how the researcher undertook his observations in an action research content. The semi-structured interview process is addressed describing the personnel who were interviewed and the issues faced by the researcher prior to conducting the interviews. The processes involved with the design, administration and presentation of the results from the questionnaire are described. The chapter closes by reporting issues of validity and reliability concerned with the data obtained from the study.

Chapter 6 Presents the fieldwork results obtained from the action research process. Soft Systems Analysis is used as the main analysis method to analyse the findings obtained from the Lean Job Position model in the case studied company.

Chapter 7 focuses on the findings and explains the results from the model and the hypotheses through reflection of the literature.
Chapter 8 concludes the research by reflecting on the research aims and the main research question. The listing the strength and weaknesses of the research approach are discussed with overall contribution to knowledge made with the model as well as providing recommendations for further research.
Chapter 2

Literature Review

The aim of this chapter is to review the existing background literature covering the work content of the Lean Production System. The intention is to provide an understanding of how work is performed in Lean Manufacture and its consequences faced working in a Lean Environment. The review is described in four parts. The first part explains the emergence of the Lean Production system and its outcome, the second part reviewing its work methods and the third part discussing the consequences of working in Lean Production with respect to Repetitive Strain Injury (RSI) and the fourth part discussing Situational Strength as a tool applied in strategic management for workplace and organisational change.

2.1 Introduction

Since the 1970s, various alternatives to Ford style mass production have emerged in the world auto industry. (Fujimoto et al., 1997): observed four distinct alternative models of production:

1. The neo-Fordist system, characterised by the introduction of advanced manufacturing technologies within an organisational context that is still bound to traditional logic;
2. The Uddevalla system (Rehder, 1992) which represents the most decisive break so far with the Fordist tradition, given the fact it has both eliminated the classic symbol of mass production the production line and gone counter to the idea of the one minute job;
3. The neo-craft system, which has been limited to special luxury models and customized products; and
4. The lean system, also called the Toyota production system, which is based on these fundamental principles just-in-time production (JIT) and minimisation of buffers, the jidoka, quality focus, the team concept, standardised work and kaizen.

2.1.1 The Rise of Lean Production

After the Second World War, the Japanese were subject to strict trading regulations and the government focused on rebuilding the economy and attracting Western manufactures to enter their fragile market. While Western mass producers enjoyed
stability, the Japanese internal market was highly segmented and in a constant state of flux. They were therefore forced to re-evaluate their entire approach to production. The rise of lean production was the beginning of the third transformation in manufacturing practice. Taiichi Ohno and Eiji Toyoda the pioneers and driving force of Toyota transformed mass production and since the 1980’s mass production became a thing of the past according to *The Machine that changed the World* (Womack, Roos Jones, 1990)

> "Our conclusion is simple: lean production is a superior way for humans to make things.... It provides more challenging and fulfilling work for employees at every level from the factory to head quarters. It follows that the whole world should adopt lean production, and as quickly as possible"

The term ‘lean production’ was coined by researchers in a research project carried out by the Massachusetts Institute of Technology (MIT) called the International Motor Vehicle Program (IMVP). This was a five year collaborative program (1985-1990) involving 52 vehicle assembly plants in 14 different countries around the world contributing to a $5million cost funded by major automakers and governments of Japan, the United States and Europe (Babson, 1993) into the performance of the global motor industry (Womack *et al.*, 1990). Lean production as described by the IMVP researchers (Womack *et al.*, 1990) pointed out:

> Lean production is lean because it uses less of everything compared with mass production half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products.

The Machine that Changed the World (Womack *et al*, 1990) written by Dan Jones was one of the most influential books (Berggren, 1992) to have been published. The reporting of MIT’s International Motor Vehicle Program, (IMVP) research results promoted the Japanese Model of “Lean Production” (Babson, 1993; Williams *et al*, 1992; Womack, Jones & Roos, 1990; Adler, 1993; Berggren, 1993). Other writers have described synonyms for “lean production”, for example, “world class manufacturing” (Schonberger, 1986) ‘Just in time (JIT) (Voss and Clutterbuck, 1989),
'Toyota production system' (Monden, 1983) 'Toyatism' (Doshe et al., 1985) or Ohnism (Coriat, 1991), Management techniques (Monden, 1983; Schonberger, 1982; Suzaki, 1987; Womack, Jones & Roos, 1990) "repetitive operations" (Adler, 1993), team work, (Kenney & Florida, 1988) workers' problem-solving and multiskilling (Koike, 1988), motivational characteristics of job design (Womack Jones & Roos, 1990) "work intensification" (Kamata, 1982, Rinehart et al, 1994), management by stress (Parker and Slaughter, 1988), "ultra-Taylorism" (Dohse, Jurgens & Malsch, 1985), "thinly stretched workforce in perpetual motion" (Fucini & Fucini, 1990), and "simply understaffed" (Berggren, Bjorkman and Hollander, 1991).

The results of the IMVP study showed a difference of 2:1 in productivity between car assembly plants in Japan and those in the West, (Boston Consulting Group, 1993; IBM Consulting, 1993; Andersen Consulting, 1993). The differences in performance resulted in reduced lead times, reduced material and staff costs, and increased quality. Since then, this has become a topic of great interest and subject of a long-standing debate for at least ten years (Berggren, 1992).

The MIT study predicted 'lean production' to succeed both mass and craft production, "Lean production combines the best features of both craft production and mass production. Lean production offers a creative tension in which workers have many ways to address challenges involved in solving complex problems something that has separated manual factory work from professional 'think' work in the age of mass production, (Daniel et al., 1990).

*The principles of lean production can be applied equally in every industry across the globe and that the conversion to lean production will have a profound effect on human society—it will truly change the world (Womack et al., 1990, p.7).*

(Williams et al., 1992), extract from (Womack et al., 1990) define lean production by its technical characteristics. Lean production contrasts other production models by its absence of indirect workers, buffer stocks and the rework characteristics of mass production and by the presence of re-skilled, multi-tasked workers using flexible equipment for small lot, just in time production with rapid change over. In short the essentials of lean production are JIT (Just in time), standardized work, continuous cost
reduction (via the elimination of waste and time) (Rinehart et al., 1997) and a flexible workforce prepared to adapt to changes in demands of production (Monden, 1983).

Lean production is defined as a flexible system by many authors both in terms of ability to change the quantity easily and produce different product variations however, research on human related and social work relation issues by (Streeck, 1992; Culpepper, 1999; Sandberg, 1995) questioned how the principles of lean manufacturing would impact upon already established production models, such as those existing in Germany and Sweden. Following this a number of case studies have examined, social and human related issues of lean manufacturing in depth. The Canadian Auto Manufacturing report (Rinehart, Huxley & Robertson, 1993), on organisation of work and social relations of production, New United Motors Manufacturing, Inc NUMMI (Adler, 1993), on the roles of the organisation of production, and Contemporary Manufacturing (Delbridge, 1998), on workplace practices, all of which have presented well-illustrated accounts of lean production.

2.1.2. The Lean Production Model

Lean production is the most widely used of competing organizing concepts for post-modern times (Williams et al., 1992). (Delbridge et al., 1993) divide the core principles of lean production into:

- Team based work organisation; involving flexible, multi-skilled operators taking a high degree of responsibility for work within their areas
- Problem solving structures, central to kaizen or continuous improvement activities;
- Lean manufacturing operations, which force problems to be surfaced and corrected, manifested by low inventories; the management of quality by prevention rather than detection and subsequent correction; small numbers of direct workers, and small-batch, just in time production.
- High commitment human resources policies which encourage a sense of shared destiny within a factory;
- Close shared destiny relations with suppliers, typically in the context of much smaller supply bases;
- Cross functional development teams; and,
- Retailing and distribution channels that provide close links to the customer and permit a make to order strategy to operate.

Sanchez et al. (2001), show their basic structure of lean production principles most commonly found in the literature, shown in Fig 2.1.2.

The most common Lean Production Principles from (Sanchez et al., 2001) Fig 2.1.2

Some of these principles have already been proposed by others, (Womack et al., 1990; Womack and Jones, 1996), where they define the lean production model as a process consisting of three key principles:

1. Improving flow of material and information across business functions;
2. an emphasis on customer pull rather than organisation push (enabled on the shopfloor with Kanban) and;
3. A commitment to continuous improvement enabled by people development.

The interest with the lean production model is mostly based on empirical evidence that it improves the company’s competitiveness (Billesbach, 1994; Oliver et al., 1996; Lowe et al., 1997). The aim of introducing lean production is to increase productivity, reduce lead times and costs, improve quality etc. (Sriparavastu and Gupta, 1997). However the definition of lean production is actually rather vague and confused
(Bartezzaghi, 1999) Karlsson and Ahlström (1996), have developed operationalised models based on the conceptual framework of Womack et al. (1990) and on case studies on manufacturing companies and others have studied the diffusion of lean production strategies within manufacturing companies (Avella et al., 1999). Lewis, (2000), argues, that the attempts by some researcher to empirically, assess lean production have not been consistent (Karlsson & Ahlström 1996; Anderson Consulting Lean Enterprise, 1993) and suggests lean production is not easily implemented and is especially problematic for managers (Oliver and Hunter, 1998). Other factors such as the firm history, the link between lean outcomes, its tools and techniques, must be considered (Lewis 2000).

2.1.3 Outcomes of Lean production
One of the main goals of lean production is the elimination of everything that does not add value to the product or service (Womack and Jones, 1996). Influenced by studies conducted by (Oliver et al., 1993; Womack et al, 1990; Adler and Cole, 1993; Prabhu and Hanson and Voss 1992 (Made in Britain study)), a survey of Australian manufacturing companies was undertaken by Sohal and Egglestone, (1994), to investigate the extent, to which “lean production,” has been implemented in Australian industry. Their findings suggest, many companies mentioned a variety of changes that took place within their organizations. These included consolidation of product lines and areas of authority; downsizing of the workforce; more focused organization structure; multiskilling of workforce; broadening of the core-manufacturing group; broadening of job boundaries; consolidation of departments; and commitment to self-actioning teams and greater autonomy.

The benefits from implementing lean production showed increased flexibility; lowering of cycle times; greater sensitivity to market changes; higher productivity levels; stronger focus on performance; improved supplier bonds; changes from reactive to proactive organization, (Sohal & Egglestone, 1994). In terms of the workers role improved training, shopfloor focus on TQM, improved employee morale; making the workforce and manufacturing processes more flexible; reducing set-up and cycle times.
Lewis, (2000), illustrates the lean production system in terms of its outcome and process, as shown in Fig 2.1.3

More markets are changing rapidly and evolutionary organisational theories suggest that if a firm cannot produce and retain enough diverse information, potential future choices will be severely restricted (Tamuz and Sitkin, 1989). Such information tends to be created through complex internal and external interactions that inevitably comprise complexity and failure forms of muda that lean production seeks to eliminate (Emiliani, 1998). Companies must adopt lean manufacturing as a working philosophy within their organizations even if it is in a modified format that best suits their particular business culture (Sohal & Egglestone, 1994).
2.1.4 Work roles in lean production

Workers roles, responsibilities, and organisation have been a consistent theme of study for industrial sociologists and management theorists (Rose, 1975). Much of the literatures since the time of F.W.Taylor have debated the aspects of the worker and organisational performance which have made increasing worker flexibility and increased involvement through team working central to the discussions of 'high performance' (Ichniowski et al., 1994; Macduffie, 1995; Osterman, 1994).

Macduffie (1995) proposes three primary roles for workers in lean production: physical labour -"doing work"-cognitive input,-"thinking work,"-member of the social entity, and "team work." He expresses the worker role of 'doing work' to be 'high labour intensive' difficult and demanding physical labour for the worker, as a cause of rigid standardization of human time and motion study consisting of cycle times, standardized work sequence and standard work in process, (Rinehart et al., 1997). The 'cognitive' role, the involvement of workers in "thinking" as well as "doing" is its goal of developing a broader contextual knowledge in the workforce about the production system in such a way that the workers knowledge is used and linked to understanding how the overall system works. Macduffie (1995) relates this 'cognitive' process to Taylorism where Taylor wanting such knowledge of the worker without having to deal with the worker was a process of 'delegitimising' the workers role in which he states "Any improvement which [the workman] makes upon the orders given to him is fatal to success." Although workers are encouraged or even expected to contribute ideas to improve their jobs, Macduffie (1995) observations tell us that they often adopt this 'cognitive process as a method for management to improve training policies and the work organisation as a whole. Wickens study at (Nissan plant manager, Sunderland) shares the same view that lean production is suffused with Taylorism and the logic of the assembly line, but other aspects of the system, teamwork, enlarged responsibilities of production workers and worker involvement in Kaizen, “allows us to move away from the alienated worker and create fulfilling meaningful jobs.”, (Wickens, 1993).

The 'social role' of the worker in “team work” is seen as extremely important for lean production. Macduffie (1995) explains goals and incentives are formulated and work is organised to support the central influence of social interaction on the production operations. Therefore making the term ‘team’ difficult to define, however his
interpretation of the definition ‘team’ tell us that it embodies a goal of a cooperative relationship among work teams, among departments among functional specialties and among organisational levels, while (Mueller, 1994) notes, the current emphasis for team working is productivity which contrasts with previous experiments which were often orientated around the ‘humanization of work’ and ‘job enrichment’. The most important social relationship of the worker is with loyalty to the company. Employees identify themselves rather than their team or department. Informal social networks are created which provides a rationale and motivation for setting aside normal inter-group differences, while at the same time pulling workers interests (identification with company goals around performance, competitiveness, and survival) away from identifying workers at other companies in the industry. Macduffie (1995) makes it clear while traditional mass production managers tend not to think about the work force as a social entity, the ‘social role’ of the worker is an “explicit effort to organise the informal social network in the production system to align employee’s interests as closely as possible with company goals.”

\[\text{2.1.5 Summary}\]

\textit{Part 1 has given a brief history of the lean manufacturing concept with its outcome and consequences studied. Section 2 turns the attention to the work content, providing a critical review of work methods commonly found in lean manufacturing. Other forms of work organisation are also reviewed outlining how certain aspects of these work organisations compare and contrast from lean production.}
2.2 Work Content in Lean Manufacturing

2.2.1 Standardisation

Lean manufacturing has often been criticised for its work practices namely in its standardisation, repetitive nature of the tasks and work intensification. Standardisation is a fundamental principle of lean manufacturing. "Standardised work has the major benefit of giving control of the job to the person who knows it best – it empowers our workers (Adler, 1993). Emphasis of standardised work is equally illustrated in the CAMI training manual taken from (Rinehart et al., 1993), "The standardisation operation shows the best methods of performing every operation in a process...improved efficiency begins with standardised operations", "everyone performs the same operation the same way." (MacDuffie, 1988) views standardisation as an important characteristic of lean production but says that it is exceeded by its job rotation and multiple responsibilities of production workers, "jobs are more complicated to perform well", while job rotation provides "an opportunity for skill development." (MacDuffie & Krafcik, 1989), propose multiple tasks undertaken by work teams associated with job rotation yield "vertically integrated jobs that require skill development," although observations from (Babson, 1993, Fucini and Fucini, 1990) at Mazda and (Graham, 1995), study of Subaru-Isuzu, indicate that work content was not much different from that in traditional mass production plants, where most of the jobs are found to be fragmented, standardised short-cycled and repetitive whilst at NUMMI (Adler, 1995), describes, standardised work to be an "intelligent interpretation and application of Taylor's time and motion studies."

Authors of lean production recognise that jobs are standardised and short cycled, they claim skills of the worker are developed through job rotation and their ability to continuously improve their jobs and workstations.

*Standardised work is simply the process that workers used to reduce variability in task performance. The basic idea is that reduced variability and team assessments of the jobs result in a whole series of interconnected improvements. We get improved quality because workers identify the most effective procedures for the job. When you have good procedures any problems with equipment very quickly come to the surface. And since every worker becomes a real expert that means that each workstation becomes an inspection station.* (Adler, 1993)
On this basis many proponents of lean production maintain that lean production workers are multiskilled. The emphasis on multiskilling as an effect of lean production as compared to the Fordist era is a position shared by (Best, 1990; Bouchut, 1988; Coriat, 1991) in that they emphasise the multifunctional worker as a precondition for flexibility. "Cross-trained workers, we are told, make lean production an especially flexible system," (Babson, 1993), Kenney & Florida, (1993), suggest it "enhances the process of knowledge acquisition," which permit workers to "familiarise themselves with various aspects of the work process... that can be applied to a variety of work situations." (Womack, Roos, and Jones, 1990) claim that lean production provide challenging jobs performed by multiskilled workers. It is also argued that by varying the work movements of each team member, "there are fewer injuries from strains and greater safety since workers get an opportunity to examine all the possible sources of strain and danger and that rotation adds equity to the operations" (Adler, 1993). However given the intensification of productivity and repetitive content of many jobs, high evidence of work related injuries are reported (Rinehart et al., 1997) in their study at CAMI.

Advocates and critics of lean production both agree that the work pace is fast and workloads are heavy. Berggren, (1992) compared the issue of job security and the egalitarian profile of working conditions in Japanese transplants in North America to those of the traditional American auto plants. His observations describe lean production as 'mean production' where he lists:

- **Unlimited performance demands:** In Japanese transplants, union regulation of performance demands or limitations on management discretion to organise work are not recognized.

- **Unlimited working hours:** Lean production is not free of buffers, amount of overtime work are ordered at short notice. Far-reaching discretion of management to determine working hours means that production quotas in principle are reached irrespective of the events happening during the day or shift; this forces the pace of improvements in production.

- **Growing health and safety complaints:** Emphasis on safety and the avoidance of accidents are central in Japanese factories however the sheer
repetitiveness of the jobs which are designed according to Tayloristic principles combined with the intense pace and long working hours lead to significant health risks above all cumulative trauma disorder (CTD) or repetitive strain injury (RSI) which are not recognized as an occupational injury in Japan.

Worker resentment against new management methods in the 1990's was reflected in the union politics at Mazda. Strong union support from its members, new conditions were implemented which included changes in plant layout, work organisation and most importantly, major improvements of the union's position regarding health and safety, for example employing a safety and full-time health representative, the implementation of written health and a safety grievance procedure, and union access to information such as symptoms and surveys, (Berggren, 1992). However paralleled with Mazda union's demands, the workers at CAMI made a difference by demanding safer jobs, longer rest breaks, setting limits on grieving workloads, and the right to refuse any in company programs.

In summary this highlights the influence of the unions which can defend and promote the independent interests of the workers and modify some of the more onerous terms and conditions of lean production (Rinehart, 1995), given flexibility and discretion by agreement of management and unions.

2.2.2 Work intensification

Drawing on primary and secondary sources some authors agree that work practices in lean manufacturing intensifies work. Graham (1995) found at the Subaru-Isuzu (SIA) plant that workers "experienced constant pressure from the assembly line" [and were] forced to work at a continuous rapid pace." The MIT study reports lean production requires "half the human effort in the factory" compared to traditional mass production. (Babson, 1993) survey at Mazda, reported that three quarters of the workers had difficulty keeping up and 73 percent of the workers were likely to be injured or worn out before retirement. This suggests that work intensification is evident as (Rinehart et al., 1997) observations explain. Intensification of work is operated through a number of mechanisms at CAMI. Firstly ensuring workloads approach maximum efficiency by maintaining minimal labour hours per vehicle, secondly area leaders to monitor jobs visually for signs of "muda" or idle time and
thirdly through the Kaizen process to eliminate non-value added labour i.e. working smarter rather than harder. ‘Tweaking the system’, includes increasing the line speed and rebalancing workloads and individual work content through kaizen to keep the “high work content.” His findings tell us that this mechanism does not ease the workload of the operator; the operator’s idle time is filled with other tasks. According to Coriat (1991) and Doshe et al., 1985), this means diminishing opportunities to slacken the pace to take a break, but (Kochan et al., 1989) suggest that from a worker’s point of view, such problems can be outweighed by the system’s relaxed supervision, high trust relations, multiple job tasks and problem-solving opportunities. While this may be true (Delbridge et al., 1992), suggests that the success of JIT/TQM manufacturing system in terms of intensifying the labour process, is a result of increased surveillance and monitoring of workers activities whereby “managerial prerogative prevails and where there is little room for employees to exercise counter controls over the pace of the work and task execution”, “workers are in fact subject to highly visible forms of managerial power, control, and process of constant surveillance and monitoring of output and performance”, (Delbridge and Turnbull, 1992; Delbridge, 1995; Garrahan and Stewart, 1992; Sewell and Wilkinson, 1992). JIT and TQM based manufacturing and production methods created new ways of more closely controlling labour, “because intensification is closely related to the loss of autonomy since the latter reduces the discretion on part of the workers regarding pace, pauses, what to do and when”, (Skorstad, 1994), but as (Delbridge and Turnbull, 1992) put it, “by organizing workers into teams and making these teams accountable for their own performance, management operating a JIT system are able to impose a ‘customer ethos’ on a workforce and harness the peer pressure of fellow team members to ensure compliance with company objectives.”

2.2.3 Job Rotation
Workers learn more systematic procedures and rotate through duties that not only add value but also add non-value, in contrast to most traditional plants, however some authors maintain job rotation is undifferentiated, and that is there is no room for exercising management discretion, Babson, (1993) survey at Mazda indicates, nearly half of Mazda workers perceived job rotation or training less than adequate or universal, on the other hand job rotation at CAMI as (Rinehart et al, 1997) reports, the consequences of increased job rotation, “was management’s concern for flexibility to
include as many members in the team as possible, secondly rotation responding to a
growing incidence of RSI and thirdly the workforce uses it as an attempt to regulate
work and restrict managerial flexibility". (Skorstad, 1994), points out that there is
almost some means of worker intensification when worker resistance is involved, in
that they [workers] do not oppose attempts at increasing the output, of the worker but
the conditions for such expected increases in work rate “as to how, when and at what
pace work is performed is governed by its standardised procedures and short fully
packed timed cycles” (Rinehart et al., 1997). Wellins et al. (1991), on the other hand
argue that job rotation and multiskilling becomes a normal role for part of the team.
Team members rotate roles to achieve work variety, identify training needs and skills
to multi skill themselves.

2.2.4 Concept of teams in Lean Production

The concept of ‘teams’ has been widely debated in Europe, although much of this has
considered the nature and the extent of the “post-Taylorist” transformation rather than
organisational performance (Delbridge et al., 1992; Garrahan and Stewart, 1992;
Sandberg, 1995). Nearly all lean manufacturing industries promote a variant of the
team concept, “perhaps the most important concept in the management of production
activities in Japanese corporations,” (Shimada and Macduffie 1987). Team concept is
applied both to the shopfloor work groups and to the overall organisation entailing
“togetherness’ in the sense of working together, helping each other and sharing
information (Shimada & Macduffie 1987), “as the heart of the lean factory”, through
the active involvement of workers in problem solving (Womack, Jones and Roos,
1990). These authors regard the team concept and work teams in general as beneficial
to workers, providing them with challenging opportunities for participation and skill
development. Kenney and Florida (1993), refer to the team concept as “self-managing
teams” similarly (Cohen et al., 1996), as ‘self-managing work teams’. Delbridge et al.
(2000), draws upon the work of (Cutcher-Gershenfeld et al., 1994), and (Mueller,
1994) for defining teams in lean production or ‘lean teams’. Their criteria used to
categorise teams as ‘lean’ are:

- The presence of a formally recognised, hierarchically distinct team leader who
  is part of the team and whose duties include some element of direct work;
- A clearly defined and relatively fixed membership;
• A span of control for team leaders that does not typically exceed twenty workers

• The teams constituted around specific, on line production activities within clearly recognisable areas of the plant.

Their findings suggest that lean teams show evidence of task diversity, and some operator responsibility but the technical skills required to deal with technology problems lies primarily with specialist functions outside the teams for example in maintenance and engineering. Decision-making is assumed to lie either with the team leader or with the team as a whole. Parker & Slaughter, (1995), critique of team concepts suggest it forms part of: a philosophy of cooperation, interchangeability of workers, reduction of job classification, de-emphasis of seniority as the basis for job bidding, transfers, standardised jobs, workers participation in increasing their workloads, more worker responsibility for production problems without more authority, an ideology that stresses cooperation between plants and personnel and a shift toward enterprise unionism in which unionism views itself as a partner of management. They argue, “team concept tries to break down the solidarity and team work of natural work groups that develop on the shopfloor in formal, highly controlled, company-designed team structures” (Parker and Slaughter, 1988). (MacDuffie & Krafcik, 1989), argue it reinforces a sense of common purpose, but (Rehder, 1990), admits, “Informal work group of traditional organisations has now been largely brought under management’s control in the transplants team system.” (Adler, 1993), maintains workers who feel peer pressured is an appropriate way to handle those who are not performing, transplant managers interviewed by Kenney and Florida (1993) say it “keeps most workers in line” others (Rinehart et al., 1997), argue peer pressure in teams benefit the company more than the worker. The workers view of the team concept at CAMI had not been very successful. For workers, the team concept meant not equality of all employees, neither partnership with management (Rinehart et al., 1997), but finding ‘social aspects’ of the team accounted for positive reactions within the concept of teams.
2.2.5 Lean Production Teams

Lean production focuses on removing 'waste' or non-added value activities from the production process, (Monden, 1994). This emphasis is maintained by eliminating buffers between work stages as well as on process simplification and standardisation. The teams are typified by standard operating procedures. Thus the work of lean production teams was found with little employee involvement in management or support activities (Banker et al., 1996; Delbridge, Lowe & Oliver, 2000) also low degree of involvement and a low scope of involvement relative to self-managing teams or flexible work groups (Parker & Williams, 2001). Many researchers have highlighted the negative effects of lean production teams, sometime referred to as 'mean' production teams on employees. Landsbergis et al., (1998) reviewed case studies and surveys found little evidence that workers were 'empowered' under lean production systems. His findings of lean production teams suggests it intensifies work demands and work pace, with increases in decision-making authority and skill levels being very modest. There is some evidence also to suggest that lean production appears to lead to increased rates of musculoskeletal disorders.

2.2.6 Types of Team Working

Appelbaum & Batt (1994) point out that researchers often fail to distinguish between different forms of team working which is partly why research findings about research in team working are often inconsistent. Cannon-Bowers, Osler & Flanagan (1992) list a total of twenty different types of teams including problem solving teams, quality circles, semi-autonomous teams, multi-disciplinary teams and product development groups.

- **Degree of autonomy and involvement in decision making**

  This is considered to be one of the most important dimensions that distinguish different types of teams. Banker et al., (1996), developed a Team Autonomy Continuum, where at one end of the scale is the traditional work group in which the supervisor manages the team in a traditional way by controlling and directing the day to day activities of the team. At the other end is the self managing team in which the team members are responsible for the day to day running of the team.
• **Degree of Multiskilling or Specialisation**
  Cordery (1996) referred to degree of multiskilling or specialisation as the degree of *intra-group task specialisation* in which he describes:
  - Vertical multiskilling refers to team members learning elements of the supervisory role
  - Horizontal multiskilling refers to learning tasks from traditionally separate occupational or job families such as carrying out laboratory tasks
  - Depth multiskilling refers to developing skills within the same occupational or skill group but which usually have a different job title e.g. as a mechanical trade person.

  The Cordery (1996), findings suggest that self managing teams tend to be characterised by medium to high degrees of vertical multiskilling and horizontal multiskilling but low depths of multiskilling.

• **Degree of Standardisation of procedures within teams**
  Teams differ in the extent to which their core tasks are standardised especially in lean production. Recent years have seen the emergence of ‘lean production teams’, which its emphasis has been on the development and adherence to standard operating procedures.

  Parker & Williams, (2001), findings of effective team working found important variations in different types of teams, their most important distinction showed degree and scope of team involvement in decision making to be important. Furthermore they emphasise nature and structure of team leadership, presence or absence of standard operating procedures, also an important factor within effective team working.

2.2.7 Effects of Team Working Change on Individuals
2.2.7.1 Self Managed Teams
Self-managed teams (SMT) are characterised by having a degree of autonomy and involvement. The main characteristics of these teams are that they have responsibility for the performance of the team (e.g. Manz & Simms, 1993; Cohen & Ledford, 1994) and the autonomy to make decisions regarding issues such as the methods of working,
assigning members to tasks, solving production and interpersonal problems and conducting meetings, (Cummings, 1978; Wellins, Byham & Wilson, 1991). The review of the literature has described various types of self-managing teams. For example, autonomous work groups, (Cummings, 1978; Clement, 1996), semi-autonomous work groups, high performance work teams (Banker et al., 1996), self-regulating teams (Pearce & Ravlin, 1987), self-directed teams (Murakami, 1997) and self-designed teams (Banker et al., 1996). Although these types of self-managing teams mentioned above are characterised by a high degree of autonomy, they tend to vary in terms of the scope of involvement that they provide. For example, autonomy is given over the organisation of the day-to-day work, whereas self-directing teams tend to have autonomy over employee relations and self-directing teams involvement in manager-employee relations. Many studies report evidence of benefits of self-managed teams (SMT), (Cohen & Ledford, 1994; Elumuti & Kathawala, 1999; Banker et al., 1966: Kenney & Florida 1993). Increased quality (Hansen & Rasmussen, 1995), increased levels of innovation (Walton, 1977), and reduced accident rates, Goodman, (1979); Walton, (1977).

The review by Goodman et al. (1988) concludes that autonomous work teams have only minor impact on productivity and with no clear trends with regard to absenteeism and turnover. In addition more rigorous studies of the implementation of self-managing teams have showed mixed views with some studies not finding strong performance effects (Wall et al., 1986), whereas others hopeful results (Batt, 1999).

2.2.8 Work Organisation:
A Comparative Review of Lean Production against Reflective Production
(NUMMI Vs Uddevalla)
Teamwork is one main characteristic of lean production. Womack et al. (1990), and Adler and Cole, (1993), refer to teams or work groups as important features of lean production. In other production approaches the use of teams are made also. It is the core element of the Sociotechnical approach (Schuring, 1996), 'Reflective Production', referred by (Engstrom et al., 1992).
An example of where reflective production has been implemented was at Volvo's plant in Uddevalla, Sweden. Explained by (Engstrom et al., 1992), "the principle behind reflective production is based upon highly parallelised material flows that enable autonomous work teams to assemble objects independently.", they add "this
means longer work cycles, requiring extended competence, on the other hand” they say “work teams are given responsibilities so that they can meet demands on, for example, quantity and quality.” They argue that ‘reflective production is as efficient as lean production and in addition they see it more “socially efficient.”

Comparing Toyota-General Motors joint venture, (NUMMI), lean production model and Volvo’s on “human centered” model based upon ‘reflective production’, Adler and Cole, (1993), argue NUMMI has the more effective model for encouraging organisational learning. Adler and Cole (1993), suggest its main factor is in its effort to make constant improvements in the details of the production process. NUMMI invested time and effort into training workers in principles and techniques of lean production. Problems are solved through a combination of worker flexibility and efforts to reduce its set-up times through standardisation of work methods are achieved. “The intense discipline created by NUMMI’s job design creates not only world class performance but also a highly motivated work environment” (Adler & Cole, 1993). In addition their detailed study of both plants describe NUMMI’s combination of technical-economic and quality of work life makes lean production the most suitable method for relatively repetitive, labour intensive activities, such as in auto assembly. However they admit working conditions at Volvo probably has a human advantage although they maintain, “NUMMI’s quality of work life, although not ideal is in the ‘acceptable’ range as far as the workers are concerned.

Work organisation within lean production has been about ways in which it has been applied not only within a Japanese context, but also in the West, (Elger and Smith, 1994; Abo, 1994; Oliver and Wilkinson, 1992; Volpato, 1996). Prabhu (1992) suggests that lean production strategies do not necessarily apply to Japanese companies or mass production firms or are restricted to larger companies only.

A study conducted by Hanson (1995), Voss (1995), in the UK and IBM Consulting group, quantified how well Britain’s manufacturing compared itself to world-class standards in adopting lean practices and performance. Their findings showed a direct relationship between adopting lean production techniques and improvements in performance, which compared to world-class standards presented little differences in performance nevertheless they emphasise “manufacturing companies succeed because
they adopt relevant practices in each of their business and implement them to ensure their performance improves.”

2.2.8.1 Distinctions between Lean production and Reflective Production
Lean production and Reflective production as assessed by many authors contrast their writings in different aspects of the work organisation; still maintaining the worker plays a central role. Lean production explicitly shares this approach and acknowledges the importance of the human being in the labour process (Hogg, 1993; Cheng & Podolsky, 1993). (Adler & Cole, 1993) and (Berggren, 1994), discuss the differences between the design of lean and reflective production. (Benders and de Leede, 1995), emphasise the lean production concept to be based on the use of standard operating procedures which have a clear hierarchy with close supervision, while the work groups based on Sociotechnical design have a certain degree of autonomy in their work methods. The Japanese approach “de-emphasises team autonomy”, where managers are responsible for its surveillance and administration. Comparisons made to Scandinavian teams are “likely to have more independence to control its work methods and pace”, and have “more administrative responsibilities than a Japanese team” (MacDuffie and Krafcik 1989). NUMMI’s operations contrast differently to that of Volvo. A key feature of the human centered approach is the level of autonomy the workers have in teams compared to those at NUMMI. Adler’s (1995) observation tell us the level of autonomy in teams at Udevella, for example (how workers perform their work, how they schedule their work time with buffers of in process inventory provided upstream and downstream) contrasts differently with operations at NUMMI where its emphasis on standardised methods meant workers were provided with no autonomy in their work tasks, the kanban principle, reduces buffers upstream and downstream provides no discretion in how teams scheduled their work and the concept of teams offering members only a narrow range of managerial responsibilities.
Table 2.2.8.1 A Comparative overview of Work Organisation between Lean Production and Reflective Production in the key areas of production.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Lean Production</th>
<th>Reflective Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>Assembly lines of mass production involves comprehensive adjustment work, Increased market demands for variants</td>
<td>Bad ergonomics injuries and manpower shortage, Disconnected assembly line or docks</td>
</tr>
<tr>
<td>Goals</td>
<td>Economic and productivity</td>
<td>Social preconditions</td>
</tr>
<tr>
<td>Approach</td>
<td>Human knowledge as asset</td>
<td>Naturally grouped assembly work based upon the product and the human being supported by assembly related language</td>
</tr>
<tr>
<td>Work Methods</td>
<td>Rigid Standardisation, relation to markets where production is the focus</td>
<td>Parallel flow production systems, Functional learning</td>
</tr>
<tr>
<td>Work Cycle</td>
<td>Short: 1-2 minutes</td>
<td>Long: 8 minutes to 2 hours</td>
</tr>
<tr>
<td>Scope of Autonomy</td>
<td>Limited part assembly line</td>
<td>Job enlargement and enrichment, Team autonomy</td>
</tr>
<tr>
<td>Multifunctionality</td>
<td>Job Enlargement</td>
<td>Relative employee autonomy</td>
</tr>
<tr>
<td>Leadership</td>
<td>Strong team leader</td>
<td>Complete part of assembly process</td>
</tr>
<tr>
<td>Reward System</td>
<td>Base and variable pay based performance</td>
<td>Base pay based on competencies</td>
</tr>
<tr>
<td>Implications</td>
<td>Attention focus on the value of complete solutions, High total production volumes is required, Bad ergonomics, injuries and manpower shortages</td>
<td>Pre determined relation between factory floor production and design is demanded, Model changes and large design changes are introduced easily</td>
</tr>
</tbody>
</table>

Taken from (Engstrom et al., 1992) and (Hummels & Leede, 2000).

The method of exercising control between both of these concepts is closely related to the aspects shown in table 2.4.1. Niepce & Molleman, (1996), explain lean production and reflective production depart from traditional Tayloristic work methods. Lean production aims to minimise buffers which characterise flow production not only by eliminating efficiencies but also by providing essential information for increasing productivity and efficiency. Reflective production aims to decouple the production process into parallel units, giving maximum autonomy to the worker. According to Sociotechnical theory, work should balance the psychosocial needs of the worker and the organisation for efficiency while in lean production, both is “secured through a set of standard operating procedures (SOP’s)” (Schuring, 1996).
2.2.8.2 Comparison of Work Design Issues in Lean Production and Reflective Production

Niepece & Molleman (1996), which contrast the role of the worker both in lean production and reflective production by considering four work design issues:

1. **Minimal critical specification**, refers to the distribution of responsibilities and the co-ordination mechanism used;
2. **Multifunctionality**, refers to the division of labour into small or whole tasks;
3. **Human values**, the understanding of how workers are motivated
4. **The extent of boundaries** of which refers to the extent teams are autonomous.

2.2.8.2.1 Minimal critical specification:

As a rule, task performance in Reflective production is defined as little as possible thus leaving adequate scope for the employees to perform tasks according to their own knowledge. Using (Mintzberg's, 1979) analogy of co-ordination mechanisms, standardisation of skill becomes an important co-ordination mechanism in this case. The worker has autonomy over their movements and control over their working pace. The co-ordination mechanism in lean production is managed by the standardisation of work processes. This causes workers to be dependent on work flow time sequences with the team having no such influence, eventually leading to a "machine like" situation in which everyone works at the same pace (Hutchins, 1990). The fact of creating an unbuffered flow produces a situation where workers are physically limited in movement and seeking to reduce process variability. This does not imply that team members have no influence at all, it is felt participation is limited only to certain areas of decision making, for example work procedures and quality. According to Klein (1989), the involvement of the worker in workplace reform in lean production is typically restricted to suggestions for improvement in continuous improvement activities such as Kaizen.

Distribution of control is connected closely to leadership style of the team leader. It is assumed teams in lean production are not autonomous from management but are designed around the supervisor. "The aim is to enlarge the problem-solving capacities of its workforce by making every worker think like an industrial engineer", (MacDuffie & Krafcik, 1992; Wood, 1989), clearly giving the worker some degree of influence. The Sociotechnical systems design suggests, "The role of the supervisor or leader is seen as a substitute for leadership, more as a facilitator and coach"
(Dumaine, 1990; Peters, 1987) which suits a more integrated model, where there is a shift of control from leaders to members without expansion of the total amount of control (Molleman & Van Knippenberg, 1995).

The above description ends by pointing out a clear distinction between co-ordination mechanisms used in lean production and sociotechnical systems. The distinction shows that lean production aims to resolve its shopfloor issues by favouring an improvement process through the standardisation of its work processes and direct supervision, while sociotechnical systems is designed to resolve its shop floor issues through mutual adjustment and flexible control which involves expanding problem-solving capacities of the worker.

### 2.2.8.2 Multifunctionality

Delbridge, Turnbull, and Wilkinson (1992) evaluation of multifunctionality accurately use the term multiskilling rather than multifunctionality. Applied in a similar manner-by (Karlsson & Ahlstrom, 1996), as multifunctionality in teams their definition relate it to a group of employees who perform many different tasks along a cell based part of a production flow in lean production. The aim is to increase flexibility and reduce vulnerability of the production system but as a consequence they find the number of job classifications decreases and the number of tasks in the group increases. “Achieving this multifunctionality however requires effort in staff training”, (Karlsson & Ahlstrom, 1996). Forza, (1996), study of lean manufacturing companies found multifunctional teams were applied more in problem solving and workers performed a higher variety of tasks and the proportion of implemented suggestions were higher than in non lean production companies. This increase in the number of tasks per worker led to a greater training effort by the companies. (Boyer, 1996), study of 200 American manufacturing companies found that lean production companies invested more in training and facilities to make teams work properly. Other studies found a positive relationship between training in multifunctional teams and lean production (Hancock et al., 1998; Hampson, 1999).

From a Sociotechnical systems perspective it argues that, a multifunctional worker is able to carry out tasks that are assigned to the group by emphasising the importance of integrating sequential and related tasks in the job of individual team members. This increases cycle times however; by observing and correcting deviations earlier in the
process how each task is influenced by each other the worker is able to improve the overall performance of the processing steps.

2.2.8.2.3 Human Values

Human values draws attention to the satisfaction needs of employees and the level of quality of working life (QWL), which involve work content, labour relations, conditions of employment and the working environment. Sociotechnical systems theory focuses on work content and job redesign. "Lean production does not emphasise a fundamental redesign of jobs to make them more appealing" (Hoerr, 1986), instead (Lincoln & Kalleberg, 1985), refer to "values and norms towards QWL seem to differ from those that are supported in the West; assumptions concerning work and human values are not necessarily the same for Japan and the West." In Japan the need for social relations to satisfy the needs of its workers is important in lean production and loyalty of the company (MacDuffie, 1995) rather than in the West where personal growth and the requirement for autonomy is greater. This suggests that motivation is seen to be externally orientated in lean production while reflective production is internally orientated with emphasis on its work content.

2.2.8.2.4 Boundaries

The principles of boundaries suggest workers who perform tasks that are closely related to each other should be located in the same team. Boundaries result from grouping activities. In Sociotechnical systems (reflective production), groups or teams boundary provides workers with a sense of identity. In lean production, the boundary structure is defined by its manufactured product and its production process is defined according to the particular sequence in which its activities have to be carried out. In this situation an open boundary is evident especially when job rotation between works units are practiced who have contacts with other groups, boundaries between groups and "autonomy of teams are strongly emphasised", (Herbst, 1962). In context of the Sociotechnical systems the most significant boundary is the group while in lean production its boundary is characterized by the factory.

The belief that ownership of the production process belongs to the worker is strong in reflective production, in lean production it interests lies with control and procedures
whilst reflective favours decentralizing control and mutual adjustment, lean supports standardisation of processes.

The comparisons made in the literature suggests both systems diverge from traditional Tayloristic work methods although some elements of it still remain, as Adler (1995), in his study of the Toyota production system at NUMMI, describes "the central role of the workers in standardised work process encourages management to share power with workers; traditional Taylorism was "often a means for asserting management's power over the shopfloor". The Swedish counterparts whose industrial culture is strongly orientated towards the "humanisation" of work posts, (Muffatto, 1999). (Engstrom et al., 1992) conclusion of reflective production bases their notions on the human preconditions for the worker, for which they argue the design of technical and administrative preconditions, dictate the shopfloor. Although (Engstrom et al., 1992) admit, lean production is a long well thought out refinement of traditional mass production, they point out that lean production created the preconditions for developing work in 'reflective production'.

2.2.9 Changing Work Practices in Lean production

Lean production's widespread adoption has motivated a series of studies in a variety of social and cultural contexts, (Delbridge and Turnbull, 1993; Oliver et al., 1994; Oliver and Wilkinson, 1992; Turnbull and Delbridge, 1993). Other studies propose the tendency to converge both production models into one by comparing its similarities and differences in production, (Engstrom et al., 1992; Oliver et al, 1988; Bennett & Katayama, 1996). The comparisons between these models are based upon control systems i.e. JIT/TQC, work organisation and industrial relations, (Benders 1993; Jurgens et al., 1993; Locke et al., 1995; Sengenberger and Campbell, 1993), the use of technology in the case of labour intensive production phases for example in assembly and the relations between and integration of human resources and technology (Berggren, 1995; Fujimoto, 1993), relationships with employee change, (Biazzo & Panizzolo, 2000). The opportunity to create effective work is considerable but so are the dangers of making it worse. New forms of work are being introduced involving changes to people's jobs. These new forms of work involve the appraisal of work place systems changes proposed by researchers (Ichnioswki, 1996; MacDuffie, 1995; Pil and MacDuffie, 1996), about alternatives to work place practices and work organisation in lean production such as 'high-performance work systems', high-
'involvement workplaces' or 'high-commitment management systems' in lean production. (Ichnioswki, 1996; MacDuffie, 1995; Pil and MacDuffie, 1996), found, consistency, based on the lean principle of 'elimination of waste' work practices to be characterised by:

- The search for workforce flexibility
- The emphasis on team working
- Employment structures e.g. (security guarantees, continuous training, performance-based remuneration systems etc.)

They also propose the following work place system change in lean production to be:

- Innovative work systems based on the 'commitment model' proposed by Arthur (1994) is defined by:
  - Participation by means of teams and problem solving groups
  - Large investments in training
  - Increased multi-skilling based rewards

- High involvement work practices (Pil and MacDuffie, 1996, also MacDuffie, 1995) as:
  - Workers involved in teams;
  - Widespread use of job rotation;
  - Quality tasks delegated to production;
  - Extensive training;
  - Sophisticated hiring criteria;
  - Contingent rewards;
  - Minimum differences in status

- High-commitment practices, (Wood and Albanese, 1995) as:
  - Development of career paths for the entire workforce
  - Trainability and commitment as major selection criteria
  - Flexible job descriptions
  - Widespread use of team structures for disseminating information
  - Structuring work and problem solving
  - Worker responsibility for quality
  - Policies, which aim to ensure job security
- Use of temporary personnel to protect the core workforce
- Rewards system based on performance and skills
- High screening hiring procedures
- Problem solving teams
- Job rotation
- Formal team practice

Other authors (Parker and Slaughter, 1988; Klein, 1989; Sewell and Wilkinson, 1992) have taken a more critical approach to conditions of work under JIT and TQC manufacturing regimes. The review suggests, evolution of work practices are manifested by choices that appear to have been inspired by European sociotechnical principles, (Jurgens, 1992; Fujimoto, 1997). Biazzo & Panizzolo, (2000) assessment regarding changes of work organisation in lean production that are currently proposed or implemented (for example in Japan) in ways or described by some authors in their literature, Kuhlmann and Schumann (1997) (Fujimoto, 1997) “do not appear as revolutionary” as described in their literature, however Biazzo & Panizzolo, (2000) point out that the analysis of workplace transformation from the workers perspective requires an understanding of what it means for the workers in terms of job demands and job decision latitude.” A study on total quality management practices in the UK, found that “employee-involvement initiatives between one organisation and another may be camouflaged because managers used the same terms to describe what are in practice, vastly different schemes” (Wilkinson et al., 1997).

2.2.10 Summary

Most importantly, the literature presented in this section suggests the work content, is characterised by short cycled, processes work intensification, repetitive work, teamwork and standardisation. The next section of this review discusses the consequences of work within the lean production system.
2.3.1 Musculoskeletal Disorders
A musculoskeletal disorder (MSDs) is a multi-factorial term used in aetiology to describe the cause or origin of a musculoskeletal disorder. This can affect the neck and upper limbs (shoulders, arms, hands wrists, and fingers), (Buckle & Devereux, 1999), back and lower limbs (knees, hips feet) and can result in weakening pain, discomfort, or numbness (Buckle & Woods 2002). Previous studies show it is necessary to take physical (heavy, static or monotonous work, extreme or constrained postures, repetitive movements, unsuitable workplaces and equipment, forces exposure to vibration ), psychosocial (work organisation, interpersonal relationships, short cycle tasks, poor work control, piece rate pay system, poor management, unsatisfactory training, lack of breaks) and personal (gender, age, seniority, exercise habits, life style, psychological characteristics and capacities) aspects into account as risk factors (Hales and Bernard, 1996; Bongers et al., 1993; Hagberg 1988, 1992).

2.3.2 Individual Factors and Musculoskeletal Disorders
Changes to work systems can accommodate individual factors and in addition reduce the occurrence of musculoskeletal disorders for example, changing physical work heights, providing alternative equipment designs, reorganizing work schedules and changing work methods. Studies between individual factors (i.e. age, gender, and ethnicity) or 'fixed constitutional factors' (Dahlgren and Whitehead, 1991) appear to have shown an association of musculoskeletal problems at work. Due to these individual factors, (for example, older workers or female workers), certain groups of workers may be exposed to factors in the workplace that leads to problems in musculoskeletal health. Some studies indicate that women in monotonous and repetitive jobs are more likely to report musculoskeletal problems than men (Woods & Buckle, 2002).

2.3.3 Age and Musculoskeletal Disorders
The review of the literature on physical workload and the ageing worker (de Zwart et al. (1995), recognised a gradual decline in physical work capacity characterised by diminished aerobic capacity and muscular capacity. For many ageing workers the age related differences between physical workload and physical work capacity suggest increases of risk of musculoskeletal disorders and complaints (Woods & Buckle, 2002), more for women than men. Evidence suggests that older people can still
acquire skills and take part in continuous improvement activities. However tasks involving complexity and intelligent reasoning are gained more from the benefits of hard-earned experience and knowledge than through reliable and robust training programmes offered by the organisation more so in the belief that “older workers have control over the specification of work methods” (Macduffie et al., 1987). In many aspects lean production uses a number of distinct, technical, related practices, which encourages workers to use their knowledge to constantly refine their jobs. However practices of these kind places greater demands on workers time and effort (Rinehart et al., 1997).

### 2.3.4 Gender and Musculoskeletal Disorders

The variable ‘gender’ has been considered in many studies concerning musculoskeletal ill health. The majority of literature reporting gender and musculoskeletal ill health shows that women are more likely to develop musculoskeletal problems than men. Findings from many studies (Leclerc et al., 1999; Feuerstein et al., 1997; Auguston and Morken, 1996; Messing et al., 1993; Gun, 1990) indicate female gender to be a risk factor for musculoskeletal ill health.

Rinehart et al. (1997) survey of gender differences at CAMI found that women were significantly more likely to report their jobs exposing them to repetitive strains and other similar injuries than men. In addition, they highlight high incidences of work related injuries, repetitive content of many jobs, work intensity, shortage of workers, increased work pace, and heavier workloads, for the high prevalence of reported injuries at CAMI. In contrast to lean production Engström et al. (1999) study of musculoskeletal symptoms at the Volvo plant among assembly line workers in Udevella indicated comparisons between females and males differed significantly in that women reported higher frequencies of musculoskeletal symptoms with respect to the hands than men, (37% female and 6% men and gender differences in musculoskeletal symptoms with respect to the wrists 58% females and 34% males). Fransson-Hall et al (1993) study of automobile assembly workers reported characteristics of work differed for male and female, typically repetitive movements with the wrists were more commonly reported for men than women. In addition although they indicate men and women are employed in the same area of work, this can affect women, and men differently (Feuerstein et al., 1997; Fredricksson et al., 1999; Virokannas et al., 1999; Thorbjörnsson et al., 2000). Kenney and Florida
(1993), indicated that repetitive motion injury in a number of automotive assembly transplants were made ‘worse’ by recruiting workers with no manufacturing experience. In other instances they found large numbers of women were placed in high-stressed jobs because a number of transplants were faced with shortages of sufficiently skilled and rotatable workers, thus being forced to remain in high stressed jobs for long periods without rotation thereby increasing the risk and actual incidences of repetitive motion injury.

Messing et al. (1994) identifies four factors that complicate male-female comparisons of work related injuries, 1) gender differences in the hours worked, 2) gendered task assignments within industrial classifications, occupations, and job titles, 3) gender differences in age/ seniority, 4) gender differences in the interaction between equipment, tool dimensions and work activity.

The physical demands of female-intensive jobs are often perceived (by those not performing the jobs) to be less strenuous than the jobs typically performed by men. Furthermore, some studies have shown that women and men working in the same factories, even with the same job titles did not always perform tasks with the same physical requirements or work organisation (Punnett and Herbert, 2000). Women tended to perform more repetitive work on average, whereas men were less likely to sit for prolonged periods compared to women. Jobs requiring high static loading of the neck and shoulders, with repetitive use of small muscle groups, involve a high risk of upper extremity disorders. During dynamic low-load manual work, the higher the speed of motion and/or the higher the demands for accuracy, increases in measured muscle forces relative to their capacity are found (Bernard, 1997; Sjøgaard and Sjøgaard, 1998).

2.3.5 Consequences for Work in Lean Production

Kenney and Florida (1993), study of problematic conditions of work organisation in Japanese transplants reported physical injuries to be the most notable drawback of the transplants they studied. “Repetitive-Motion Injuries are common in automobile assembly and other forms of labour that place continuous stress on workers’ wrists arms, shoulders, backs etc” (Kenney and Florida, 1993).

Most advocates and critics of lean production share the same view that lean production is arduous and intense; as a result loading more and more work onto jobs
creates the issues of ‘overburdening’ jobs that can easily lead to RSI problems (Rinehart et al. 1997). These are often under reported, in contrast to what some critics have implied, such a high-level of repetitive motion injury is not a necessary result of Japanese production work organisation but rather management’s failure to implement the Japanese system properly which large numbers of repetitive motion injuries at some transplants appears to result from, (Kenney & Florida, 1993). Indeed they observe that workers with high impact jobs in Japanese automobile assembly plants rotate quite often (once every hour) to minimize the risk of repetitive motion injury, but in contrast to Japanese transplants they observed the Japanese system not to be managed in the same manner. They argue that it is not the failure of the system but management’s failure to implement the Japanese system of work organisation properly. Bourgeois (2000) studied the risk factors in organisational change and studied the link between organisational changes, such as lean production, and the occurrence of musculoskeletal disorders. He argues that the cause is not lean production but the organisational option selected by the company in introducing it. He describes changing from production line working to independent teams, management hopes to make work less monotonous and increase flexibility. Yet he mentions such changes have no guarantee of reducing the rate of musculoskeletal disorders and could indeed be a signal for their appearance. The fear is also on the part of management that preventing musculoskeletal disorders results in a slowing of performance. Musculoskeletal disorders arise when this kind of organisational dependence exists. Operators are less and less able to use their own resources (their skills, know how, creativity, etc.) in deciding their movements. More accurately, he concludes that the organisational risk factor lies in the application principle adopted (for example, the elimination of buffer stocks) rather than in the production concept of lean manufacturing itself.

Davies and Sparrows (1985) identified that as employees became older they were less likely to engage in heavy physical work. This view shared with some interest envisions high task variety to be an immediate solution in reducing the number of repetitive strain effects with repetitive work, but given the intensity of the work and repetitive content of many jobs there are still moderate to high risks of RSI and work related injuries. Most injuries commonly affect the worker through repetitive movements of wrists and fingers. However production lines that operate at high
speeds and at maximum capacity recognise the need for a 'more-safer job design' in terms of ergonomical value than worker output.

2.3.6 Concept of Work Related Upper Limb Disorders (WRULD)

Upper Limb disorders (ULDs) encompass a variety of musculoskeletal problems. ULDs are also termed WRULDs for 'work related' ULDs. WRULD is an umbrella term for conditions caused by risk exposure in the workplace that includes a range of musculoskeletal disorders known to affect the upper limb of the body (tissues of the hand, wrist, arm shoulder, and neck), (Silman & Newman, 1996; Buckle & Devereux, 1999). Alternative terms used for these are overuse syndrome, repetitive strain injury (RSI) and cumulative trauma disorder (CTD). The medical literature considers RSI to be a subset of disorders with work related and upper limb disorders (WRULD), being the generic term used to classify these type of injuries. The term Work Related Upper Limb Disorders (WRULD), is used as an umbrella term. It includes a variety of clinical conditions of the upper body that results from occupational pain or trauma. Other terms for example RSI, CTD, Overuse Syndrome have been used interchangeably to describe the same concept, but to a more concise point there are slight differences in the way they are classified according to their symptoms they posit although (in some cases depending on the nature of the disorder) they do not overlap with each other as shown in the Venn diagram in figure 2.3.6

Work Related Upper Limb Disorder Umbrella Term

Source: Silman & Newman, (1996) Fig 2.3.6
2.3.7 Nature of Work Related Upper Limb Disorder

The cause of WRULDs results from workers needing to exert desirable force, use uncomfortable hand grips or adopt static difficult postures in the workplace paralleled with continuous repetitive work or insufficient rest or recovery.

A report studied on the assessment for potential causes and recommendations of toner control cartridge assembly lines for Work Related Upper limb Disorder (WRULD) by Loughborough University Consultants Ltd, (Ellis et al., 2000) describes, its symptoms and classification with respect to the regulations of the Health and Safety Executive:

WRULDs: Description

The musculoskeletal system is well suited to produce repeated motions at low force levels. Undesirable forces may however, be imposed on muscles, tendons, and joints by some job demands and working practice. Such stresses are usually within the physical capacity or strength of the tissues, provided the forces are short duration and rest periods are adequate; prolonged tissue loading caused by static postures or performance of very frequent exertions can, however be harmful, resulting in a diminished functional capacity.

A number of musculoskeletal disorders that appear to be caused or exacerbated by work factors have been described in the literature. Some risk factors associated with disorder are now reasonably established, while for others occasional reports indicate less clear evidence of a definite link. Some of the disorders described represent well-defined diseases; other appears as ill-defined symptoms, which nevertheless may indicate an underlying problem. The main sites affected are the fingers and hands, wrist, elbow, and shoulder.

A Classification

No generally agreed framework exists to classify adequately the range of WRULDs. They vary enormously in what causes them, what the underlying disease mechanisms are, their severity and outcome as far as the individual is concerned. As they mostly concern disorder or dysfunction of the soft tissues however it is convenient to group them as follows:

a) Inflammation or trauma of the tendon, muscle-tendon junction or surrounding tissue, particularly the tendon sheath. Such inflammatory conditions in and
around the tendon are for the most part of a temporary nature but in some individuals may become chronic.

b) Inflammation of tissue of the hand caused by constant bruising or friction of the palm (a similar condition may occur in the elbow or knee). Collectively these are known as the 'beat conditions';

c) Compression of the minor nerves serving the upper limb, particularly the hand. Many of these conditions termed as carpal tunnel syndrome may arise spontaneously in the general population and may be aggravated by work conditions;

d) Temporary fatigue, stiffness, or soreness of the muscles comparable to that following unaccustomed exertion but where no permanent pathological conditions results. Full recovery occurs after appropriate rest.

This is not a definitive or precise list. The conditions are not mutually exclusive and some individuals exhibit several variants simultaneously

Symptoms

Although many symptoms are associated with WRULDs, the most notable are pain, restriction of joint movement and soft tissue swelling; in the early stages there may be little or no visible sign of bruising or swollen joints. In some conditions the sense of touch and manual dexterity may be reduced.

Because of the onset symptoms is often gradual, a person's response to pain and restricted mobility may result in an adaptation to the way in which work is performed. There may then be involvement of other parts of the limb and a complex symptom pattern may result.

Repeated strain and strains (the terms often used to describe over-exertion injuries) may produce a pattern of tissue inflammation that is often the forerunner of chronic injury. A permanent disability is sometimes the result.

2.3.8 Terms or Definitions used to refer to RSI

Repetitive Strain Injury (RSI), cumulative trauma disorder (CTD) and overuse syndrome (shown in Fig 2.3.6) are used identically to categorise the same meaning; however confusion arises when published criteria interpret each of these terms differently, in their own respective contexts.
A report published for the European Agency for Safety and Health at Work, on repetitive strain injuries in the member states of the European Union illustrates well the terms or definition used to refer to RSI from European member state countries. The report highlights the need for an exact definition of RSI by governments in the European member states. Although some member states do not commonly use the expression RSI for example Germany, Austria, Italy, and many others, they have adopted other terms to describe RSI. In the United Kingdom it is seen from the report on repetitive strain injuries in the member states of the European Union that they are reluctant to use the expression RSI whereas the term is commonly used in the media.

The use of ULD (Upper limb disorder) or WRULD (work-related upper limb disorder) in which they apply reflect better medical facts, and discourages the use of the term RSI, as RSI is seen to be invalid and misleading.

Alternatively, various concepts of RSI are interpreted differently in different member states.

- The stress which is the cause of the disease (repetitive work/cumulative traumas: tennis elbows, etc)
- The region of the body which it is affected (upper limbs/neck, shoulders, etc.);
- The disease itself, some member states e.g. Germany, Denmark and Finland list well the defined diseases in their occupational health disease lists
- Others e.g. Sweden pay more attention to the structures involved (muscles, articulations) than the nature of the disease it self.

Repetitive Strain Injury (RSI) is common in young aged adults, (Silman & Newman, 1996) but also affects middle-aged adults. The cause of RSI is significant in manufacturing, food, and construction industries whose occupation demands repetitive movements of the wrist and hand. Various synonymous definitions suggest RSI to be collective amongst a range of conditions characterised by discomfort, persistent pain in muscles, tendons and other soft tissues. The results of these symptoms are caused by aggravated work associated with repetitive movement sustained or constrained postures and / or forceful movements. Workers in jobs requiring repeated performance of a given task or set of tasks with cycle times of two minutes or less are considered at most risk from disorders such as RSI. Tasks defined as highly competitive typically have cycle times of 30 seconds or less. A cycle time of 1.5 minutes is considered optimal for tasks with a fast pace.
A research report written for the European Agency for Safety and Health at Work by (Buckle & Devereux, 1999), on upper limb neck musculoskeletal disorders suggested little evidence available for a standardised criterion across the European Union (EU) member states for assessing WRULDs. The size of WRULD problem is reflected in the evidence available from within the EU member states work concerning WRULDs of which (Buckle & Devereux, 1999), in their report state “consistently reported risk factors requiring consideration in the workplace, postural (notably relating to the shoulder and wrist), force applications at the hand, hand-arm exposure to vibration, direct mechanical pressure on body tissues, effects of a cold working environment, work organisation (psychosocial work factors).”, while the limited understanding of interactions between these variables means the relationship describing the level of risk for varying amounts of exposure to risk factors in the workplace are difficult to deduce, (Buckle & Devereux, 1999).

2.3.9 Classification of different types of Disorders
The scientific committee for musculoskeletal disorders, of the International Commission on Occupational Health (ICOH) describes a wide range of inflammatory and worsening diseases, and disorders that result in pain and functional impairment (Kilborn et al., 1996). Hagberg et al. 1995), relate these disorders according to the specific upper part of the body i.e. tendon, nerve muscle circulation and joints. Researchers and Clinicians have relied upon different bodies of knowledge to justify the criteria used for measuring the disorders. General diagnostic criteria have been developed by individual member’s states for work related upper limb and neck disorders for example in the UK (Harrington et al., 1998; Cooper & Baker, 1996), Netherlands (Sluiter et al., 1998), Finland, (Waris et al., 1979), Sweden (Ohlsson et al., 1994) and Italy (Menoni et al., 1998).

Figure 2.3.9 gives an indication of the specific work related upper limb and neck disorder identified within the literature. Hagberg et al., (1995) have classified the disorders according to its relation with tendon nerve muscle, circulation, and joint.
The classification of some neck and upper limb musculoskeletal disorders according to pathology

Table 1. Classification of some neck and upper limb musculoskeletal disorders according to pathology. (Hagberg et al., 1995)

<table>
<thead>
<tr>
<th>Tendon-related disorders</th>
<th>Nerve-related disorders</th>
<th>Muscle-related disorders</th>
<th>Circulatory/vascular type disorders</th>
<th>Joint-related disorders</th>
<th>Bursa-related disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendinitis/tenosynovitis</td>
<td>Carpal tunnel syndrome</td>
<td>Tension neck syndrome</td>
<td>Hypothermic hammer syndrome</td>
<td>Osteoarthritis</td>
<td>Bursitis</td>
</tr>
<tr>
<td>De Quervain's disease</td>
<td>Cubital tunnel syndrome</td>
<td>Muscle strain and strain</td>
<td>Raynaud's syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epicondylitis</td>
<td>Guyon canal syndrome</td>
<td>Myalgia and myositis</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Dupuytren's contracture</td>
<td>Pronator teres syndrome</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trigger finger</td>
<td>Radial tunnel syndrome</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ganglion cyst</td>
<td>Thoracic outlet syndrome</td>
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<tr>
<td></td>
<td>Cervical syndrome</td>
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<tr>
<td></td>
<td>Digital neuritis</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Source taken from Buckle & Devereux, (1999)

2.3.10 Size of Self reported (WRULD) problems within some of the EU member states

The size of the problem according to (Buckle & Devereux, 1999) varies substantially across European member states. Although they mention such data is useful, the prevalence of self-reported symptoms can be over estimated (for example in surveys carried out by EU member states) because of methodological difficulties. In Great Britain, a labour force survey conducted by the Health and Safety Executive estimated 506,000 workers experienced a self-reported condition that affected the neck or upper limbs in 1995. These types of disorders are presented in Appendix 1.

However the perception in the UK is that there is a much higher increase in work related upper limb disorders that are presented to medical experts and dealt with through the legal system and which are not prescribed as industrial diseases (Helliwell, 1996). Two surveys conducted in the UK by the Institute of Occupational Health (University of Birmingham) provided information regarding the priorities in research according to occupational physicians and personnel managers (Harrington, 1994; Harrington and Calvert, 1996). Both of these surveys concluded that
musculoskeletal disorders with neck and upper limbs need research priorities but found personnel managers considering practical strategies more important than risk factor identification with musculoskeletal disorders. Data from the 2nd European Survey on Working Conditions (Paoli, 1997) identified industries (across the European member states) where 40% or more of the workers were exposed to three or more of the following risk factors for at least 25% of the working time: working in painful positions, moving heavy loads, short repetitive tasks, and repetitive movements. The industries of the greatest risk included:

- Agriculture,
- Forestry and Fisheries
- Mining,
- Manufacturing

Among musculoskeletal disorders upper limb disorders rank extremely high in the UK and this has led to a rapid increase in the number of disablement benefit cases, (Muggleton et al., 1999). There are a number of working environments in which it is possible to picture a high incidence of work related upper limb disorders, namely, food processing plants (Streib and Sun, 1984; Maesar et al., 1986), automotive plants (Brandon, 1992), quarries (Bovenzi, 1994) and shipyards (Letz et al., 1992).

With respect to the amount of information available about the prevalence and occurrence of RSI, a survey carried out by the Health and Safety Executive reported an estimated self-reported related illness of 500,000 people suffering work-related musculoskeletal condition affecting neck or the upper limbs. Other information studied found gender to be significantly correlated to prevalence and occurrence of RSI complaints between some countries of the EU member states.

2.3.11 Development of Upper Limb Disorders

Researchers from Denmark, Finland, Sweden, England, and the United States developed a conceptual model to promote the understanding of the possible pathways leading to the development of neck and upper limb musculoskeletal disorders (Armstrong et al., 1993). This model shown in Fig 2.3.11.1 describes four sets of interacting concepts, exposure, dose, capacity, and response.
Worker activity produces internal forces acting upon the tissues of the body over time (termed a dose). The dose causes effects such as increased circulation, local muscle fatigue and other various physiological and biomechanical effects, this means there is a response by the body initiated by the internal stimuli which themselves occur from external factors

A conceptual model of neck and upper limb musculoskeletal disorders that describe the pathways involved in the pathogenesis of these disorders

From Armstrong et al. (1993)

Source taken from Buckle & Devereux (1999) Fig 2.3.11.1

The response of the body may increase or decrease the ability to maintain or improve the capacity to cope with further responses. Over a period of time a reduced capacity may affect the dose and the subsequent effect, it means if there is insufficient time to allow the capacity of the tissues to regenerate then a further series of responses is likely to deteriorate the available capacity. This is likely to continue until slight tissue deformation occurs which is experienced as for example pain, swelling or limited movement. This model proves useful for explaining the cumulative effect of neck and upper limb disorders; however models by (Van der Beek and Frings-Dresen, 1998; Winkel and Mathiassen, 1994) propose a pathway between work capacity and work activity. The concept is expanded to include work requirements acting as the working situation, the actual working method, and posture, movements and exerted forces by (Van der Beek and Frings-Dresen, 1998).
This model posits that a reduction in work capacity may result in a reduction in the amount of work performed, thereby allowing sufficient worker capacity to increase shown in Fig 2.3.11.2.

The working situation is characterised by work demands and job decision latitude. The latter is defined as the extent of autonomous and opportunities for workers to improve (or make worse) the working situation by altering the work demands. The working situation is therefore characterised by the organisation of work (work organisation) factors and the perceptions held by the workers concerning the method the work is organised (psychosocial factors). The working situation constructs the way a worker performs the work activity. This can be affected by individual characteristics such as anthropometry, physical fitness, age, gender, and previous medical history. The method an individual worker adopts affects the level, duration, and frequency of exposure to work postures, executed movements and the forces exerted. This will or can affect the internal factors previously described in fig 2.3.11.1.

A model from the National Research Council (1999) provides additional concepts for factors that lie external to the individual (factors considering exposure Armstrong et al., 1993) shown in figure 2.3.11.3.
The Conceptual Framework of physiological pathways and factors that potentially contribute to musculoskeletal disorders (National Research Council, 1999).

**Figure 4. Conceptual framework of physiological pathways and factors that potentially contribute to musculoskeletal disorders (National Research Council, 1999).**

Source taken from (Buckle & Devereux, 1999) Figure 2.3.11.3

### 2.3.12 Workplace Interventions

Literature by Westgaard and Winkel, (1997) reviewed studies that changed job exposures considered harmful to musculoskeletal health. These studies included interventions into mechanical exposure (for example postural load), other risk factors, production system, organisational culture alterations, affecting mechanical exposure; interventions modifying behaviour and/or capacities of individual workers (for example, exercise relaxation programmes, and physiotherapy). Regardless of the methodological difficulties in conducting intervention research in the workplace (Rubenowitz, 1997; Zwerling et al., 1997), reducing mechanical exposure to neck and upper limb disorders especially where work situation levels were perceived to be high. The interventions involved reducing the mechanical exposure directly through modifying workstations or indirectly through alterations in organisational culture.
(Westgaard and Winkel (1997), defined organisational culture in terms of health and safety as "Systematic activities of major stakeholders within an organisation, relating to health, safety and environment and comprising measures to influence for example management systems, behaviour and attitudes for dealing with potential or manifest musculoskeletal health problems of the workforce."

Several field research studies have provided evidence that demonstrates the effects of multi-factorial interventions in the workplace upon exposure to risk factors and reductions in several musculoskeletal health outcomes (National Research Council, 1999). Smith et al. (1999), in his NRC (National research Council) report, provides evidence showing some intervention strategies that can prevent the development of musculoskeletal disorders in specific industries and occupational groups (e.g. nurses, meatpackers, assembly, and postal workers). Examples found were multiple ergonomics redesign, movement pattern training, and physical therapy interventions resulted in reduced recorded neck and upper limb musculoskeletal disorders, lost workdays, numbers of days of restricted activity and employee turnover (Harma et al., 1988; Orgel et al., 1992; May and Schwoerer, 1994; Parenmark et al., 1988).

2.3.13 Summary

As discussed earlier a clear meaning of the RSI term has not yet been established and different interpretations of its meaning still exist. The fact common to most incidences of Repetitive Strain Injuries (RSI) is underlined by the notion that females appear to be physically more affected than male. The literature suggests, an attempt to reduce its prevalence's are through workplace intervention and organisational change. The final section of this literature review ends by presenting a concept for organisational and workplace change. Situational strength as a tool applied in strategic organisational change is considered as an approach for identifying the level of RSI risk. The researcher presents the concept of situational strength and discusses how this concept could be applied as a tool for identifying levels of RSI risk.
2.4 Situational Strength

Situational strength by Walter Mischel (1977), whose studies from an interaction perspective in social psychology identifies conditions under which individual differences are likely to be relatively more or less important in making such choices. Drawing on this concept of situational strength, many researchers have applied the theory of ‘strong and weak’ situations, for example, in strategic change in organisations, job autonomy, perception of management discretion in strategy changes and personality and job performance outcomes.

Strategic theorists, (Child, 1972; March, 1981) argue that complex decisions are impacted by behavioural factors. Other empirical studies of strategic change have focused on situations where environmental factors have dominated the decision process (Meyer, 1982). Mischel defines strong situations as those that generate relatively uniform expectancies concerning appropriate behaviour (Mischel, 1977). He suggests that strong situations constrain the expression of personality, and the behaviour is more a function of the situation than of personality. In addition it is one that is uniformly encoded by most actors for which actors agree on and are able and motivated to make a consensual response (Mullins & Cummings 1999). Hough and Schneider (1996) suggested that personality has a greater relation with job performance in weak situations as opposed to strong. This theory believes actors in strong situations interpret the situation in the same way. The situation itself provides incentives to make the appropriate responses and dominate individual differences in determining decisions and courses of action, in which, “strong situations have widely accepted rules of conduct which constrain and direct behaviour” (Weiss & Adler, 1984).

Equally Mischel defines weak situations in which there is ambiguity in the meaning of the situation (Mullins & Cummings, 1999), where the situation does not provide clear incentive, support, or normative expectations, (Beaty et al., 2000). A weak situation is therefore one in which different actors encode the situation differently, disagree with an appropriate response and or with the lack of motivation or ability to respond, (Mullins & Cummings, 1999).
2.4.1 Personality and Situational Strength
Personality researchers (Mischel 1977; Monson, Hesley and Chernick, 1982; Weiss and Adler, 1984), argue that situation strength moderates the extent to which personality differences affect individual behaviour, including decision making. In particular, weak situations are those in which personality differences are most likely to influence decision-making and behaviours. Carpenter and Golden, (1997) suggest that strategic issues are often encountered in weak situations based upon ambiguity and uncertainty of strategic formulation process (Mintzberg et al., 1976) Personality-situation interaction suggests that managerial situational characteristics can interact with the discretion of the manager’s perception over making and deciding strategic issues. However Hattrup and Jackson (1996) suggest situations could be defined and based upon four differing situational attributes: information from the environment attributes of the task, physical characteristics and social norms.

2.4.2 Autonomy and Situational Strength
Relationships between personality characteristics and behaviour moderated by situational strength have been mentioned by (Bem & Allen, 1974; Bem & Funder, 1978; Chatman, 1989; Mischel, 1977; Moson, Hesley & Chernick, 1982; Stagner, 1977; Weiss & Adler, 1984). Barrick and Mount, (1993), found situational strength as the moderator for the level of autonomy in job performance environment moderated the relationship between personality and job performance; personality and job performance associations found to be higher in highly autonomous work situations than in less autonomous work situations. Schneider and Hough (1995) suggested that the personality-job performance relation might not be the same for all individuals in all settings.

2.4.3 Strategic Change and Situational Strength
Drawing further on the work from Mullins & Cummings, (1999), they find the notion of strong and weak situations for proposing strategic change a useful framework for thinking about environmental and organisational contingencies in the likelihood of strategic change. In addition two personality constructs from (Lewin and Stephens, 1990) tolerance for ambiguity and openness to experience are considered also within the framework to assess the impact of individual differences on proactive strategic change. With Mischel definition of strong and weak situations in mind, Mullins and
Cummings, (1999), conceptualise a set of constructs for strategic change. They propose:

1. Uniform encoding of the situation;
2. Consensus as to the appropriate response;
3. Motivation to respond; and;
4. Ability to make that response

Uniform encoding of the situation
Defined to the degree of which most situations are encoded by most observers in terms of perception, interpretation, and classification of data into meaningful categories. Uniform encoding among leaders of different firms is likely when there is little uncertainty in the operating environment (Daft & Lengel, 1988). Mischel argues even though the encoding between individuals maybe uniform, and the responses are agreed upon, the situation may still nonetheless be a weak situation if the incentives to make the appropriate response are lacking.

Consensus to the appropriate response
The appropriate response to the situation or lack of consensus by firms may be driven by differing perceptions (of the external situation, e.g. environment) which can result in differences of encoding. It implies differentiation between a firm's strategic choices in decision making when considering its core competencies or company mission objectives.

Motivation to respond
Motivation can be driven by the presence of incentives (Burke, 1984) to agree upon the appropriate response in the decision making process. Such incentives may include magnitude and certainty of outcomes resulting from individual decision makers in organisations for example senior director or production managers. Mischel's theory argues the absence of incentives for example, promotions, or salary increases, may influence individual differences upon change of strategy.

Ability of actors to make consensual responses
Prahalad & Hamel, (1990) suggest the ability of the actors to make consensual responses is driven by its resources and core competencies at organisational level.
With the adequate amount of resources and core competencies available, companies who pursue strategic decision alternatives in themselves create a strong situation although as (Mullins & Cummings, 1999), suggest individual differences among strategic decision makers within the same type of industry are likely to make little impact because firms play a central role in the choice to proceed with their initiatives or not.

Strong situational factors dominate decision-making (Hrebiniak & Joyce, 1985), and individual differences play a much larger role, consistent with the strategic choice perspective in weak situations (Child, 1972). This explains that situational strength can make a moderate impact on individual differences amongst strategy makers, if the factors above drive situational strength for strategic change. This should equally exert a similar impact on individual differences in the likelihood for changes in making strategic decisions.

The effects of ambiguous situations in strong and weak situations that cannot be adequately structured or categorised by an individual due to insufficient information (Budner, 1963) is seen as a riskier form of uncertainty. Intolerance for ambiguity defined by (Norton, 1975) is a tendency to perceive, or interpret; information marked by vague, incomplete, fragmented, multiple, probable, unstructured, uncertain, inconsistent, contrary, contradictory, or unclear meanings as actual or potential sources of psychological discomfort or threat. Since Norton (1975) identifies the tolerance for ambiguity being consistent across different situations (Mullins and Cummings 1999) argue this form of ambiguity may be seen as a stable personality trait that can explain the relationships between personality and strategy decisions in management and marketing (Miller and Toulouse, 1986; Walker and Ruekert 1987), as well as in personality and job performance (Barrick and Mount, 1993).

Moreover from an industrial point of view, individuals that are more tolerant are more likely to engage in strategic change given conditions of uncertainty with the results of the new strategy and sustained competitive advantage (weak situation) as opposed to those who are less tolerant (strong situation). Personality traits, openness to experience and tolerance for ambiguity suggest individuals again are likely to play an important role in the likelihood of strategic changes. Mullins and Cummings,
(1999) maintain individuals are more likely to initiate differentiation strategies than those who are closed and less tolerant towards ambiguity under conditions (according to Mischel that should lead to weak situations) than those who are more open and have more tolerance for ambiguity. They advocate that weak versus strong situations provides a useful approach which can help managers to assess the impact of environmental conditions they face, understand the roles of uncertainty the diversity of strategic choices, differences in competencies in competitors and other factors that can impact strategic decision making.

2.5 Statement of beliefs
The statements of beliefs put forward are formulated from the literature. It aims to provide the reader with an understanding of the novelty of the work carried out by the researcher. The formulation of beliefs for this research is based upon a number of views the researcher has developed during the literature review. Until this point there has already been a great deal of study reported within the literature of work organisation in lean production. Below outlines the following beliefs from the researcher putting a case forward for conceptualising and developing the research problem.

Belief 1: Operators can modify the lean job to suit their style of working
This statement is true when senior management allow the operator to make changes to their work situation with a certain amount of discretion. The managers do not always appreciate these modifications unless the individual or team can be supervised closely, (Jhugroo & Burns, 2002)

Belief 2: Increasing the workload of the operator with knowledge and experience increases the level of RSI risk
This makes the assumption when work loads are increased the operator is confronted with a strong situation with a high capability to change their job situation therefore decreasing the potential level of RSI risk. Literature from (Macduffie et al., 1987), (Chapter 2) report “older workers have control over the specification of work methods.”
Belief 3: Complaints made by operators are common because of their discontent with management to introduce counter measures to reduce the level of RSI risk in their processes
The belief is that team leaders are expected to implement counter measures to reduce the level of risk RSI when an operator is subjected to risk. These issues are often overlooked by senior management as “they may consider their perceived inability to influence their environment as a threat (Dutton and Duncan, 1987) and team leaders are sometimes reluctant to implement the counter measures without their consent. The locus of control may affect the extent to which managers perceive themselves to have discretion in a variety of situations (Rotter, 1966).

Belief 4: Older employees subjected to RSI are more likely to suffer with more work stress than younger employees.
This statement believes the capability (ability and motivation) for change in the job situation by older employees are not suited to the requirements of the employee but to maintain the balance of the processes. The literature suggests for many ageing workers the age related differences between physical workload and physical work capacity suggest increases of risk of musculoskeletal disorders and complaints (Woods & Buckle, 2002), more for women than men, (Chapter 2 section 2.3.3).

Belief 5: The level of RSI risk in a lean job can be reduced if the operators have more involvement and control over the daily management of their processes
This belief assumes that many operators lack motivation and confidence to make decisions because much of the decisions are controlled by engineers and management. It is perceived that many operators have the capability to change the job situation by being given more discretion and autonomy to do so. Personality and job performance associations found to be higher in highly autonomous work situations than in less autonomous work situations, (Barrick and Mount, 1993).

Belief 6: “Lean jobs are strong situations”
It is perceived that lean jobs are strong situations with very little discretion made by the operator to change the job situation. This belief posits the assumption that there exists a positive correlation between a strong situation and the level of RSI risk
(Lewchuk & Robertson, 1996; Rinehart et al., 1997; Babson, 1993; Berggren et al., 1991; Graham, 1995).

2.6 Conclusion
At present the research literature related to Repetitive Strain Injury (RSI), is interpreted in different ways. Much of the literature surrounding repetitive strain injury uses the definitions inter-changeably adding to the broadness and confusion of the term itself. The literature suggests an exact meaning of RSI has not yet been defined, because of cross-cultural studies and interpretation of meaning. In reviewing the literature the researcher therefore only selected references that specifically associated issues with the term RSI. In most studies the emphasis has been on the relationship between workplace factors and the prevalence of its risk and disorders. In addition the cross sectional nature and critique of the lean production system in many studies limits the possibility of determining exactly the understanding between its work processes and repetitive strain injuries in lean manufacturing industries that apply the total lean production system and those who adopt only certain aspects of lean production.

The aim of the literature review is to develop an understanding of the related work in the area. Furthermore, the aim is to provide the reader with an understanding of the original work conducted by the researcher. There has already been a significant amount of work being studied with lean manufacturing in the automotive industry, however at present there exists:

a) A lack of understanding of how RSI is generated in lean manufacturing without understanding in depth the work processes that manifest injuries in real world settings.

b) A need to focus from the perspectives of those involved how can situational strength perceive the level of RSI risk and determine the ability and motivation of the operator to change the work situation as a result of reducing the number of repetitive moments and incidence of RSI risk as the outcome.

c) The aim of creating an empirically grounded understanding that can pull together a multiplicity of research domains and approaches into developing new understanding of situational strength and potential risks of RSI by those involved in creating new methods of work in lean production.
2.7 Summary

The next chapter describes the conceptualisation and the development of the research problem. This is presented by conducting a simulation with the results of an initial questionnaire pilot study conducted by the researcher. A theoretical model is presented from which a series of hypotheses are derived.
Chapter 3

Conceptualisation and Development of the Research Problem

This chapter explains the conceptual framework for this research. A management game is used to simulate the results obtained from an initial pilot study questionnaire to characterise jobs in a lean environment. Following this simulation a conceptual model is developed based upon the concepts of situational strength and repetitive modes of work from which three research hypotheses are derived for testing.

3.1 The Conceptual Research Problem

To further the theoretical investigation, results obtained from the initial questionnaire pilot study is used with a management game to simulate a relationship between the lean job situation and RSI.

A lean job as a strict set of tasks is defined by:-

1. **Standard Work Sequences**: Specifying the layout of the working area, required tools, fixtures, and tasks of each job.
2. **Standard Work-in-Progress**: The daily number of units or piece parts required for an even and on-time flow through each workstation.
3. **Standard Cycle Times**: The total time taken by each operator to complete a whole process.

The characteristics of a lean job are associated with the above set of procedures (Rinehart, 1997). The capability to change the job situation when RSI is present assumes that the amount of added-value work carried out and repeated by an operator in a process is contributing to RSI. The causes of this are thought to be perpetuated by repeated use of the same upper body part.

Walter Mischels theory between the interaction of the person and the situation suggest that it was necessary to consider how the environment influenced behaviour and how behaviour and the people who generated it in turn shaped the environment in a continuous enduring interaction. In the case of lean production, much complex human behaviours are regulated by interactions that depend intimately on situational conditions. Therefore assuming the tolerance in a strong situation is unlikely to change; proactive changes or strong industrial norms should be put in place by senior...
management and health and safety personnel to guide the firm's practices and behaviour (Smith et al., 1985) and to identify if RSI would occur in a strong situation. If this is so, decision making opportunities by senior management and health and safety personnel should be provided to the operator to enable them to reduce their level of RSI risk.

The characteristic of a lean job is most often, created by a certain set of motion procedures that involve significant body motions that are arduous and repetitive. Smith (1985) indicates that as the work becomes more repetitive, the timings become shorter, and the work disrupts the body rhythm. The assumption in this research is that the strength of the situation influences the amount of repeated body movements in the job. The situation is defined as either strong or weak. Definitions of strong and weak situations are provided below:

- **A Strong Situation** with high RSI risk involves relatively little ambiguity in decision-making, making the repetitive work patterns difficult to control by the individual.
- **A Weak Situation** with low RSI risk involves ambiguity in decision making with the resulting individual personality and disposition having a significant effect upon the work pattern.

The assumption that the strength of the situation influences the amount of repeated body movements in the job, and the characteristics of lean job are defined as a set of strict tasks defined by standard working procedures, a pilot questionnaire study was conducted at obtaining a clearer insight into the characteristics of lean jobs in Lean Manufacture. The detail of how the pilot questionnaire study was carried out is described in the next section.

**3.2 Pilot Questionnaire Study**

A questionnaire in a form of a pilot study was put forward as a means of identifying if RSI occurred in a lean job situation. The initial questionnaire study was piloted to form a basis for understanding the lean job situation to identify the characteristics of RSI present within the job. The design of the questionnaire was tested at two levels. The
The first design was presented to peers (supervisor and director of research) and other researchers in the same research group and the second design pre-tested on a trial basis (Churchill, 1995) to other researchers who were familiar with the subject area.

The review of the first design resulted in a number of changes that were added mainly for extra information. The outcome of the second design resulted in re-wording for some of the questions. Following this, a search was performed by the researcher on lean manufacturing companies or companies that adopted lean working methods as part of their company strategies around the university area using keywords searches associated with lean manufacturing on databases and using company directories. A final review of the pilot study questionnaire was conducted by the researcher's supervisor and the final version of the initial pilot questionnaire was sent to 60 local companies that were mostly lean or those that adopted lean techniques as part of their manufacturing strategy.

The questionnaire was designed and written in a clear and simple format for the respondent to understand. The beginning of the questionnaire stated the purpose of the research and a statement was written defining the meaning of 'lean' for the design of jobs in Lean Manufacture.

The questions that followed asked the respondent to answer aspects related to their job tasks, changes to their work procedures, to identify problems of a repetitive nature that could cause a Repetitive Strain Injury, and also identify the types of people that could work in a lean job.

Each questionnaire sent to these companies was analysed by the researcher. A letter of invitation was addressed to the production department of each company. Where it was possible to address it to a particular person in the production department a name was identified and added on the letter. The letter addressed the theme of the research and asked the personnel to devote some of their spare time to complete the questionnaire. The letter proposed that given the contact details upon returning the questionnaire a feedback report would be submitted. A self addressed envelope, with the letter of invitation and the questionnaire was sent by the researcher by mail.
Information about the characteristics of RSI in a lean job and what it meant to them was sought from the questionnaire. The replies obtained from the companies identified themselves as using lean working methods as part of their company operations. Most of them agreed that they did and also when asked if RSI caused a problem in the lean working environment, a mixed response resulted with some of the companies agreeing and some disagreeing that it did cause a problem.

Although the responses obtained from the pilot study questionnaire could not indicate the strengths of the lean working environment, but the responses did indicate that there were six important parameters thought by them to be important in categorising what they thought were the most important factors influencing RSI in a lean job. The resulting six parameters obtained from the pilot study are listed below:

- Adaptation
- Learning
- Flexibility
- Selection of Individual
- Personality Fit
- Age Range

Definitions of these parameters presented a set of explanations that were considered to be important in identifying the characteristics of RSI in a lean job.

- **Adaptation**: Refer to changes by the operator in the lean job making it suitable for a new or special job application or situation.
- **Learning**: Involves the act, process, or experience of gaining knowledge or skill from the assigned lean job.
- **Flexibility**: An individual’s ability to withstand and change or modify the lean job
- **Selection of Individual**: A male or female worker regarded unique to suit the particular lean job
- **Personality Fit**: The psychological qualities and traits, of the worker e.g. character or behaviour, that are suited to the specific lean job
- **Age Range**: Refers to the length of time (years or months) of experience engaged on the same job.
The responses from the pilot study questionnaire presented some opportunity but not all for the operator and the organisation to explore the capability for change. However where lean manufacturing was central to company strategies some organisations gave the impression that they were allowing the operator to show discretion and for capability for change in their processes but these responses did not indicate whether the lean job was conducted in a strong or a weak lean working environment. From this the researcher felt the responses obtained from the pilot study were not sufficient in themselves to indicate that some discretion was allowed or enabled by the operators to make changes to their processes when they felt it was necessary to do so. Under this basis the researcher decided to develop a simulation by means of testing the six parameters from the pilot study to identify if these could allow the operator to show discretion or capability for change in their processes. This experiment was set up the researcher using a management game called the Buckingham Supply Chain Game.

The Buckingham Supply Chain Game was used to investigate the characteristics of a lean job. The game was chosen because it enabled the researcher to examine the movement and response of an operator under a controlled circumstance and it also enabled the researcher to change the settings and conditions of the operator's work situation to investigate this. It was also a preliminary to more extensive testing in the actual working circumstances. The Buckingham Supply Chain game was chosen because it is a well known lean simulation tool and it is easily adjustable. It also involves a considerable number of controlled movements of individuals within a working situation.

3.3 The Buckingham Supply Chain Game
The Buckingham Supply Chain game aims to illustrate lean manufacturing and Just in Time (JIT) concepts in a way which involves participants not only in learning through participation but also in decision making. The game was developed by John Bicheno (2001), in 1983 originally with Industrial Engineering students at the University of Witwatersrand Johannesburg South Africa, and subsequently extended at the University of Buckingham. The Buckingham Supply Chain game was developed for managers and operators at all levels. It has been extensively used and tested in industrial training settings.
The game was formerly known as “The Buckingham JIT Game” and was used in several countries, e.g. America and by companies e.g. Qantas Airways Limited, universities e.g. Monash University and consultants, e.g. Nestadt Consulting. The version used by the researcher is a revision from the previous one used at the University of Witwatersrand where John Bicheno incorporated his experiences whilst working on performance measurement. This game is a companion to the Lean Leap Logistics game which looks at supply chain issues.

The game takes approximately 4 hours, and is played using lego bricks with about 8-10 role-playing participants, the minimum being six players. The players make key decisions affecting performance after each of the 30-minute game rounds. The game involves the production and supply of multiple products using Lego and Duplo blocks with high variability demand. It encourages the team to progress from a traditional “push” big batch, slow response environment, with limited flexibility, to a lean, “pull” best practice environment, where techniques such as JIT Cell, Cross Docking, Synchro Manufacture, Quick Response, and other combinations are introduced and tested.

The researcher observed how the game was played by attending a simulation exercise at the University of Liverpool to examine how the game was conducted over a four hour period. During this time, the researcher noted which operations could simulate repeated movement of the hand and wrist by looking at each game participant closely.

The researcher pre-observed the press operator and the assembler during the first rounds of the game. In the second round the researcher stood behind the press operator to look at closely the movements carried out by the press operator. The press operator was targeted because all of his operations carried out the same repeated movement. In the third round the assembler was observed. The researcher stood behind the assembler and looked closely at his operations. His operations were repeated and also fixed.

Improvements to the operation of the game were made. The instructor decided which out of the eight changes were most beneficial from a list of eight possibilities provided with the game. The changes in terms of improvements made were aimed to obtain a smooth process flow of operations in a JIT environment. These changes were implemented on a gradual basis and included changing the scheduling pattern reducing the changeover times, from 30 seconds to 15 seconds for the press operator, by using a
stopwatch, rebalancing the line between the machine operator and the assembler by relaying out their stations closer to each other and repositioning their parts within their work area. Finally with all the changes made to improve the process flow a Just in Time (JIT) type environment was simulated at the end of the four hour period. To achieve the aims of the research, the researcher used the Buckingham Supply Chain game to investigate the characteristics of RSI within a lean job. The purpose of the game enabled the researcher to observe for repeated movements in their operation and to also observe the possibility for changes to operations by openly discussing participant suggestions for change.

3.3.1 Purpose
The rationale for the simulation was explained to a sample of postgraduate students by the researcher's project supervisor. The participants in the sample were briefed from the researcher's supervisor about the game, the learning experience and the benefit of the researcher's study. The participants were informed of a number of basic Just in Time (JIT) techniques, and the interaction of these techniques as a form of preparation prior to carrying out the simulation.

3.3.2 Equipment Set Up
The Buckingham Supply Chain game cards and stations were arranged by the researcher to carefully position the parts to obtain repetitive movements. The researcher identified which operations would create repeated movement of the hand and wrist from his visit to the University of Liverpool. The preparation for the simulation involved laying out the equipment of the game and arranging the tables in a form of a lean production layout. Each area of the room was arranged like small flexible cells with the game instruction cards clearly laid out ready to use on each table.

Each participant in the cell had a particular role to play, for example, a heat treater, machine operator, assembly operator, or a master production scheduler. These roles were explained by the game cards. Eight participants (five males and three females) were used for the simulation in total.
The layout of the game setup is shown in Fig 3.3.2

![Diagram](image)

**MPS: Master Production Schedule**

The layout used during the simulation

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### 3.4 Method of Simulation

The method used by the researcher by which RSI in a lean job could be identified in a strong or a weak situation was to simulate it through timing the hand and wrist movement with the use of a stopwatch. This measured how frequently the same repeated movement occurred with the hand and the wrist within the time the completed job task time. The parts were laid out by the researcher so that each lego brick used by the press operator and assembler would be carried out in exactly the same way within their operations each time a product colour was requested by the customer. The figure shown in 3.4. illustrates how this arrangement was set up by the researcher for the press operator and the assembler.

![Diagram](image)
The repeated movements for the press operator and the assembler involved picking up each coloured Lego brick, by the hand from its container, twist of the wrist to place it on to its colour base and then pressed down firmly. Each designated product colour was assembled using the same movement from the press operator.

![Red Product Colour Diagram](image)

Sequence followed by the press operator for a red product colour

The colour sequence for making the desired product was guided by the Master Production Schedule. The master production schedule controls the sequence in which the products are started by the press operator. This is the sequence of products to be started by the press operator. However if the first product colour demanded by customer is not listed on the master production schedule sheet, then the press operator continues to proceed with the other product colour until the one that had been requested at the beginning is available. The press operator pushes the product onto the assembler where the assembly operation adds all the necessary Lego blocks using the same repeated movement as the press operator before it is passed on to the station.

Each station has one operator working on a specific task situation. The task situation for each operator is fixed and each operation is followed by a set of instructions cards provided with the game. Each operator is fixed at their work station. Once each operator has completed their operation, the products are put into containers for transfer to another work station. The transfer of parts to each station is handled by an operator acting as an automated guided vehicle. This operator moves from one station to another...
delivering the parts to the next station. The stations are set 1.5 m apart to ensure close proximity, aimed at reducing the downtime in travel from one station to another for each operator. Once these parts are received the operator then proceeds with the required operations and then the parts are transferred through the system until it reaches despatch.

The stations shown in figure 3.4 were laid out in this configuration to obtain an overall better balanced line and also to observe clearly repeated hand and wrist movement. To obtain a better view, the researcher stood behind the operator workstation by looking closely at how he positioned his parts with his hand and wrist movement to identify the possibility of noting repeated hand and wrist movement. The researcher stood behind the press operator and the assembly workstations to pre-observe the movements before implementing a Kanban system for making a strong and a weak situation to characterise repeated hand wrist movement to identify levels of RSI risk.

### 3.5 Kanban Operation

To simulate a strong and a weak situation, a Kanban system was implemented because it is a disciplined repetitive system. The advantage for simulating this type of system enabled the researcher to identify if RSI could be characterised in a lean job by a strong or a weak situation through repeated patterns of work. Fig 3.5 illustrates the setup used for the kanban operation.

---

**Key:**
- KS = Kanban Store
- KSp = Kanban space (usually indicating the parts to be prepared by the colour on the kanban cards).
Chapter 3  Conceptualisation and Development of the Research problem

The game participants used to simulate the Kanban operation were students. When they were asked by the researcher if they had experienced a Kanban operation five students disagreed and the three remaining students admitted that they had a working knowledge of it and it was their first time carrying out a Kanban operation. This suggested the game participants used in the simulation were inexperienced and did not match actual employees in a real lean environment however they demonstrated the capability to understand the key working processes of using a Kanban system.

The Kanban operation starts when the signal is pulled from when the customer places an order. The product is directly loaded onto heat treatment. A Kanban space is created between assembly and the press operator. The signal is passed to assembly taking the product from the Kanban space between assembly and the press operator. A Kanban quantity of at least 2 different coloured products was used so that a disciplined repeated system could be operated. The next section describes the actual process being simulated by the researcher to characterise the lean job in a weak and strong situation using the Kanban operation.

Round 1: Weak Situation
Round 1 was implemented in an uncontrolled environment characterising a weak situation. In this case a store was implemented having a quantity of at least two bricks of different colours and placed in the areas where the researcher identified repetitive hand movements to take place from the pre-observation between the press operator and assembly.

The weak situation is created when an order is signalled by the customer. An order is placed requiring different quantities of different colours at once, e.g. red, blue and green. The operations are fulfilled by the press operator, assembler and the heat treater. The use of the weak situation means that the operator could change the sequence to show discretion or capability to change their job tasks in terms of the choices they make to complete the order signalled by the customer.

The researcher decided to have a larger Kanban quantity store with three colour coded colours of bricks to anticipate the order signalled by the customer. Each order was signalled every 1.30 seconds for a period of 10 minutes. The effect of making a larger
Kanban store encouraged uncertain patterns of repeated movement between assembly and heat treatment and between assembly and the press operator.

**Round 2: Strong Situation**

Round 2 was implemented in a strictly controlled environment to characterise a strong situation. In this case a kanban priority board was used to guide the press operator about how much of the products desired by the customer should be made. A Kanban store of only two colours was used, red and blue.

The researcher organised the time for the customer to order a blue or red colour brick from 1.30 seconds (in the weak situation) to 60 seconds, i.e. a customer demand every 60 seconds. Every 60 seconds a red or blue colour was announced. In some cases when the order was placed the researcher arranged the role of the customer to demand several quantities of the same colour e.g. a demand for 1 red, then the customer would demand 4 reds and 5 blues the next time an order is placed. Therefore the operator sequence of movements was strictly controlled and this provided frequent repeated pattern of movement on a regular basis. The set up and change over times to follow the demands set by the customer occurred every 15 seconds for the press operator, measured by a stopwatch. This signal also prompted other participants e.g. assembly, heat treatment, inspection, warehouse and despatch to respond to signal frequencies.

The researcher set up a uniform work pattern to respond to each order signalled by the customer. The researcher instructed the participants to conduct their roles in a more controlled manner, by following the kanban priority board and only when the customer was instructed by the researcher to demand only red or blue bricks, each participant carried out their required operations. During this period hand and wrist movements were being observed for a total of 3 minutes, before another order was placed.

Most repeated hand and wrist activity occurred between the press operator and assembly. The researcher discussed whether they would try new ways of completing the same task in the same situation or arrange their work patterns to suit their preferred ways of working. In many respects it was simply to determine if there were any opportunities to show discretion for change in a strong situation.
Round 3 The Lean Job Parameters

This round used the six parameters obtained from the pilot questionnaire study i.e. adaptation, learning, flexibility, selection of individual, personality fit, and age range. These parameters were used to measure if the responses obtained from the initial pilot study accurately identified the possibility of showing any discretion to change when there would be a potential RSI risk. In Fig 3.5 the same procedures and layout were followed for simulating the strong situation and the weak situation. Below describes how each parameter was implemented for simulating the strong and the weak situation using these parameters:

Adaptation
The aim was to observe how well or badly each participant could adapt to their new role. It was possible to observe how each participant adapted his or her role to carry out the build operations in the game.

Learning
The key for the researcher was to understand what each participant could do to improve their job task situation in terms of altering their sequence of movements by either reducing or eliminating repetitive actions from their new role in the game.

Flexibility
The intent was to understand each participant felt with his or her new task. This allowed the researcher to observe what each individual could do in the to increase their flexibility with their particular job.

Selection of Individual
The researcher gave freedom of choice to the game participants to choose which new role they would like to play. In this round, the roles of press operator, assembly and heat treatment were chosen by the female students and the other roles of warehouse, customer and despatch were chosen by the male students in the sample.

Personality Fit
The personality fit enable the researcher to note changes in character and body behaviour when work rates were increased for the game participants. This was made by
changing the demand patterns on a regular basis. Questions were asked by the researcher as a measure to identify if they thought they had any discretion or capability to change their work situation in their new role. The purpose was to see how this would affect their new job situation. The limitation of these questions could not accurately define the exact change in behaviour of the participant within a short term experiment, enough to identify if the operator could experience RSI.

1. Describe your job role?
2. Do you think that this job could lead to personal injury in a repetitive work environment?
3. Do you think that there are unnecessary movements taking place in this job?
4. Do you think the job can be better designed and carried out using standard operations?
5. How could you make this job better?
6. How do you think about these series of lean jobs in general?

Age Range
The given sample consisted of postgraduate students (male and female) and the ages were between twenty three and twenty six years across the sample.

In the weak situation, repeated twisted movement of the wrist and hand was observed. It was used to organise their job task situation in a way they found suitable to them, in particular these were the press operator, and the assembler e.g. for organising the layout of their equipment as part of their improvement in their working methods. In the strong situation there was more frequent repeated movement of the hand and wrist when the work rates increased resulting in a smaller reach distance within their operation.

3.6 The outcome of the simulation
Although the researcher felt the participants contributed well to making improvements to the layout of their operations the press operator and the assembler stated that repetitive movement occurred in their operations in a strong situation. Therefore the press operator and the assembler had the greatest amount of hand and wrist movement. During this period suggestions for improvements to their operations were put forward.
by the game participants especially the press operator and the assembler to build in ways in which they could develop a weak situation in their work process.

This suggested the press operator and the assembler had the greatest amount of repetitive hand movement within their operations. Therefore they adjusted their working patterns to show discretion to change their working situation. Warehouse, inspection and despatch recognised that controlling their method of working in their operations, would make improvements to their work processes by being more organised and identifying repetitive movement when their work rates increased. The repeated movements involved picking up each coloured Lego brick, by the hand from its container, twist of the wrist to place on to its colour base and then pressed firmly.

Each designated product colour was assembled using the same repeated movement. Once each repeated movement was complete by the press operator and the assembler, the researcher measured these repeated movements by using a stop watch. The measurements were timed for the press operator and then subsequently for the assembler in a strong situation, a weak situation and also with the lean job parameters in these two situations. The timings recorded are presented in Table 3.6.

Times measured for the press operator and assembler during strong and weak situations

<table>
<thead>
<tr>
<th>Situational Strength</th>
<th>Press Operator</th>
<th>Assembler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong situation</td>
<td>10 seconds</td>
<td>7 seconds</td>
</tr>
<tr>
<td>Weak Situation</td>
<td>14 seconds</td>
<td>11 seconds</td>
</tr>
<tr>
<td>Strong situation</td>
<td>8 seconds</td>
<td>6 seconds</td>
</tr>
<tr>
<td>with lean job parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak situation</td>
<td>13 seconds</td>
<td>10 seconds</td>
</tr>
<tr>
<td>with lean job parameters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.6

The outcome of the simulation suggested that the game participants used their job task situation in the weak situation to adapt to their preferred method of working showing control within their operations and discretion to change. The strong situation provided
all the game participants to become more methodical and organised in carrying out their operations because the strong situation was carried out in a more strictly controlled environment therefore not enabling them to learn and adapt to their task situation in the search of developing weaker situations. This resulted in some changes in character. The process of learning, adaptation and flexibility contributed to developing weaker situations (showing the discretion to change) whilst the selection of the individual and the age range created stronger situations in respect with the participants having different personalities which affected the strength of the situation.

The use of a Kanban system to characterise a weak and a strong situation, provided a good indication of how situational strength in a job task situation, could develop in a lean environment. It was felt by the researcher that the simulation could not identify if repeating patterns of work could be significant to identify levels of RSI risk within a strong or a weak situation. The simulation was used to obtain some visualisation of lean manufacture and it provided a good understanding how a lean job could be characterised under a strong and a weak situation.

The limitations of the game were such that it could not simulate the length of time an operator could experience RSI, the participants were students taking part in a short term experiment and they could not experience the company working culture in a real lean manufacturing environment to suggest if an RSI risk would be possible within a strong or a weak situation during the simulation.

The game participants suggested that when the situations were strong they would adjust their operations to develop weaker situations to have more discretion to reduce any repeated movement of the hand and wrist within their operations. However in a real lean environment the capability to show discretion by the operator would be also affected by other constraints other than the job task. To show how discretion could influence the change in the job for an operator in a strong and a weak situation a list of factors are considered in Table 3.6.1.
Factors affecting the ability to show discretion in job task change with situational strength

<table>
<thead>
<tr>
<th>Factors</th>
<th>Strong</th>
<th>Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle Time</td>
<td>Short Cycles / seconds</td>
<td>Long Cycles / minutes</td>
</tr>
<tr>
<td>Work Pacing</td>
<td>Repeated Movement</td>
<td>No Repeated Movement</td>
</tr>
<tr>
<td>Machine Pacing</td>
<td>Machine Paced</td>
<td>Operator Paced</td>
</tr>
<tr>
<td>Team Leader Decisions</td>
<td>Pro active</td>
<td>Reactive</td>
</tr>
<tr>
<td>Management Style</td>
<td>Authoritative</td>
<td>Flexible</td>
</tr>
<tr>
<td>Culture</td>
<td>Strong</td>
<td>Soft</td>
</tr>
</tbody>
</table>

Table 3.6.1

We assume the above factors at this stage each factor to show discretion to change the job task situation is governed by a standard work procedure carried out in a repetitive manner or controlled by the use of hand assisted tools built within the work processes.

3.7 The Conceptual Framework

Following the outcome of the simulation and applying the research of Cooper and Smith, (1985), Karasek and Theorell (1990), Parker and Wall (1998), Mullins and Cummings (1999), gave an insight into developing a conceptual framework. This conceptual framework was developed to identify if high or low levels of repeated patterns of work in a lean job in a strong or a weak situation could identify the level of RSI risk. The Lean Job Position Framework shown in Fig 3.7.1 posits the scenario where a lean job can be situated. The lean job is controlled by:

- The capability for change in a job in
- A Strong or a Weak Situation

The Capability for Change in Job Situation: in a job situation the capability for change is determined by the ability and motivation of the individual or operator for changing the job situation. The ability is knowledge and aptitude of the operator to enable him or her to change repeated forceful body movements and the motivation being the perceived drive or wish of the operator to make the change of repetitive
forceful body movements. Using these explanations the conceptual framework below was developed:

The level of RSI risk in the Lean Job
Capability to make changes in how the job is organised
(Ability and Motivation of Individual age)
(In organisation or by operator)

<table>
<thead>
<tr>
<th>Strength</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situational</td>
<td>Moderate Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>Weak</td>
<td>Moderate RSI</td>
<td>Low RSI</td>
</tr>
<tr>
<td>Strong</td>
<td>High RSI</td>
<td>Moderate RSI</td>
</tr>
</tbody>
</table>

The Conceptual Framework Fig 3.7.1

The assumption of this model is that RSI is affected by situational strength and the nature of the job in so far as there is capability for changes in the job by the individual or organisation requiring the job action.

From Figure 3.7.1 a list of conceptual propositions are derived from the framework:

- Low capability for changing the job in a strong situation will incur high potential risk for RSI.
- High capability for changing the job in a strong situation will incur moderate potential risk of RSI
- Low capability for changing the job in a weak situation will result in moderate potential risk of RSI
- High capability for changing the job in a weak situation will result in low potential risk of RSI

A third axis to the framework was also added. This axis represents the Repetitive Forceful Body Movements of the operator whereby the number of repeating movements of the upper body part (wrist, arm, fingers and shoulder) is considered within the work area of the operator, measured by the amount of force (N) and reach.
distance (m). These constructs together formulated a conceptual model to develop the research aim at this stage. The main axes for the model are presented in Figure 3.7.2.

**Main axes of the Model**

- Capability to make changes in how the job is organised
- Ability and Motivation of Individual (age) In the organisation or by the operator
- Repetitive Forceful Movements (N)

**Main axes of the Lean Job Position Model**

The Lean Job Position Model

**Figure 3.7.3** Illustrates the developed model from the conceptual framework

**The Lean Job Position Model**

- Capability to make changes in how the job is organised
- Ability and Motivation of Individual (age) In the organisation or by the operator
- Repetitive Forceful Movements (N)

**Key:**
- Left Face
- Right Face
- Front Face
- Bottom Face
- Rear Face
- Top Face
Figure 3.7.4 Illustrates the level of RSI risk for each area of the Lean Job Position Model.
3.8 Conceptual Definitions
Producing a conceptual model is incremental and is obviously shaped by the research agenda (Miles and Huberman, 1994). By theorising and using exploratory research the model has developed three areas framed into the conceptual model shown in (figure 3.7.3). These have focussed on: 1) capability of the operator or organisation to make the change in the level of RSI risk, 2) the capability (ability and motivation) of the operator or organisation to change the strength of the situation, 3) the organisational situational strength by considering other company influences shown in Table 3.6.1. The conceptual framework in figure 3.7.1 conveys this idea by defining it in terms of their constructs and has presented the first step of the constructs of the model, (Churchill, 1995). This is used as a basis for the development of operational definitions that will determine the data collected in the main study (Tull and Hawkins, 1993).

The formulation of the research hypotheses is based upon a number of beliefs the researcher has developed during the literature review in Chapter 2 and conceptualisation of the research problem. The basis for the conceptual framework now moves into the stage where the researcher formulates the following research hypotheses.

3.9 Research Hypotheses
Research questions produce theoretical assumptions which focus on the direction of the data collection. Formulating research questions follows the conceptualisation and modelling of the research area. In this study the research is descriptive in nature meaning it will only describe the extent of the association between variables (Green and Tull, 1978). This does not mean testing statistical hypotheses or establishing casual relationships but formulating research questions and research hypotheses. Hypotheses are educated guesses which have been designed to answer a research question at the outcome of empirical work (Tull and Hawkins, 1993). The hypothesis specifies in what context they shall be studied and what shall be studied and who shall be studied. The role of the hypothesis serves to:-

- Guide the direction of the study.
- Identify facts that are relevant and those that are not.
- Suggest which form of research design is likely to be most appropriate.
• Provide a framework for organising the conclusions to that result.

Good hypotheses are hypotheses that do not require techniques that are unavailable within the present state of the research art, explanation that defies physical or psychological laws and derivative or cannot be deduced for testing purposes. Below presents the main research question, as set of major hypotheses from the model and the main hypotheses for this research.

The Main Research Question:
Do Lean Jobs constitute high levels of work stress and as a result are they presently contributing to increasing numbers of RSI incidents?

3 main hypotheses are derived in support of the main research question:

The Lean Job Position Model:

<table>
<thead>
<tr>
<th>Factors contributing to the strength of the situation</th>
<th>Potential Level of RSI Risk</th>
<th>Ability and Motivation of the Operator (Age) years</th>
<th>Repetitive Forceful Body Movements (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group or organisational situational strength</td>
<td>Low</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>High group or organisational situational strength</td>
<td>High</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Low group or organisational situational strength</td>
<td>Low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Low group or organisational situational strength</td>
<td>Moderate</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>

Table of hypotheses derived from the Lean Job Position Model

The set of hypotheses below are derived from the model in Figure 3.7.3

Hypothesis 1
If the organisation or group situational strength is **high** the risk of RSI is:
- **Low** when the ability and motivation of the individual to change the situation is **high** with **low** repetitive forceful body movements
- **High** when the ability and motivation of the individual to change the situation is **low** with **high** repetitive forceful body movements

If the organisation or group situational strength is **low** the risk of RSI is:
- **Low** when the ability and motivation of the individual to change the situation is low with low repetitive forceful body movements
- **Moderate** when the ability and motivation of the individual to change the situation is high with high repetitive forceful body movements

**Hypothesis 2**
High organisational or group organisational strength has a positive correlation with RSI in a lean environment.

**Hypothesis 3**
Most people can adjust the lean job by modifying, strong and weak situations to reduce the level of RSI risk.

**3.10 Testing of the Hypotheses**
What does this mean with respect to the testing of the above hypotheses?

- We assume repeated patterns of work indicate very little decision making by the operator in a given situational strength.
- The discretion of the individual to make the decision and control the amount of repetitive work is relatively small.
- The capability to reduce the number of repeated patterns of work depends on the strength of the situation.
- The time frame for testing the hypotheses will require a minimum period of 3 months in an industrial setting that is lean manufacture orientated or adopts lean manufacturing techniques as part of their company strategy.
- The use of the model could identify how strong and weak situations are created.

The testing phase will also require the use of 2 sub-hypotheses to support the main hypotheses and the model. The sub-hypotheses below posit the following information relevant for the hypotheses and the model.
Sub Hypothesis 1
Most operators can (depending upon the situation strength) adapt the lean job to reduce the level of RSI risk
Objective: To identify if an operator can change a strong situation into a weak situation to suit his or her preferred way of achieving the same build target.
Research Action: Work shadowing with team leader, semi-structured interviews with Health and Safety, Occupational Health and the Auditor. The use of a questionnaire in a lean manufacturing setting with operators
Lean jobs are generally considered to be a complex set of tasks. It is perceived that lean jobs mostly involve repetitive movements and cannot be altered quickly.

Sub Hypothesis 2
Most operators can modify the situational strength to reduce the risk level of RSI
Objective: To understand the job capability of the operator for making a change in a strong or weak situation.
Research Action: Administration of a questionnaire in a lean manufacturing setting. A semi-structured interview with Health and Safety, Occupational Health and the Auditor and direct observation by the researcher
Theoretically it is thought that most operators can adjust themselves to suit their way of working. Modifying will involve changing the flow and layout of tasks in the process. However the capability of the operator to make this change under strong or weak situations may mean modifying some tasks to suit the repetitive work flow.

3.11 Summary
The simulation from the Buckingham Supply Chain game provided an insight into how a lean job could be affected by repeated patterns of work under the influence of a strong and a weak situation. The outcomes of the simulation presented an understanding of a relationship that could be created between the lean job situation and situational strength to identify, the level of RSI risk. The result of this has been through the development of a conceptual framework by which a model and a set of research hypotheses have been derived. The next chapter that follows describes the research process for conducting the research study.
Chapter 4
Methodology

This chapter begins by positioning the research in the context of its philosophical stance and links this to the research approach. The chosen methodological approach and its limitations taken by the researcher are described. Finally the research process is discusses how the research process is to be administered.

4.1 Philosophical Stance

There are philosophical problems associated with different approaches to management research. The theme for this research has been highlighted in the first two chapters, introduction and the literature review. The interest is concerned with identifying the level of RSI risk in high or low situation strength. At this stage it is perceived the task situation of the operator is defined by a set sequence of actions and movements on a repeated basis. It is assumed at this stage that the capability of the operator to make changes in how the job is organised when the level of RSI risk is identified may differ from one lean job to another therefore suggesting that the level of ability and motivation by each operator may vary in a low or a high situational strength.

From a philosophical standpoint social sciences can be paralleled with natural sciences together allowing them to predict and control social interactions by adopting positivist approaches. However many researchers suggest by paralleling social and natural sciences together to make such positivist inferences feel that these fit within the "common sense" of the world and that it is rooted within the western culture (Johnson & Duberley 2000).

The epistemological and ontological debate influences what is seen as truth or valid research findings. Realist ontology and positivist epistemology theories can be proved or disapproved by comparing them with facts which can be impartially obtained by employing a correspondence theory of truth. The consensus theory of truth tells us theories are suggested according to their fit with the established paradigm, (a view taken within a particular group or community). If reality is externally independent, our version of reality is created within our own paradigm and therefore cannot be mutual.
Results emerging from one particular paradigm are likely to be meaningless in another because the whole frame of reference is different. Burrell and Morgan's views believed different paradigms could co-exist (Johnson and Duberley 2000). Whilst Kuhn argued that only one paradigm was dominant at any one time.

Researchers in positivist's traditions judge their own methodology for the bias and influences of their own ability, within the community they operate in, but fail to focus on what is or what changes and actions should take place in the future. Yet this reflects the traditional positivist view that researchers are independent of what is being researched and its science proceeds through a process of hypothesising fundamental laws that are operationalised, which enable facts to be measured quantitatively and demonstrate its truth or falsity by using samples of sufficient sizes that are generalised.

It is possible to constitute our understanding of reality and explain a phenomenon, rather than search for external sources or fundamental laws (Easterby-Smith, 1991; Remenyi et al., 1998). Even though knowledge is socially constructed it is bordered by the real world, meaning the truth can only be considered real if it actually helps people within their own frame of reference without empirically testing theory against reality. There are a number of paradigms that are similarly expressed as the constructivist approach, e.g. non-traditional, descriptive, naturalistic and interpretivist. The assumptions which emerge from this position are explained below:

- The researcher himself, conducting the study plays an interactive and active role in the development of understanding, which is context specific and not generalisable to larger populations.
- Truth is a matter of consensus among informed constructors and not in correspondence with an objective reality;
- Perspectives on a lean job role and its capability for change in the job situation identifying the level of RSI risk characterised either by a strong or weak situation, may therefore vary widely between individuals. A true reality can be constructed by those involved in this role;
• The proposition that reality is continually being constructed and continually being influenced by the values and motivation of those involved, there is very little opportunity to determine a link between its cause and effect;

• The specific questions asked by this researcher will influence the context of how they are discussed and the way relationships are presented. Its outcome will be a result of the interaction between the meanings judged by the researcher and the meanings contributed by the participant.

Equally "there is no single qualitative method; different aims will be accomplished by different interpretative approaches" (Bannister et al; 1994). Even though the reality of a constructivist approach is multiple, holistic and constructed, the criteria for assessing qualitative research is less established than that of quantitative research.

The philosophical position outlined in this research, the research question seeks to test the hypotheses developed in (Chapter 3) for a detailed understanding of identifying RSI under strong and weak organisational situational strength. Therefore detailed in-depth data in this research context is mainly qualitative, and context specific that is situated in the constructivist paradigm.

Pidgeon and Henwood (1997) argue the underlying assumptions of positivist and constructivist epistemologies are distinctly different. This school of thought encourages methodological pluralism because each methodology cannot be seen as superior or complete to one and another therefore methodologies can permit different aspects of a situation to be explored in a different way. The major strengths and limitations between the two epistemologies are compared in Table 4.1 overleaf.
Table 4.1 Comparison of its strengths and weaknesses of quantitative and qualitative approach (used from Amaratunga, Baldry, Sarshar and Newton, 2002)

<table>
<thead>
<tr>
<th>Theme</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positivist</strong></td>
<td>Provide a wide coverage of the range of situations.</td>
<td>Ineffective in understanding processes or the significance people attach to actions.</td>
</tr>
<tr>
<td>Quantitative Paradigm</td>
<td>Fast and Economical Statistics are aggregated from large samples.</td>
<td>They are not very helpful in generating theories.</td>
</tr>
<tr>
<td></td>
<td>They may be of considerable relevance to policy decisions.</td>
<td>Because they focus on what is or what has been recently, they make it hard for policy makers to infer what changes and actions should take place in the future</td>
</tr>
<tr>
<td><strong>Phenomenological</strong></td>
<td>Data gathering methods seen as more natural than artificial.</td>
<td>Data collection can be tedious and require more resources.</td>
</tr>
<tr>
<td>Qualitative Paradigm</td>
<td>Ability to look at change processes over time</td>
<td>Analysis and interpretation of data may be more difficult.</td>
</tr>
<tr>
<td></td>
<td>Ability to understand people's meaning</td>
<td>Harder to control the pace, progress and end points of research process</td>
</tr>
<tr>
<td></td>
<td>Ability to adjust to new issues and ideas as they emerge</td>
<td>Policy makers may give low credibility to results from qualitative approach</td>
</tr>
<tr>
<td></td>
<td>Contribute to theory generation.</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Decisions between Qualitative and Quantitative Methods

The uses of qualitative or quantitative techniques are often discussed as methods of data collection. In general, qualitative researchers prefer narratives and accounts of the way they interpret the world, whereas quantitative researchers use mathematical models and statistical tables to relate research in impersonal terms, (Denzel & Lincoln, 1994).

Qualitative techniques typically require answers to research questions in a specific way. Richards and Richards (1994) perceive four constraints which outline the use of qualitative techniques; 1) the volume of data, 2) complexity of analysis, 3) flexibility and momentum of analysis, 4) details of classification record.
Qualitative methods are often of a considerable depth, and allow probing different lines of inquiry; but because of their lack of rigour and objectivity they are not particularly wide-ranged in terms of sample sizes (Mutchnik & Berg, 1996).

Quantitative approaches allow for a wide range of data to be collected from a large number of sources (Mutchnik & Berg, 1996) following different lines of inquiry. The data can be assimilated and collected easily with minimum bias which does not require the researcher to go through layers of processing between collection and analysis. However this is critical because the essential element of research is ignored and can be distant from the subject of the research.

The intent is to search for depth of meaning that may well be context specific to the research problem. As discussed, quantitative research is pre-disposed to the measurement of variables, its identification of causal links and generalisability of results, whereas qualitative focuses on contextualisation, complexity and generating theory. The research is suited to qualitative methods of inquiry which is indeed appropriate for answering the research problem.

To summarise, the following table below outlines at both levels the two contrasting modes of inquiry. Table 4.2 Quantitative and Qualitative modes of inquiry (adapted from Glesne and Peshkin 1992 and from Amaratunga, Baldry, Sarshar and Newton, 2002).

<table>
<thead>
<tr>
<th></th>
<th>Qualitative Constructivist</th>
<th>Quantitative Positivist</th>
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<tbody>
<tr>
<td><strong>Basic Beliefs</strong></td>
<td>Reality is socially</td>
<td>The world is external</td>
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<td></td>
<td>constructed</td>
<td>and objective</td>
</tr>
<tr>
<td></td>
<td>Focus on meanings and</td>
<td>Observer is independent</td>
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<tr>
<td></td>
<td>substance</td>
<td>The focus is on facts</td>
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<td></td>
<td>Emic (insider perspective</td>
<td>Etic (outside perspective)</td>
</tr>
<tr>
<td><strong>Research Agenda</strong></td>
<td>Interpretation</td>
<td>Prediction of trends</td>
</tr>
<tr>
<td></td>
<td>Understanding</td>
<td>Casual explanations</td>
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<td></td>
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<tr>
<td><strong>Research Approach</strong></td>
<td>Pursues Pluralism</td>
<td>Seeks consensus to the</td>
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<td></td>
<td>The use of qualitative</td>
<td>normal</td>
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<td></td>
<td>data</td>
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<td></td>
<td>Naturalistic settings</td>
<td>The use of quantitative</td>
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<td></td>
<td>Manipulation and control</td>
<td>data</td>
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<tr>
<td><strong>Researchers Stance</strong></td>
<td>Personal involvement</td>
<td>Experimentation</td>
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<td></td>
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<td>Emergence and portrayal</td>
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<td>Detached and impartial</td>
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</table>
Although the above table provides these two modes of inquiry independently of each other, it is still valid to suggest that they can be used interchangeably. It is argued these two approaches may be side-by-side informing one and another and the suitability of any particular approach should be indicated by the nature of the research question, (Mutchnik & Berg, 1996). Although table 4.2 addresses the main characteristics of qualitative and quantitative research the case for choosing qualitative data collection method is further strengthened by the works of Miles and Huberman (1994). The researcher is now in a valid position to argue why this method is applicable for this research. Its strengths are explained below:

- Confidence in the data is boosted through local groundedness, the fact that the data is collected in close proximity to a specific situation
- Qualitative data is rich and holistic and has a strong potential for revealing complexity
- It is fundamentally well suited for locating the meanings people place on events and for connecting these meanings to the social world around them
- It focuses on naturally occurring, ordinary events in natural settings so that we can understand what “real-life” is like
- The possibility for underlying or non-obvious issues is strong
- In essence qualitative data provides “thick descriptions that are vivid, nested in a real context, and have a ring of truth that has strong impact on the reader.”

In this research aspect the researcher is disadvantaged by the lack of control he has over the research context. The pressures of the business to establish a causal link between its events and its impact it has on its company performance is one limited characteristic of organisational research. The nearest he is able to achieve this is to understand the limitations of the environment he is set in and to have a realistic view of what is required in this research.

It is required from him to identify using qualitative data collection methods to identify the level of RSI risk of an operator when the group or organisational situational strength is strong or weak to show the discretion or capability to make changes in how the job is organised, with the information being recorded in support of answering the research question.
4.3 Research Design
Robson (1994) identifies three types of research enquiry. These are defined as descriptive, exploratory or causal, (Churchill, 1995; Green and Tull, 1978). Each form of inquiry is connected on the premises of the existing research area. The strategy for choosing a research design is dictated by the researcher's understanding of the research (Robson, 1994).

4.3.1 Exploratory Research
Exploratory research is similar to descriptive research. Both designs can sometimes be used interchangeably although they are not entirely the same (Mutchnik & Berg, 1996). The purpose of this design allows the researcher to conduct research on a phenomenon to seek new insights and ask questions about what can be uncovered about a group or population (Mutchnik & Berg, 1996).

4.3.2 Causal Research
Causal (or explanatory) research designs are very different to exploratory (or descriptive) designs. Hypotheses are applied to guide the research to identify a cause and effect relationship (Churchill 1995). It is used to guide the research by predicting under what conditions a particular event may occur. This is summarized by using deterministic causation (an item as a function of another) or probabilistic causation (assuming a generalised relationship from a known number of variables to determine a further variable) (Green and Tull, 1978). In contrast to exploratory research casual research questions are closed and require numbers as data to solve whereas descriptive research questions are open and require words as data to answer (Perry, 1996).

4.3.3 Descriptive Research
Descriptive research involves observation and description of variables as they are distributed throughout a population (Crowl, 1993). Generally, a descriptive research design may be used in either a qualitative or quantitative manner. Like causal research descriptive research can also be guided by hypotheses. Because these are descriptive by nature hypothesising what sort of trends are expected they differ in the research findings. These trends may be used to infer possible relationships between variables.
and derive hypotheses that can be tested in a casual way. Descriptive research focuses on gaining participants understandings of their environments, involvements, and experiences typically collecting data by interviewing group members and making sense of how they experience the group process. Information is used to provide a description of the situation for example by capturing how frequently events occur (Churchill, 1995).

4.4 Research Design Strategy

The design strategy in this research lies in the desire to create a new working process model that can be applicable to industry. This does not depend on the assumptions of existing knowledge in the real world. It relies on selecting the most appropriate research design. The initial stages of this research focussed upon developing research hypotheses, therefore making an exploratory design appropriate for grounding this research (Churchill, 1995).

The main study aims to answer the research question for which an exploratory or a causal design was not suited. Eliminating these designs led to a descriptive research design where a cross section study or a pilot study for a descriptive research design (Churchill, 1995), was given. A pilot study questionnaire (Chapter 3) was selected to provide a snapshot of variables at one point in time. A longitudinal study proved to be unclear where the immediate results or risk of errors could emerge therefore making it time consuming over a period of time.

4.5. Application of Chosen Data Collection Methods

4.5.1 Interviews

Interviews are widely used in case studies because they are highly flexible as a research method and capable of producing rich data about phenomena under investigation. A key feature of qualitative research interview method is the nature of the relationship between the interviewer and the interviewee (King, 1994). The type of interview influences the interviewee response (Yin, 1984). Yin (1984) presents three types of interviews; focused open-ended, and survey. Focused interviews are semi-structured in nature where the interviewer concentrates on a set of questions related to the subject area of interest. They also have a disadvantage related to the
time constraint with the interview. Open-ended questions are unstructured where the discussions are spontaneous and the data are wide in scope ranging from facts, opinions and insights not giving a clear concise answer to the questions. Survey interviews are structured where the questions are mostly closed and require answers to be plotted on a scale devised by the researcher. These were all taped by the author and the interviewer records and the interviewee respond by filling in a questionnaire.

There are advantages and disadvantages associated with each of these methods of interviewing, however some of them are common to all methods of interviewing. The real strength of the qualitative research interview method is its suitability for exploring meanings that the interviewee attaches to concepts and phenomena under investigation (King, 1994). The flexibility of the interview allows the researcher to focus on specific issues of this research study, for example, how the strength of a situation can affect the level of risk of RSI but as well on broader issues such as the levels of repetitivity in each lean job in the process. This can save time and also provide leads that can be pursued if necessary. Another advantage of the qualitative research interview is that it is commonly accepted by most research participants (King 1994).

A main disadvantage experienced by the researcher is its time consumption spent not only during data collection but also during data analysis. The researcher must be constantly aware of the importance of balancing the necessary issues of the research study but at the same time be open to new opportunities, which can lead to new possibilities in the data collection phase of the research.

The problem of poor recall or inaccurate description of the interview based on memory alone can be “subjects of poor bias, poor recall, or poor articulation” (Yin 1984). This issue can be addressed by taping the interviews. This allows the researcher to concentrate on listening and observing the interviewee. This permits the researcher to reflect on what is being said by the respondent and this can be an invaluable source when certain information needs to be verified, clarified or further explained. The problem of bias can be solved by triangulating the interview data with other relevant data using other research methods of data collection. The practical reason for choosing semi-structured interviews as one of the research methods was to
make best use of the time available with the personnel involved in the research study. Unstructured interviews and structured interviews were eliminated because of time and resource constraints with the present research. The remainder of interviewing methods available, semi structured interview was chosen as the most appropriate interviewing method for the following circumstances:

1. The interview situation enables the researcher to build up a relationship with the participants in order encourage a more open discussion and exploration of issues that may not be discussed in front of others, or would not be noted on a questionnaire.
2. This type of interview would ensure that the same areas could be addressed across all respondents and it would enable the researcher to make “consistency checks” and explore the interview data more deeply.
3. It was felt that this would be a suitable mechanism to encourage flexibility allowing the respondents to introduce new insights and explore complex relationships between the interview data.
4. Group discussions or focus would generate a set of dynamics such as group thinking thus influencing the data produced in ways that would not be easily identified.
5. It was much more convenient to take the personnel away from their work for consecutive periods of time rather than groups of people concurrently. The researcher made every effort to ensure the interview dates coincided with the organisational schedules.
6. Finally using this form of interview enabled the researcher to give his complete attention to the study by not encouraging any distractions from the research process and the content of its output.

Semi-structured interviewing was considered as the most appropriate method for discovering new meanings, to develop new insights in the research study.

4.5.2. Use of Direct Observation

In the context of this research “Direct observation, when added to other research yielding depth and /or breadth enhances consistency and validity (Adler and Adler 1994). Direct observation can help to build a rich picture and can get a feel for their job and how they do it. “What people say is often very different from what people do”
(Hodder, 1994). By directly observing the operators, managers and health and safety the researcher can observe how this is reflected in their actions.

The advantage of this is that it “enables the researcher to understand new dimensions, to probe and be systematic” (Mintzberg, 1973). This allows the researcher to observe reality in terms of the interrelationships, their significance, and meanings. As a research method it is easy to use and “when employed as part of a methodological spectrum that includes member-articulated data gathering strategies such as in depth interviewing or participant observation, it is the most powerful source of validation” (Adler and Adler, 1994).

Direct observation can be time consuming. Mintzberg (1973) identified five problems with the use of direct observation. These problems concern the researcher being excluded from certain meetings, missing out an hour’s work, researcher’s inability to follow all of the simultaneous running activities in the organisation, problems of coding, and finally the effect of the researcher’s presence on the data.

The researcher must be aware of these problems during data collection. However using direct observation to record events as it occurs would not be possible through document research or interviews, or in particular, data related with the interaction of others. Direct observation is used to support data obtained from semi-structured interviews and questionnaires which serves as a prerequisite for selecting direct observation in the data collection process.

4.5.3 Use of Questionnaires
The use of the questionnaire in the fieldwork aims to support accurate data collection from the respondent and record the data collected to aid the analysis and processing of the data (Hague 1992). Questionnaires are a widely used form of capturing large amounts of information, in a short space of contact time, structuring the data collection process (Frey and Mertins Oishi, 1995), however much administration and questionnaire design must be involved if the successful outcome is to be effective and relevant to the research (Tull and Hawkins, 1993).
Although the ordering of the sections in some cases is arbitrary these are iterative and interrelated (Churchill, 1995). The type of questionnaire and the method of administering it are interrelated (Churchill, 1995). These require the researcher to specify what information is being sought during the data collection and analysis process (Churchill, 1995).

The information required for data collection and analysis was determined by the research hypotheses and the main research question in Chapter 3. The questionnaire was considered in the researcher's mind to be most appropriate because of its versatility. Different types of data can be represented in a relatively short time in a compressed format making it easier to enter data for analysis and in the latter stages for presentations and discussions.

### 4.6 Process of Data Analysis

The process of data analysis is to make meaning from the collected data. The search for their meanings can take place in many forms (Churchill 1996). The process of analysing the data in this research is followed by Miles and Huberman (1994) where they describe the generic processes of data analysis clearly to be defined by “three linked sub processes”:

- Data reduction
- Data display
- Conclusion, drawing and verification

#### 4.6.1 Data reduction

Data reduction refers to the process of selecting, focussing simplifying, abstracting and transforming the data that appear in written field notes or transcripts (Miles and Huberman, 1994). It is a form of analysis that sorts, focuses, and organises data in a way that “final” conclusions can be drawn and verified. The data reduction and transforming process continues after the fieldwork and until the final report is completed (Miles and Huberman, 1994).

The use of qualitative research data analysis research software “QSR NUD.IST 4 (Non-numerical Unstructured Data Indexing, Searching and Theory-building)” was
also considered as part of data reduction. The software is widely used in analysis projects that involve complex and large amounts of unstructured data, for example from interviews. The data is usually reduced into single text lines thereby creating nodes for a network of constructs that finally develops an index system. This method of analysis is time consuming and demands much effort from the researcher to become efficient before it can be used to suit the purpose of the research. The decision to reject this method of analysis was two fold; firstly the initial coding entry of data for this research could be done faster than by computer and secondly one could lose sight of the meanings and themes in reducing the data into single lines.

4.6.2 Data display
The objective is to present the research data in an organised form so that the reader can follow the interpretation of the data. In designing displays the researcher decides the format and the content of the display. The creation of the display is part of the data analysis (Miles and Huberman, 1994). The intention of displaying the data is to demonstrate an understanding “through summarising detailed notes about themes, selecting illustrative quotes and producing a coherent story of the findings” (King, 1998). To use direct quotes from the participants to provide an account of the rich data gathered during the fieldwork. Using direct quotes from the participants, the intention is to make the process of verifying conclusions as transparent as possible. This is discussed in the next section.

4.6.3 Drawing and verifying conclusions
According to Stake (1995) the researcher arrives at new meanings about cases “through direct interpretation of the individual instance and through the aggregation of instances until something can be said about them as class.” Thirteen are identified by Miles and Huberman (1994) and five out of the thirteen strategies were seen as appropriate to use in this research study. Each one is discussed in terms of the research study below.

- Noting and seeing patterns
- Clustering
- Making contrasts/comparisons
- Building logical chain of evidence
• Making conceptual/ theoretical coherence

Noting and seeing patterns
In this research one is searching for patterns in direct observations questionnaires and semi structured interviews by coding the data collected and finding patterns. “The search for meaning often is a search for patterns for consistency, for consistency within certain conditions” (Stake, 1995).

Clustering
This tactic is found to be applied at many levels. This research study requires the need to cluster specific information from questionnaires, direct observations and semi structured interviews. At this level “clustering” the information leads to a better understanding of the internal ability and motivation of the individual to reduce the potential risk of RSI in high or low situation strength by grouping and conceptualising objects that have similar patterns and characteristics (Miles and Huberman, 1994).

Making contrasts and comparisons
The intention is to compare and contrast the research findings in the field with what the literature suggests about situational strength and the risk level of RSI.

Building a logical chain of evidence
This is treated at the conceptual level of the research problem. Each link of the logical chain is essential which leads to the next logical step.

Making conceptual/ theoretical coherence
At this stage of the research the results begin to emerge from the research question related with the concepts of the research findings. “We need to tie the findings of our study to become overarching, across more than one study propositions that can account for ‘how’ and ‘why’ of the phenomena under study” (Miles and Huberman, 1994). Miles and Huberman (1994) propose thirteen tactics for verification. The most coherent and relevant for verifying drawn conclusions in this research are discussed.
Three methods of verification and their features are discussed in terms of this research study:

1. Checking for the researcher effect
2. Triangulation
3. Getting feedback from informants

Checking for the researcher effect
To reduce the effects of bias from the case study the researcher will keep a record of his feelings during the research period and speak to other people in the organisation. The intention is to brief these participants involved about the aims and objectives of the research, what is expected from them and be sensitive to their needs and demands at all times wherever possible.

Triangulation
This term is often used with analysis and confirmation issues with multiple meanings. Methodological triangulation (Denzin 1989) aims to strengthen the research by using combination of multiple research resources that ensures the variances are related to the treatment and not with the measures. Therefore triangulating semi structured interviews, questionnaires and direct observations ensures that the same meanings are generated.

Getting feedback from informants
"One of the most logical sources of corroboration is the people you have talked with and watched", (Miles and Huberman, 1994). It is believed the people contributing in this research know their jobs and surroundings intimately and will therefore enable the researcher to obtain feedback to verify the outcome of the research findings.

4.7 Soft System Analysis
Soft systems analysis (SSA) was developed by Peter Checkland 1969 and is used primarily for investigating problems located within a system. The method is used to plan and implement change as a practical tool for use on complex systems involving human activity (Checkland, 1981 Scholes, 1990). It is an organized series of relatively well structured stages through which a soft systems approach is taken for examining and understanding the behaviour of complex entities. These complex entities form
part of a system that is composed of parts or elements which themselves are interrelated and interconnected as a whole. The assumption of this analogy is that people see the world in different ways i.e. people's differences reflect the nature of reality holding different interpretations of the world thereby being part of the situation. The situation is typically a human complex activity system.

Soft systems analysis can be applied in different ways. A number of essential characteristics are incorporated in various stages which fall into these seven categories:

1. Participation by the actors in the system.
2. Structure and organisation of the process
3. Imagination and innovation
4. Analysis and logic
5. Comparison of model with the rich picture
6. Agenda debated amongst the players or actors
7. Implement agreed changes.

Stage 1
This involves an initial examination of the problem situation under analysis. During this stage the scope of the system is reviewed and the analyst (researcher) decides upon methods for collecting data and the key roles that plays a part in the problem situation.

Stage 2
This entails gathering a wide range of relevant data which represents "a rich picture" of the problem situation. This can take a variety of forms including interviews, observations and questionnaires, for this research the data collection methods have been direct observations, semi structured interviews and questionnaires. The rich picture of the problem situation includes data on issues that people raise (e.g. education and training issues). However at this stage the analyst refrains from creating an explanatory model of the problem situation as the rich picture at this stage does represent a systemic representation of the problem domain or characterise the problem type.
Stage 3
The analyst (researcher) pursues new ways of tackling the existing problem situation as being “Relevant Systems” The relevant system can be either task based or issued based. For the purpose of this research problem the situation is task based. Then the function of each relevant system is to develop a root definition for each relevant system investigated. The root definition is seen as a precise verbal description of what is implied by the choice of the relevant system. However the root definition and its constituent parts defined by the CATWOE process on (pg 186) vary according to the chosen relevant system. The output of stage 3 is a selected relevant system with the associated root definition for that system.

Stage 4
The analyst (researcher) develops a model which uses deductive logic and is abstract. Naughton (1984) provides advice about this type of model and states that 6-12 activities that are listed should be simple rather than complex. The key point at this stage is concerned with what is done and not “how something is done” or “who does it”.

Stages 3 and 4 are used concurrently with each other whereby if the relevant system has changed then the root definition and the conceptual model must change. At this level much iteration between these two stages is expected because the analyst (researcher) tries out different relevant systems to verify if the definitions agree with the conceptual model.

Stage 5
This stage involves a comparison between the new conceptual model in (stage 4) and the rich picture developed in (stage 2). This comparison identifies parts of the conceptual model that do not fit in the real world or items that occur in the real world but are not part of the conceptual model. This stage can be handled in an unstructured way where a comparison of the conceptual model and the real world are made or in a structured way and each part of the conceptual model is examined. The intention is to ensure that the conceptual model built for the research data analysis is examined in a structured way where each of the constructs of the conceptual model are compared against the rich picture developed in stage 2. The output of stage 5 is a possible
agenda of changes of a series of topics for discussion which reflects on "what" rather than "how" the conceptual model is developed from the rich picture (stage 2).

Stage 6
The objective of this stage is to identify changes that are agreed on a systematic level and that are culturally feasible. A change can be implemented when both of these criteria are met. If a change cannot be met then another relevant system is developed to incorporate the desired changes. The outcome of stage 6 is based upon an agreed set of changes or agreement not to change.

Stage 7
Is the implementation where the changes have both been agreed as both feasible and desirable. The changes could include new structures procedures polices or processes.

Stages of Soft Systems analysis: Stages 1,2,5,6 and 7 real world activities, stages 3 and 4 are conceptual activities (in Cassell & Symon 1998) shown in figure 4.7

Strengths and Weaknesses of Soft System Analysis
The main reasons for rejecting other methods of analysis and deciding upon soft system analysis are four fold:

1. This method is broadly participative and encourages different views and perspectives of differing people to the problem situation i.e. the research problem
2. This method provides structure and organisation to the process of examining complex systems involving human activity (i.e. the capability to change repeating patterns of work within strong and weak situations). This structure is helpful to all actors in the process, (researcher) and offers a set of consistent rules which are not limited in the way they can be applied in this case the research problem or in most other cases the real life problem situation.
3. Its main strength lies in its ability to allow the researcher to view the problem situation (research study) from another perspective therefore providing other alternative solutions.

4. Its flexibility allows methodological rigour for the researcher to view the particular research problem with a set discipline of stages that involve not only the researcher but other actors in the analysis of implementation and change.

There are three main limitations using soft system analysis:

1. The understanding of “language” and “terminology”. The constructs presented in this analysis such as ‘rich pictures’ ‘relevant systems’ ‘root definitions’ and ‘conceptual models’ are not easy to convey to other members of the problem situation. Although this is presented as one of three weaknesses the researcher has taken this point into consideration prior to analysing the research data.

2. This method is conservative in the results it aims to present. Change can be made only when agreements are made however in some cases change may
not be implemented if both system desirability and cultural feasibility are not agreed upon by senior management or stakeholders of the organisation.

3. Implementing change is its main final focus however very little is being described about the ‘nature’ of the changes taking place and how the changes will take effect in the problem situation.

The reasons for favouring soft system analysis have been because of its usefulness and organised series of iterative stages. It is a method of analysing data well suited with action research. It helps to incorporate different forms of data from different sources (i.e. direct observation, questionnaire and semi structured interviews) by providing means for analysis and understanding problems in complex situations with the use of building a ‘rich picture’ of RSI and developing a conceptual model of strong and weak situations in terms of the capability of the operator to change the job situation.

4.8 Research Method

A critique of traditional science has been to assume the researcher maintaining a distance from the study thereby producing objective results. However Flick (1998) states “despite all the methodological controls, the research and its findings are unavoidably influenced by the interests and the social and cultural background of those involved”, meaning the findings from the research is a product between the researcher and the participants contributing to the research as well as developing interpretations from the research question and its hypotheses.

In section 4.2 the researcher selected the use of qualitative inquiry. It was subsequently realised that a choice had to be made by the researcher about his level of participation for the data collection phase. There were a number of issues to consider, in deciding to act as a passive or an active researcher. The issues entailed a review of this research area was presented in the literature review with the purpose of obtaining an understanding of the area. Secondly the literature review presented some preconceptions but not all about the nature of RSI and its relationship with organisational situational strength. Thirdly it was felt these preconceptions would be vital in the understanding and the belief that the literature review was not sufficient enough in itself to provide a contextual understanding of the research problem,
therefore action research was chosen as the most suited process for carrying out the research investigation.

4.9 Action Research (AR)
Many authors broadly define Action Research, (Foster, 1972; Susman and Evered, 1978; Peters and Robinson, 1984; Argyris et al., 1985; Whyte, 1991; Aguinis, 1993; Coghlan, 1994; Baskerville and Wood-Harper, 1996; Eden and Huxman, 1996; Checkland and Holwell, 1998; Greenwood and Levin, 1998; Gummerson, 2000; McDonaugh and Coghlan, 2001) as:

- Research in action, rather than research about action
- Participative;
- Concurrent with action;
- A sequence of events and an approach to problem solving

(Coughlan, and Coghlan, 2002)

“Committed to the production of knowledge through the seeking of solutions or improvements to “real-life practical problem situations” (Elden and Chrisholm 1993; Shanks et al., 1993), “to ameliorate a situation perceived as problematic should form part for developing, testing and refining theories about aspects of the particular problem” (Avison, 1993; Susman and Evered, 1978).

Action research addresses issues that focus both at solving social and organisational problems by being participative. Members of the system being studied become actively involved in the cyclic process by being concurrent with the action in a sequence that is effective while simultaneously building a body of scientific knowledge. The sequences of events comprise iterative cycles of gathering data from the researcher and to those of concern for analysis and for subsequently planning, and taking action.

Its desired outcome is an application of scientific method requiring action from members of the organisational system and researcher to find solutions to immediate problems through fact findings and experimentation. These are intended to contribute to scientific knowledge and theory.
Action research has often been criticised for its lack of systematic methods (Robson 1994). Critics of action research suggest that when interventions are deemed successful some would argue that causal connections and explanations cannot be successfully made (Baskerville and Wood Harper, 1996). Researchers are questioned over a perceived lack of impartiality and bias (Avison and Wood-Harper, 1991). The supposed lack of scientific rigour and discipline, the lack of validity of data (Baskerville and Wood Harper, 1996) and the difficulty of generalising results have lead to it being in academic circles which evaluate research according to scientific criteria (Avison and Wood-Harper, 1991).

In contrast to these critiques action research compared to other intervention techniques are often isolated by means of their implementation in the research study showing how a standard approach can be adjusted to suit a specific setting. However much of its implementation is questioned over the set backs the researcher experiences prior to its application, the amount of context or description of the implementation approach and its comparisons with other reported situations.

The philosophical assumption underlying action research is not to test theories or preconceptions made from the literature review but obtain a contextual understanding of interaction via a steady process between the researcher and the researched. There is a sense in which the action researcher is viewed as a key participant in the research process (Checkland, 1991; Hult and Lennung, 1980) immersed in the setting in contrast to findings from positivist approaches which are validated by logic, measurement and the consistency of prediction and control allowing for lack of involvement from the research situation (Coughlan, and Coghlan; 2002). Although this is not only the focal point of the study but its members should be ready to apply the outcome of its findings within the organisational setting.

Robson (1994) cites the work of Rapoport (1970) in action research by saying it “aims to contribute both to the practical concerns of the people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable framework”.

This scientific definition:

- Emphasises the importance of both scientific contributions and the solving of practical, real-life problems.
- Assumes the researcher needs contact and interaction with clients to really know their problems and influencing factors.
- Focuses on the common values and standard of researchers and clients.

(Gronhaug & Olson, 1999)

Gummersson (2000) lists ten positive characteristics of action research, five of which are considered with this research study:

* **AR includes all types of data gathering methods:** - Surveys and interviews are commonly used but AR does not prevent the use of other data collection methods. Data collection tools such as surveys and interviews can generate data by measuring feelings, content or hostility. However the data can be significant in this case if the researcher focuses primarily on collecting the data and does not direct his or her attention to detail.

* **Action research requires a breadth of pre-understanding:** - the knowledge the action researcher brings to the project, refers to the understanding of the operations in the organisation and it’s dynamics of the operation in its contemporary business environment. Such an understanding requires a broader knowledge of organisational systems which is tacit to the success of an AR project.

* **AR requires an understanding of the ethical framework:** - The ethics in AR involves a common purpose between the action researcher and the client to determine how they understand the process and when to take action in the particular context. Authentic relationships are formed in the outcome of this intervention.

* **AR should be conducted in real time:** - The research in a retrospective way is treated as a “live case study” where the research unfolds as the case is being written. In such situations the case forms a “learning history” and is used as an intervention technique to promote reflection and learning in the organisation (Kleiner and Roth, 1997).
AR is interactive: Requires the researcher to be interactive in the action research process between himself and various personnel i.e. health and safety, occupational health, team leaders, engineers and assistant production managers.

As it is required by the researcher to act in an active role, it was then necessary to find a method (after subsequently explaining the important characteristics of action research) for this study to satisfy the pre-conceptions and increase rigour in the investigation, “the challenge is to define and meet standards of appropriate rigour without sacrificing relevance” (Argyris & Schon, 1991). As far as this is possible, AR is the self involvement of the researcher. This feature itself is a role that the researcher must make rigorous when the research question is related to describing an unfolding series of events over time (Coghlan and Brannick, 2001).

Works on typology of inquiry by Schein (1999) describes how self involvement can be made more rigorous by considering the differing types of inquiries:

1) Pure Inquiry: the action researcher prompts the elicitation of the story of what is taking place and listens carefully and neutrally, asks for example “what is going on?”; “Tell me what happened”.

2) Exploratory diagnostic inquiry: a method of inquiry which the researcher (action researcher) begins to manage the process of how the content analysed by the other by exploring:
   - Emotional processes;
   - Reasoning; and
   - Actions.

Therefore the action researcher may ask “How do you feel about this?” or why do you think this happened?”

3) Confrontive inquiry: where the action researcher is sharing his or her own ideas, challenges others to think from a new perspective. These ideas may refer to:
   - Process; and
   - Content
The action researchers by and large act as facilitators of the action and the reflection within the organisation. In such specific applications the method of inquiry may vary from one process to another. It is important that the method of inquiry judged appropriate by the researcher is kept consistent throughout, avoiding subjectivity and bias. Exploratory diagnostic inquiry is chosen to be rigorous and suitable for the needs of the research problem.

Subjectivity is widely considered a main weakness in the implementation of action research. In a sense reflexivity is a way of representing “subjectivity” of the researcher. Including reflexivity into the rigour of data collection and analysis permits people external to the research to assess logic and rigour of the links made from the data and drawn inferences from it, it “tells a more complete account of the research process than is to be found in the customary and sanitised versions of scientific report writing”, (Pidgeon and Henwood 1997).

This section has put forward the case for action research appropriate for this study. The relevance of action research has been described to be an important move towards addressing the research question.

The process of action research as discussed earlier was selected as the main method for data collection. Schein (1989) defines the action research process as “the assumption that one cannot understand a human system without trying to change it, only by learning over a long period of time and becoming a member of the system of how it operates could a passive observer decipher it.”, making the role of the researcher active rather than passive. Lincoln and Guba (1985) similarly identified the active and passive role in terms of the approach adopted by the researcher as a positivist role or a constructivist role whereby:

- “Positivist” The object of the inquiry is independent from the inquirer, the knower and the known constitute a discrete dualism
- “Naturalist” or “Constructivist”, the inquirer interacts with the object of the inquiry to influence on another therefore making the knower and known inseparable.
Action research depends on the collaboration between the researcher and the practitioner becomes actively involved in the process (Robson, 1994), “the researcher’s role often becomes that of a facilitator who works collaboratively with research participants although the forms and extent of that collaboration may vary” (Glesne and Peshkin, 1992).

As described by (Robson, 1994), Kurt Lewin first invented the term action research in 1946. His role actively promoted change by differentiating problem solving research from objective scientific research between the researcher and the researched. However action research is not commonly founded in pure research environments or journals but is becoming apparent in the ‘real world’ “there is still strong opposition to its acceptance as ‘real’ research”, Bannister, et al (1994), however the term action research “has been used in somewhat different senses by later workers ........ although “improvement and involvement seem central to all uses of the term” (Robson, 1994).

Rapoport (1970) suggests action research serves two purposes for generating meaning central to action research, which is of “both to the practical concerns of people in problematic situations and to the goals of social science by joint collaboration within a mutually accepted framework.” Although he’s assumption has been challenged by advocates of the practitioner approach overleaf lists a number of key important action research principles that have been used to guide the progress of this research study:

1. Earlier work presented to the researcher results with assumptions and expectations about the activities in a real world context. These assumptions formulate the initial hypotheses in the researcher’s mind which are explored in the context of this research study.

2. Collaboration with the practitioner sets the ground for implementing the research by establishing a framework. Their understanding and co-operation provides the framework for the research to be conducted.

3. The understanding led by the researcher is achieved by driving the change process through the interaction of the researcher and the actual context of the research.
4.10 Generation of Theory
Action Research projects are situation specific. In this research the research questions are specific and aim contribute to the theory of knowledge by generating it through the processes of Action Research.

Eden and Huxam (1996) describe how the action research process contributes to the theory of Action Research which is a precursor for generating the theory from this process:

- Theory building as a result of AR is incremental moving from the particular to the general in small steps.
- AR demands an explicit concern with theory that is formed from the conceptualisation of the particular experience in ways that are intended to be meaningful to others.
- It is not enough to draw on the generality of AR through the design of its tools, techniques and models, as the basis for the design but it must be explicit and shown to be related to generating the theory.
- AR generates an emergent theory in which it develops from a synthesis of that which emerges from the data and that which emerges from the use in practice of the body of theory which informed the intervention and research intention.

4.11 Company Selection
The methodological problem associated with targeting a selection of companies to contribute in this research was overcome by generating a contextual understanding of the research problem. Although the researcher had obtained prior knowledge of the research problem through exploratory research, the intention was to empirically generate contextual information of RSI from the research in one organisation that focussed in depth, the understanding of RSI rather than generating it through a sample of companies with little of the actual content being studied.

The factors that were likely to have an influence on the type of company studied would be the size of the population under investigation, i.e. size of organisation, products made, the type of processes used, the management style, age of personnel and the gender. All of these factors were taken into consideration with the help of the researcher's supervisor and doing so a company contact was established.
4.11.1. Theoretical Sampling

The researcher used the theoretical sampling technique to address the issues of sampling to identify the scope required for collecting the required data in the research sample. Theoretical Sampling was developed by Glaser and Strauss (1967) as a process of generating data collection whereby the researcher collects, codes and analyses the data to develop theory as it emerges by finding what data to collect and where to find it. This emerging theory is controlled and based upon the participant’s ability to add new insights to develop an understanding rather than its significance being based upon a general population.

Theoretical sampling as Flick states (1998) “is the more appropriate sampling strategy in qualitative research, whereas classical sampling procedures remain orientated to the logic of quantitative research.” Pidgeon and Henwood (1997) suggest exploring these issues is important because it serves as a device for both challenging initial assumptions and modifying and elaborating theory where necessary. This can add rigour to the investigation by making certain the researcher can disconfirm as well as confirm the emerging theories therefore avoiding the pursuit of early conclusions.

“Premature closure” refers to the reaching of a conclusion before the theory has been fully explored and theoretical saturation the point at which no new insights are emerging. This process is therefore most applicable when to determine how many case studies to study that will generate understanding rather than to test hypotheses through many case studies. Therefore the researcher must try to avoid premature closure and reach theoretical saturation.

4.11.2. Sampling

Designing the sample and collecting the data follows the detail planning and the data collection method defined by Tull and Hawkins, 1993. Churchill (1995) identifies a useful six step procedure for drawing out a sample from a population.

1. Define the population
2. Identifying the sample frame
3. Selecting a sample procedure
4. Determining the sample size
5. Selecting the sample elements
6. Collecting the data from the designated elements.

4.11.3 Defining the population
Churchill (1995) defines the population of the sample as "The totality of cases that conform to some designated specifications and which define the elements that belong to the target group of interest and those that are to be excluded." This research is concerned with identifying the capability to make changes in how the job is organised by the operator in terms of (ability and motivation of the operator) to reduce the potential risk of RSI in high or low situation strength. The population for defining this sample should include elements i.e. personnel related to the design and manufacturing aspect of its products. Therefore the population in this sample includes team leaders, quality investigators, operators and senior management, i.e. the Health and Safety officer, and the Production Manager.

4.11.4 Identifying the sample frame
This differs from the whole population as the sampling frame is the listing of the elements from which the actual sample will be drawn (Churchill, 1995). In selecting the sample there would be a danger of bias. It was expected that the nature of this research would involve some bias in terms of targeting the selection for a company or companies to participate in this study. Although this research being descriptive by nature rather than causal, the dangers of bias were accepted in order to find companies that would be committed to participate in this research rather than those having no interest.

4.11.5 Selecting a sampling procedure
This is "intertwined with the identification of the sampling frame because the choice of the sampling method depends largely on what the researcher can develop from a sampling frame" (Churchill 1995)
At this stage of the research, it was difficult to define what sample elements from the company would mostly affect the sample. It was decided that the researcher had to decide which aspects for the sample could be best applied. These were for example, age and height of the operators, the types of hand assisted tools used in the process, the team sizes, number of operators (male and female) working per cell, and number of senior operators.
4.11.6 Determining the sample size
Sixty companies were contacted during the pilot study questionnaire in Chapter three. Companies who replied, that suggested initially to generate an interest after subsequently providing their contact information withdrew their willingness to collaborate any further in the study. The risks involved in disclosing company confidential information and being potentially exposed for providing lack of welfare for their employees was a risk some companies were not prepared to be involved with therefore because of the sensitive nature of the research being investigated, this reduced the sample size for targeting potential lean companies participating in the study. However having taken this as an important consideration, a company contact was established with the aid of the researcher’s supervisor.

4.11.7 Selecting the sample elements
The “elements to be included in the study” (Churchill 1995), was decided by the researcher when a company contact was secured with the aid of the researcher’s supervisor.

4.11.8 Collecting data from the designated sample elements
Data collected from the designated sample elements was identified when a research steering group was secured and discussed together by the researcher and the Health and Safety officer at the case study company.

4.11.9 Interaction Settings
The 1st initial visit involved a factory tour around the production line cell areas of the factory and accompanied by a selected team leader and lasted one day. The objective of the visit was to study the team leaders and several operators in their work surroundings and brief health and safety about the research programme. The information sought were the types and sequences of manufacturing, the repetitive aspects of manufacturing particularly hand and wrist movements and the approach to standard operating procedures, A brief history of the work centres where there have been incidents of RSI, some medical details but not all, of the common types of injuries being sustained in the factory. A 2nd stage visit was to target specific areas of the production cells with an action plan formulated by the researcher for conducting the research. The action plan consisted of a two step procedure which included:
Step 1: Purpose: A factory visit to investigate the following variables causing RSI; Multitasking, use of hand assisted tools, age, gender and ethnic origin of the people. This entailed researching five cells on this visit. A senior operator and team leader was spoken to briefly in each cell. Information obtained and questioned on this visit was

- The existing correlation between the work of the operator and RSI
- Standard operating procedures
- Adaptation of the work place to suit the operator
- Job suitability for the worker on assembly
- The designated person for the job on assembly and sub assembly

After the factory tour ended a brief meeting with the Health and Safety officer and the Health and Safety co-ordinator was held for discussing the supervision of the research project.

Step 2: To formulate a research proposal identifying a methodology to be carried out in the factory on the 3rd visit. This contained details of the; The tools and techniques that were used, types of data collected, processing of the data, presentation of the data and how the data would be of use to the company. The decision for a 3rd stage visit was finalised resulting from the outcome of the 2nd factory visit detailing the research methodology over a 6 month period. The proposed methodology was delivered to the health and safety officer and the production manager in the form of 6 Phases:

1. Action Research
2. Qualitative Techniques, (questionnaires, semi structured interviewing and direct observation)
3. Data Gathering, (Questionnaire administration and questionnaire reporting to Health and Safety. Results compared with the existing literature.
4. Feedback (Regular meetings organised by the researcher on a weekly basis)
5. Action planning (Reporting the testing of the Lean Job Position Model).
6. Proposing suggestions in a form of an in company report for commissioning changes in identifying levels of RSI risk and raising the awareness of RSI.

4.12 Action Research Cycle
The research cycle in the action research process identifies three steps: (adapted from Coughlan and Coghlan, 2002), of which is considered by the researcher to be an integral component of conducting action research. The cycle comprises of the following:

1. A pre step to understand its contexts and purpose
2. Six main phases, i.e. collect data (semi structured interviews, direct observations and questionnaires) gather feedback, analyse data, plan, implement and evaluate action.
3. A Meta step to monitor.

*Pre step to understand its contexts and purpose:*

*Six Main Phases:*

1. Data Assimilation: Assimilation of data can be gathered in many ways depending on the context of the application. “Hard Data” is often made reference to gathering operational statistics, financial information and marketing reports. In this phase the researcher used health and safety reports, manual handling reports and risk assessment records as hard data. The second type of data referred to as “Soft Data” was collected by the researcher in forms
of observations, discussions in formal meetings and interviews on an informal basis.

2. Data Feedback: After a 5 week period "soft data" in form of written observations were submitted in a company report. This outlined issues affecting operator's task activity, such as restricted hand and body movements with the use of hand tools (for example rivet guns and air drivers), the varying height of operators male and female on workstations, and pushing of motorised and unmotorised trolleys.

3. Data Analysis: Followed by an evaluation and analysis of the in company report, an action plan approach was based on the criteria for directly linking the aim of the intervention i.e. observations to the purpose of the research.

4. Action Planning: The plan for action was to identify the level of RSI risk on certain work stations identified by work shadowing the team leaders and quality investigators. Prior to undertaking this event, certain questions were identified similar to those presented by Beckhard and Harris (1987) which asked;
   - In what parts of the organisation?
   - What types of changes are required?
   - Whose support is needed?
   - What needs to change?

5. Implementation: Health and Safety provided procedures and information for implementation. Their desired changes took place in collaboration with its key member's i.e. assistant production manager's team leaders', senior operators, operators and the researcher.

6. Evaluation: The intended and unintended outcomes of the evaluation were reflected by its action. The key members (assistant production managers and team leaders) of the action plan were requested to take the responsibility of evaluating their changes on a regular basis.

Meta step: Monitoring
The planning, implementation and evaluation was a continual process dynamic within the re-iterative cycle. By and large some cycles may have experienced shorter time
cycles (such as action planning, if such an event took place, for example identifying the level of RSI risk by conducting risk assessments once every 6 months). However in doing so, the researcher with the Health and Safety officer and the Occupational Health Advisor monitored the inquiry of the action planning, implementation and evaluation of the research cycle on a frequent basis.

4.13 Administration of the Action Research Process

The research problem aims at addressing the causes of RSI by using the level of ability and internal motivation (in terms of age) to identify the level of RSI risk in a strong and a weak situation.

Already the researcher felt the literature review was not sufficient to provide him with an in-depth understanding of the problem and felt the purpose of this research was to study this in a manufacturing setting.

This understanding was seen as fundamental to testing the conceptual model developed in Chapter Three. Without such an understanding a number of problems could be envisaged:

1. Organisational research involves the disruption of people's lives and the daily operation of running their business. If the researcher displays a lack of understanding of their situation, they may well not envision its worth and be unwilling to participate.

2. The researcher himself is investigating the way in which people in a manufacturing setting perceive their own environment. If the contextual framework is inappropriate in their environment, the results and analysis will be inconsistent within the framework of study.

3. Most importantly, if the conceptual framework is not grounded in the real world then the research aim will not be answered because the answers will either be searched in the wrong places or questions asked to the wrong people.

4. The initial data collection could interfere with the issues and interpretations of the clients if the researcher does not understand these correctly.
4.14 Summary

This chapter has discussed and compared the major philosophies involved for conducting this research. Firstly a philosophical stance identified the design of the study and its overall aim was described in the context of the research philosophy. The research process was described at every stage and highlighted the reasons for the choices made. Lastly the research cycle was described outlining the processes it is to take for conducting the action research process. The following chapter describes the in depth research phase with the case study company.
Chapter 5
Case Study

This chapter describes the main study conducted in Company A and reports the findings from the observations process. The chapter discusses the semi-structured interview process and the administration the questionnaire undertaken in Company A. Finally the chapter closes by addressing issues concerning validity and reliability of this research.

5.1 The Case Study Company Studied
For the purpose of keeping the details of the company confidential the researcher has promised not to disclose the company name. In this research a fictitious name for the company is given. The company name is called Company A and its parent company is called Company X.

5.1.1 Profile of Company A
Company A was established in 1936 specialising in the production of sensitized paper. Today Company A has 118 subsidiaries, of which 89 are in Japan with over 50000 employees, 11 research institutes and 29 modern manufacturing plants world-wide.

Company A is a subsidiary of the main parent Company X in Japan. It was the first European production plant setup in the UK. Production began in January 1985 with the opening of the selenium drum plant and was followed by the opening of the new toner production facility in March of the same year. Photocopy production began in May 1986 and together with the toner and drum plant remained the core business of Company A.

The company is located on a 52 acre site in the new town of Telford, currently employing 650 employees working on the site. The employees and finances are regarded as their two most important resources. Its catchment area includes the neighbouring towns of Wolverhampton and Shrewsbury. Partnerships established with local training institutions around the Telford area ensure that their workforce is continuously developed to meet the challenges of its modern manufacturing work place. The parent Company X in Japan is seen as the key
stakeholder and management provider of all its assets ensuring maximum financial returns in the form of dividends and royalty payments. Table 5.2.3 shows the characteristics of Company A being studied.

Company A competes with other Company X’s group subsidiaries for the licence to produce products for the European market. Its main internal competitor within the group is its French counterpart. Whilst other small subsidiary companies are owned by Company X, these sell Company A’s other manufacturer’s products. Company’s A mission statement was initially formulated in 1990 by a cross-section of local and Japanese management team. This was designed to comply with the corporate directions of Company X in Japan while taking into account the needs of its other main stakeholders.

Company A Information for Year 2002

<table>
<thead>
<tr>
<th>Type of product manufactured</th>
<th>Digital black and white photocopiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process of production</td>
<td>Flexible Cell Manufacturing</td>
</tr>
<tr>
<td>Estimated market share for product in Europe</td>
<td>25.5%</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>650</td>
</tr>
<tr>
<td>Sales Revenue (1999)</td>
<td>9m</td>
</tr>
</tbody>
</table>

The strategy for achieving the Company’s A mission are attributed to the following:

**Mission:** The mission of company A is to be recognised by our customers and within the group as a truly dependable company and this shall be achieved by maximising the benefits of European Market Place Production.

**Vision:** To be the number one subsidiary and an acknowledged leading environmental and socially responsible company.

**People:** We will respect all employees for their individual and collective contributions and encourage and empower our people by training and development, in order to obtain maximum involvement through their commitment and enthusiasm.

**Technical Innovation:** We will continuously improve our products, services and manufacturing processes through culture of innovation and implementation of new designs, technologies and techniques.
**Integrity:** We will treat all employees, customers, suppliers and society with respect, openness and honesty.

**Responsible Citizenship:** We will carry out all our operations in a safe and healthy manner and introduce innovative activities to improve all aspects of the environment.

The vision statements were formalised in 2001 by the general management under the guidance of the local company director. All managers are required to demonstrate their commitment to the mission vision and values by acting as role models. Managers are required to ensure that all decisions support the achievement of the mission and vision whilst not compromising the values in any way. This process is formally evaluated by the general manager's team who formally test all activities they approve against the values they set. The visions are based on the expectations of the key stakeholder Company X.

As a minimum the mission, vision, and values are reviewed at the start of a mid term Plan. A workshop is organised by the company secretary and is attended by a cross section of the management team to test the relevance of the statements against the changing needs of the business. This year the mission statement was re-focussed to reflect the change of its global production strategy.

**5.1.2. Company A Management**

Company management define their leaders as managers responsible for other employees by demonstrating their leadership to the value and mission statements set by Company X. These are achieved by showing examples with all their dealings the company management has with their employees and partners. Peer pressure is used to ensure consistency of approach across the management team with examples of good role model behaviour being shared through the management meetings. All managers encourage empowerment by defining dimensions and limits of authority and influence within job descriptions for all the employees. Within many roles the managers allow the authority of the employees to make autonomous decisions and encourage this within the confines of their own job. The general managers meet on a weekly basis to monitor business performance and current issues. These keep the employees up-
to-date with activities within their section and communicate information as they see appropriate.

Company management encourage all employees below management level to identify improvements through a suggestion scheme usually in the form of improvement activities. Employees including senior management are encouraged to implement their suggestions. These suggestions or improvements are inputted into a suggestion scheme and senior management encourages participation from all levels of the organisation to make such suggestions.

5.1.3 Company A Division

The main research study was undertaken in the manufacturing division by the author where its main core activity is in the manufacture of photocopierns known as Plain Paper Copier (PPC). The production processes of Plain Paper Copier are a highly labour intensive mass production system and at present have changed its manufacturing layout to a flexible cell manufacture assembly process. The main focus of its production activity relies on the skill of its operators to complete the majority of the assembly tasks. All of the assembly processes were monitored using a work study based system to identify the optimum assembly process called MOST. A production index is then calculated from MOST to monitor the overall cell efficiency and also taking into account factors such as production downtime and direct to indirect assembly operator ratios.

The present process configuration is based upon the flexible manufacturing cell concept used by Company A. They use the term ‘Quick Response Manufacturing’ where the productivity for each cell is monitored based upon the production demand with its downtime integrated into its production schedules. The overall cell throughput is managed via a bespoke software package where it calculates the cell flow rates, monitors the actual output of photocopying machines leaving the cells and displaying the daily targeted output for the day’s production.

This outcome of the highly intensive labour process resulted in the rise of RSI (Repetitive Strain Injury) risk within its operations. Earlier the manufacturing
management had recognised the need for raising an awareness of RSI issues within its operations and at that time the level of RSI risk was not widespread and production capacities were within the operator’s capability. However now with the changes in market demand, innovation and increase in customer requirements the level of RSI risk has increased by eight percent annually within its production operations and at present there has been a need to raise issues of RSI within senior management. At present there have been cases of operators reporting injuries, and some working with RSI injuries in production.

The company has recognised its future target by implementing measures and procedures to reduce the level of RSI risk within its employees. Slow and manageable direct improvements have been achieved through process re-engineering and have improved procedures to change over time within other sectors of production but unfortunately not reducing the RSI risk. The researcher realised the potential to conduct his research within these settings for testing the lean job position model and also the research hypotheses. In parallel with this the researcher also planned to propose changes in Company A for reducing levels of RSI risk within its internal company operations.

5.1.4 Company’s A Assembly Operations
Company A’s assembly operation for manufacturing the Plain Paper Photocopier follows a ten step process which is listed below:

1. Warehouse: Warehouse issues parts for the photocopy machines to the stockers in the Haizen area.
2. Haizen: ‘Hai’ means to deliver ‘Zen’ means deliver to tray. Haizen operators fill the trays with the correct parts and number necessary to build the photocopier.
3. Quick Response Manufacturing Cells (QRM): The operators have set processes that are defined by the process book, each to build onto the machine. As the machines travels through each cell more processes are added until the machine is completed and transferred by trolley operators to the scanner line.
4. The scanner line builds the scanner for the photocopier. This sub-assembled unit is built onto the photocopier and is then transferred by a trolley operator to the main assembly line.

5. Adjustments are made on the main assembly where a series of data are inputted by a service program by quality controllers at the end of its build process to ensure that the photocopiers are operating in service mode ready for configuration and copy testing.

6. Configuration and Copy Quality operators conduct electrical testing, software testing and copy testing on the photocopiers to ensure that they operate to photocopy standards and specification.

7. After testing the machines are transferred by the trolley operators to the main line assembly build to be cleaned thoroughly by quality controllers. The quality controllers on the main assembly build line ensure each photocopy machine is given the correct documentation and instruction manuals.

8. The completed photocopy machines are then transported to the packing area via an AGV (Automated Guided Vehicle). The packing area ensures the photocopy machines are packed correctly and will not be damaged during transit.

9. Quality Assurance randomly check the finished production of machines ready for despatching.

10. Despatch records all the current stock of photocopy machines ready for despatch to the customer.

Figure 5.1.4 shows the layout of the assembly process in Company A.
PLAIN PAPER COPIER ASSEMBLY LAYOUT

Base frames for the Photocopier are built in the Spin Pop Rivet Area and are transferred by trolley operators to the Quick Response Manufacturing cells.

Cell 1

Cell 2

Cell 3

Cell 4

Spin Rivet Line

Sub-assemblies for cells 3&4

Cell 5

Cell 1 Work Area

Cell 2 Work Area

Cell 3 Work Area

Cell 4 Work Area

Cell 4 Spin Rivet Line

Machines are completed by cells 1, 2, 3, 4, & 5. These are transferred to the Main Line Assembly Build.

Completed machines are transferred to the packing area via AGV'S

QUALITY CONTROLLERS

45CPM

CONFIGURATION & COPY CHECKS

Machines imported from China worked on the 45 CPM area (45 copies per min machines)

Quick Response Machines (QRM) 45CPM loaded onto the Main Assembly Line using Trolley Operators from the Cell areas

MAIN ASSEMBLY LINE

MAIN ENTRANCE

Major Work Flow

The layout of the assembly process in Company A

Figure 5.1.4
5.2 Main study conducted in Company A
The objective of the researcher was firstly, aimed at fulfilling the requirement of the research and secondly raising RSI awareness to senior management and Health and Safety in their internal company operations. The main study conducted at the time in Company A, was judged to be accurate when the researcher himself undertook the research process. The time spent in the company involved the researcher mainly communicating closely with the Health and Safety officer, the Health and Safety co-ordinator and the Occupational Health advisor. Their job roles within Company A are described in Section 5.6.

Permission to work shadow with all the team leaders and all the quality investigators on the shop floor was granted when the Health and Safety Officer pre-warned all the team leaders about the remit of the researcher's study. Meetings on a one to one basis were arranged by the researcher with the Occupational Health advisor to discuss if there had been any recent incidents of RSI reported on a weekly basis. A log of incidents were monitored by the Occupational Health advisor recording the number of RSI incidents reported by operators and also detailing the various types of RSI injuries or injuries related to RSI. Meetings on a two week basis were arranged by the researcher with the Health and Safety officer to discuss the progress made with the observations. An agenda was compiled by the researcher reporting the items for discussion. The items included, the observations made, RSI problems with the operators discussed with the team leaders on the shop floor, administering the questionnaire and organising the next proposed observations. At this time an interim report to the Health and Safety Officer in Company A was submitted reporting the preliminary observations made by the researcher.

Individual time was organised by the researcher to recollect his thoughts about his observations he had seen and logged during the time he spent work shadowing the team leaders on the shop floor. The use of a desktop personal computer was made available to him by the Health and Safety officer. The researcher was able to conduct a series of searches on the company on-line database to investigate the types of procedures e.g. risk assessments, station evaluations and manual handling operations as supporting information for
conducted his observations. A sound understanding of each of the main processes had to be obtained to identify the levels of RSI risk within all its processes. The researcher read the process books (standard operation procedures written and compiled by industrial engineers) and on a daily basis (for one and a half hours in the mornings, and afternoons), work shadowed with the quality investigators and the team leaders on the shop floor to understand its processes more in depth. Furthermore during this time the researcher took the opportunity to hold discussions with the team leaders, with the aim of identifying where parts of its processes could give rise to a RSI risk.

5.3 Observation Process conducted in Company A

The team leader presented the researcher which specific workstation the team leader thought there was repetitive movements occurring within the cell. During the observation lasting from a two to a three day period close attention was paid specifically to the hand movements of the operator by identifying how many times this occurred on a repeated basis. The researcher stood by the side of operator at the workstation looking very closely the following movements of the operator. The researcher visualised the following movements of the operator:

- The hand movement of the operator that was used or involved in the repeated motion of the job process.
- The number of times hand assisted tools were used in the process.
- The working posture of the operator i.e. bending, stretching or reaching.
- The workstation height relative to the operator height.

Key point definitions were used in the observations to make the process more rigorous. The definitions applied were:

**Repetitive Movement:** Carrying out the same motion within the same specific process time, e.g. insertion of screws in a certain sequence, use of an electric driver hand tool to insert differing types of screws on the assembly. Measured by the force applied (N's/kg's) per day by the operator or by repeated movement of the same upper body part in the same motion within the same process.

**Body Part in Contact:** Fingers, wrist arm, shoulder and back.
**Assembly**: Small builds (sub-assemblies) that are completed as a modular unit e.g. scanner unit for attaching to the full build of the photocopy machine.

**Process Time**: The total build time for a complete sub assembled part of the machine.

The level of risk of RSI injury is defined as the risk of injury when the operator is at his working position and is subjected to a number of repeated actions with a certain force measured at a certain reach. The definition applied to characterise the level of RSI risk in the operators working zone considered the number of repeated movement, involving and including the use of the hands, arms, wrists and shoulders in one action in one cycle time.

The meaning of the risk factor for defining the level of RSI risk is unclear. Researchers and authors do not report consistent uses of the term. However Last (1983) has defined risk by advocating it as “a probability that an event will occur”.

Further to analysis of other epidemiological studies (Buckle and Devereux, 1999), propose a well established three zone model for identifying most of the recognised risk factors thought to be appropriate to define the level of risk, shown in Figure 5.3.

A three zone action model to identify the level of risk factors

<table>
<thead>
<tr>
<th></th>
<th>High Risk</th>
<th>Medium Risk</th>
<th>Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>This zone identifies those at highest risk for the development of upper limb disorders and where action is almost certainly required.</td>
<td>Work factors require close attention and remedial actions may be necessary.</td>
<td>Areas of least concern, although some action may be prudent. Assessment may provide useful information to inform workplace interventions elsewhere. Routine assessment and surveillance should be extended to this group.</td>
</tr>
</tbody>
</table>

Taken from Buckle and Devereux (1999) Figure 5.3
All the observations in this study were conducted applying the same key point definitions and time scale in each area where the observations took place. The different groups of assembly workers addressed during the observation process were undertaken in the following areas of the shop floor assembly. This contained a composition of male and female operators from different age groups and ethnic backgrounds. Each cell listed below contained thirty operators in total.

- Quick Response Manufacturing Cells, Cells1, 2, 3, and 4
  - 35 CPM (35 copies per minute photocopy machines)
- Configuration and Copy check cell
- Scanner Cell
- 45 CPM (45 copies per minute photocopy machines) cell area

### 5.4 Observations of Assembly Operators in Company A

35 CPM (35 copies per minute photocopy machines) (Quick Response Manufacturing Cells, Cells 1, 2, 3, 4 and 5) comprised of a mixture of male and female workers, a mixture of young male and female aged (20-25 years old), middle aged male aged (30-40 years old) and quite old male aged (40-50 years old) operators. This cell contained 30 operators in total with 15 females and 15 males. Observations in this cell area found RSI injury to the wrist and back were common with operators between (30-40 years old). These injuries particularly affected the wrists from using hand assisted tools on a regular basis, without any rest. Seven females were affected with this injury and five males with back strains from pushing heavy main frame units of the photocopier on un-motorised trolleys. Work shadowing with the quality investigations reported this problem to the Health and Safety officer. This resulted in discussions being held with the team leader and the Health and Safety officer. It was both agreed by them after station evaluation carried out by the industrial engineers that this cell had to rebalance its work loads with certain operators to reduce the RSI risk.

The Scanner cell comprised 18 female middle aged operators between (30-40) years old and 12 male operators (20-25 years old). This cell had observed repetitive use of hand assisted tools i.e. the use of rivet guns and air drivers by
female operators of which when this was observed had not seen a reduction in the number of times it was used although this had been requested by one female middle aged operator.

Configuration and Copy check areas contained a fair proportion of middle aged operators aged between (30-40) years old. This cell contained 18 males and 12 females. The nature of its standard set up processes includes electrical testing, mechanical testing, and memory testing. This cell experienced low level of RSI risk.

45 CPM (45 copies per minute photocopy machines) cell area contained quite a high proportion of middle aged (30-40) to old (40-50) aged female operators. This cell contained 16 middle aged male operators and 14 old aged female operators. Findings from this cell reported a medium risk of RSI. Discussions took place by the researcher with the team leader for this cell. The outcome of resulted in nine female operators and seven male operators of ages (40-50) years old carrying RSI injuries of the wrists and arm and whilst also carrying out their assembly operations.

The result of the observations needed to identify the potential level of RSI risk within its processes for Company A. A risk level matrix was developed together by the researcher and the Health and Safety officer to present to senior management as a tentative but not as a definitive indicator of the level of RSI risk to injury to an operator within its processes. The matrix shown on page 127 was developed because senior management requested improvements had to be made within all operators processes before the start of launching the production of the new model. Therefore based upon a production day the risk level matrix was developed taking into account the following variables:

- The approximate age of the operator (constant)
- The level of RSI risk to the operator dependent on time in the production day (constant)
- The number of photocopy machines produced (variable)
These variables were based upon the information being exchanged by the researcher and the Health and Safety officer and the Production Manager. The layout of the risk level matrix was judged appropriate to use by the Health and Safety officer within its processes at the time of the study in Company A.

The matrix is set by conducting a station evaluation assessment on a workstation with the operator at the beginning of the production day. The information obtained from the station evaluation assessment e.g. layout of equipment, height of workstation, obtained from the engineers are applied together with the industrial engineers to improve its process. The matrix is then applied by the Health and Safety officer to measure when the level of RSI risk is likely to cause an injury to the operator. By taking into consideration the variables described for the matrix, i.e. the approximate age of the operator, the level of RSI risk to the operator dependent on the time in the production day, the actual number of photocopy machines produced, the matrix identifies during the production day when safety measures should be introduced to reduce the level of RSI risk for the operator.
5.5 Conclusion of the observation process in Company A

Throughout the observational study, the researcher played a dual role that of a change agent and action researcher. As a change agent, the researcher was able to influence and experience the change process itself by documenting both his own experiences and observable behaviours of the operators and as an action researcher he was able to have close access to the operator’s workstation cell area by standing aside with the operator in close proximity of the workstation cell.

Some but not all observations were recorded at the workstation cell areas because management decisions to transfer cells, relocate, and merge certain parts of the build processes to introduce the launch of new models by the instruction of Company X for Company A therefore it reduced the possibilities of verifying the observations already made by the researcher.

However the observations also provided the opportunity to add valuable insights into the cultural aspects of Company A which were by the researcher perceived to be an indication of identifying ‘strong’ and ‘weak’ situations in relation with the level of RSI risk.

5.6 Semi-Structured Interview Process in Company A

The motives behind the choice of applying semi-structured interviews are discussed in Chapter Four. The interviews that were conducted involved the Auditor, (from the Quality Assurance department), the Occupational Health advisor and the Health and Safety Officer. The researcher also targeted the production manager for interviewing however at the time of asking, he admitted he would not be available to participate because of meetings and shop-floor commitments. However permission for interviewing the operators experiencing RSI injuries were not approved by the Production Manager. His reasons were that it would be time consuming and would create downtime for the team leaders to relieve their operator’s time off production. Due to the lack of spare capacity to replace the operators and the fear of them disclosing confidential company information, criticisms over their work practices, how the operators are managed by certain team leaders and the resentment of operators towards senior management, the proposition to interview operators with RSI injuries by the researcher did not occur.
However semi-structured interviews were conducted with these participants to formulate a consensus about what they thought contributed to levels of RSI risk. The researcher felt by interviewing the Auditor, the Occupational Health advisor and the Health and Safety officer, it would generate in-depth conversations and add an invaluable insight into repetitive strain injury and situational strength. The bases for choosing these participants contributed to the following reasons:

1. The experience of the Health and Safety officer dealing with operators with RSI injuries;
2. The auditor's knowledge of the intricate parts of processes involving hand movements;
3. The medical expertise of the Occupational Health advisor in diagnosing RSI problems with the operators.

The job roles of each participant interviewed by the researcher in Company A, are described below:

- Auditor (Quality Assurance) role is to carry out all the aspects of sampling, re-sampling and reliability inspection to ensure field quality targets are met. They also liaise internally with other related departments e.g. health and safety and assist the team leader ensuring the inspection, reliability and quality of the photocopy machines are met.

- The Occupational Health Advisor role is to provide occupational health advice to its client (employees of the company) who has a continuing underlying medical condition or disability. Liaise with production managers and health and safety as appropriate to provide expertise on musculoskeletal disorders and Repetitive Strain Injuries (RSI) relating to the working environment in accordance with existing legislation within the framework of existing policies, including work modifications by way of health monitoring, carrying out workplace and risk assessments in conjunction with managers. Provide health education on relevant issues in order to minimise health related absence from work.
• The Health and Safety Officer role is involved with assisting with promoting occupational health and safety awareness. Investigating and reporting on all incidents, injuries and occupational health problems and notifying OHSE of incidents and hazards in line with reporting requirements. Co-operation and liaison with occupational health and safety representative(s) on occupational health and safety activities in their zone or department in line with the procedures detailed in the Appendix of the Occupational Health and Safety Policy; and dealing with health and safety issues in line with the procedures detailed in the Appendix of the Occupational Health and Safety Policy.

5.7 Issues concerning the Semi Structured Interview Process
The intention was to ensure from an ethical perspective that all issues were clarified before the interview took place. The following issues were considered in the interviews.

Confidentiality
Confidentiality agreements were made between the interviewees and the researcher. All copies of the transcripts when transcribed were reported back to the interviewees i.e. Auditor, Health and Safety officer and Occupational Health Advisor.

Inconvenience experienced by the sample of the respondents interviewed
Appointments were arranged and organised by the researcher. The interview procedure was explained to the interviewees before commencing the interview. The aspect of confidentiality was again mentioned. Interviews were held internally at the respondent’s normal place of work.

Interviewer Biasness
To avoid bias, the interviewer remained neutral and did not interject expectations or opinions during questioning (Frey and Mertins Oishi 1995). An open mind was kept by the interviewer (researcher) during the interview.
Unsuitable responses given by the respondent
Most of the interviewees understood what was being asked by the interviewer. The questions were formally introduced as open-ended questions manageable enough not to appear too intimidating and challenging for the respondent. The interviewer took an interest in the interviewee asking them appropriate questions and adjusted the approach to suit the unique circumstances of each interviewee (Hague, 1992). The researcher, prior to the start of the interview ensured the interviewees that they were not obliged to answer any section of the questions, if it made them feel uncomfortable. The researcher assured the interviewee that all questions were acceptable and its information provided would be kept confidential by the researcher and by the Health and Safety officer.

5.8 Design of the Questionnaire
The aim of the questionnaire was to understand what type of injuries caused RSI in their workplace and identify any discretion for change by the operators to reduce the level of RSI risk. The questionnaire used in the fieldwork study is shown Appendix B. The questionnaire was written in a form of a statement at the top of the page in blue arial font. This colour was used to draw the attention of the respondent to the key purpose of the questionnaire. The questionnaire was designed in two sections to ensure control and consistency of the information in terms of how it would be presented and described to the respondent.

The first section required information from the respondents to write answers to the questions in the rectangular boxes provided. The second section required the respondents to choose from a selection of ten responses and rank them in order of importance. A closing statement at the end of the questionnaire was presented explaining what the results would be used for. The questionnaire was administered by the researcher by keeping a record of the number of copies given out to each team leader and the number of completed questionnaires returned from each team leader.
5.9 Outline of the Questionnaire
The layout of the questionnaire can make a difference to the interest level of the respondent and the amount of time they are willing to devote to filling it in (Easterby-Smith et al., 1991). Described below is the physical characteristics used in the questionnaire for the process of data representation.

Typeface and Readability
All worded questions used 11 point Arial font. Arial font was used because its typeface was simple and letters easier to read. The intention was to keep the questions short, clear and simple for the respondents to answer. Feedback was given by the Health and Safety Department in Company A to improve the readability and content of some but not all of the questions.

Preparation analysis of Questionnaires
The requirements for the layout of the questions and spaces for writing and using the tick boxes were considered before analysing the responses from the questionnaire. All questions were numbered, responses well spaced not only for the respondent but also for ease of entering the data for each question from each respondent within the two sections of the questionnaire.

Instructions and question explanation to the respondents
A trial version of the questionnaire was submitted to Health and Safety in company A for editing and comprehension. This action by the researcher was taken to ensure that the questions were not breaching any confidential information of the respondent and the organisation (protected by the data protection act). The decision was made by Health and Safety and the researcher that no general instructions or further guidance were to be added for helping the respondents in completing the questionnaire.

5.10 Process of administering the questionnaire
The Health and Safety officer and the Production Manager did not to take part in the questionnaire study because they both wanted to formulate a consensus of operator's views. They felt that the method of administering a questionnaire to the operators provided an opportunity for them to express an opinion about their
job situation and contribute useful information, for example, making suggestions to reduce the level of RSI risk. It enabled the Health and Safety officer and the Production Manager to evaluate the views of the operators and that they would be most particularly concerned with, for example making changes to improve their processes or ideas the operator’s may have or would like to see implemented as improvements.

The administration of the questionnaire took place in a way which the researcher saw appropriate. The researcher administered the questionnaire by using electronic mail. The researcher sent an electronic mail written on behalf of the Health and Safety officer asking the team leaders and their operators to complete the questionnaire and submit them to the researcher by a specific date. The electronic mail was written on behalf of the Health and Safety officer because this would prompt the team leaders and the operators to respond quickly. A date for completing the questionnaire was set by the Health and Safety officer.

5.11 Validity
Qualitative methods have been criticised with regards to validity and reliability. Validity and reliability are interpreted differently depending on the underlying research paradigm but forms an important aspect of a research design (Mutchnik & Berg 1996)
Traditionally this is defined as a study’s ability to plausibly demonstrate a casual relationship between a particular treatment (independent variable) and a particular outcome (dependent variable) (Robson, 1996). The complexity and the depth of research information it generates makes it hard to assess the true validity of qualitative research from an outside perspective. A number of qualitative researchers for example (Janesick, 1994) replace the emphasis on validity with emphasis on credibility. Credibility is gained through establishing a match between the constructed realities of the study participants and reconstructions attributed to them. This included an understanding of the contextual framework described in Chapter 3, the inclusion of theoretical sampling and the use of sampling methods explained in Chapter 4 respectively.
External validity can be defined as a study's ability to produce generalised results (Robson, 1996). This research study is not aiming for generalisibility; but transferability. Transferability is determined through empirically checking the degree of similarity between sending and receiving contexts. If a study’s results are transferred to another context then “the burden of proof for claimed transferability is on the receiver” (Guba & Lincoln, 1989). Transferability requires a “thick description” of the study. Such description is aimed at enabling someone to make the transfer and arrive at a conclusion about what is transferable and what is not. However it is not the researcher’s responsibility to provide a “thick” description of what is to be transferred but instead to provide a data base that makes the transferability judgements possible on the part of the potential appliers” (Lincoln & Guba, 1989).

5.12 Reliability
Reliability aims at minimising errors and the bias of a study to ensure that the results are independent of the researcher. If at all it is arguable whether this can be achieved in qualitative research set in the constitutive research paradigm, such as case studies. The constitutive research paradigm’s interpretation, or substitution, of reliability is dependability concerned with the stability of data (Guba and Lincoln, 1989). Using a positivist approach, applying quantitative methods would assume a certain margin of error and generalisibility within a broad population therefore the quest for reliability in this research requires an active and practical role. Meaning to generate new understanding through a constructivist approach calls for the reliability of the research to be conducted in the real world for which it’s use and application demands qualitative methods.

5.13 Summary
The next chapter presents the field work results from the direct observations, the semi structured interviews and the questionnaire. Soft Systems Methodology is applied for analysing the data obtained from the case studied company.
Chapter 6

Fieldwork Results

Chapter 5 discussed the process of analysing the research data collected from conducting direct observations, the semi-structured interview process and the questionnaire in Company A. This chapter now presents the fieldwork results and discusses the stages of its analysis for generating the outcome of the fieldwork data using Soft Systems Methodology.

6.1 Research Sampling

As mentioned earlier in Chapter 4 a theoretical sampling approach was chosen as opposed to population sampling. The advantage of theoretical sampling allows data collection to be populated by the emerging knowledge rather than pre-determined expectations found in the literature. The key is to ensure a large enough base dependent upon the participant’s ability to add new insights. The number of participants required to add new insights in the research is driven by the need to avoid premature closure and the ability to recognise theoretical saturation by the researcher. The objective of this study is then to identify the factors that can enable the internal ability and motivation of the individual to reduce the potential risk of RSI in high or low situation strength.

6.2 Interview Analysis Method

Data obtained from the semi-structured interviews are in the form of transcripts describing the interaction between the researcher and the respondent. The analysis of these interviews presents a number of options for the researcher. Content analysis, discourse analysis, conversational analysis and analysis techniques associated with grounded theory (Glaser and Strauss 1967). Discourse analysis uses the structure of the language to convey a meaning rather than the meaning itself. Content analysis identifies how many times a specific issue is raised arising from the research study and is therefore not strictly considered as a qualitative approach. Conversational analysis concentrates on the conversation itself and discusses how it can make “social action and interaction, mutual sense making, and social reality construction possible” (Heritage 1997). Therefore the use of the conversational style method is used as a tool for understanding the meanings of the conversation rather than directly investigating the meaning itself.
Grounded theory developed by (Glaser and Strauss, 1967) has come to be associated with analysing qualitative data, generating theoretical understanding from empirical data with the absence of hypotheses. The focus of grounded theory concentrates upon the development of meaning and theory through a process of flexible data analysis techniques for data collection such as pattern coding, indexing, memo writing, and category integration. It was decided to use the grounded theory approach for analysing the semi-structured interviews and for interpreting the interview data.

6.2.1 Process of analysing the interview data
Stage 1 of the research data provides a framework for investigation by firstly explaining the process of analysing the outcome from the interviews. The first stages in analysing the interview data involved listening to the tapes and transcribing them. The next section describes the procedures of how the interview data was analysed and coded by the researcher.

6.2.2 Procedure 1
The researcher initially listened to the tapes and wrote down the responses by hand with line numbers added to the end of each sentence. Each interviewee transcript was then subsequently typed out using a PC in the same format as the interviewee transcripts which were hand written. Any discrepancies were avoided by repeating each interview in turn and carefully transcribing these responses again either by adding or removing any irrelevant material which may have been present on the first attempt.

6.2.3 Procedure 2
Through the transcriptions, themes began to emerge. All individual statements that emerged as a theme were underlined. New themes were placed within existing themes for categorizing. However where the researcher felt there was little or no comparison of statements within the existing theme a new theme was created. On several occasions the researcher fragmented the themes to incorporate them into new themes where he felt it to be appropriate. This process continued until the researcher believed theoretical saturation began to occur and no new themes (index codes) emerged.
6.2.4 Procedure 3
From every emergent theme underlined, an index code determinant was related with its index code. An index code determinant for each theme was related to each index code because the researcher felt this to be a systematic way to logically represent the data and sequence the emergent themes during the transcription stages of the analysis. Assuming theoretical saturation was achieved under this process the researcher made the decision to include these in the final analysis.

The final analysis of analysing the data resulted in representing the findings in a table identifying the index code determinant, related to the appropriate index code, question number, line number and pieces of the interview transcript that suited the required index code. The researcher at this stage looked for possible linkages between each of them and inserted them into the table, by taking each theme in turn and comparing them carefully to every other theme generated.

6.2.5 Procedure 4
The chosen quotes “seek to identify those themes which are of most central relevance to the task of building an understanding” (King, 1998). Therefore care was taken in analysing the quote from the interview data. The intention was to ensure that the interpretation of these quotes were meaningful. This process of analysis then resulted in the following outcomes:

- The researcher felt that statements that were overlapping, a new heading was created
- Where the researcher felt that two or more themes were related in some way, a connection of two or more themes were developed.
- The creation of a new theme was developed where the researcher felt that statements from two separate themes belonged together.

As anticipated an iterative process followed with more themes added and clustered together. Further iterations were produced and compared again with each other for clarity and purpose. At this point it was clear to see that the data from each theme became more closely integrated and no themes were discarded. With process of coding and factor-clustering of the data it was possible to distinguish for each theme, where theoretical saturation emerged.
6.3 Evaluation of time invested in the Interviewee Data

The process explained in Section 6.2.1 proved to be time consuming. Although no themes were omitted, identifying the relationships between each theme proved to be a complex task requiring concentration, constant revision, and the ability of the researcher to add new insights to all points of the analysis. As a result, a table format was developed to report the outcomes of the interview data by presenting the key concepts of internal ability and motivation of the individual to reduce the potential risk of RSI in high or low situation strength in a clear structure for the reader to follow. It was also considered during this stage of the analysis, that this would make the context of the interview data within each table clear for the reader to understand and easy to follow. The following format that is applied for each person interviewed is illustrated in Figure 6.3.

- Index Code Determinant
- Index Code
- Question Number
- Line Number
- Interview Transcript Text

Format applied in the stages of the Interview analysis

Figure 6.3
<table>
<thead>
<tr>
<th>Changing the work situation Determinants</th>
<th>Index code</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations or weak situations</td>
<td>Q3</td>
<td>(1-4)</td>
<td>No not in all people, there's a lot of people out there and just want to come and do the work day to day, but there are some people just want to make an effort and try and change their processes or layout of their workstations who are motivated on a daily basis.</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations or weak situations</td>
<td>Q2</td>
<td>(5-6)</td>
<td>The operators walk round with their hair down and stuff like that so I'd suggest the whole training program would need improving</td>
</tr>
<tr>
<td>Operator and Task Evaluation</td>
<td>Standardisation</td>
<td>Q2</td>
<td>(7-9)</td>
<td>we have introduced a report which enables us to standardize the approach that we do in training and evaluate the training via the process books, so hopefully that is improved, prior to that I'd say there are a lot of loop holes</td>
</tr>
<tr>
<td>Potential to change work situation</td>
<td>Management Decision</td>
<td>Q2</td>
<td>(13-16)</td>
<td>now we are trying to close the loop holes by getting them to sign that they have completed the training and evaluating them periodically and make sure the operator have achieved they're target before they move on to the next training session so I would say that's improved.</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations or weak situations</td>
<td>Q3</td>
<td>(4-6)</td>
<td>In a morning meeting the perception would be why have lost these 4 m/c's? Instead of we've had good quality. The way the management I feel the culture of PPC at the present stage is that it is driven more by production and not by quality</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations, and weak situations</td>
<td>Q3a</td>
<td>(8-9)</td>
<td>From the feedback from the operators, there is a lot of people who can make the changes, to improve the processes and their working environment</td>
</tr>
<tr>
<td>Production Orientated</td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>(12-15)</td>
<td>however it does depend what team you are actually work for some team leaders are willing to listen willing to help some team leaders are willing to &quot;get the counter out&quot; again it does depend who you've got in charge of you (to meet the daily production of machines)</td>
</tr>
<tr>
<td>Potential to change work situation</td>
<td>Management Decision</td>
<td>Q3a</td>
<td>(12-15)</td>
<td>When the cells are set up from the team leaders they run quite effectively, they've got the time to make improvements so the team leaders will brainstorm and make improvements, other teams which are struggling with their performance, e.g. quality or productivity, they have not go that opportunity</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>23-25</td>
<td>Assistant managers and the production manager seem to try and squeeze the team leaders to achieve the targets without actually thinking of supporting them, why can't they achieve the targets whether its training or time constraints or resource constraints, the frustration from the team leaders is very easy to see on the shopfloor</td>
</tr>
<tr>
<td>Potential to change work situation</td>
<td>Management Decision</td>
<td>Q3a</td>
<td>(30-34)</td>
<td>I know of one team leader put in approx 20 suggestions in and he had not one single reply from management for support for the problems therefore it shows that the management say they will give the help but the team leaders are not getting the support, then low morale is seen through the senior operators and then inevitably to the operators which keep on causing quality and production problems.</td>
</tr>
</tbody>
</table>
### Occupational Health Advisor

**Table 6.4.2**

<table>
<thead>
<tr>
<th>Changing the work situation Determinants</th>
<th>Index code Changing the work situation</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situation and weak situations</td>
<td>Q4</td>
<td>(2-4)</td>
<td>We are not sure what areas are going to cause significant problems, we don’t get the amount of time perhaps we feel we ought to have a look at the area in actual depth. Due to our work schedule and due to the production schedules over there (RPL 2), but saying that they are pro-active (engineers &amp; managers) and they will look at the processes and layout of the work stations and they will move forward in time it just appears to take longer than perhaps I would have expected.</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations</td>
<td>Q5</td>
<td>(2-3)</td>
<td>I don’t think beneficial to them operators have as much control over their function as perhaps would be</td>
</tr>
<tr>
<td>Culture Issue</td>
<td>Management Style</td>
<td>Q8</td>
<td>(1)</td>
<td>The culture of the company seems to be quite historic things seems to be very set, very difficult to change things</td>
</tr>
<tr>
<td>Culture Issue</td>
<td>Management Style</td>
<td>Q9</td>
<td>(1-3)</td>
<td>It orientates around production targets and not in the way I see the operators carry out their movement and actions in their processes correctly on a daily basis.</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change, via strong situation</td>
<td>Q10</td>
<td>(2)</td>
<td>That they don’t believe that engineers and managers are listening to them and that they have very little effect on change</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change, via strong and weak situation</td>
<td>Q14</td>
<td>(2-5)</td>
<td>I do think there has been a vast improvement over the last 12 months, if you came in 12 month earlier you would have been shocked by the level of safety awareness. I think we are moving in the right direction we are not actually there yet but we are well on the way to improving our safety culture.</td>
</tr>
</tbody>
</table>
### Health and Safety Officer

**Table 6.4.3**

<table>
<thead>
<tr>
<th>Changing the work situation Determinants</th>
<th>Index code</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations and weak situations</td>
<td>Q15</td>
<td>(3-5)</td>
<td>I think cell working has reduced RSI and increased flexibility within our working processes to a certain extent in comparison to our previously production line layout</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations and weak situations</td>
<td>Q15</td>
<td>(5-6)</td>
<td>I think in cell working has introduced a number of variations in the tasks and also the introduction of motorized trolleys will certainly make a difference to what we had before. (i.e. was unmotorised trolleys)</td>
</tr>
<tr>
<td>Perception of Situational Strengths</td>
<td>Degree of latitude to change via strong situations and weak situations</td>
<td>Q16</td>
<td>(1-3)</td>
<td>If the team leaders are pro active and willing to listen to management then &quot;yes&quot; I think they do get the opportunity to make slight variations in their processes within their cells</td>
</tr>
<tr>
<td>Culture Issue</td>
<td>Management Style</td>
<td>Q20</td>
<td>(6)</td>
<td>I think the management could be improved in the area by using more updated training methods perhaps giving a little more expertise in their field</td>
</tr>
<tr>
<td>Motivation and Ability Determinants</td>
<td>Index code Motivation Or Ability of Operators</td>
<td>Question Number</td>
<td>Line Number</td>
<td>Interview Transcript</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------</td>
<td>-------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Level of motivation and ability of the operator</strong></td>
<td>Capability of changing the work situation</td>
<td>Q1</td>
<td>(1)</td>
<td>No not in all people and do the work day to day There's a lot of people out there and just want to come to make an effort and change their processes or layout of their workstations who are motivated on a daily basis</td>
</tr>
<tr>
<td><strong>Potential to change the work situation by the operator or team leader</strong></td>
<td>Management Decision</td>
<td>Q2</td>
<td>(4)</td>
<td>They don't know how the basic principles of holding air drivers, how to use ear ring setters and digital rules and so they walk with their hair down and stuff like that have completed the training and evaluate them periodically and make sure they have achieved their target before they move on to the next training session</td>
</tr>
<tr>
<td><strong>Operator behaviour</strong></td>
<td>Attitudes towards changing in the work situation</td>
<td>Q3</td>
<td>(7)</td>
<td>Shows on their (operators) faces (frustration)</td>
</tr>
<tr>
<td><strong>Level of motivation and ability of the operator</strong></td>
<td>Capability of changing the work situation</td>
<td>Q3a</td>
<td>(7a)</td>
<td>From the feedback of the operators there is a lot of people who can make the changes</td>
</tr>
<tr>
<td><strong>Level of motivation and ability of the operator</strong></td>
<td>Capability of changing the work situation</td>
<td>Q3a</td>
<td>(7b)</td>
<td>Improve the processes and their working environment.</td>
</tr>
<tr>
<td><strong>Operator Behaviour</strong></td>
<td>Attitudes towards changing the work situation</td>
<td>Q3a</td>
<td>(11)</td>
<td>Some negative and positive vibes from the operators</td>
</tr>
<tr>
<td><strong>Potential to change the work situation by the Operator or team leader</strong></td>
<td>Management Decision</td>
<td>Q3a</td>
<td>(12)</td>
<td>When the cells are set up from the team leader they run quite effectively they got the time to make the improvements so the team will brainstorm and make improvements. Other teams which are struggling with their performance e.g. quality or productivity, they have not got that opportunity</td>
</tr>
<tr>
<td><strong>Management Support</strong></td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>(16)</td>
<td>If there would be more support from the management side for the team leaders then this would rub off the actual effect it would have on the operators From what I can see from the management side with the team leaders the general lack of support team leaders seem to get from the management is quite poor</td>
</tr>
<tr>
<td><strong>Operator Behaviour</strong></td>
<td>Attitudes towards changing the work situation</td>
<td>Q3a</td>
<td>(21)</td>
<td>I do feel negative vibes come from the team leaders</td>
</tr>
<tr>
<td><strong>Operator Behaviour</strong></td>
<td>Attitudes towards changing the work situation</td>
<td>Q3a</td>
<td>(26-27)</td>
<td>The frustrations from the team leaders is very easy to see on the shopfloor The low morale is seen through the operators and then inevitable the operators</td>
</tr>
</tbody>
</table>
### Occupational Health Advisor

**Table 6.4.5**

<table>
<thead>
<tr>
<th>Motivation and Ability Determinants</th>
<th>Index code (Motivation Or Ability of Operators)</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential to change the work situation by the Operator</td>
<td>Management Decision</td>
<td>Q5</td>
<td>(1)</td>
<td>No not to a great degree I don’t think operators have as much control over their function as perhaps would be beneficial to them</td>
</tr>
<tr>
<td>Management Support, Potential to change the work situation by the Operator or team leader</td>
<td>Management Discretion, Management Decision</td>
<td>Q5</td>
<td>(2-4)</td>
<td>I think a bit more communication between the operators and management would go a long way in that respect</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q9</td>
<td>(5)</td>
<td>Lack of support with adequate training describes how this is reflected in general about the culture of the company</td>
</tr>
<tr>
<td>Level of Motivation of the Operator, Potential to change the work situation by the operator or team leader</td>
<td>Capability of changing the work situation, Management Discretion</td>
<td>Q10</td>
<td>(1)</td>
<td>On the whole operators seem quite demotivated. They don’t (operators) believe that engineers and managers are listening to them and that they have very little effect on change</td>
</tr>
</tbody>
</table>

### Health and Safety Officer

**Table 6.4.6**

<table>
<thead>
<tr>
<th>Motivation and Ability Determinants</th>
<th>Index code (Motivation Or Ability of Operators)</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q16</td>
<td>(1)</td>
<td>It depends on the style of management managing or managed by the team leaders</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2-4)</td>
<td>If the team leaders are proactive and willing to listen to management then “yes” I think they do get the opportunity to make slight variations in their processes within their cells</td>
</tr>
</tbody>
</table>
### Fieldwork Results

**Table 6.4.7**

<table>
<thead>
<tr>
<th>Management Determinants</th>
<th>Index code Management</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q3</td>
<td>(3-5)</td>
<td>The way the management I feel the culture of PPC at the present stage is that it is driven more by production and not by quality and that shows on the faces (i.e. operators express the same opinion of management) the culture of PPC.</td>
</tr>
<tr>
<td>Production Orientated</td>
<td>Management Attitudes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>(16)</td>
<td>I think perhaps if there would be more support from the management side for the team leaders then this would rub off the actual effect it would have on the operators. From what I can see from the management side with the team leaders, the general lack of support team leaders seem to get from the management is quite poor.</td>
</tr>
<tr>
<td>Potential To change the work situation</td>
<td>Management Decision</td>
<td></td>
<td>(19)</td>
<td></td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>(30-34)</td>
<td>It was stated to the team leaders that when the team leaders did experience problems they should write it down on a problem sheet and then they would get started as soon as possible, I know of one team leader put in approx 20 suggestions in and he had not one single reply from management for support for the problems therefore it shows that the management say they will give the help but the team leaders are not getting the support, then low morale is seen through the senior operators and then inevitably to the operators which keep on causing quality and production problems.</td>
</tr>
<tr>
<td>Potential To change the work situation</td>
<td>Management Decision</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Occupational Health Advisor**

**Table 6.4.8**

<table>
<thead>
<tr>
<th>Management Determinants</th>
<th>Index code Management</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q4</td>
<td>(1)</td>
<td>Due to recent changes at the present moment in time we are not sure what areas are going to cause significant problems,</td>
</tr>
<tr>
<td>Production Orientated</td>
<td>Management Attitudes</td>
<td>Q9</td>
<td>(1-3)</td>
<td>It orientates around production targets, Again I feel the pressures of the production targets combined with variable heights of some operators on some workstations</td>
</tr>
<tr>
<td>Management Determinants</td>
<td>Index code Management</td>
<td>Question Number</td>
<td>Line Number</td>
<td>Interview Transcript</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------</td>
<td>-----------------</td>
<td>-------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q16</td>
<td>(2-4)</td>
<td>If the team leaders are pro active and willing to listen to management then “yes” I think they do get the opportunity to make slight variations in their processes within their cells</td>
</tr>
<tr>
<td>Potential To change the work situation</td>
<td>Management Decision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of motivation and ability of the operator</td>
<td>Capability of changing the work situation by the operator</td>
<td>Q18</td>
<td>(1-3)</td>
<td>I would like to see team leaders use it (the lean job position model) to evaluate where their operators are hence it would make the management style a bit more pro active rather than reactive.</td>
</tr>
</tbody>
</table>

| Management Support       | Capability of changing the work situation by the operator |                  |             |                      |
| Potential to change the Work Situation | Management Discretion |                  |             |                      |
| Management Support       | Capability of changing the work situation by the operator |                  |             |                      |
| Level of motivation and ability of the operator | Capability of changing the work situation by the operator | Q18             | (1-3)       | I would like to see team leaders use it (the lean job position model) to evaluate where their operators are hence it would make the management style a bit more pro active rather than reactive. |
### Fieldwork Results

**Index Code: Perception of Culture**  
**Table 6.4.10**

<table>
<thead>
<tr>
<th>Culture Determinants</th>
<th>Index code Perception of Culture</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Orientated</td>
<td>Management Attitudes</td>
<td>Q3</td>
<td>(2-7)</td>
<td>For instance, if we build 96 culture of PPC at the present stage is that it is driven more by production and not by quality m/c’s? Instead of we’ve had good quality. The way the management I feel the m/c’s and we should have achieved 100 m/c’s with 4 down but our quality was really good, in a morning meeting the perception would be why have lost these 4 m/c’s? The way the management I feel the culture of PPC at the present stage is that it is driven more by production and not by quality and that shows on the faces (i.e. operators express the same opinion of management) the culture of PPC.</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q3a</td>
<td>(18-20)</td>
<td>From what I can see from the management side with the team leaders, the general lack of support team leaders seem to get from the management is quite poor.</td>
</tr>
<tr>
<td>Production Orientated</td>
<td>Management Attitudes, Management Discretion</td>
<td>Q3a</td>
<td>(23-33)</td>
<td>Assistant managers and the production manager seem to try and squeeze the team leaders to achieve the targets without actually thinking of supporting them, why can’t they achieve the targets whether its training or time constraints or resource constraints, the frustrations from the team leaders is very easy to see on the shopfloor. It was stated to the team leaders that when the team leaders did experience problems they should write it down on a problem sheet and then they would get started as soon as possible, I know of one team leader put in approx 20 suggestions in and he had not one single reply from management for support for the problems therefore it shows that the management say they will give the help but the team leaders are not getting the support</td>
</tr>
</tbody>
</table>

**Occupational Health Advisor**  
**Table 6.4.11**

<table>
<thead>
<tr>
<th>Culture Determinants</th>
<th>Index code Perception of Situational Strengths</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q8</td>
<td>(1)</td>
<td>The culture of the company seems to be quite historic things seems to be very set, very difficult to change things</td>
</tr>
<tr>
<td>Production Orientated</td>
<td>Management Attitudes</td>
<td>Q9</td>
<td>(1)</td>
<td>It orientates around production targets</td>
</tr>
<tr>
<td>Culture Determinants</td>
<td>Index code Perception of Culture</td>
<td>Question Number</td>
<td>Line Number</td>
<td>Interview Transcript</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------</td>
<td>-----------------</td>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q14</td>
<td>(1)</td>
<td>In terms of a safety culture I don’t think there is a safety culture as yet</td>
</tr>
<tr>
<td>Management Support</td>
<td>Management Discretion</td>
<td>Q15</td>
<td>(1)</td>
<td>Repetitive tasks, the nature of the tasks lack of thought of how some of the tasks could be modified to eliminate some of the risks</td>
</tr>
</tbody>
</table>
### Index Code: Repetitive Strain Injury

**Table 6.4.13**

<table>
<thead>
<tr>
<th>RSI Determinants</th>
<th>Index code RSI</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator and Task evaluation</td>
<td>Standardisation Management Decision</td>
<td>Q2</td>
<td>(14)</td>
<td>By getting them (operators) to sign that they that they have completed the training and evaluate them (operators) periodically</td>
</tr>
<tr>
<td>Potential to change work situation</td>
<td>Degree of latitude to change via strong situations or weak situations Management Attitudes,</td>
<td>Q3</td>
<td>(8-12)</td>
<td>however it does depend what team you are actually work for some team leaders are willing to listen willing to help some team leaders are willing to &quot;get the counter out&quot; (to meet the daily production of machines) again it does depend who you’ve got in charge of you there are some negatives and positives vibes from the operators</td>
</tr>
</tbody>
</table>

**Occupational Health Advisor**

**Table 6.4.14**

<table>
<thead>
<tr>
<th>RSI Determinants</th>
<th>Index code RSI</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of the Work</td>
<td>Repetitive tasks</td>
<td>Q4</td>
<td>(1)</td>
<td>We know RPL 2 is a problem (Cases of operators having RSI problems)</td>
</tr>
<tr>
<td>Reduce the level of operator risk</td>
<td>Modification of the job</td>
<td>Q5</td>
<td>(4)</td>
<td>I think a bit of more communication between operators and management would go a long way in that respect.</td>
</tr>
<tr>
<td>Reduce the level of risk</td>
<td>Modification of the job</td>
<td>Q6</td>
<td>(3-4)</td>
<td>we would be better able to deal with the risk obviously</td>
</tr>
<tr>
<td>Operator Risk,</td>
<td>Work Layout,</td>
<td>Q8</td>
<td>(3-4)</td>
<td>Everybody would be using the model in a continuous fashion to suit the design needs e.g. from a design point of view engineers from an engineering point of view etc,</td>
</tr>
<tr>
<td>Nature of the Work, Production Orientated</td>
<td>Repetitive tasks, Management Attitudes,</td>
<td>Q9</td>
<td>(1-4)</td>
<td>It orientates around production targets and not in the way I see the operators carry out their movement and actions in their processes correctly on a daily basis, Again I feel the pressures of the production targets combined with variable heights of some operators on some workstations with incorrect use of hand assisted tools e.g. an air driver</td>
</tr>
<tr>
<td>Nature of the Work, Operator Risk</td>
<td>Repetitive tasks, Work Layout,</td>
<td>Q11</td>
<td>(1-5)</td>
<td>This is difficult for us because when we diagnose an operator as a suspected RSI or somebody returning to work with MSD then that person has to be put back into that specific work place which will then lead to further difficulty because the full range of movement for that operator is restricted and therefore the risk to injury is greater and the impact becomes more wide spread.</td>
</tr>
</tbody>
</table>
### Health and Safety Officer

Table 6.4.15

<table>
<thead>
<tr>
<th>RSI Determinants</th>
<th>Index code RSI</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of the Work</td>
<td>Repetitive tasks</td>
<td>Q15</td>
<td>(1-2)</td>
<td>Repetitive tasks, the nature of the tasks lack of thought of how some of the tasks could be modified to eliminate some of the risks,</td>
</tr>
<tr>
<td>Reduce the level of operator risk</td>
<td>Modification of the job</td>
<td>Q15</td>
<td>(5-6)</td>
<td>I think cell working has reduced RSI and increased flexibility within our working processes to a certain extent in comparison to our previously production line layout where operators on line were doing the same tasks over and over again</td>
</tr>
<tr>
<td>Nature of the Work</td>
<td>Repetitive tasks</td>
<td>Q17</td>
<td>(3-8)</td>
<td>I think the culture over there (RPL 2) towards RSI has been a far and few between far example claims have been made by operators to an external company where they had received distributed leaflet drops around the area. It had come to our attention that we received high claims from operators that claims had been made against us for RSI. Now these were influenced by employees who had already made claims to this company and had prompted other employees to make the same claims also</td>
</tr>
</tbody>
</table>
### Fieldwork Results

**Index Code: Training**  
**Table 6.4.16**

<table>
<thead>
<tr>
<th>Task Determinants</th>
<th>Index code Training</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Structure</td>
<td>Training programme</td>
<td>Q2</td>
<td>(2)</td>
<td>There are two forms of training, which is the first initial training; at Ricoh is the basic training for 2 days. We had recently produced surveys about our training reported back with the team leader's comments. The results that came out of from the training were very poor.</td>
</tr>
<tr>
<td>Operator and Task evaluation Potential to change work situation</td>
<td>Standardisation</td>
<td>Q2</td>
<td>(8)</td>
<td>We have introduced a report which enables us to standardise the approach that we do in training and evaluate the training via the process books</td>
</tr>
<tr>
<td>Training Structure Potential to change work situation</td>
<td>Training programme</td>
<td>Q2</td>
<td>(12-13)</td>
<td>It would be easy to blame training as the culprit now we are trying to close the loop holes by getting them to sign that they have completed the training</td>
</tr>
<tr>
<td>Training Structure, Operator and Task evaluation, Level of motivation and ability of the operator Potential to change work situation</td>
<td>Training programme, Standardisation, Capability of changing the work situation, Management Decision</td>
<td>Q2</td>
<td>(14)</td>
<td>By getting them (operators) to sign that they that they have completed the training and evaluate them (operators) periodically And make sure the operator have achieved their target before they move on to the next training session.</td>
</tr>
</tbody>
</table>

### Occupational Health Advisor

**Table 6.4.17**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Index code Training</th>
<th>Question Number</th>
<th>Line Number</th>
<th>Interview Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Structure</td>
<td>Training programme</td>
<td>Q9</td>
<td>(5)</td>
<td>Lack of support with adequate training describes how this is reflected in general about the culture of the company</td>
</tr>
</tbody>
</table>

150
<table>
<thead>
<tr>
<th>Task Determinants</th>
<th>Training Structure, Management Support</th>
<th>Training Structure, Potential to change work situation</th>
<th>Interview Transcript</th>
<th>Index Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question Number</td>
<td>Q18</td>
<td>Q19</td>
<td>Q20</td>
<td>Q20</td>
</tr>
<tr>
<td>Line Number</td>
<td>(2)</td>
<td>(17)</td>
<td>(7)</td>
<td>(5)</td>
</tr>
<tr>
<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
</tr>
<tr>
<td>Training Programme</td>
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<td>Training Programme</td>
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<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
<td>Training Programme</td>
</tr>
</tbody>
</table>

Fieldwork Results

Table 6.4.18

Health and Safety Officer
6.5 Issues concerning the Questionnaire

The questions were worded using direct and specific language with a conversational tone (Frey and Mertins Oishi, 1995). The responses were mutually exclusive where one tick was required for each check box. Some attention was paid to the way questions were worded in the questionnaire (Churchill, 1995; Moser and Kalton, 1992), and what information was required from the questionnaire the content for individual questions were considered (Churchill, 1995). The following were decisions taken into consideration that could affect the content of the questions (Churchill, 1995; Tull and Hawkins, 1993; Moser and Kalton, 1992).

Was the sample of respondents capable of answering the questions?
Operators were selected because of their knowledge of their job task. The questions were relatively independent from each other and therefore no recall was required for further explanations.

Was the question necessary?
Only questions related to the information presented in Table 6.6 were required for answering.

How many questions were required to gain the information?
One main question was used to obtain the information with multiple responses presented to the respondent.

The orders of questions were worded in a straightforward way to make the questionnaire easier to use. All the questions were group together and varied to provide interest and consistency in questioning for the respondent (Moser and Kalton, 1992).

The first part of the questionnaire was aimed at targeting the respondent's job situation. The phrases that were used were short and direct. "Can you", "do you", "how many", "what part", prompted the respondent to emphasise their opinion and knowledge of what each thought about their job situation. Respondent classification questions were asked last i.e. second part of the questionnaire. In most cases the questions were worded as simply as possible in a conversational tone prompting the
respondent to voice an opinion or personal understanding of the job situation. This was felt to be in line with the questionnaire objectives.

Appropriate within the aim of the questionnaire some questions unfortunately did not fulfill the measure of being a) comprehensive to all of the respondents b) the interviewer having no difficulty in administering the question; c) of not requiring the question to be rephrased by the interviewer (Frey and Mertins Oishi, 1995). It was found that some of the questions were left unanswered by the respondents. The reasons believed to be the wording of the questions, lack of understanding, and inability of some respondent to convey they're knowledge in a written form, lack of confidence in their contribution and confidentiality of giving personal information. Upon reflection some of the questions could have been better worded, rephrased and more consistent.

6.5.1 Process of Measurement
Measurement is the allocation of a number or symbol to represent the characteristics of objects or events in a way that represents some kind of reality (Tull and Hawkins, 1993). Therefore measures should be taken of characteristics about objects, or events, rather than the objects themselves being measured (Churchill, 1995).

6.5.2 Scale Development
A measurement scale is a means by which an object, event, or person can be given a dimension (Moser and Kalton, 1992). The scale development required for this research included developing the type of scales required for each question, identifying the form of response on the questionnaire, and producing the scale format.

6.5.3 Scale Format
The power of a scale is the amount of information that it can convey and the permissible statistical analysis that can be applied to the data obtained (Diamantopolous and Schlegelmilch, 1997). It is not the object itself but the items used to describe the object that determines the most powerful scale that can be used (Churchill, 1995) and the form the responses on the questionnaire will take. The scale level in ascending order of power can be nominal, ordinal, interval, or ratio. However the power of scale used in part 1 of the questionnaire was nominal and in the second
part ordinal. Both of these scales were examined to determine what the most
appropriate scale type was to measure (Churchill, 1995) and these were chosen
because they were the most powerful possible for the types of items being measured.
In some cases an exact ratio could not be given and also some of the information
being asked could be deemed as sensitive, therefore ordinal scales were used (Tull
and Green, 1993), for example in question seven.

Nominal scale data were collected by the use of open-ended questions in Part 1 of the
questionnaire. Most of the data collected in part I were dichotomous; that is the
respondents were only provided with two possible answers e.g. in questions 4, 5, and
9, thus listing mutually exclusively and collectively exhaustive categories for the
object being measured (Diamantopoulous and Schlegelmilch, 1997). Some
dichotomous scales prompted the respondent to make a choice between one of the two
boxes. Therefore dichotomous scales developed for this questionnaire required the
respondent to check or not to check the corresponding box. This type of layout
devised together by the researcher and Health and Safety officer was produced for
ease of display, understanding and use for the respondent. The inconvenience of this
format is that the respondent may not pay particular attention to each of the item, or
could have misread some of the responses. This could imply some of the responses
may have been skipped and could affect the reliability of the questionnaire instrument.

To avoid this, main statement at the beginning of the questionnaire was outlined in
bold to maintain the attention of the respondent before he or she began completing the
questionnaire.

Ordinal scales in Part 2 of the questionnaire were used to measure the items that
characterised the objects being measured in the questionnaire. The categories and
boxes were listed down the page of the questionnaire and the respondent was asked to
rank from the above list the easiest or most acceptable change to make in an order
from one to ten.

6.5.4 Form of Response
The form of response can be open-ended or closed-ended. Open-ended questions
allow the interviewee to respond in the way they felt is most appropriate (Tull and
Hawkins, 1993). Closed-ended questions can take the form of multiple-choice
Chapter 6  

Fieldwork Results

(multichotomous), dichotomous or scales (Churchill, 1995). Open-ended questions 
allow the respondent the freedom to give the answers that is most suitable for nominal 
data that is coded after the collection process. The majority of the questionnaire in 
Part 1 used open-ended questions. This allowed personal category questions (question 
4 and 5), idea source (question 1, 2 and 3), and questions on collection and 
dissemination methods (questions 6, 7, 8 and 9). In these questions the respondent had 
also the opportunity to add a comment, thought or an idea in questions 4, 5, 6, 8, and 
9.

The second section of the questionnaire used closed questions, providing a checklist 
of statements for reducing the risk of injury. The advantages of using closed questions 
over open questions reduces interviewer bias and are generally easier to ask and to 
answer providing low potential for recording errors, makes data analysis easier and 
provides better compatibility between respondents, (Aaker et al., 1995; Tull and 
Hawkins, 1993; Malhotra, 1996). A disadvantage of closed-ended choices is that the 
researcher must spend significant time and effort developing the appropriate 
responses (Malhotra, 1996). There is also the danger that the format and content of the 
answers offered may distort the results (Tull and Hawkins, 1993) or force respondents 
to make choices that are arbitrary, rather than their true feelings (Moser and Kalton, 
1995).

6.6 Explanation Content of the Questions

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Information Required</th>
<th>Question content explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 You can change the situation you are working in or the sequences of jobs or tasks that you do?</td>
<td>The capability of the operator to change the work situation</td>
<td>The question tries to find out what the respondent thinks about the capability to change his or her work situation. This question needs to prompt the respondent only slightly to assess the situation strength of the work situation.</td>
</tr>
<tr>
<td>Q2 What level of risk do you think your job is mostly likely to be suited to?</td>
<td>Risk level</td>
<td>It is important to find out the what level of risk each respondent is suited to as a result of carrying out the process on a daily basis.</td>
</tr>
<tr>
<td>Q3 Why have you selected this level of risk?</td>
<td>How the level of risk in Q2 is achieved in the process</td>
<td>The reply from Q2 requires each respondent to justify which part(s) of the process produces this level of risk.</td>
</tr>
<tr>
<td>Q4 Can you change this level of risk? If not who do you think can</td>
<td>Control of the work situation</td>
<td>The aim is to identify the amount of work control of each respondent within the work situation to change the level of risk.</td>
</tr>
<tr>
<td>Q5 Do you want to? If so how would you change it?</td>
<td>Incentive to change the level of risk</td>
<td>An opinion is required from each respondent to classify what changes could be made given the incentive to carry out the change in the work situation with management consent.</td>
</tr>
<tr>
<td>Q6 What part of the processes in your</td>
<td>Task Breakdown</td>
<td>This question requires each respondent to predict what part(s) of the process could be changed to reduce or identify the level of RSI.</td>
</tr>
</tbody>
</table>
6.7 Questionnaire Returns

A total of 120 questionnaires were administered by the researcher to a population size of 120 shop-floor workers during the course of the fieldwork. The questionnaires were handed to the team leaders and were then distributed to their operators. From 120 questionnaires distributed, a total of 60 questionnaires were returned completed to the researcher resulting of a 50% response rate. The remainder 50% of those was non-returners. The causes for the non-returners at this time were due to operator’s lack of understanding, inability to read and write, lack of interest, could not envisage the benefits of this study, lack of confidence to share their opinions with fears of being sanctioned by management, absenteeism, and sicknesses. Those out of the sample who did not contribute to the study were later contacted by the researcher with permission from the team leaders. However when spoken to, they refused to take part in the study because some of them were not willing to account any of their spare time in completing the questionnaire.

6.8 Questionnaire Analysis Method

Editing, coding and tabulation are the most common and preliminary steps before representing the findings “that involve inspecting and in most cases correction of each questionnaire or observation form”, (Churchill, 1995). Some questionnaires can have
some entire sections omitted and some can be judged by the respondent’s interest, for example by only some of the sections being partially filled. Then the purpose is to impose some minimum quality standards on the raw data (Churchill 1995) using field edits or central office edits.

6.8.1 Field Edit
The field edit is a preliminary measure designed to identify inaccuracies in the data. It is usually controlled after the administration of the questionnaire so that problems resulting from the field edit can be corrected. Within the field edit some corrections can enable the researcher to verify:

Completeness: To scrutinise the data to ensure no sections were omitted. A blank incomplete section for a specific question could imply a respondent refusal to answer or reflect on the respondent’s part to know the answer.

Legibility: The lack of legibility on behalf of the respondent means impossible coding and interpretation of the responses from the questionnaire.

Comprehensibility: A recorded response may be read and interpreted incorrectly from the researcher therefore checking for this effect the researcher is able is verify any misunderstandings or make the necessary clarifications.

Uniformity: Important for the researcher to verify that all the responses have been recorded in uniform units, to each question ensuring no confusions are made with the responses during the latter stages of analysis.

Consistency: Consistencies should be identified to note for any ambiguity made by the respondent. Any indication of inconsistency found from the researcher may show carelessness in administration.

6.8.2 Central Office Edit
To ensure correctness of the questionnaire returns, the central office edit calls for a lengthy process which involves each part of the questionnaire being divided into data collection instruments rather than by its respondents. This involves in detail, exact examination and correction of the completed questionnaire returns. This edit relies less upon the follow-up process. The pursuit of more accurate answers is likely to be more difficult because of the time elapse needed for chasing the particular respondent again for more clarification. Unlike the field edit, the central office edit poses as a
main disadvantage and is deemed unsuitable for editing questionnaires used in this research study.

6.8.3 Coding
The initial step in coding is to specify the categories or classes into which the responses are to be placed (Churchill, 1995) and the list of codes for each corresponding response group in a code frame (Hague & Jackson, 1996). The coding frame depends on the type of questions used in the questionnaire opened and or closed. Coding closed questions is "simple because the coding is established for all practical practices" (Churchill 1995) although the respondents code their responses themselves with the questions, coding open ended questions "is quite a problematical activity" (Hague & Jackson, 1996) because it can bring in errors and the "researcher has to determine a suitable category on the basis of the answers that are not always anticipated" (Churchill 1995). In this particular case the researcher has decided to apply the Factor Cluster Analysis as the means for coding suitable category of information obtained from the semi-structured interviews in the action research process.

6.8.4 Tabulation
Cross tabulation involves the use of two or more variables where these are treated simultaneously. Although the use of one way tabulation is useful, this research study does not require examining the variables of the study independently. Drawing analysis from a cross tabular sample requires that the sample is representative, that is "it mirrors the population in at least important characteristics and is an important mechanism for examining the relationships among and between variables to learn how the dependent variable varies from the sub group to a sub group (Churchill, 1996) of making comparisons between sub groups of the sample" (Hague & Jackson, 1996).

It enables the relationship between two variables or more to be examined therefore the likelihood of analysing the internal ability and motivation of the individual to reduce the potential risk of RSI in high or low situation strength requires the use of factor cluster analysis with the conceptual model explained in Chapter 3. Factor analysis and cluster analysis are applied simultaneously where the focus of factor analysis reduces the attributes to a smaller number of component factors where the bases of the
responses are defined in terms of their component factors. For cluster analysis the responses are homogeneously clustered into groups on the basis of their component factors. What is being analysed by the researcher is to seek out and represent the key characteristics of RSI and understand how internal motivation and repetitive forceful movements in strong and weak situations can affect the capability of the individual to change the lean job to reduce the level of RSI risk by applying factor cluster analysis.

6.9 Direct Observation Analysis Method
According to (Churchill 1995) analysing data from observations can be determined from the identification of two types of basic non sampling errors methods; non-observation errors and observation errors, whereby non observation errors results from the failure to obtain data from parts of the survey population and observation errors resulting from inaccurate errors from the sample elements or report findings (Churchill 1995).

At this stage, it is possible for the researcher to develop his own bias because of non coverage or non response. It is possible with observation errors the researcher can compare the true value observations with his detailed log of all the activities taking place during the course of the research against previous assumptions documented in the literature, therefore consolidating the possible effects of non coverage and non response. The possibility of non coverage and non response are consolidated in the analysis by citing the relevant literature. The relevant literatures to support the hypotheses from the Lean Job Position model with the two other hypotheses are discussed in Chapter 7.

6.10 Fieldwork Results
The fieldwork results in Chapter 6 show the findings from Company A. The results identify the outcome of the research conducted by the author. All the fieldwork results presented in Chapter 6 are fully discussed in Chapter 7 respectively.
6.11 Questionnaire Results

Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

Cell 1 Paper Tray Spin Pop Rivet & Buffer Operators

- 28% Strongly Agree
- 44% Agree
- 11% Disagree
- 11% Strongly Disagree

No of respondents (n) = 18

Figure 6.11.1
Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

Cells 2 & 4

- 22%
- 11%
- 22%
- 45%

No of respondents (n) = 9

Figure 6.11.2
Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

Scanner Cell

- Strongly Agree: 20%
- Agree: 20%
- Disagree: 40%
- Strongly Disagree: 20%

No of respondents (n) = 6

Figure 6.11.3
Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

Configuration & Copy Checks

38%

62%

No of respondents (n) = 8

Strongly agree and strongly disagree acquired null responses from 8 respondents who participated in the questionnaire.
Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

45 CPM Modular Build & Main build

- **21%** Strongly Agree
- **21%** Agree
- **16%** Disagree
- **42%** Strongly Disagree

No of respondents (n) = 19

Figure 6.11.5
Q1 You can change the situation you are working or sequences of jobs or tasks that you do?

Summary of Results for Q1:

- 17% Strongly Agree
- 12% Agree
- 30% Disagree
- 41% Strongly Disagree

Total no of respondents who answered Q1 (n) = 60

Figure 6.11.6
Q2 What level of risk do you think your job is mostly likely to be suited to?

Cell 1, PaperTray, Spin Pop Rivet, Buffer Operators

![Bar graph showing levels of risk](image)

No of respondents (n) = 18

Figure 6.11.7
Q2 What level of risk do you think your job is mostly likely to be suited to?

Cell 2 & 4

- High Risk (Death/Amputation)
- Moderate Risk (Fracture)
- Low Risk (Strain/Cut)

Number of responses per level of risk

No of respondents (n) = 9

Figure 6.11.8
Q2 What level of risk do you think your job is mostly likely to be suited to?

Scanner Cell

<table>
<thead>
<tr>
<th>Level of Risk per type of Injury</th>
<th>Number of responses per level of risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Risk (Death/Amputation)</td>
<td></td>
</tr>
<tr>
<td>Moderate Risk (Fracture)</td>
<td></td>
</tr>
<tr>
<td>Low Risk (Strain/Cut)</td>
<td></td>
</tr>
</tbody>
</table>

No of respondents (n) = 6

Figure 6.11.9
Q2 What level of risk do you think your job is mostly likely to be suited to?

Configuration & Copy Checks

Level of Risk per type of Injury

- High Risk (Death/Amputation)
- Moderate Risk (Fracture)
- Low Risk (Strain/Cut)

Number of responses per level of risk

No of respondents (n) = 8

Figure 6.11.10
Q2 What level of risk do you think your job is mostly likely to be suited to?

45CPM Modular Build & Main Build

![Graph showing levels of risk]

- **High Risk (Death/Amputation)**
- **Moderate Risk (Fracture)**
- **Low Risk (Strain/Cut)**

Number of responses per level of risk

No of respondents (n) = 19

Figure 6.11.11
Q2 What level of risk do you think your job is mostly likely to be suited to?

Summary of Results for Q2

- **Low Risk (Strain/Cut)**
- **Moderate Risk (Fracture)**
- **High Risk (Death/Amputation)**

Total no of respondents who answered Q2 (n) = 60
Chapter 6

Fieldwork Results

Q4: Can you change this level of risk?

Cell 1 Paper Tray, Spin Pop Rivet, Buffer Operators

50%

Q5: Do you want to?

Cell 1 Paper Tray, Spin Pop Rivet, Buffer Operators

50%

Figure 6.11.13

No of respondents (n) = 18

Figure 6.11.14
Chapter 6

Fieldwork Results

Q4: Can you change this level of risk?

**Cells 2 & 4**

- Yes: 78%
- No: 22%

Q5: Do you want to?

**Cells 2 & 4**

- Yes: 33%
- No: 67%

Figure 6.11.15

No of Respondents (n) = 9

Figure 6.11.16
Q4: Can you change this level of risk?

Scanner Line

0%

100%

Yes  No

Q5: Do you want to?

Scanner Line

67%

33%

Yes  No
Q4: Can you change this level of risk?

Configuration & Copy Check

- Yes: 38%
- No: 62%

Q5: Do you want to?

Configuration & Copy Check

- Yes: 38%
- No: 62%

Figure 6.11.19

No of Respondents (n) = 8

Figure 6.11.20
Q4: Can you change this level of risk?

45CPM Modular Build & Main Build

- Yes: 74%
- No: 26%

Q5: Do you want to?

45CPM Modular Build & Main Build

- Yes: 42%
- No: 58%

Figure 6.11.21

Figure 6.11.22

No of Respondents (n) = 19
Q5: Do you want to?

Summary of responses for Q5

- Yes: 54%
- No: 46%

Q4: Can you change this level of risk?

Summary of responses for Q4

- Yes: 24%
- No: 76%

Figure 6.11.23

Total no of respondents who answered Q4 and Q5 (n) = 60
Q7: How many improvements do you make to your work station without putting them in the suggestion scheme

Number of Responses per workstation Cell Area

<table>
<thead>
<tr>
<th>Number of Suggestions made per workstation Cell Area</th>
<th>45 CPM Modular Build &amp; Main Build</th>
<th>Configuration &amp; Copy Checks (QRM) Main Build</th>
<th>Scanner Line</th>
<th>Cells 2&amp;4 (QRM) Main Build</th>
<th>Cell1, Paper Tray Spin pop Rivet, Buffet Operators (QRM) Main Build</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
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<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
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<td>4</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

Quantity of Work station improvements made per workstation cell

- Red: 1 or more per month
- Purple: 1 or more per week
- Blue: 1 or more per day

Figure 6.11.25 Total no of Respondents (n) = 60 only 30 out of 60 replied providing only a response rate of 50% for Q7
Q9: Do you have enough information or training to do your job properly?

![Bar Chart]

- 45 CPM Modular Build & Main Build: 5 (No), 14 (Yes)
- Configuration & Copy Checks (QRM) Main Build: 1 (No), 7 (Yes)
- Scanner Line: 1 (No), 5 (Yes)
- Cells 2 & 4 (QRM) Main Build: 0 (No), 9 (Yes)
- Cell 1, Paper Tray Spin pop Rivet, Buffet Operators (QRM) Main Build: 1 (No), 17 (Yes)

Number of Responses per workstation cell area

- (No) Respondents who do not have adequate training
- (Yes) Respondents who have adequate training

Total no of Respondents (n) = 60 who answered Q9
What do you think would be most effective to reduce the risk of injury?

Measures favoured most effective to reduce the risk of injury by operators in PaperTray, Cells 1-4, Buffer Operators & Spin Pop Rivet

- A defined Safe System of Work
- Simple Device
- Technological Improvements
- Relayout of Equipment
- Alteration Of Workflow

Results showing the most acceptable or easiest change to make to reduce the Risk of Injury

- Modification Of Process Books
- Perform Tasks Outside Job Role
- Job Rotation
- Height of the Operators (m)
- To measure the amount of Force (N)
What do you think would be most effective to reduce the risk of injury?

**Measures favoured most effective to reduce the risk of injury by Operators in Configuration & Copy Checks**

- A defined Safe System of Work
- Simple Device
- Technological Improvements
- Relayout of Equipment
- Alteration Of Workflow

**Results showing the most acceptable or easiest change to make to reduce the Risk of Injury**

- Modification Of Process Books
- Perform Tasks Outside Job Role
- Job Rotation
- Height of the Operators (m)
- To measure the amount of Force (N)
What do you think would be most effective to reduce the risk of injury?

Measures favoured most effective to reduce the risk of injury by operators in the Scanner Cell

- A defined Safe System of Work
- Simple Device
- Technological Improvements
- Relayout of Equipment
- Alteration Of Workflow

Results of the most acceptable or easiest change to make to reduce the Risk of Injury

- Modification Of Process Books
- Perform Tasks Outside Job Role
- Job Rotation
- Height of the Operators (m)
- To measure the amount of Force (N)
What do you think would be most effective to reduce the risk of injury?

Measures favoured most effective to reduce the risk of injury from by operators in the 45 CPM Cell Area

- A defined Safe System of Work
- Simple Device
- Technological Improvements
- Relayout of Equipment
- Alteration Of Workflow

Results showing the most acceptable or easiest change to make to reduce the Risk of Injury

- Modification Of Process Books
- Perform Tasks Outside Job Role
- Job Rotation
- Height of the Operators (m)
- To measure the amount of Force (N)

Figure 6.11.33

Figure 6.11.34
Summary Of Results

Measures favoured most effective by the operators to reduce the risk of injury

- A Defined Safe System of Work
- Equipment Relayout
- Job Rotation
- Operator Height (m)
- Measure the amount of Force (N)

Results showing the most acceptable or easiest change to make to reduce the risk of injury

- A Defined Safe System of Work
- Equipment Relayout
- Job Rotation
- Operator Height (m)
- Measure the amount of Force (N)

No of Responses / Measure

Figure 6.11.35

No of Responses / Measure

Figure 6.11.36
6.12 Data Analysis applying Soft Systems Methodology

Soft Systems Methodology (SSM) helps decision-makers understand real world situations by comparing people's perceptions with constructed theoretical models.

Chapter 1 presented the problem situation or the undesirable situation of RSI. Chapter 2 defined the problematic situation through an extensive literature review with the 'rich picture' being created through a statement of beliefs from the researcher. Chapter 3 selected the 'relevant system' by conceptualising RSI the 'problem situation' with a simulation from the Buckingham Supply Chain Game. A conceptual framework was then constructed by defining strong and weak situations in terms of RSI as the 'root definition'. Figure 6.12 below shows the process of analysis by applying the Soft Systems Methodology to this research.

Stages of data analysis using Soft Systems Methodology

- Stage 1: The problem situation defined in Chapter 1
- Stage 2: Statement of beliefs in Chapter 2 to build the rich picture
- Stage 3: Chapter 3 Simulation of RSI in strong and weak situations
- Stage 4: Testing of the Lean Job Position Model 'Conceptual model' using direct observations, semi-structured interviews and questionnaire
- Stage 5: Comparison of the Lean Job Position Model and the Risk Level Matrix In the 'real world' context
- Stage 6: Debate actions from the direct observations, semi-structured interview and questionnaire with Departments in Company A
- Stage 7: Implement agree on changes as control measures
The CATWOE analysis from the root definition of (Chapter 4 pg 96) follows that:

C: Operators perceive their job situation to be guided by little decision making over their work pattern i.e. a strong situation or operators having the disposition to suit their way of working thereby creating a weak situation.

A: The strength of the situation i.e. a strong situation or a weak situation can govern the number of repetitive forceful body movements in the job task.

T: The number of repetitive forceful body movements of the operator considered within the work area of the operator.

W: Operators in a strong or a weak situation can show the capability (ability and motivation of how the job is organised) to enable him or her to change repeated forceful body movements.

O: The capability of the operator to make changes in how their job task is organised to reduce the level of RSI risk depends on their ability and motivation to change repetitive forceful body movements.

E: The nature of the lean job is created by its set standard of procedures.

The outcome of the direct observations resulted in a risk level matrix to identify the potential level of RSI risk to injury of an operator. It was felt by the researcher that the risk level matrix and the conceptual model would be suitable to compare with the real situation in Company A.

The real situation was such that the Lean Job Position Model and the risk level matrix could be incorporated as a means of a control measure for station evaluation, and training. The Health and Safety officer suggested the risk level matrix was to be incorporated into they’re risk assessments evaluations whilst the Lean Job Position Model would need further testing at a later date by the Health and Safety Officer.

The ‘rich picture’ from the analysis resulted in addressing certain key action areas recommended by the researcher to Company A for reducing the level of RSI risk in their processes, shown in Table 6.12.
<table>
<thead>
<tr>
<th>Action</th>
<th>Department Responsible in Company A</th>
<th>Summary</th>
<th>Potential Risk at Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Handling</td>
<td>H+S, HR, APM, T/L</td>
<td>Training must be made available to all employees A defined safe system of work to be implemented</td>
<td>High</td>
</tr>
<tr>
<td>Alteration to Jig and platform</td>
<td>APM, T/L, Eng</td>
<td>Remove platform Re-modify jig and placement of hand assisted tools e.g. air drivers</td>
<td>Medium</td>
</tr>
<tr>
<td>Height of Trolleys</td>
<td>Eng</td>
<td>Replace flow-tube trolleys</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ind Eng</td>
<td>Review process books to re-align and rebalance assembly work tasks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>APM</td>
<td>Introduce part process build between operators</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>H+S</td>
<td>Assess height of male and female operators through Risk Assessments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T/L, Eng</td>
<td>Align the workload to suit the operator condition and line balance the cell</td>
<td></td>
</tr>
<tr>
<td>Rivet Guns</td>
<td></td>
<td>Equipment relay out by the operator To provide frequent rest periods between use of the rivet gun during the process cycle</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>H+S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layout of Scanner Cell</td>
<td>APM</td>
<td>Increase space allocation between workstations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HR</td>
<td>Introduce job rotation between operators Training to be provided by HR to senior operators and the team leaders to train their operators on line.</td>
<td>Low</td>
</tr>
</tbody>
</table>

Recommended key action areas for reducing the levels of RSI risk in Company A

Table 6.12

Key to the table: H+S (Health and Safety), Eng (Engineering), T/L (Team Leader), Ind Eng (Industrial Engineering), HR (Human Resource), APM (Assistant Production Manager)
The use of Soft Systems Methodology in this research provided a good structure for managing and coping with complexity of information involving human activity in an organized series of iterative stages. Analysis of the data from this perspective provided a means of analysing and understanding problems of a complex system in action research content.

6.13 Summary

This chapter has discussed and presented the format of the fieldwork results from the action research process. The next chapter draws the attention of the reader to the discussion in Chapter 7 where further reports of the fieldwork results are discussed in depth with the research hypotheses in Chapter 3.
Chapter 7

Discussion

The research findings from the three specific research hypotheses presented in Chapter 3 are discussed. The following sections in this chapter relate to the fieldwork results from Chapter 6 to the discussion of each of the specific research hypotheses in this chapter.

7.1 Introduction

This research was stimulated by a number of key issues highlighted in the literature review but there was relatively little documented evidence about how strong or weak situations could identify the level of RSI risk, moreover how the level of RSI risk could be evaluated in a lean manufacturing industry.

The research processes were driven by the exploration of the research objectives. Although shaped by the researcher, the fieldwork results from the model and the hypotheses represent the perspectives of those involved in a lean manufacturing environment. This suggests the picture created, does not provide a complete set of explanations for all aspects of the work organisation in a lean manufacturing setting, but shows the relationship to assist our understanding of how a better work organisation can be created.

In this research study, the researcher in Company A, engaged in the action research process to develop explanations that would prove or disprove the hypothesis and provide some validity to the Lean Job Position Model. The following section of this chapter addresses these issues by discussing the findings of the research hypotheses from in Chapter 3.

This chapter intends to include elements of reflectivity which in part aims to satisfy the requirement for this research. It enables people external to the investigation to evaluate the rigour and logic between inferences drawn from the data, and enable the researcher to identify where his preconceptions have an influence upon the research process.
7.2 Format of Findings

The main methods of the data collection for this research study will be presented in a structured format to aid the progress of the reader through the discussion. The format is described below:

**Direct Observations:** The format for this discussion will highlight the major observations for each hypothesis. References from the literature will be used to validate the observations using quotations were appropriate.

**Questionnaires:** Differences or similarities in results are explained noting patterns or themes by referring to the appropriate figures in the fieldwork chapter, (Chapter 6)

**Interviews:** The evidence provided itself, is in the form of quotations (in italics) from the interviewees. These quotes are not exhaustive but are examples providing the reader with a view of the strength of the data collected. Finally the relationship between the theme explored and the findings of the hypotheses will present the outcome of the data exploration. The outcome will be clearly differentiated between each finding, generating meaning from the data thereby adding to the process of reflexivity through the literature.

### 7.3 Findings from the Lean Job Position Model

<table>
<thead>
<tr>
<th>Factors contributing to the strength of the situation</th>
<th>Potential Level of RSI Risk</th>
<th>Ability and Motivation of the Operator (Age) years</th>
<th>Repetitive Forceful Body Movements (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group or organisational situational strength</td>
<td>Low</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>High group or organisational situational strength</td>
<td>High</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Low group or organisational situational strength</td>
<td>Low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Low group or organisational situational strength</td>
<td>Moderate</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>

Hypotheses derived from the Lean Job Position Model

Table 7.3

Discussed previously in Chapter 3 the following hypotheses were generated from the lean job position model, shown in table 3.9 page 77

These first set of research hypothesis derived from the model were aimed at understanding the ability and motivation of the individual, under high and low group or organisational situational strength. The capability of the individual to change how
the job is organised against repetitive forceful body movements involving high and low repeated forceful body movements, presented these findings from the hypotheses:

| If the organisational or group situational strength is high the level of RSI risk is: |
|------------------------------|------------------|
| Low when the ability and motivation of the individual to change the situation is high with low repetitive forceful body movements. |

7.3.1 Observations made by the researcher
Observation 1
The culture in this company is primarily production orientated. High situational strength is created by a management 'drive to getting the daily machines produced out of the factory' in each production day. The team briefing in the morning gives feedback from the previous day's production. Achieving their target from the previous day's production needs high levels of motivation and ability, and there is little interest from the operator to change their way of working so "You all know what you have got to do," (Team leader) tends to enforce current ways of working.

There is evidence to suggest that people actively choose their situations (Emmons & Diener, 1986; Swann, 1983), and tendencies exist to perform best in situations that are most compatible to their own tolerance of ambiguity in a particular situation strength, for example as (Diener et al., 1984) describe "people tend to be happier when they are in settings that meet their particular needs or are congruent with their dispositions." In addition peer discipline is a main situational constraining characteristic perceived to develop high situational strength in the workplace and evident in early morning team briefings. This suggests that in most Japanese transplants there is a view to "keep most workers in line," (Kenney & Florida, 1993), by using a form of hegemonic control that establishes identification with workers between the company and its goals, spurring workers to work hard and assist in motivating fellow workers to make sense of their mission to secure co-operation from the workforce (Ezzamel et al., 1999).
7.3.2 Questionnaire Results (Q1)

Results for Q1 figure (6.11.6) considered that 41% of the respondents from the sample were able to implement changes to their work sequences or tasks within their work situation. However results from Figure (6.11.4), 62% disagrees to changing the work situation or sequences within their jobs. Illustrated in this following exchange between the operator and the quality engineer, the high ability and motivation to change the work situation, suggests a perceived lack of control by the operator to an appropriate consensus encoding of the work situation, because his motivation and ability to make the required response is prevented by the task uncertainty and by his work situation:

"There's really not much I can do I have tried everything, I have followed the standard procedure in the process book, searched in the manual and I have done everything, but still there is an error on the display panel, what do you think it could be"?

Literature on work re-design aspects of job tasks for example by (Cummings, 1978, Slocum and Sims, 1983), indicated technical interdependence and technical uncertainty affected the work design success of the individual while the variety of skills needed to complete the task for which the employees were responsible, were limited by technological reasons.

Studies by (Lee et al., 1990), into interactive effects of type A behaviour and perceived control on worker performance, with job satisfaction, found perceived control to be a critical moderating variable in the study of type A behaviour. In organisational settings, their findings suggest people with high levels of type A behaviour and perceived control tended to be more productive, with higher job satisfaction rather than type A behaviours with low perceived control.

7.3.3 Interview Findings

When asked if there is a lot of motivation and ability amongst the operators to change their work situation (encode their work situation differently) the quality auditor admits "No not in all people all they want to do is do the work day to day but there are some that just want to come to make an effort and change their processes or layout of their workstations who are motivated on a daily basis." This he adds "from the feedback of the operators there are a lot of people who can make the changes to improve the
Chapter 7 Discussion

processes and their working environment." Indicating there is a mixture of operators who encode their work situations in different ways.

From the company's culture point of view Occupational Health advisor argues "the culture of the company seems to be quite historic, things seems to be very set, very difficult to change, I don't think operators consider it to be beneficial to have as much control over their function as perhaps they could have." This suggests a high velocity environment where strategic decision-making choices by management impose their discretion by uniformly encoding a strong situation thereby seeking consensus for the appropriate response by every operator.

A good indication of perceiving the operator's ability and motivation to change his circumstance can be obtained from the following: "In a morning meeting the perception would be why we have lost these 4 machines? Instead of we've had good quality. The way I feel about management, and the culture of PPC at the present stage is that it is driven more by production and not by quality," and that it shows on the faces (i.e. operators express frustration of management) within the culture of PPC.

Therefore the findings from this hypothesis suggest high group situational strength of encoding low repetitive movements of operators by management in 'strong' situations, are evaluated and rewarded on the basis of their ability to help coworkers, show support for organisational policies and procedures. In terms of strong contextual performance, there are unambiguous environmental suggestions that contextual performances are expected, valued and rewarded (Beaty et al., 2001).

If the organisational or group situational strength is high the risk of RSI is:

High when the ability and motivation of the individual to change the situation is low

with high repetitive forceful body movements.

7.3.4 Observations made by the researcher

Observation 1

Health and Safety and Occupational Health advisor assessed an operator to be working with arm movements at shoulder height. The risk level diagnosed by Occupational Health was reported as a moderate to high risk. In the course of this
repeated movement, this resulted in the operator discontinuing this task and removing it from his process. This recommendation put forward by Occupational Health to the team leader to remove this task from the whole process was not followed. "This is one of the biggest problems in that area, I have recommended my actions, but we are a contracted advisory service with no real means of securing action". The team leader together with the operator had put forward recommended actions for reducing the level of risk to be reviewed by engineers but information on its assessment were unavailable. Studies made in the literature indicate working above shoulder height is widely recognised as a risk factor, "highly repetitive arm and shoulder movement increases the risk of shoulder tendon disorders (Bjelle et al., 1981, Ohlsson et al., 1989, 1994, 1995; NIOSH 1997), although there is no evidence to suggest as far, as the shoulder is concerned that working below shoulder level (e.g. chest height or waist height) is safe (Buckle & Li, 1999), the movement of the shoulder may be very different (in terms of pattern and speed) from that of the hand and wrist (Buckle & Devereux, 1999). Literature reviewed by NIOSH (1997), in this area regarding force/load and duration as risk factors associated with shoulder arm disorders found insufficient evidence to suggest firm conclusions regarding the relationship between force and shoulder disorders. The conclusion led to a variety of different assessment approaches and health outcomes.

Observation 2
A shopfloor female operator obtained a RSI injury to her wrist by repetitively rotating a component on a sub assembly, (drum unit) through her inspection duties. Under observation she had obtained a RSI injury and continued working without rest despite reporting this to her team leader. When the injury was further aggravated she was relieved from the task, by request of the team leader and Health and Safety until she recovered from the injury.

Kenney & Florida, (1993), argue in some instances "the work pace maybe so demanding that supervisors and team leaders do not allow workers to go to scheduled doctors appointments", although, "the team member's responsibility is to talk to workers who are having problems offer support and through this process reinforce company policies." Large numbers of women are being placed in a number of high stressed jobs, for long periods of time without rotation thus increasing both the risk and actual incidence of repetitive motion injury, (Kenney & Florida, 1993, Leclerc et
al., 1999; Feuerstein et al., 1997; Auguston and Morken, 1996; Andersson et al., 1993; Messing et al., 1993; Gun, 1990, Rinehart et al., 1997).

Repetition has been widely recognised as a risk factor associated with both hand/wrist tendonitis, carpal tunnel syndrome (Buckle & Devereux, 1999) and Repetitive Strain Injury. NIOSH (1997) has recognised the importance of force as a risk factor associated with hand and wrist musculoskeletal disorders. In some studies by (Silverstein et al., 1986), high repetitive tasks have been defined as those with a work cycle time of less than 30 seconds or with more than 50% of the cycle time involved in performing the same motion pattern (Buckle & Devereux, 1999). In some work situations, a work cycle may not exist or if it does, cycle time can vary periodically which makes it difficult to assess within a limited observation period (Buckle & Li, 1999), therefore repetition should be assessed upon the basis of movement rates (i.e., number of times repeating similar motion per minute). The movement rate of 10 times per minute was regarded as being appropriate for the wrist (Kilborn, 1997). In brief the literature suggests the frequency of exposures to repetitive hand and wrist movement of the individual may place the worker in a high-risk zone of obtaining hand wrist disorders.

Observation 3
Rivet guns which are hand vibration tools are commonly used for inserting and tightening screws onto a sub assembly. The observation found insufficient rest periods between its uses. The risk level of RSI for wrist injuries is assumed by Occupational Health to be more frequent for older operators and temporary operators. Her observation, she quotes “If an operator has to use the rivet gun 16 times within the tact time (cycle time), then the suggestion is to use the gun 8 times and do something else then use it again for another 8 times, however due to increases in production demands and layout changes at the moment he can't do this.” Many of the wrist injuries are caused from the internal vibrations of the gun especially by older operators who use these tools throughout the production day on a repeated basis.

The fact that hand-arm exposure to vibration, direct mechanical pressure on body tissues, effects of a cold working environment contributes to hand and wrist injuries, epidemiological evidence from (Cannon et al., 1981, Conner and Kilisek 1986,
Sieslander et al., 1989), suggest that carpal tunnel syndrome, is significantly correlated with exposure to vibration from hand-held tools although (Miller et al., 1994, Pelmear and Taylor, 1994) argue that hand arm vibration syndrome is often mis-diagnosed, as carpal tunnel syndrome, and can be also found in a number of workers exposed to vibration under high load conditions (Hagberg et al., 1995) and tendon related disorders (Stenlund et al., 1993).

7.3.5 Questionnaire Results (Q2)

Figure 6.11.7 and 6.11.8 and 6.11.9, revealed a fair proportion of operators to be exposed to low-level risks of RSI within their job. Even though these were measured by the operators to be a low-level risk, the potential to obtain such injuries were based upon the following job tasks being carried out by the operators:

- Strains of the arms due to pulling and lifting of sub-assembled units on a regular basis every 2 minutes without rest periods
- Handling of sharp metal plates that have rough edges and lifting of sub-assembled frames onto the AGV (Automated Guided Vehicle)
- RSI to the wrists, from the use of electric air drivers and cuts to the fingers from manual handling of the sub-assembled units

Whereas, figures 6.11.4 and 6.11.6 reported a smaller number of operators were also exposed to risks of RSI.

Literature in this area have distinguished strong and weak situations where (Barrick & Mount, 1993), found situational strength to be a moderator for measuring the level of autonomy in job performance. They suggest the person (operator) is restricted to the range of behaviours that she or he may be both willing and able to exhibit in strong situations with little autonomy, for example in assembly line jobs where close supervision, highly structured and machine paced work provides very little opportunity for individual differences in personality to be expressed. Weak situations provide less pressures and demands to conform to certain behaviours giving some degree of discretion of the individual (operator), to determine which behaviours to undertake, however this does not reflect the results from Q2 of the questionnaire. Furthermore they propose personality differences prevail more in strong situations where specific behaviour types are adopted and when the level of autonomy is low.
(high forceful repetitive movements) than high levels of autonomy (low repetitive forceful body movements) the demands to conform to certain behaviour types are not warranted in weak situations.

Repetitive movements are defined as the basis for Repetitive Strain Injuries (RSI) by (Blatter and Bongers, 1999) and repetitive tasks as the basis for monotonous work having detrimental effects on the learning capacities of workers (Pack and Buck, 1992). A survey conducted for the European foundation for the improvement of living and working conditions by (Dhondt et al., 2002) presented a high correlation with short and long repetitive, monotonous work where machine technology seemed to be a requirement for such repetitive work.

The effect of working conditions on pace constraints studied by (Boisard et al., 2003) for assembly operators indicated they were often frequently exposed to repetitive hand and arm movements, and vibrations from hand tools. It may be reflected by an increase in the number of identical operations to be performed in a given time (Bennett, 1999). A combination of commercial and industrial/bureaucratic forms of organisation increases the number of situations involving repetitive work under severe time constraints, (Boisard et al., 2003). Similarly (Delbridge et al., 1992), argue the success of JIT/TQM manufacturing system in terms of intensifying the labour process, is a result of increased surveillance and monitoring of workers activities whereby “workers are in fact subject to highly visible forms of managerial power, control, and process of constant surveillance and monitoring of output and performance”, (Delbridge and Turnbull, 1992; Delbridge, 1995; Garrahan and Stewart, 1992; Sewell and Wilkinson, 1992, Section 2.3.2 Chapter 2).

7.3.6 Interview Findings
The intolerance for ambiguity from Norton, (1975) points out that there is a tendency to perceive, or interpret; information marked by vague, incomplete, fragmented, multiple, probable, unstructured, uncertain, inconsistent, contrary, contradictory, or unclear meanings by the operators:

"Assistant managers and the production manager seem to try and squeeze the team leaders to achieve the targets without actually thinking of supporting them, why can't
they achieve the targets whether its training or time constraints or resource constraints, the frustration from the team leaders is very easy to see on the shopfloor
Health and Safety: If the team leaders are pro active and willing to listen to management then “yes” I think they do get the opportunity to make slight variations in their processes within their cells. This view holds the same uniform encoding of the situation by the auditor where he responds:

“It does depend what team you are actually working for, some team leaders are willing to listen and willing to help. Some team leaders are willing to “get the counter out” again it does depend who you’ve got in charge of you (to meet the daily production of machines) When the cells are set up from the team leaders they run quite effectively, they’ve got the time to make improvements so the team leaders will brainstorm and make improvements, other teams which are struggling with their performance, e.g. quality or productivity, they have not go that opportunity.”

Occupational health’s view is that there is a lack of time to target perceived areas of high risks with strong situational strength as she explains:

“We are not sure what areas are going to cause significant problems, we don’t get the amount of time perhaps we feel we ought to have a look at the area in actual depth. Due to our work schedule and due to the production schedules over there (RPL 2), but saying that there are pro-active (engineers & managers) and they will look at the processes and layout of the work stations and they will move forward in time it just appears to take longer than perhaps I would have expected. They (operators) don’t believe that engineers and managers are listening to them and that they have very little effect on change.”

There is perceived to be a shift in situational strength from strong situations to weak situations where the consensus by management and engineers to encode uniformly high repetitive forceful body movements into low repetitive forceful body movements are uncertain. “From what I can see from the management side with the team leaders the general support team leaders seem to get from the management is quite poor, If there would be more support from the management side for the team leaders then this would rub off the actual effect it would have on the operators.”
The ambiguity regarding work behaviours by management to value high repetitive forcible body movements in strong situations and change them into low repeated forcible body movements in weak situations can be a result of the working environment not providing clear clues about the desired behaviours of the operators leading to differences in perceptions of different job performance behaviours that creates a weak job situation, (Beaty et al., 2001).

If the organisational or group situational strength is low the risk of RSI is:

Low when the ability and motivation of the individual to change the situation is low with low repetitive forcible body movements.

7.3.7 Observation made by the researcher

Observation1

Observation for this hypothesis reported an operator carrying out mechanical checks on photocopying machines as part of the configuration process. Under observation with the team leader, the operator explains his new process due to process changes on his workstation: "Before I used to carry out only mechanical checks, now due to the processes in these cells merging together, I've being given a new process and my workstation has been enlarged. I no longer do the same task over again, them (management and engineers), have combined the processes together. Its better job satisfaction, something different, once I will get used to the process books then I will be able to do the job much quicker."

Review from the literature in (section 2.3.5 Chapter 2) in this case indicates management hopes to make work less monotonous and therefore increase flexibility. Yet such changes have no guarantee of reducing the rate of musculoskeletal disorders and could indeed be a signal for their appearance as Bourgeois (2000), indicates where organisational dependency exists operators are less able to use their own resources (their skills, know how, creativity, etc.) in deciding their movements.

7.3.8 Questionnaire Results (Q1)

An average of 40% in each of the group studied in the sample reported in Figures (6.11.1, 6.11.2, 6.11.3, 6.11.5), favoured changing their work situation or job tasks or sequences. The overall score of 41% within the studied sample agreed, to changing
their work situation. Weiss (1978) found that people aligned their values with the values of their leaders if they perceived their leader to be considerate, competent and successful. Similarly a study by Kohn and Schoder (1978), determining relative effects of person characteristics (intellectual flexibility) and situation characteristics (work complexity) found people influenced their jobs more than their jobs influenced them – people who were more intellectually flexible enhanced the complexity of their work.

The negative response in Figure 6.11.4 showed a score of 62% disagreeing about the changes occurring within their work situation or job tasks or sequences. Evidence from the literature suggests ability to exercise job discretion is limited by job grades and usability (Clegg et al., 1997) and large investments, in the technology built in to operator’s processes.

7.3.9 Interview Findings

This finding indicates weak situations do exist where the researcher indicates operators are able to encode their work situations differently.

"From the feedback of the operators there are a lot of people who can make the changes."

The ability to show discretion of the operator’s (ability and motivation) to encode changes in their work situation characterises a low situational strength or a ‘weak situation’. This non-uniform encoding of the situation leads to individual differences among their decision-making or encoding of the situation to identify low levels of repetitive forceful body movements. This indicates that each operator within the team strategically impact each other by interacting their individual differences in behaviour moderated by situational strength (Mischel, 1977) to make choices for improvement and their tolerance for ambiguity, to construe environment certainty by developing a weak situation.
If the organisational or group situational strength is low the risk of RSI is:
Medium when the ability and motivation of the individual to change the situation is high with high repetitive forceful body movements.

7.3.10 Observation made by the researcher
Observation 1
The results from this observation were undertaken when production was suspended temporarily, for the introduction of a new model. The observations in this section report the layout changes that occurred in the Scanner cell.
Previously, a conveyor line was used for this operation and cycle times (tact times) were used by team leaders for monitoring production and operators were often working quicker than the cycle times (tact times) so that they could have longer rest breaks. The introduction of the new model has changed the process layout and a U-shaped layout was implemented by engineers and production managers to allow quicker response times by increasing operator flexibility, eliminating tact times, and improving fluency of production flow of scanners throughout the cell. Shortly after its implementation it was observed the build up of buffer stocks behind each workstation, reduced mobility of the operator, and imbalanced workflow added to the pressures of the operator's working situation. As one operator on her workstation cell quotes: "We feel more pressured to work harder here, before the production line was easier, because we had time to take a breather, here we are pushed all the time. Our team leader, is not happy about this and she sympathises with how we feel with this new layout, but within a year we will all be able to produce a scanner by ourselves yes that's good, job rotation will eventually come, but this will mean that there will be no jobs for temporary workers but I know I will still be here."

The literature relevant to this observation describes how important organisational and individual values are strongly held together. Values are a type of social cognition that facilitates a person's adaptation to his or her environment and values that have implications for his or her behaviour (Fishbein & Ajzen, 1975; Weiner, 1988). In this observation strong organisational values are both intensely held and widely shared which is how many researchers define strong culture firms (Davies, 1984; Deal & Kennedy, 1982).
Drawing on Mischel's (1977) framework of strong and weak situations, and (Jackson, 1966; O'Reilly, 1983) definition of organisational values systems in terms of crystallization, they explain that intense and crystallized values are described as strong situations, "which an individual comes to understand the values, abilities, expected behaviours and social knowledge that are essential assuming an organisational role and for participating as an organisational member (Louis, 1980; Van Maanen & Schein, 1979).

7.3.11 Interview Findings
The findings for this hypothesis led Health and Safety to comment on RSI with regards to the process relay out changes in response to the new model:
"I think cell working has reduced RSI and increased flexibility within our working processes to a certain extent in comparison to our previous production line layout."

The conclusion, drawn from this hypothesis, indicates a strong task performance situation. Explained by (Beaty et al., 2001) between the personality and contextual performance in strong versus weak situations, operators are evaluated and rewarded on the basis of their ability to complete their assigned tasks. However measures characterising performance developed by the organisation leads employees to hold a uniform perception of desired performance behaviours. These behaviours are less frequent than task performance behaviours and expectations for contextual performance behaviours are less likely to be as high as those for task performance behaviours, where these are seen to be more appropriate because the situation provides clear clues about the importance of task performance.

7.3.12 Conclusion of Fieldwork Results from the model
The findings emphasises how important individual and organisational values are strongly held together in lean organisations or in organisations that adopt lean techniques. The findings suggest when there is perceived to be 'weak situations' or low situational strength, operators align their corresponding work tasks and ideas to suit their complexity of work (Kohn and Schoder, 1978), also with their leaders (Weiss, 1978) by enforcing (Mischel, 1977) the desired performance behaviours to reduce high levels of repetitive movements. However analysis of the interview findings suggests that when managers cannot provide clear clues of the environment
certainty, a shift in weak to strong situation’ occurs because the desired behaviours of
the operators are exacerbated by a variety of existing roles and norms of the
organisation. This reveals a striking mismatch of perceptions leading to differences in
perceptions of different job performance behaviours that creates weak job situations,
(Beaty et al., 2001) but when managers can predict the desired behaviour and uniform
perception of its operators then a shift from strong to weak situational strength occurs
allowing the operator to show discretion to change his or her job tasks or sequences to
reduce high levels of repetitive forceful body movements.

The interview findings suggest the perception of operators to respond to appropriate
responses from managers differ situationally. These findings emphasise the
continuing dominance of operators to change their work situations into weak
situations. Weak situations are construed by operators to making the appropriate
interpretation of the same responses from their team leaders by aligning their
behaviours and personality in settings that are congruent with the needs and work
disposition of the managers. However when the situation arises where high repetitive
movements are visible within the operators work situation, managers consider their
perceived inability to influence their environment as a threat posed by the operator,
(Dutton and Duncan, 1987), systematically associated with qualities of the issues
themselves for example their complexity or framing (Kahneman and Tversky, 1979),
of the environment interpreting identical situations differently (Dearborn and Simon,
1958; Starbuck, 1976; Weick, 1979), being situation specific and highly variable,
(Hambrick and Finkelstein, 1987; Hambrick et al., 1993).

Situations that provide much discretion, by managers for team leaders and operators
to conform to appropriate consensus of the situation provide relatively little
(Hambrick and Abrahamson, 1995), discretion when the locus of control a personality
characteristic of the manager to exercise discretion among employees to the degree to
which they control or are controlled by their environment (Rotter, 1966) is stable and
is shown not to vary across situations (Kinicki & Vecchio, 1994; Miller and Rose,
1982). This is a continuously changing process but there remains a dependency on
what is known and what is familiar by manager’s even though the perception of
“individuals generally have a view on how well they have performed and use some
indicators to assess their own performance. The effects of personality on behaviour of
the operator are likely when situational pressures are weak and less restrictive in terms of the possible behaviours that may be exhibited, (Monson, Hesley & Chernick, 1982; Price & Bouffard, 1974), by their team leaders and production managers. The findings shows that these perceptions are reinforced by the desire of operators to make changes in their work situations by creating 'weak situations' to compensate for the lack of clear and established perceptions posited by managers.

7.3.13 Summary of the findings from the Model
The findings from the model suggest management rely on their own increasing perceptions of the operator's work situation. Managers tend to respond with some degree of reciprocating behaviours that create strong situations. This suggests these behaviours are created by their own interpretation of the task certainty in their operating environment, and how well the situation is structured to allow a change in the work situation by the operator.

7.3.14 Conclusions of the Findings from the Model
In the context of this research, the outcome from the model provides a good representation that assists with the process of understanding situational strengths for identifying the level of RSI risk. The findings do not provide a rigorous explanation of the dynamics of these relationships. Instead the proposed model is a conceptual and theoretical model, which aims to help researchers, and practitioners think in a systematic way about how the relationship of strong and weak situations can help to identify the level of RSI risk with changes in job or task situations. It is envisaged as organisational needs and structures grow increasing complex, the process of understanding the relationships of situational strength and RSI and its meaning will be different within many different lean organisations.
7.4 Findings from Hypothesis 2

High organisational or group organisational strength has a positive correlation with RSI in a lean environment

7.4.1 Observation made by the researcher

Work Related Upper Limb Disorder (Section 2.3.6, Chapter 2) from the Occupational Health advisor in this case study suggest many operators have sustained wrist and arm injuries for a number of years especially older operators on the same workstations. These affect female operators because of the physiological structure of the hand which is different and more fragile than male operators, secondly the repetitive action that causes the strain over long periods of time and thirdly of age, females aged between 23-50 years. This view is equally shared by researchers, Engström et al. (1999) and Rinehart et al. (1997), section 2.3.4.

Beaty et al. (2001) describe high organisational or group situational strengths to be associated with a strong task performance situation where employees working in a strong task situation share the perception that their performance is evaluated and rewarded on the basis of their ability to complete assigned tasks.

"There seems to be an increase in the number of cases at this time of year, RSI type injuries (towards the latter end of the year's production) unplanned absences, and sicknesses will rise in the forthcoming months, (commented one team leader) this is likely to cause problems with older people between 35-45 years old, they will be less motivated to come to work in the mornings, therefore I suspect more hired temporary replacements, will be made", to replace spare capacity and account for unplanned absences. Occupational health's opinion of operators with RSI quotes "at the moment a structure is being put in place to identify problems of RSI by carrying more risk assessments and workplace assessments, however the lack of communication between management and health and safety and our intervention we find operators performing manual handling tasks incorrectly." Many research studies have aimed at redesigning work in order to reduce work related disorders, but it has proven difficult to establish a clear relationship between work conditions and the prevalence of musculoskeletal disorders (Johansson et al., 1993).
Issues related to RSI were raised by the Health and Safety officer when engineers and production managers implemented improvements on the shopfloor to increase production capacity. They explain "due to the clear lack of instruction and communication in RPL 2 we are always the last to know and problems appear within the operator's tasks when we carry out manual handling, risk assessments and work place assessments."

Given this perspective, operators carrying or sustaining injuries during production were likely to take unplanned absences or paid leave because of the lack of workplace improvements being provided for them. Increases of RSI cases and unplanned absences were clear to see as some teams were often left under staffed and sometimes lacked spare capacity to cope with increases in production capacities.

7.4.2 Questionnaire Results

Results from this study in Fig 6.11.27 page (180) showed within a mixture of young (20-25), middle aged (30-40) and mature aged (40-50) operators, a defined safe system of work (15%) and a relay out of equipment (17%) featured most highly. RSI injuries in this cell appeared to in particular affect the wrists of the operators, and height of the operator’s carryout workstation assembly tasks at shoulder height.

The configuration cell in Fig 6.11.29 comprised a fair proportion of middle aged operators. This cell also favoured a safe system of work and a relay out of equipment. Although their workstation tasks involved mechanical testing, electrical testing and memory testing, the potential level of RSI risk was low, i.e. a very low number of cases were reported.

Figure 6.11.33 results, found quite a high proportion of middle aged (30-40 years old) to old aged female operators (40-50 years old) work in this cell. Some female operators were reported to have RSI injuries to their wrists and other repetitive strains. Results of Fig 6.11.35 reported a defined safe system of work and a relay out of equipment to be the most important for reducing the potential level of RSI risk. Injuries that occurred in this cell were mainly from the repeated use of rivet guns and electrical air drivers, none of which, when this cell was observed, the researcher saw a reduction in the number of times they were used. The findings in Fig 6.11.36 showed that a safe system of work and a relay out of equipment were measures most favoured by male and female operators in the sample to reduce the potential level of risk to injury through RSI.
7.4.3 Interview Findings
The findings from Occupational health and Health and safety suggest RSI is a problem. "We know RPL 2 is a problem (cases of operators having RSI problems) but she explains, this is difficult for us because when we diagnose an operator as a suspected RSI or somebody returning to work with MSD then that person has to be put back into that specific work place which will then lead to further difficulty because the full range of movement for that operator is restricted and therefore the risk to injury is greater and the impact becomes more wide spread". In the following extract Health and Safety considers the economic impact RSI has had on the company; "Claims have been made by operators to an external company where they had received distributed leaflet drops around the area. It had come to our attention that we received high claims from operators that claims had been made against us for RSI. Now these were influenced by employees who had already made claims to this company and had prompted other employees to make the same claims also."

A study suggests "the highest risks of an injury occurring and a claim being made appears to be in the first year" (Health and Safety Engineering Consultants Ltd, 2000). Older workers are less likely to perform less stressful jobs. It is expected the incident rates of claims would increase with age as the body becomes less able to deal with repetitive work as the workload increases.

7.4.4 Summary of Hypothesis 2
The overall findings of this hypothesis indicate the correlation between RSI in high organisational or group situational strength is positive. The key factor in this hypothesis points out, a defined safe system of work and a relay out of equipment is needed to identify the level of RSI risk. The positive correlation suggests there is a lack of clarity by management to identify exactly the level of RSI risk within its work processes. The variety of perceptions played between managers and operators within the organisation seem to revert to familiar and trusted behaviours of their own, to enforce their own beliefs what constitutes the level of RSI risk.

7.4.5 Conclusion of Findings from Hypothesis 2
Fig 6.11.35 illustrates the number of responses for a defined safe system of work was the most favourable when the questionnaire was undertaken. An average of 20% was
obtained from each cell group. Equipment relay out, job rotation; operator height and the amount of force were the least favoured. By large this result assumes operator's views are important and justifies to a reasonable degree that operator's job or sequences of tasks are conducted in 'strong situations'.

Observations on cultural issues of the case studied company found senior management and engineers resistant to production changes. The outcome suggests the perception between engineers and senior management provided a lack of consideration for the welfare of its operators. As the quality auditor explains "I know of one team leader put in approx 20 suggestions in and he had not one single reply from management for support for the problems therefore it shows that the management say they will give the help but the team leaders are not getting the support, then low morale is seen through the senior operators and then inevitably to the operators which keep on causing quality and production problems", the lack of discretion by managers and engineers to deal with these problems result in "the lack of thought of how some tasks could be modified to eliminate some of the risks", (Health and Safety), by drawing the right resources together. However she admits that there has been a slow progression towards raising awareness of safety in terms of the safety culture in the company "I do think there has been a vast improvement over the last 12 months, if you came in 12 month earlier you would have been shocked by the level of safety awareness. I think we are moving in the right direction we are not actually there yet but we are well on the way to improving our safety culture".

7.5 Findings from Hypothesis 3

Most people can adjust the lean job by modifying strong and weak situations to reduce the level of RSI risk.

7.5.1 Observations made by the researcher

Observation 1
The company recognise the importance of training for its operators, in particular technical training (cross training), to increase its skill flexibility and educate its operators more about their job tasks to reduce the potential risk of injury through RSI. Its efforts to identify what types of training are required were carried out through station evaluations. This system was designed and used as a measure by production
managers and engineers to identify further training requirements for its operators. In this particular process, a safety-environment evaluation was observed. Carried out by quality auditors within each work station cell, one evaluator described the process as being an important tool to identify “the problems of what operators in the process should draw more attention to, for example awareness of basic health and safety procedures in their processes, such as height, posture movement layout of workstation etc.” A team leader explained “I welcome this evaluation and I am in favour of this, it means we can identify in terms of health and safety what types of training is required for our operators so that we can prevent any further injuries happening, this is a positive approach to getting things RFT, (Right First Time) but at this moment it is not a good time because we have to start building our machines.” Moreover some team leaders perceived the evaluation as a potential threat, not only to themselves but to their operator’s also.

Literatures on training in lean production advocate that lean-flexible systems place a heavy emphasis on training and that the Japanese model provides workers with the skills they need to control their work environment. As Adler (1993), argues systematic training of workers not only prepares them for lean production, but establishes a process by which the system is improved through the continuous input of workers. However Saganski, (1995) study on work centred education and training approach in lean production found when training occurs, the type of systems approach utilised in most lean production strategies are mechanistic in nature of which makes the content and goals of the training make lean production unique, (Jacobs, 1995).

Indeed many lean production operations employ training methods that are done on their processes and equipment, utilising company developed strategies and methods (Jacobs, 1995), which if any little concern is placed on the perspective of the worker. Although workers seek alternatives to the current organisation of work and workplace training they must often contend with hierarchy of workplace management who then must be persuaded to share the process of organisational change (Saganski, 1995).

Observation 2
Parts defects had been observed by the team leader on a sub assembly exiting Cell 2, entering Cell 3. An explanation was given by an engineer describing how the defect
could have happened. He was unable to give a definite answer at this time, and he requested quality engineers to examine the problem. The team leader explained that this operator had tried to modify her work task when she initially discovered the potential of her obtaining an RSI injury to her wrist because of repeated use of an electric driver. The team leader explained the problem was reported by her to the engineers “We have asked the engineers to have a look at the possible causes, but nothing has been said to us and they say that it is operator error that is the culture of this company”.

In terms of the culture it was observed that much of the decisions to make work task changes or improvements were closely bonded by engineers and managers, more often senior management making the final decision. It was found many engineers had their own agendas and pressure from senior management to implement improvement projects resulted in little discussions about work practice problems concerning operators risk to injury.

The interactions between factors in the work system require an understanding of the tasks undertaken, workspace, work organisation and equipment, as well as on the impact of the worker (Buckle & Devereux, 1999). A number of studies on the effectiveness of ergonomics interventions have been reviewed by Westgaard and Winkel (1997). They conclude that the “following intervention strategies have the best chance of success when:

- Organisational culture interventions with a high commitment from stakeholders, (in this observation, team leaders, assistant production managers, health and safety and engineers), utilising interventions to reduce the identified risk factors
- Using modifier interventions, especially those that focus on workers at risk using measures that actually involve the worker.

Saganski, (1995), argues from this perspective, lean production strategy of expanding the responsibility of workers become feasible to the degree that the power of organisational change lies with the workers although a strong and well defined union role is essential for this to occur.
7.5.2 Questionnaire Results

Fig 6.11.25 revealed the quantity of work station improvements made without putting their ideas in the suggestion scheme reflects the quantity of work station improvements made. The operators who took part in this study aged (30-50) mentioned that they did not require any further training, assistance by engineers or their team leaders. Most of the improvements made by the operators in each of the workstation cell area accounted for work station layouts, improvements of their job tasks, and slight alterations to the sequences of their job tasks. Suggestions to reduce the risks of potential injury through RSI were very low suggesting the least priority given by some operators.

Results reported in Fig 6.11.26 shows a fair proportion (number or responses) of operators per work station cell area have enough information or training to do their job properly. This suggests operators are trained to a reasonable skill level of carrying out their daily job tasks or sequences without regular supervision by their team leader. Those who undertook the questionnaire mentioned they could build in improvements to their job tasks, layout of their workstations, and submit recommendations to their team leaders either to improve production flow in the cells.

The results described in the findings from hypothesis 2 in section 7.4.2, revealed a defined safe system of work to be most favoured by the operators, however Fig 6.11.36 equipment relay out was most favoured by operators as measures for the capability for change in the job of the operator (ability and motivation) situation in a strong or weak situation for identifying the level of RSI risk. This indicates those who contributed to the study felt equipment relay out and a defined safe system of work was the most acceptable or easiest change to make in terms of reducing the potential risk to injury. Results from Figures (6.11.28, 6.11.30, 6.11.32, 6.11.34) revealed on average between (20-30%) per each work station cell favoured this change.

7.5.3 Interview Findings

When asked about how well trained the operators are health and safety explain,

"They are quite well trained. Operators do have classroom sessions when they come into the company obviously process books are detailed to them they also have off line
training and online training. Off-line training away from the production cells whilst production is still continuing however after a week of induction and 4 days of classroom training they are put into selected teams and once they have completed the training correctly then they are ready to go in the production cells. The problem with our training is that we've never had signatures,” Discrepancies were noticed between the actual procedures carried out by operators on their workstations and the procedures in the process books. A survey was carried out as the quality auditor explains; “We had recently produced surveys about our training reported back with the team leader’s comments. The results that came out of from the training were very poor. Presently they have restructured the process of training where “We have introduced a report which enables us to standardise the approach that we do in training and evaluate the training via the process books. It would be easy to blame training as the culprit but now we are trying to close the loop holes by getting them to sign that they have completed the training and evaluate the operators periodically to make sure the operator have achieved their target before they move on to the next training session.” Health and safety lays the emphasis of its training structure on management “I think the management could be improved in the area by using more updated training methods perhaps giving a little more expertise in their field.”, although Occupational health view of training and health and safety describes the process of its training structure in terms of the company’s culture “Lack of support with adequate training describes how this is reflected in general about the culture of the company.”

“I think it comes back to the culture of the business is training recognised in Ricoh?”

7.5.4 Summary of Hypothesis 3
The results indicate that operators are adequately trained to make changes and improvements to their work processes. Operators have the capability and prefer to make changes in their job or tasks into weak situations while management try to obtain strong situations by establishing control. These findings therefore identifies a gap between managerial and operator perceptions of the task environment which from management is seen to be unambiguous but from the view of the operators ambiguous.
7.5.5 Conclusion of Findings from Hypothesis 3

The findings indicate most operators can adjust their job tasks or sequences by modifying strong and weak situations. Results from fig 6.11.25 show that suggestion for improvements can be regarded as a characteristic for identifying when strong situations changes into a weak situation. With management intervention it is assumed that strong situations will prevail to gain control of the situation. Although fig 6.11.25 present low numbers of suggestions, this could identify when the strength of the situation will change.

The interview findings suggest operators are given adequate training techniques to carry out their job tasks or sequences to a level accepted by their team leaders, and health and safety. Operators are able to modify themselves and their work situation against the strength of the situation by opting in favour of changes in their job task situation that could identify levels of RSI risk. Equipment relay out received more responses than a defined safe system of work as described in the findings of hypothesis 2.

7.6 Discussion of the Strengths and Weaknesses of the Model

![The Lean Job Position Model](Fig 7.6)
Chapter 7 Discussion

7.6.1 Strengths of the Model

The Lean Job Position Model is a working process model. The model is designed to enable users to think about the capability for change in job and job task with low or high repetitive forceful movements in strong or weak organisational situational strengths in an organised way. The intention at the initial stages of the design was to make the model as flexible as possible so that it could be used in any manufacturing business context. Considering the capability of the operators (in terms of their ability and motivation in age) to make changes in how their job tasks are organised within high or low group or organisational strength allows users of the model, for example, engineers, health and safety, occupational health and production managers to incorporate measures (such as work station evaluations, risk assessments training etc that were used in the case study company for this research) to test these against the model. It also could be useful as a basis for learning and understanding the potential level of RSI risk by raising awareness of RSI within senior management and operators. "Increasingly organisations are perceiving learning as a critical element of competitive advantage and it is said than an organisation’s ability to compete is only as good as its members’ ability to learn.”, (Dalziel, 1995). It is envisaged that some measures would be assessed formally and other informally against the model.

7.6.2 Weaknesses of the Model

The Lean Job Position Model only covers ‘what’ if the three domains of the model shown in fig 7.6 occur simultaneously. It shows a static picture of the findings but it is does not suggest that it is a proof for the model. It is an interpretative model, and is ideally suited for the capability of the operator to make changes in how their job tasks are organised (in terms of ability and motivation) in a strong or weak situation for identifying the level of RSI risk. However the meanings of the model are subjected to different interpretations, that may be influenced by organisational politics, personal prejudices, fear of change, admission of failure and so users of the model may not always have time to reflect the meanings associated with the performance of the model. The model shows only the key relationships but it does not does not inform us how the process or dynamics of the situation are created. The model just shows key relationships but also these are not all independent variables. However it is believed these may depend on other issues e.g. the operations involved in making improvements, and the dispositions of the operators.
Some users (for example engineers and assistant production managers) may feel overwhelmed by the constructs of the model. Feedback within the organisation may not always be possible because some users may need assistance and such reflections about the model may be subjective rather than contextual.

7.6.3 Views regarding the Lean Job Position Model

The personnel who contributed to this research agreed with the use of the model and its rationale behind identifying the level of RSI risk. The following extracts below illustrate their views;

Occupational Health “Everybody would be using the model in a continuous fashion to suit the design needs e.g. from a design point of view and from an engineering point of view. “I think it would be very useful because we would be literally “singing from the same song sheet” we would both have something that we could both use and know exactly what the risk would be and we would be better able to deal with the risk, obviously if we both obtained the same information.” Health and Safety would encourage the use and application of the model in their operations “It would be more useful to us (Health & Safety), hopefully in the future. I would like to see team leaders use it to evaluate where their operators are hence it would make the management style a bit more pro active rather than reactive.”

“I think it would be advantageous because jobs would be categorized more easily, it would make it easier for team leaders to rotate people about with from a high risk scale to a low scale depending on the details and severity of the suspected patients injuries in the past. The model presented could be useful in a number of different industries e.g. food industries where psychological pressures are enormous and input by operatives in this industry is at a very high risk level and production orientated. It could be useful in light manufacturing and also in heavy manufacturing industries such the steel industry where they’re tasks are very intensive very production orientated and therefore the high risk level of input and psychological pressures are enormous and these can be quite serious at times. All in all it does look like a very useful model for all types of industries as a whole.” thereby adding to the process of validation.

When asked about how reliable the model could be of use to Health and Safety they replied “I think it would need to be tested and I would like to see it in operation first
and see what results it comes back with but looking at it as it is now, it does look as if it would be a useful tool.”

7.7 Generalisability of Results
The intention at the research design stage was to be open to data all times and gain multiple viewpoints about operator’s capability for change in the job in strong or weak situation for identifying the level of RSI risk. In this research multiple viewpoints were obtained by work shadowing every team leader, and observing operators at workstations perceived to be conducting repetitive movements in this case study, multiple viewpoints adds to the validity of research findings (King, 1994). One case study company resulted in this research this approach was to provide an “in-depth treatment of a limited number of cases in an under researched and relatively novel area” (Gill and Johnson, 1991). The rationale behind the chosen company were two fold, firstly aiming at fulfilling the requirement of the research study and secondly raising RSI awareness within the studied case studied company.

The risks of possible bias resulting from the “researcher’s prejudices and prior expectations”, (King, 1994), was taken into account and minimised during all stages through the research process. Care was taken in selecting the quotes from the interview data. The intention was to remain open to data but at the same time ensure the conclusion drawn was a result of the analysis and interpretation of selected quotes for the hypotheses. This was important in ensuring reliability of the research findings. In developing the theory, the data was regularly visited during data analysis and interpretations examined. Agreements and contradictions in data and the relevant literature were actively pursued. The research findings for each hypothesis were compared or either contrasted with the relevant literature. Multiple research methods enabled the researcher to strengthen his findings by combining multiple research methods, (Yin, 1984, Gill and Johnson, 1991).

Even though it was appropriate for this research to consider multiple research findings it was felt by the researcher that this would enhance the overall outcome of the findings. Combining, direct observation by shadowing team leaders (Mintzberg, 1973) using semi-structured interviews (Yin, 1984, King, 1994) and questionnaires (Churchill, 1995), enabled the researcher to obtain a rich representation of the Lean Job Position Model.
Chapter 7 Discussion

It is envisaged the model would be applicable in identical industries that are lean or which adopt lean methods as part of their company strategy, however the researcher appreciates, there may be a number of independent variables in the organisation that are not considered within the model. It is the researcher belief that the model has shown the key relationships that exist and the findings from the hypotheses have attempted to represent these to a reasonable degree but proof of this is still required. The model provides a good visual representation of understanding the processes of situational strength in terms of the operator to show discretion for change in job for identifying the level of RSI risk. Therefore within the present condition from which the research was conducted the hypotheses have been proved to an extent where the model has identified the existence of these key relationships.

7.8 Summary
The next chapter makes the conclusion for the whole research and suggests recommendations for future work.
Chapter 8

Conclusion

This chapter summarises the overall research approach taken and its contribution to knowledge. Recommendations for further research are discussed suggesting improvements for the model.

8.1 Introduction

This chapter will briefly outline the conclusions drawn from the literature and highlight the researcher's own view on the strengths and weaknesses of his approach in the research process. The contribution of knowledge will be discussed and the chapter will end with recommendations for future research.

Chapter 7 discussed and summarised the main findings of the research. The research question together with the findings from Chapter 7 have to a reasonable extent proved that lean jobs do constitute high levels of work stress and as a result contribute to increasing numbers of repetitive strain injury incidents.

Appendix (D) illustrates injuries of an RSI nature are evident. The findings from the model and the hypotheses seem to indicate that there is a uniform perception and a wish of operators to change their work situation into a weak situation in particular when the level of RSI risk is high.

The thesis began with a thorough review of the literature tracing the existing background literature covering the work content of the Lean Production System. The understanding of how work is performed and the consequences faced by the worker in the lean environment were discussed. The review in four parts gave an account of the lean production system and its operation, its work organisation, and a discussion providing the consequences for working in lean production with respect to Repetitive Strain Injury (RSI) and situational strength in part four as a framework for strategic change for work organisation in a lean production environment.

The perspective of most authors have shown the view of work organisation in lean production to be a complex set of practices where changes from productivity to socio-technical issues in the literature have given rise to new measures involving changes to people's jobs working within a lean environment. These have been given more
evocative names such as high involvement work practices (Pil and MacDuffie, 1996, also MacDuffie, 1995) and high-commitment practices, (Wood and Albanese, 1995). The review of the literature found work organisation in lean production to present a number of physical difficulties in some lean jobs resulting in high potential risks of RSI. Kenney and Florida (1993) identified Repetitive Strain Injuries to be a main drawback of work organisation in lean production companies. Although the thrust of Chapter two has reviewed literature from the automobile industry, it is envisaged that other sector of the manufacturing industry that are lean or adopt lean working methods for example in the electronics industry could experience identical work organisational problems of this nature.

In summary the literature has described the work content, in lean manufacturing to lead to short cycled processes, intensification of work, repetitive work, teamwork and standardization, all potentially leading to a risk for Repetitive Strain Injuries (RSI.). The findings from the research indicated work content in lean manufacturing has created a gap between perceptions of what the actual content of a lean job should be and in reality how the content of the lean job should identify the level of RSI risk.

Although in this current context the perception of managers and operators alike revert to what is known and what is familiar by reinforcing their own job roles through their own behaviour and knowledge of their work situation. The Lean Job Position Model has illustrated this effect by representing its key relationships by assisting the process of how these roles can be understood.

8.2 Contribution to Knowledge
The literature review brought together three distinct fields to this research. The Lean Job Position Model combined a number of definitions into a comprehensive model, which has not previously been developed in the current literature. The researcher contributed to a change initiative by attempting to identify the level of RSI risk through the model and with two hypotheses, provided a series of valuable, context specific findings for assisting employees and employers to design better jobs in lean manufacturing.
Previous research has provided case studied accounts of social and human related issues of lean manufacturing, (Rinehart, Huxley & Robertson, 1990), on organisation of work and social relations of production, (Adler, 1993), on the roles of the organisation of production, and contemporary manufacturing (Delbridge, 1998), on workplace practices, and its major perspective on productivity (Womack et al., 1990) on other forms of manufacturing, but these studies have only presented accounts based upon the application of priori assumptions based on existing theories. This research in its own context has formed a grounded understanding of some key relationships and characteristics in a lean job.

The Lean Job Position model combined different measures that explored different levels of meanings with the lean job incorporating work organisation, strategic decision making and work disorders. A similar model to date has not been found in the literature that together encompasses these three aspects.

This view contrasts with much of the existing literature where this research has focussed on the individual's work situation and their capability to change the job tasks under forceful repetitive movements by applying psychological theories of organisational behaviour and strategic change, rather than providing an explanation with already proven organisational or market driven models.

The research findings shows, the capability of a person to carry out changes in a job can be complex. The understanding of situational strength enables us to understand the key associations of job task situation risks likely to occur providing a versatile framework that can address issues of strategic change and work organisation together.

8.3 Strengths and weaknesses of the research approach

Strengths
- The overall design of the Lean Job Position Model is novel and has generated a valuable insight to the study of work organisation within Lean Manufacturing
- The research has generated a new theory that is both relevant and appropriate to the subject area
The findings are grounded in a real world investigation and have a high degree of relevance to those involved in the research and their experience of work organisation and strategic management in a Lean Production environment.

The methodology was designed based upon qualitative methods and its analysis based upon grounded theory.

**Weaknesses**

- The Lean Job Position model has been used to explore new knowledge and understand the experience of work organisation in Lean Manufacturing.
- The findings do not represent a complete theory of work organisation but it highlights aspects relevant to those involved in the subject area.
- The research findings cannot be viewed as facts or objective truths, they are result of an interaction between the researcher and the researched.
- The research findings cannot be assessed in terms of reliability, rather their value results from their degree of credibility to those with interest in the area.

It is clear that the lack of clarity and uncertainty results in a reliance on what is known and what is familiar between operators and managers. Work therefore needs to be conducted to define behaviours and personalities that can clearly reflect and reinforce what RSI means to them and identify the risk level within their work processes to best suit their strategy and means of operation. Senior management should be first to visibly support and provide new prevention strategies for operators when injuries occur and align their processes accordingly to reflect a new emphasis on maintaining a risk free environment rather than reciprocating to adversarial behaviours posed by the operators.

**8.4 Recommendations for future research**

The proposed Lean Job Position model, can only identify ‘what changes’ or key relationships are needed in job task situation change within the given context, that is the number of forceful repetitive body movements. The model does not give any guidance as to ‘how’ to provide a prevention framework to implement these changes. Future research is recommended to identify and focus on implementing these context specific changes.
Chapter 8

Conclusion

The Lean Job Position Model is limited in terms of guiding the precise steps needed to identify changes that are context specific to the number of forceful repetitive body movements.

There are various perspectives that could be taken to test the model:

1. The model requires to be tested in a number of similar lean manufacturing environments, for example in food and beverage industries.

2. It is required that a study of work organisation behaviours through a direct comparison of low repetitive and high repetitive forceful body movements is required to identify the associated level of RSI risk over time.

3. It is required that a study of personality profiles using personality tests for example 16PFI on various ages of individuals to identify which personality traits effects the behaviour of individuals in strong and weak situations to enable us to assist the understanding of job task change.

4. Improvement to the model can be suggested for example to examine the process of team dynamics by identifying factors which can assist the process of understanding strong and weak situation further in depth.

The researcher would recommend that a longitudinal study of RSI risk in lean industries and non lean industries are conducted to provide a broader contextual understanding of how strong and weak situations can be characterised in different working environments.

8.5 Closing Comment

Within the existing model there is clearly also a need for investment in operator training. Current approaches to work practices and work organisation by senior management further account for operator dissatisfaction and frustration with its operators and vice versa. The increasing levels of inter-connectivity between operators and senior management personnel create a certain degree of dependence between each other. What is ignored is the growth of these dependencies over time which is likely to be the consequence of RSI injuries and less than optimal work performance from its operators.

8.6 Concluding Summary

This research has been conducted with the aim of proposing a model that enables both academics and industrialists to consider a concept to design a lean job situation
more effectively in a lean environment. The factors that influenced the development of the model had been to consider the key relationships of work organisation, strategic management and the level of RSI risk involved. The model allows its users to consider measures of improving it to suit or change the levels of RSI risk. The aim is such that any improvement made to the model would contribute to an improved method of work organisation in a lean environment.
References and Selected Bibliography


Hampson, I. (1999), Lean production and the Toyota production system – or, the case of the forgotten production concepts. Economic and Industrial Democracy, 20, 3, pp. 369-91.


References and Selected Bibliography


Kilborn A. (1997), Repetitive work of the upper extremity guidelines for the practitioner In: From Experience to Innovation, IEA 97, Tampere Finland, 4 pp. 66-68.


Richards, T., & Richards, L. (1994), Using computers in qualitative analysis, in Denzin, N. and Lincoln, Y. (Eds.), Handbook of Qualitative Research, Sage, Thousands Oaks, CA.


Sewell, G., & Wilkinson, B. (1992), Someone to watch over me: surveillance, discipline and the just in time labour process Sociology, 26, 2, pp. 271-89.


Wieslander, G., Norback, D., Gothe, C.-J., & Juhlin, L. (1989), Carpal tunnel syndrome (CTS), and exposure to vibration, repetitive wrist movements, and heavy manual work: a case referent study. British Journal of Industrial Medicine, 46, pp. 43-47.


Appendix A
This research-funded programme with university collaboration is concerned with the design of jobs in lean manufacture.

I would appreciate it if you would devote two minutes of your time to complete the enclosed questionnaire. The information you will provide will be strictly confidential and your company will not be identified in the reports that will follow.

Any participation in this project will be gratefully appreciated and I can be contacted at the address above. Please leave a contact name in your response so that a feedback report can be returned to you. A self-addressed envelope is enclosed for your convenience.

Yours Sincerely

Avinash Jhugroo
Research Student
My research is concerned with the design of jobs in Lean Manufacture. For the purpose of this research I have defined lean as:

"Reducing the time from customer order to manufacturing and delivering products by eliminating non-value added waste in the production stream. The ideal of a lean system is a one-piece flow.

A lean manufacturer is continuously improving in the direction of that ideal"

I would greatly appreciate if you could spend a few minutes of your time to complete the following questionnaire concerning jobs in Lean Manufacture. Your views are invaluable to my research and will be strictly confidential. After completion I will send you feedback about the results of this survey.

1. Does your organisation use lean working methods as part of its company operation?
   Yes [ ] No [ ]

   If yes please answer the following:

2. Are the job tasks and methods specified by standard operating procedures?
   A standard operating procedure is defined as cycle times, standard work sequences and standard work in progress
   Yes [ ] No [ ]

3. Can the people in the lean job environment change their work procedures?
   Yes [ ] No [ ]

4. Do you think that Repetitive Strain Injuries (to wrists, ankles etc) causes a problem in the lean working environment?
   Yes [ ] No [ ]

5. Do you think that only certain types of person can work at a lean job?
   Yes [ ] No [ ]

6. Would you agree that lean jobs only suit younger people?
   Yes [ ] No [ ]

If you would be willing to have further discussion about this research please tick this box [ ]

Any collaboration in this project will be extremely grateful. If you would like to add any further comments please use the spaces provided overleaf.

2
Please use the space below to add any further comments that you may feel are relevant.

Please insert a contact name and address, for feedback of the survey
Appendix B
Questionnaire Used in Company A

As many of you are already aware Company A is supporting a university study into working practices within a manufacturing environment. As part of the study it would be appreciated if you would spend a few minutes of your time to complete this questionnaire. Please be as detailed and honest as possible as all the information you will give be treated in strict confidence.

Name: (optional) Position:
Station Number: Cell No:

Part 1:

1) You can change the situation you are working in or the sequences of jobs or tasks that you do?
   Strongly Agree [ ] Agree [ ] Disagree [ ] Strongly Disagree [ ]

2) What level of risk do you think your job is mostly likely to be suited to?
   High [ ] Moderate [ ] Low [ ] None [ ]
   e.g. Death/Amputation    e.g. Fracture    e.g. Strain/Cut    e.g. No Injury

3) Why have you selected this level of risk?

   

4) Can you change this level of risk? Yes [ ] No [ ]
   If not who do you think can?

   

5) Do you want to? Yes [ ] No [ ]
   If so how would you change it?

   


6) What part of the process in your opinion is most likely to change in response to Q5)?

[Blank]

7) How many improvements do you make to your workstation without putting them in the suggestion scheme?

- 1 or more per day
- 1 or more per week
- 1 or more per month

If so, how many changes have you personally made?

[Blank]

8) How do you know what to do in your role?

[Blank]

9) Do you have enough information or training to do your job properly?

- Yes
- No

If not what type of training do you think you require?

[Blank]

Please Turn Over
Part 2:

What do you think would be most effective to reduce the risk of injury? (Please tick boxes)

1. A clearly defined safe system of work which takes into account 'operators' views
2. A simple device
3. Technology based improvements e.g. motorised trolley, sensors etc
4. A re-layout of equipment to reduce movement or reach
5. An alteration in the flow of work within the cell
6. A modification of the process book
7. For operators to perform tasks outside their scope of their job e.g. preparation during downtime
8. To rotate the job on a more frequent basis
9. Match height of operators during paired working
10. To measure the amount of force applied by the operator

From the above list which is generally the most acceptable or easiest change to make

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
1 2 3 4 5 6 7 8 9 10

Signed ..................................................  Date...........................................

Thank you for your time in answering this questionnaire. The results will be used for the research report and by Occupational Health to support health and safety improvements within the workplace. Information on the results of the study will be made available to all employees in the early part of next year. If you have any questions please do not hesitate to contact the EHS Section.

Kind Regards

Health and Safety Officer
Appendix C
Anthony Thomas: Auditor

Q: Do you think there's a lot of motivation and ability amongst the operators to change the situation i.e. by the way they work?

A: No not in all people, there's a lot of people out there and just want to come and do the work day to day, but there are some people just want to make an effort and try and change their processes or layout of their workstations who are motivated on a daily basis.

Q: How well are the operators trained, do you think they are very well trained?

A: There are 2 forms of training: Which is the first initial training, at Ricoh is the basic training for 2 days. We had recently, produced surveys about our training reported back with the team leaders, comments. The results that came out from the training were very poor. They don't know how the basic principles of holding air drivers how to use ear-ring setters and digital rules and so the operators walk round with their hair down and stuff like that so I'd suggest the whole training program would need improving and the other area is job specific which is on line that is slightly different, we have introduced a report which enables us to standardize the approach that we do in training and evaluate the training via the process books, so hopefully that is improved, prior to that I'd say there are a lot of loop holes, so if we had a quality problem and it went back to the engineers or production manager then it would be easy to blame training as the culprit, in fact it wasn't and now we are trying to close the loop holes by getting them to sign that they have completed the training and evaluating them periodically and make sure the operator have achieved they're target before they move on to the next training session so I would say that's improved.

Q: How would you perceive the culture of PPC?

A: I see it more driven by the production than quality. I think the culture now is we focus more on the negatives than on the positive vibes for instance, if we build 96 m/c's and we should have achieved 100 m/c's with 4 down but our quality was really good, in a morning meeting the perception would be why have lost these 4 m/c's ? Instead of we've had good quality. The way the management I feel the culture of PPC at the present stage is that it is driven more by production and not by quality and that shows on the faces (i.e. operators express the same opinion of management) the culture of PPC.

Q: From what the operators tell you, do you think they have much motivation or ability to change the way they carry out their job?

A: From the feedback from the operators, there is a lot of people who can make the changes, to improve the processes and their working environment, however it
does depend what team you are actually work for some team leaders are willing to listen willing to help some team leaders are willing to “get the counter out” (to meet the daily production of machines) again it does depend who you’ve got in charge of you there are some negatives and positives vibes from the operators for instance: When the cells are set up from the team leaders they run quite effectively, they’ve got the time to make improvements so the team leaders will brainstorm and make improvements, other teams which are struggling with their performance, e.g. quality or productivity, they have not go that opportunity, I think perhaps if there would be more support from the management side for the team leaders then this would rub off the actual effect it would have on the operators. From what I can see from the management side with the team leaders, the general lack of support team leaders seem to get from the management is quite poor. There is currently 1 manager in charge of PPC, 3 Assistant managers, when auditing and being out on the shopfloor quite a lot of times I do feel negative vibes come from the team leaders, e.g. from the managements lack of support from the assistant managers. Assistant managers and the production manager seem to try and squeeze the team leaders to achieve the targets without actually thinking of supporting them, why can’t they achieve the targets whether its training or time constraints or resource constraints, the frustrations from the team leaders is very easy to see on the shopfloor. It was stated to the team leaders that when the team leaders did experience problems they should write it down on a problem sheet and then they would get started as soon as possible, I know of one team leader put in approx 20 suggestions in and he had not one single reply from management for support for the problems therefore it shows that the management say they will give the help but the team leaders are not getting the support, then low morale is seen through the senior operators and then inevitably to the operators which keep on causing quality and production problems.

Marcia: Occupational Health

Q: What areas of the production do you think causes risk of RSI.

A: We know RPL 2 is a problem, due to recent changes at the present moment in time we are not sure what areas are going to cause significant problems, we don’t get the amount of time perhaps we feel we ought to have a look at the area in actual depth. Due to our work schedule and due to the production schedules over there (RPL 2).

Q: From what the operators tell you do you think they have much motivation and ability to change the way they carry out their job?

A: Not to a great degree no. Again due to production targets I don’t think operators have as much control over their function as perhaps would be beneficial to them I think a bit of more communication between operators and management would go a long way in that respect.
Q: A model had been developed to identify areas of low risk medium risk and high risk, how well do you think this could be used?

A: I think it would be advantageous because jobs would be categorized more easily, it would make it easier for team leaders to rotate people about with from a high risk scale to a low scale depending on the details and severity of the suspected patients injuries in the past.

The model presented could be useful in a number of different industries e.g. food industries where psychological pressures are enormous and input by operatives in this industry is at a very high risk level and production orientated. It could be useful in light manufacturing and also in heavy manufacturing industries such the steel industry where they're tasks are very intensive very production orientated and therefore the high risk level of input and psychological pressures are enormous and these can be quite serious at times.

All in all it does look like a very useful model for all types of industries as a whole.

Q: How reliable do you think this model could be?

A: I think it would need to be tested and I would like to see it in operation first and see what it comes back with (What the results are) but looking at it as it is now it does look as if it would be a useful tool.

Health and Safety
Louise Hunter (Health and Safety Officer)
Helen Smith (Health and Safety Coordinator)

Q: How do you perceive the culture of PPC?

A: In terms of a safety culture I don’t think there is a safety culture as yet, however I do think there has been a vast improvement over the last 12 months, if you came in 12 month earlier you would have been shocked by the level of safety awareness. I think we are moving in the right direction we are not actually there yet but we are well on the way to improving our safety culture.

Q: What do you think leads to RSI, in PPC?

A: Repetitive tasks, the nature of the tasks lack of thought of how some of the tasks could be modified to eliminate some of the risks, I think cell working has reduced RSI and increased flexibility within our working processes to a certain extent in comparison to cut previously production line layout where operators on line were doming the same tasks over and over again. I think in cell working has introduced a number of variations in the tasks and also the introduction of motorized trolleys will certainly make a difference to what we had before. (i.e. was unmotorised trolleys.)
Q: A model has been developed to identify areas of low risk, medium risk and high risk do you think this is a good idea? How well do you think this could be used?

A: I think it would be very useful because we would be literally “singing from the same song sheet” we would both have something that we could both use and know exactly what the risk would be and we would be better able to deal with the risk obviously if we both obtained the same information.

Q: How useful do you think the model could be applied and by whom in PPC?

A: It would be a good idea if the model were applied by engineers by people like design of the workstations and by managers even team leaders to a degree (Not specified in terms of time) again everybody would be using the model in a continuous fashion to suit the design needs e.g. from a design point of view engineers from an engineering point of view etc.

Q: Please talk about the culture of the company?

A: The culture of the company seems to be quite historic things seems to be very set, very difficult to change things but saying that they are pro-active (engineers & managers) and they will look at the processes and layout of the work stations and they will move forward in time it just appears to take longer than perhaps I would have expected.

Q: How do you perceive the culture of PPC?

A: It orientates around production targets and not in the way I see the operators carry out their movement and actions in their processes correctly on a daily basis. Again I feel the pressures of the production targets combined with variable heights of some operators on some workstations with incorrect use of hand assisted tools e.g. an air driver and lack of support with adequate training describes how this is reflected in general about the culture of the company.

Q: Do you think there is a lot of motivation and ability amongst the operators?

A: On the whole a lot of the operators seem quite demotivated in that they don’t believe that engineers and managers are listening to them and that they have very little effect on change.

Q: The impact of RSI on the operators?

A: This is difficult for us because when we diagnose an operator as a suspected RSI or somebody returning to work with MSD then that person has to be put back into that specific work place which will then lead to further difficulty because the full range of movement for that operator is restricted and therefore the risk to injury is greater and the impact becomes more wide spread.
Q: Do you think there is a lot of motivation and ability amongst the operators to change the way they work?

A: It depends on the style of management managing or managed by the team leaders. If the team leaders are pro active and willing to listen to management then "yes" I think they do get the opportunity to make slight variations in their processes within their cells I also think if you've got a poor team leader I mean a team leader that is very reactive to situations under pressure then they tend not listen and will change the tasks after when there is an injury, so again it depends on the management style and I know there are different styles of management from different managers managing different team leaders.

Q: What do you think the impact has been in terms of RSI Vs Culture in PPC?

A: Obviously engineers have a lot to play because they design all the workstations at the end of the day. I think engineers need to be aware of the possibilities of RSI incidents , I think the culture over there (RPL 2) towards RSI has been a far and few between far example claims have been made by operators working at Ricoh to an external company called "Claims Direct" where they had distributed leaflet drops around the Telford and Wrekin area. It had come to our attention that we received high claims from operators of Ricoh with the notice of "Claims Direct" that claims against had been made against us for RSI. Now these were influenced by employees who had already made claims and had prompted other employees to make the same claims. Now in terms of the culture of business makes Ricoh look very bad however to alleviate this problem we pre warned Claims Direct not to pursue any cases and in the meanwhile measures were put into place to restrict Claims Direct from targeting our employees.

Q: A model had been developed to identify areas of low risk medium risk and high risk, how well do you think this could be used?

A: It would be more useful to us (Health & Safety), hopefully in the future. I would like to see team leaders use it to evaluate where their operators are hence it would make the management style a bit more pro active rather than reactive.

Q: How well are the operator's trained, do you think they are very well trained?

A: They are quite well trained. Operators do have classroom sessions when they come into the company obviously process books are detailed to them they also have off line training and on line training. Off line training away from the production cells whilst production is still continuing however after a week of induction and 4 days of classroom training they are put into selected teams and once they have completed the training correctly then they are ready to go in the production cells. The problem with our training is that we've never had signatures
from the trainee and trainer on the training records to say that the training session has been successfully completed by the trainer.

Q: What are you views on Management in PPC?

A: There are positive and negatives. It's difficult to answer because I don't know how much support the assistant manager has had and to what level of training they also have had I don't know if they have received specialist training. I would imagine they would have come up from the ranks as a team leader. I think the management could be improved in the area by using more updated training methods perhaps giving a little more expertise in their field, I think it comes back to the culture of the business is training recognized in Ricoh?
Appendix D
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EHS: Environmental Health and Safety  
PPC: Plan Paper Copier  
B+S: Business Support  
HR: Human Resource  
H+S: Health and Safety
Appendix E
Model Based Definitions

Definitions:

Repetitive Forceful Body Movements of the operator whereby the number of repeating movements of the upper body part (wrist, arm, fingers and shoulder) is considered within the work area of the operator, measured by the amount of force (N) and reach distance (m).

Repeated Movements: Actions of the operator that require the same body part to perform the same motion many times

Work Movements: Placing or moving a part either by rotating, bending or stretching to or in a specific position in a certain time interval (cycles/min. cycles/sec).

Body Part: arms, fingers, wrist and shoulder.

The Potential Risk of RSI is defined as: The probability that RSI will occur in a particular situation and is influenced by disposition of an organisation or group situational strength to change inherent repetitive forceful body movements.

Under those circumstances the risk of RSI is

Low when the number of injuries reported per person is below than (a fixed number of shifts) per certain period of time.

Moderate when the number of injuries reported per person is represented as an average (fixed number of shifts) per certain period of time.
High when the number of injuries reported per person is above (a fixed number of shifts) per certain of time

**Ability:** The knowledge and aptitude of the operator to enable him or her to change repetitive forceful body movements.

**High Ability:** The physical disposition of the operator to change high repetitive forceful body movements in a low organisational group or situational strength.

**Medium Ability:** The physical disposition of the operator to change low and high repetitive forceful body movements in a high organisational or group situational strength.

**Low Ability:** The physical disposition of the operator to change high repetitive forceful body movements in a high organisational or group situational strength.

**Motivation:** The perception drive or wish of the operator to change repetitive forceful body movements in an organisation or group situational strength

**High Motivation:** The perception of the operator to change high repetitive forceful body movements in a low organisation or group situational strength high repetitive forceful

**Medium Motivation:** The perception of the operator to change high and low repetitive forceful body movements in a high organisation or group situational strength
**Low Motivation:** The perception of the operator to change high repetitive forceful body movement’s high organisation or group situational strength

**Situation Strength:** The degree of ambiguity in decision latitude in a particular situation

**High Situation Strength** – Low ambiguity of decision latitude in a particular situation

**Low Situation Strength** – High ambiguity of decision latitude in a particular situation

**RSI** – Injury resulting from work repeating movements

**The Capability for Change in Job Situation:** in a job situation is determined by the ability and motivation of the organisation or operator (ability and motivation (age) for changing the situation to determine the problems of RSI, whereby the ability is knowledge and aptitude of the operator to enable him or her to change repetitive forceful body movements and motivation being the perceived drive or wish of the operator to make the change of repetitive forceful body movements.