Performance measurement system design for continuous improvement in cellular manufacturing

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Performance Measurement System Design for Continuous Improvement in Cellular Manufacturing

by

Robin Charles Daniels B. Eng (Hons)

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy of Loughborough University of Technology

August, 1995

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Contents.

Acknowledgements. 10

Abstract. 11

(1) Philosophical Considerations in the Design of the Research. 12

(1.1) Positivist versus Phenomenological Paradigm. 14

(1.2) Basic Features of the Research Design. 18

(1.2.1) Stages and Levels of Enquiry. 18

(1.3) Preliminary Summary of the Research Design. 20

(2) Initial Literature Survey 22

(2.1) World Class Manufacturing and the Japanese Experience. 22

(2.2) Measures of Manufacturing Performance. 25

(2.3) The Role of Management Accounting Research. 28

(2.4) Goal Congruence and Strategy. 32

(3) Initial Aims of the Research. 35

(4) Introduction to Dunlop Cox Ltd. 36

(4.1) The Company. 36

(4.2) Organisational Hierarchy. 37

(4.3) Company Culture; Overview and Recent History. 41

(4.3.1) Education and Training. 41

(4.3.2) Kaizen and Autonomy. 41

(4.3.3) The Unions. 43

(4.4) Production Cells. 43
(4.5) Production Processes.


(5.1) The Bonus or Labour Performance Indicator (LPI) System.

(5.1.1) The LPI Calculation

(5.1.2) The Bonus Calculation

(5.2) Production Planning and Control.

(5.3) Quality Management and Control.

(6) STAGE I: Research Methodology

(6.1) Initial Appraisal.

(6.2) Determination of Production Drivers.

(6.2.1) Production Manager Viewpoint.

(6.2.2) Production Manager Driver Ranking

(6.2.3) Production Manager Questionnaire Feedback

(6.2.4) Cell Leader Viewpoint

(6.2.5) Cell Leader Questionnaire - Results

(6.2.6) Production Operative Viewpoint

(6.2.7) Production Director Viewpoint

(6.3) Collection, Collation and Plotting of Historical Data.

(6.4) Analysis of Historical Data.
(7) Comparison of Perceived Driver Relationship Interaction and Historical Data over Forty Weeks. 93

(7.1) Production Manager: Perceptions vs. Reality. 93
(7.2) Cell Leaders: Perceptions vs. Reality. 94
(7.3) Production Director: Perceptions vs. Reality. 95

(8) Summary of Stage I - Review of Initial Objectives. 97

(9) Secondary Literature Survey: The Argument for Change and the Optimum Direction. 101

STAGE II RESEARCH

(10) Statement of Hypotheses. 113
(11) Structure of Stage II Research. 115

(11.1) Research and Control Groups. 115
(11.1.1) Research Group Profile and Purpose. 116
(11.1.2) Control Group Profile and Purpose. 122
(11.2) Data Collection and Analysis. 127

(12) Chronological Examination and Analysis of the Research Group. 131

(12.1) Initial Attitudinal Cell Questionnaire 132
(12.1.1) Questionnaire Analysis 139
(12.2) Research Group Formation and Education 143
(12.3) Election of the Team Leader. 145
(12.4) Identification of Drivers. 147
(12.5) Finalising Driver Identities and Setting Goals. 151
(12.5.1) Measure Definition. 153
(12.6) Planning Data Collection, Recording and Analysis. 158
(12.7) Group Dynamics - allocation of responsibilities. 162
(12.8) The Kaizen Notice Board. 164

(13) The Role of the Researcher. 166

(14) Initial Progress of the Control Group. 168

(15) Collection, Collation and Plotting of Historical Data II. 170

(16) Analysis of Historical Data II. 171

(16.1) Research Group - Existing Measures 177
(16.2) Control Group - Existing Measures 177
(16.3) Research Group - New Imposed Measures 178
(16.4) Control Group - New Imposed Measures 179
(16.5) Research Group - New Group Measures 179
(16.5.1) New Group Measures: Detailed Measure Analysis and Discussion. 181

(17) Resultant Kaizen Activities. 186
(18) Changes in the Performance of the Nissan 936 Cell. 195
   (18.1) Labour Efficiency Indicator (LPI). 195
   (18.2) Absenteeism. 197
   (18.3) Cost of Consumables. 197
   (18.4) Cost of Accidents. 197

(19) Changes in the Performance of the Nissan 909 Cell. 198
   (19.1) Labour Efficiency Indicator (LPI). 199
   (19.2) Absenteeism. 199
   (19.3) Other Existing and New Imposed Measures. 199

(20) Final Cell Attitudinal Questionnaire. 200
   (20.1) Final Attitudinal Questionnaire Results Analysis. 207
   (20.2) Final Attitudinal Questionnaire Discussion and Conclusions. 212

(21) Research Group Analysis Questionnaire. 216

(22) Further Research Group and Measurement Developments. 223
   (22.1) Tool and Plant Downtime Detailed Analysis. 225
   (22.1.1) Detailed Power Press Downtime Analysis. 226
   (22.1.2) Power Press Downtime - Outline Improvement Plan. 231
(23) Summary of Research.

(23.1) Review of Stage I. 235
(23.2) Review and Discussion of Stage II. 238

(24) Transferability of Results 252


(25.1) A Contingent Approach to Driving Improvement. 257
(25.2) Optimising the Measure Driven Cycle. 259
(25.3) A Model and Guidelines for Implementation. 265
(25.3.1) Definition of Measure Validity. 271
(25.3.2) The Role of Validation. 272
(25.3.3) Using Invalid Measures to Drive Kaizen. 272
(25.3.4) The Choice of Initial Project. 274
(25.3.5) Role of the Cell Leader. 275

(26) Examination and Evaluation of the Methods of Research Employed. 277

(26.1) Primary Level: General Structure and Framework. 277
(26.2) Secondary Level: Philosophical Considerations. 279
(26.2.1) Defining Systematic Error. 281
(26.2.2) Types of Role Motivations. 281
(26.2.3) Noninteractional Experimenter Effects. 283
(26.2.4) Interactional Experimenter Effects. 285
(26.2.5) Bias and Objectivity. 287

(26.3) Tertiary Level: appraisal of tools employed. 290
(26.3.1) Correlation Statistics. 290
(26.3.2) Semi-Structured Interview. 291
(26.3.3) Questionnaire. 292
(26.3.4) Participant Observation. 294

(26.4) Critique Summary 295

(27) Implications for Further Research. 295

(27.1) The Salient Findings. 295
(27.2) Specific Points arising from the Research. 297

(28) Overview of the Research 304

References. 308
<table>
<thead>
<tr>
<th>Figure</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>69</td>
</tr>
<tr>
<td>6</td>
<td>73</td>
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<tr>
<td>7</td>
<td>86</td>
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<td>87</td>
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<td>88</td>
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<td>11</td>
<td>90</td>
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<tr>
<td>12</td>
<td>117</td>
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<tr>
<td>13</td>
<td>125</td>
</tr>
<tr>
<td>14</td>
<td>128</td>
</tr>
<tr>
<td>15</td>
<td>165</td>
</tr>
<tr>
<td>16</td>
<td>172</td>
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<tr>
<td>17</td>
<td>173</td>
</tr>
<tr>
<td>18</td>
<td>174</td>
</tr>
<tr>
<td>19</td>
<td>175</td>
</tr>
<tr>
<td>20</td>
<td>176</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>21</td>
<td>Steel Stores Scrap Data vs. Cell Scrap Data for the Nissan 936 Cell for Weeks 41 to 80 inclusive.</td>
</tr>
<tr>
<td>22</td>
<td>Relationship between Cell LPI (including Kaizen Hours) and Percentage of Total Hours Booked to Kaizen for the Nissan 936 Cell for Weeks 41 to 80 inclusive.</td>
</tr>
<tr>
<td>23</td>
<td>A Pareto Analysis of the Tool/Plant Downtime Category for the Nissan 936 Cell.</td>
</tr>
<tr>
<td>24</td>
<td>Total Power Press Downtime by Press in descending order of utilisation for all products and the Nissan 936 Cell for Weeks 41 to 75 inclusive.</td>
</tr>
<tr>
<td>25</td>
<td>Total Power Press Downtime versus Category of Fault with Number of Occurrences per Fault for the Nissan 936 Cell for Weeks 41 to 75 inclusive.</td>
</tr>
<tr>
<td>26</td>
<td>Press Downtime versus Category of Fault with number of Occurrences per Fault for Press P302 for Weeks 41 to 75 inclusive.</td>
</tr>
<tr>
<td>27</td>
<td>The relationship between total Press Uptime and total Press Downtime for the Nissan 936 Cell for weeks 41 to 75 inclusive.</td>
</tr>
<tr>
<td>28</td>
<td>The Introverted Measure Driven Cycle.</td>
</tr>
<tr>
<td>29</td>
<td>The Optimised Measure Driven Cycle.</td>
</tr>
<tr>
<td>30</td>
<td>The Virtuous Circle.</td>
</tr>
<tr>
<td>31</td>
<td>The Expert Measurement Framework.</td>
</tr>
<tr>
<td>32</td>
<td>The Novice Measurement Framework.</td>
</tr>
<tr>
<td>33</td>
<td>The Contingent Measurement Framework.</td>
</tr>
</tbody>
</table>
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Abstract

The shortfalls of traditional measures of manufacturing performance are well documented and the drive to become World Class has led many industrialists and academics to explore alternative methods of performance measurement.

Empirical research in the areas of management accounting practice, strategy formulation and goal congruence has established some key cornerstones. There remains, however, a shortage of research into the behavioural consequences of performance measures and the potential for exploiting this link in the pursuit of continuous improvement activities.

This research uses the production facility of Dunlop Cox Ltd. as a case study in which an analysis of the existing performance measurement system and its behavioural consequences provides the basis for the introduction of a Cell Generated Performance Measurement System which drives kaizen and can be compared directly with the existing, imposed, system.
(1) Philosophical Considerations in the Design of the Research.

Clarification of the situation and viewpoint from which the following research was conducted serves as a precursor to a brief discussion of the decision processes which the researcher went through in designing the research methodology employed.

The research is an in depth case study and was based within Dunlop Cox Ltd. in Nottingham, U.K. A brief introduction to the company is given in Section 2.

The researcher was employed by the Company in June 1992, straight from University, as a Deputy Cell Leader. Subsequently the researcher was promoted to Cell Leader and, finally, Senior Cell Leader. In September 1992 the researcher approached the Company and Loughborough University with the view of undertaking a research degree. At this stage the subject was to be in the Organisational Design/Cost Accounting area. However, the emphasis moved quickly towards shop floor management and control. This came about as the result of a shift in the interest of the researcher and a preference on the part of the Production Manager (the researcher's direct superior) for the work to:

(a) Be relevant to the duties and responsibilities of a Deputy/Cell Leader as he (the Production Manager) saw them;

and (b) Take the researcher away from the shop floor as little as possible.

The position of the Production Manager and the Company, therefore, was that the research would be sponsored in terms of student enrolment/supervision costs but no work time would be given over to research activity. In other words, as long as the research did not detrimentally effect the researcher's ability to carry out his duties as a Deputy Cell Leader, then financial support would be maintained. Any
theoretical or other work which would mean that the researcher would be off the cell for any length of time would have to be carried out in the researcher's own time. Access to internal records and other personnel would be unlimited, subject to time constraints as above.

The details of these arrangements were arrived at through a convivial and balanced process of negotiation which left all three parties (researcher, University and Company) satisfied with the outcome. Thus, the political considerations which often weigh so heavily in empirical management research were, to some extent, faced and resolved in the earliest stages. This was made easier than otherwise by the fact that the researcher was employed full time by the Company and so issues of confidentiality, access to records and personnel and difficulties caused by the researcher being unaware of internal politics etc. assumed relatively little significance (although consideration of such factors, it was recognised, would be continually necessary).

As mentioned above, the focus of the planned research moved to the shop floor and this, coupled with the researcher's growing interest in financial and non-financial performance measurement and their effects on production management and control, led to the idea of a project which would examine the production drivers in effect within the organisation and their specific effect on the shop floor.

This, then, was the loose framework within which the research was bounded, although the intention was always to proceed for a period of time in a fairly broad brush way before defining more precisely the objectives of the research and the hypotheses which would be tested.

The situation of the researcher and the outline of the project, therefore, prescribed, to some extent, the philosophy of research design which would be followed. However, there were decisions to be made, some initially and some much further into the research.
(1.1) **Positivist versus Phenomenological Paradigm.**

There are several excellent works which deal with the issues within Management Research and it is not the intention that this should in any way be repeated here. However, the explanation of the design of research selected in this case necessitates reference to the philosophical arguments underlying the process.

In the field of the social sciences and management research in particular there are currently two established approaches.

**Positivism** is based on the idea that the social world exists externally, and that its properties should be measured through objective methods, rather than being inferred subjectively through sensation, reflection or intuition [1].

**Phenomenologicalism** is cited at the opposite end of the spectrum and states that 'reality' is socially constructed and given meaning by people [2].

The second paradigm has come into existence and gained popularity only during the last fifty years or so and is in no way derived from the positivist approach. As has been continually pointed out there is rarely one best way to solve a management research problem any more than there is one best methodology or philosophy to adopt [3]. Consequently, there is a wide array of philosophical positions which can be taken along the continuum and, even at the extremes, there are variations in actual research methods and techniques employed. Figure 1 illustrates the key features of the positivist and phenomenological paradigms. Within the table there are points which directly, or at least loosely, reflect the situation of this research. These appear in heavy print. Taking each of these in terms of the project in hand:

(a) **Basic beliefs:** Due to the constraints placed on the researcher as outlined above, it became clear that the research would be cell based
although, in determining the production drivers in operation, it would also be necessary to consult, question and analyse people at all levels of the organisation. The leaning of the research, therefore, was to be towards the behavioural implications of the production drivers in place.

This early clarification meant that the view of the world as being socially constructed and subjective most closely reflected the reality in the situation. However, the view that the world is external and objective certainly had a place in the philosophical considerations. The need to maintain an objective position (intellectually at least) was a conscious consideration from the outset. Because the approach of the researcher would, by definition, be participative it was felt that an objective element to the research framework would be important in maintaining 'distance' between the researcher and the subject (i.e. the organisation and culture within which he was immersed and the people with whom he would, over time, develop an intimate working relationship).

(b) **Researcher should:** The considerations above dictated, in many ways, the features and structure which the research would possess. An approach based somewhere between the positivist and phenomenological approaches would take account of the subjective character of the situation while lending objective balance to the process.

For example, peoples individual attitudes to, and ideas about, drivers, gleaned through interview and questionnaire, could be cross referenced through the statistical analysis of data related to those same drivers. An important element of the positivist approach was the need to structure the research through the formulation and evaluation of hypotheses. Although this was not carried out in detail in the very early stages it was felt that such an approach would provide a framework and direction to the research which would be important for the successful completion of an industrially based
(c) *Preferred Methods include:* The methods given in Figure 1 encapsulate perfectly the approaches identified in the early stages and outlined above. A longitudinal, in depth case study using different methods to establish different perspectives on the same phenomena defined describes, in broad terms, the character of the proposed research.
<table>
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<th><strong>Phenomenological paradigm</strong></th>
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<td>and objective</td>
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<td>Science is value-free</td>
<td>Science is driven by human</td>
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<td>interests</td>
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<td><strong>Researcher should:</strong></td>
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<td>focus on meanings</td>
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<td>fundamental laws</td>
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Figure 1: Key features of positivist and phenomenological paradigms.

(Taken from 'Management Research', Easterby-Smith *et al.* (1991). [1])
The philosophical considerations define a research methodology at a point along the continuum which draws on a mix of positivist and naturalist epistemologies and methods. The advantages and disadvantages which each extreme approach has mean that a sound experimental methodology is a vital prerequisite to sound research practice. This position is thus defined by the term *Realism* which seeks to reconcile the realist (etic) and idealist (emic) understanding of human action [3]. It recognises the existence of an external reality, its subjective interpretation and the role of human agency in affecting the external social world.

(1.2) Basic Features of the Research Design.

Having described the philosophical approach adopted it is possible to summarise the key practical issues which were defined by circumstance and through the search for the most practical approach to the problem.

(1.2.1) Stages and Levels of Enquiry.

In behavioural research there are three levels of enquiry which may be used as discrete elements or together in a sequence. These are;

(a) Descriptive Enquiry
(b) Relational Enquiry
(c) Experimental Enquiry [4]

Each of these elements and the order in which they appear relate closely to the loose framework laid down in the early stages of the research. To summarise the functions of each:

(a) Three Functions of Descriptive Enquiry

- Provide groundwork by which to take a complex behavioural or organisational structure with which we are unfamiliar or which requires clarification.
- Establish the boundaries of the research problem, once the nature of the situation is revealed.
- Raises, by implication, ideas that can be tested in relational or experimental studies.

The above describes the process of initial enquiry and the formulation of an outline research plan which has sufficient detail only to prescribe the choice of philosophical approach as described above.

(b) Three Functions of Relational Enquiry.
- Uncovers the relationships among variables
- Allows the search for long term patterns which may suggest future trends and allows one to see how social, political and economic conditions can influence behaviour over a long period of time.
- Allows determination of the validity of intervening variables.

The above outlines the process envisaged for the identification of the drivers, the analysis of their interactions and the behavioural consequences which these may have.

(c) The Options for Experimental Enquiry.

The final stage of enquiry, the experimental stage, could not be clearly defined at the initial stage of the research or before the descriptive enquiry stage had taken place and clarified the situation sufficiently to define the objectives of the research. Furthermore, experimental research as it is traditionally defined does not take account of the difficulties associated with social scientific or behavioural research especially where there is no 'captive' population which is under the absolute control of the researcher (as in pure
science). Researchers, especially those working from the positivist paradigm, recognised some time ago the practical difficulties of producing pure experimental designs, and thus the idea of 'quasi-experimental' designs was developed. The best known version of this approach is that of Campbell and Stanley (1963) [5] who used the technique to evaluate a number of designs which make use of multiple measures over time to minimise the effect of experimental and control groups not being fully matched. This approach is not without its critics, however, and a number of different tests may be required over time to ensure that the characteristics and behaviour of the control group is fully understood and can be accounted for.

An alternative to this approach is that of ethnography which is a category of fieldwork involving the researcher becoming fully immersed in the culture of the subject organisation. This, clearly, describes well the situation of the researcher in this case, although an element of quasi-experimental design may lend an element of objectivity to the programme.

(1.3) Preliminary Summary of Research Design.

The decisions and choices regarding research design outlined above provide some direction for the project and an outline methodology to follow. While the fundamental issues can be clearly resolved even at this early stage much of the detail, especially relating to experimental design, will only become apparent as the research progresses. Consequently such issues will be covered chronologically as they arise and are resolved throughout the course of the research. A reflection of the choices made and the methods employed appears at the end of this document.

In summary, it would appear that the ilk of methodology employed is likely to be most closely related to Realism as defined earlier being at some point between the pure extremes of positivism and phenomenology. In practical terms the programme will follow the
Descriptive, Relational, Experimental path with the details relating to each stage evolving as the research progresses. The issue of ethnography and the opposing need to maintain a degree of positivism can be reconciled through the idea of action research which best summarises the situation outlined above. As Easterby-Smith et al put it:

'Action research and the researcher are then seen as part of the change process itself' [1]

where 'change' is the continual state of any social phenomena. The following two features are normally part of action research projects:

(a) A belief that the best way of learning about an organisation or social system is through attempting to change it, and this therefore should to some extent be the objective of the action researcher;

(b) The belief that those people most likely to be affected by, or involved in implementing, these changes should as far as possible become involved in the research process itself. [1]

The fact that the researcher is a Cell Leader and that the project is to be cell based means that the continual improvement in the operating efficiency of the cell which the Company requires the Cell Leader to bring about appears to be the natural focus for the project as well as the industrial, 'real life', aspect of the industrial/academic research project [6].

What follows is, firstly, a survey of the relevant performance measurement literature which will frame the initial statement of research objectives.
Initial Literature Survey

This section will, through a review of the relevant literature, trace the progress of performance measurement research to date. Through this it will be demonstrated that there exists a gap in current knowledge and that there is a real need for pertinent study to fill that gap. It is intended that, as the focus of this research narrows, there will be a second, and more specific, literature survey which will, in turn, assist in the definition of a hypothesis for testing.

Before considering performance measurement in detail however, it is necessary to briefly examine the factors which brought to light the need for change.

(2.1) World Class Manufacturing and the Japanese experience.

'In the last decade it has become clear that some engineering manufacturing companies, particularly those based in Japan, operate much more competitively and effectively than others.' (Lucas Industries plc., 1992) [7].

The success of many Japanese companies, often at the expense of Western competitors is now well documented [8]. The root of their success appears to be the management practices employed (a heavy reliance on teamwork for example) and the criteria which often drive their manufacturing systems. As a result typical features of a Japanese company will include the following:

- Higher sales per employee
- More new product introductions
- Shorter lead time in new product introductions
Higher profit over sales ratio
Higher return on capital employed.

Behind each of these accomplishments is a feature common to much of Japanese industry and that is the philosophy of continuous improvement or Kaizen [9,10]. The idea and basic elements of Kaizen have been widely known to Western manufacturers for only the last fifteen years or so. This is despite the fact that it was an American, W. Edwards Deming, who, at the end of the Second World War, taught the Japanese the way of systemised continual improvement through customer focus and the use of Statistical Process Control. Through his 'Fourteen Points' Deming sought to provide a route to quality and productivity which, while being explicit in aim and content, would be equally applicable to any company; industrial or service, Western or Japanese [11].

Since Deming many others have expressed a similar message in differing ways. In the 1950's Feigenbaum coined the phrase 'Total Quality Control' and, along with others - most notably Juran - developed and expounded on the concepts of waste reduction at all stages of the production process and the pushing down of responsibility for quality to the point of operation and the line worker himself [12,13].

It was not until the 1980's that Western academics and industrialists began to consider some of the 'softer' or human aspects of, what had become known as 'Japanese Business Practices' [14] and to begin to consider a more holistic approach than had previously been considered attainable in a culture as alien to Japanese philosophy as that of the West [15]. Indeed, during the late eighties the importance of human aspects was brought to the forefront of the academic debate;
'......changes (in manufacturing organisation) will not succeed, or will not be as successful as they could be. without full consideration of human.....issues'

(Wilson, 1992) [16]

World Class Manufacturing is a term which was coined by Schonberger in the mid-eighties when he helped to dispel the myth that the culture difference was an insurmountable barrier to the emulation of Japanese success;

'The message learned and then told was that Japanese success is not culture based. Its basis is a quite different set of concepts, principles, policies and techniques for operating a manufacturing enterprise. All of it is easy to understand, not hard to accept (once known), eminently teachable and learnable, and not so difficult to apply.' [17]

The philosophy has been presented with different titles; Total Quality Management is one which, while being a natural progression from the Quality Circle movement and the Total Quality Control school of Feigenbaum and Juran, seeks to broaden the philosophy to encapsulate the human aspects as well as considering the business as a whole and not as a collection of functional and, by definition, insular departments. [18]

Although the term World Class Manufacturing is a very broad one the philosophy behind it will include the following specific requirements;

- a new approach to product quality
- just-in-time production techniques
- change in the way that the workforce is managed
- a flexible approach to customer requirements. [19]
Against a backdrop of Japanese success and the emerging threat of fast developing Pacific Rim countries [20] dramatic changes have begun to occur in many Western companies. Targets of increased competitiveness through improved quality, reduced lead times, reduced costs and enhanced production flexibility have highlighted a need which goes to the very root of manufacturing management.

Since the industrial revolution manufacturing has changed almost beyond recognition. There has been a general move away from large batch/production line type manufacture to small batch, flexible manufacture and the use of Group Technology and Cellular production organisation. However, the management accounting measures which were developed in the early 1900's to control and direct business have remained almost completely unaltered. It has become clear, therefore, that in order for a company which wishes to become 'world class' to monitor and develop those characteristics deemed desirable there has to be a change in, not only the definition of the criteria for success, but also the methods of performance measurement employed. The case for empirical performance measurement research can thus be argued.

(2.2) Measures of Manufacturing Performance.

Before considering the developments in performance measurement research in particular it is first necessary to define what it is we are actually concerned with. The drive towards World Class performance measures has, by definition, been centred around the needs of existing and potential markets and customers. From a marketing perspective organisations achieve their goals by satisfying their customers with greater efficiency and effectiveness than their competitors [21]. The words efficiency and effectiveness are used precisely in this context [22]. Effectiveness refers to
the extent to which the customer requirements are met while efficiency reflects the degree of resource consumption by the organisation in achieving its goals [23]. Here two of the three fundamental dimensions of performance are defined, the third is time [24,25,26]. From this argument Neely suggests a definition of Performance Measurement;

'The efficiency and effectiveness of action at a point in time'
and further;

'Performance Measurement': the process of quantifying the efficiency and effectiveness of action at a point in time;

'Performance Measure': a metric used to quantify the efficiency and/or effectiveness of action at a point in time;

'Performance Measurement System': the set of metrics used to quantify the efficiency and effectiveness of actions at a point in time.

Since the mid-eighties researchers have been attempting to specify a way of identifying those few key performance criteria whose adherence to and success in meeting will result in a World Class company. In 1985 Shlomo Globerson in the International Journal of Production Research stated:

'It is important for every organisation to identify and develop a performance criteria system which is the basis for effective management planning and control. An integral part of every evaluation system deals with decisions concerned with the choice of criteria to be evaluated, establishing standards for
Globerson suggested the assignment of relative weights to Performance Criteria by the pair comparison technique or by graphical technique to be the most effective way of aligning the performance measures taken with the strategy of the business. In this way Globerson, along with others, set out along the route of performance measurement research which sought, not only to develop methodologies to measure what the Japanese measured, but also to align the measures of performance (which should be applicable to all employees) with the central requirements of the manufacturing and financial strategies [23] and thus build into the whole system what has since been termed 'Goal Congruence' [28,29,30]. While Globerson offered little detail in terms of the practical measurement of the chosen criteria he did offer the idea of supporting continuous improvement through performance measurement. Two approaches were suggested:

(a) the static approach fixes the standard at a certain performance level which remains unchanged until a new analysis is performed, and;

(b) the dynamic approach expresses the standard as a rate of expected improvement.

The dynamic approach, which Globerson favoured, was based on the learning curve phenomenon [31] and designed to be supported by other approaches such as Work Study and Management by Objectives [32]. There has been much debate over the choice of measures which are to be included in a new performance measurement system. Almost always this debate has been centred around the problem of strategy formulation [33,34]. According to Leong et al. [35] it is widely accepted that the key dimensions
of manufacturing performance can be defined in terms of quality, delivery, speed, delivery reliability, price (cost) and flexibility. However, there continues to be confusion over the literal connotations of such generic terms, especially flexibility [36,37].

The field of performance measurement research related to Goal Congruence and Strategy formulation is a large and expanding one and in order to follow the path of the research chronologically it is necessary to leave this area temporarily and briefly examine the other main focus of academic attention in the last decade.

At the same time as Globerson and others were beginning to examine the role of criteria choice in strategy formulation others were looking at the source of the vast majority of existing performance measurement techniques. The traditional Management Accounting function may be considered not only the source but rather the reason why performance is measured in the way that it is.

(2.3) The Role of Management Accounting Research

As previously stated the financial performance measures which the vast majority of companies use to formulate their strategies, guide their managers and operate the business were already established by the beginning of the twentieth century. The fact is that such traditional accounting measures as return-on-investment and earnings per share are out of step with the changing shape of business [38,39,40,41,42]. Furthermore, such measures can give misleading measures for continuous improvement and innovation. Despite the evidence for change the accountancy profession has been reluctant to modify it's central practices. This entrenchment is exemplified by the 1989 CIMA report 'Management Accounting: Evolution not Revolution' in which it is stated;
'Evidence of the benefits of new accounting techniques and the continued benefit of some existing techniques is only beginning to emerge. No general crisis has been identified vis-à-vis a changing manufacturing environment and therefore no radical reforms are recommended at this stage'. [43]

There has, however, been some shift in opinion with more recent CIMA reports at least acknowledging a need within industry of some alternative measures [44,45,46]. The 1993 CIMA report concludes the following:

- Most companies base their decisions on financial measures (rather than non-financial ones);
- Board members, bankers and external investors usually use financial measures exclusively;
- Executives tend to be receptive to the use of internal non-financial measures;
- Individual companies should tailor their mixture of measures (financial and non financial) to suit their particular situation. Non financial measures to be adopted should be quality, delivery, process time and flexibility. [45]

Despite the slow reaction to pressure on the part of mainstream accountancy there has been some development of alternative accounting tools and methods within the traditional framework which seek to address some of the criticism. Activity Based Costing and Backflush Accounting [47,48] for example. Despite this there is evidence that, within industry the adoption of alternative accounting practices is fragmented at best [49]. The reason for this, it is suggested, is that there is extreme resistance to change
on the part of accountants within companies and/or badly managed introductions of novel techniques have led to almost unavoidable failure. Only on the fringes of the profession, therefore, has there been real movement and the genuine recognition that the performance measurement system of the future will not result merely from making financial measures more relevant or from considering operational measures like cycle time and defect rates in total isolation [50,51]. The reality is that managers want (and need) a balanced picture of the state of the business and information which is both financially and operationally based [52]. This type of integrated performance measurement includes elements such as bench marking and customer analysis which, it is intended, will give managers a fast yet comprehensive view of the business [53,54]. A pioneer of the integrated approach is Kaplan who, along with Johnson and Cooper, has developed the 'Balanced Scorecard' [55,56] which is designed to provide such a concise and balanced picture. Kaplan recognises that traditional accounting techniques (as well as Activity Based Costing etc.) intrinsically do not drive the process of continuous improvement. Indeed the measures employed actually encourage long production runs, inventory build up, maximisation of plant and labour usage, the exclusive use of standard times etc. [57]. The potential role which the management accounting function can have in the tracking, control and reduction of Quality Costs or the costs associated with poor quality [58,59] and the associated goal of Zero Defects [60] is one which has similarly been proposed with little response from accountants.

The conflict which exists between the fundamental principles of Just-In-Time manufacture [61] and traditional accounting techniques is a related area which has spawned much work [24,25,62,63,64,65]. If a production process is going to compete in a JIT environment then the systems which monitor the efficiency, effectiveness and, of course, timeliness of that process cannot be based on standard times and costings [63]. As McNair et
al stated in 1990;

'JIT was calling for production of the right number of the right units, when they were needed, and with no tolerance for waste or defects. The standard costing system, however, ignored these changes, thereby building all types of waste (e.g. scrap, rework) directly into the benchmarks used to evaluate the system.' [66]

In this aspect of manufacturing research the Japanese have again led the West in developing alternative systems which help to redefine the role of the accounting function against a World Class backdrop [67,68]. There is, however, no general consensus among the literature as to the precise form and function of the Management Accounting function of the World Class organisation. What is clear is that the information provided has to be of greater relevance and timeliness than that provided by traditional systems. According to Williams and Taylor [69] accountants have the opportunity to 'lead the revolution from their understanding of the economics of the business'. However, the extent to which a revolution in manufacturing can be led by the Management Accounting function rather than in partnership with manufacturing and not inherit some of its predecessors irrelevance to the shop floor is not discussed.

The question of relevance of performance related information to the receiver and alignment with stated company strategy is the central question which has been addressed by a large section of the research community in recent years. It is an area which has developed alongside, and is inescapably linked to, the Management Accounting question and yet is not bound by the dogma of the Accountant and the consequent restricted deviation from tradition. The reticence of accountancy is in direct contrast to the work of
researchers such as Drucker who points out;

'As soon as CAM-I began its work, it became clear that the traditional accounting system could not be reformed. It had to be replaced.' [70] - (c.f. [43]).

(2.4) Goal Congruence and Strategy

The formulation of a relevant manufacturing strategy has been a key concern in industry for many years but, despite this, the translation of strategy into relevant goals and measures has proved extremely problematic [71,72,73]. The research which has resulted has focused firstly on the definition of the 'key performance criteria' [27] and, secondly, on various attempts to create a logical framework for manufacturing strategy formulation. Platts and Gregory [33], for example, advocate a manufacturing audit by which the participants are invited to map market requirements against achieved performance with reference to the key performance criteria. Variations between actual and desired performance provide the raw materials for new strategy formulation.

Other work, notably that of McKinnon and Bruns [74] and Vora [75] has sought to define the role of information (content and flow) in an organisation. The role of information systems and flow is a central aspect of performance measurement research and the attention paid to it has revealed the importance of system drivers and the way that information translation at each level of an organisational hierarchy and functional boundary can either strengthen or seriously undermine the degree of Goal Congruence within the business.

Work to link the concepts of Goal Congruence and Strategy Formulation within a framework for engineering a relevant, market driven, performance measurement system represents some of the most recent
research in the field [34, 53, 75]. Through such work has come the idea of complete organisational redesign in order to facilitate strategy realisation and the need to tailor measures of performance to individual needs with goals becoming more specific and planning horizons shorter as measures are articulated down through the organisation [76]. This approach suggests localised, relevant and practical measures on the shop floor which enable realisation of the manufacturing strategy through targeted continuous improvement.

Incorporated into much of the strategic research are methodologies such as Competitive Benchmarking [77] and the notable work of the CAM-I group and their Integrated Performance Measurement System seeking to provide appropriate performance measures at each level of an organisation from Corporate body to Department or Cell [50]. There is also a recognised need for the performance measurement systems of World Class manufacturers to be flexible and robust enough to be able to constantly monitor the key criteria and update the system accordingly [78] and secondly to adapt to changing market characteristics in a proactive manner in a way which traditional systems do not [79].

The research in the field of performance measurement to date has, therefore, fallen into two, at times entwined, but nevertheless distinct, areas;

(a) The role of Management Accounting in World Class manufacturing. The need for an increase in the relevance of the accounting information used to run business and a recognition of the need for fundamental change in the way that information is collected, collated and fed back into the system as well as a change in the nature of that information.
(b) The need to develop a framework for the engineering of appropriate manufacturing strategies for business which should be coupled to the financial and marketing strategies. The development of methodologies for performance measurement system design which will, through ensuring inter and intra hierarchical Goal Congruence, also ensure adherence to and satisfaction of the manufacturing strategy.

Due to the situation of this research, as described in Section 1, the focus of the project will be very much in the second rather than the first of the categories above. The attention paid to the strategic issues, however, means that there is also a shortage of reliable empirical evidence especially concerning the effect of performance measures on the shop floor. This may be due to the difficulties inherent in such research as discussed in Section 1 and the problems of access which can hinder the in-depth case study. Therefore, using the knowledge gleaned from the initial literature survey as a basis, bearing in mind the situation of the researcher in this case and considering the lack of practical empirical evidence in the area the following initial research objectives are proposed. Satisfaction of these objectives will facilitate increased focus and the proposal of a hypothesis whose formulation will also draw on a second, more specific literature survey.
(3) **Initial Aims of the Research**.

(i) To examine and analyse the Performance Measurement System at Dunlop Cox Ltd. as it impinges on the Production function.

(ii) To identify the Performance and Production Drivers acting on the Shop- Floor and any differences in the stated identity of these between individual actors at various levels.

(iii) To examine relationships that exist between these drivers as perceived at each level of the Production function hierarchy.

(iv) To examine the actual measure of the drivers over time and to identify the degree of mis-match between perceived and actual driver inter-relationships.

(v) To examine the degree of any mis-match in perceived driver inter-relationship between various levels of the function hierarchy.

(vi) To draw on the results of the above and use these as a basis for the development of alternative measures and/or systems which will benefit the Company, the Production function and the shop floor. (This assumes that at least one of the above objectives will reveal sub-optimal characteristics of the existing system.

It is intended that these Objectives will provide the framework for Stage I of the research and at the end of Stage I it will then be possible to formulate the Hypotheses to be tested.
(4.1) The Company.

Dunlop Cox Ltd is a subsidiary of the financial holding group BTR plc. BTR has proved to be highly successful in maintaining improved performance in recent times despite the recession in the U.K. and, especially, in continental Europe where most of its companies trade. The fastest growing areas are, however, the Far East and Pacific Rim. The BTR Interim Results for 1993 showed a profit before interest and tax of £684 million (1992- £645 million) on sales of £4872 million (1992- £4310 million).

Dunlop Cox specialise in the design, development and manufacture of vehicle seats and seat mechanisms including slides, reclines, height adjusters, seat frames and fully trimmed seats. Eight-way integrated seat mechanisms, combined slide, recline and height adjustment functions, are available as either manually or electrically operated units.

The company currently supplies a wide range of automotive manufacturers including Nissan, Vauxhall, General Motors, Volvo, Saab, Rolls-Royce and Land Rover all of which demand Just In Time supply with varying degrees of buffer stock.

In 1993 the company had a turnover of about £22 million with approximately 500 employees on its payroll, with approximately 430 employed as direct labour on the shop floor. However, falls in the levels of new car sales over the past two years and the continued depression of the European car market (the company's principal market) has led to a marked fall in output. In addition the Rover Group contract (excluding Land Rover) ended in early 1994 and was not renewed. While there are replacement contracts on the horizon these proved too distant to prevent redundancies in late 1993 / early 1994.
The company occupies a purpose built factory on the outskirts of Nottingham which was opened in 1987 shortly after the company was bought by BTR from the TI Group under which production was split between sites at Nottingham and Leicester.

(4.2) The Organisational Hierarchy.

The company is organised into functional departments which reflects a common division and allocation of responsibility. Figure 2 shows the Organisation Chart as it applies to the Board.
(4.3) Company Culture; Overview and Recent History

The Culture of the company may be described as a Role Culture according to Harrison's definition [80]. As previously demonstrated the management of the company is divided into functional areas of responsibility. This has led to a certain degree of compartmentalisation and introspective departments still engage in 'over the wall' manufacturing.

(4.3.1) Training and Education.

All but two (out of ten) of the Cell Leaders have risen to their current position from roles on the shop-floor such as Production Operator, Tool Setter or Technician. A Tayloristic type culture is deeply embedded on the shop floor although more recently new and progressive thinking has begun to influence the management of certain cells. The level of formal training and education of Cell Leaders in man-management varies from none through NEBBS qualifications (two or three) to degrees (two, of which the author is one). Generally training has a low priority at shop-floor level as is demonstrated by the low levels of both on and off the job training given to Production Operatives.

(4.3.2) Kaizen and Autonomy.

Since 1991 there has been a drive towards the adoption of continuous improvement techniques or Kaizen. This is seen as being vital if the Just in Time production systems which the company aims to operate are to improve and meet the increasingly high quality, delivery and service requirements of its customers, especially Nissan. In addition the threat of increased competition from Japanese parts suppliers provides increased impetus for the company to become 'world class'. The initial projects carried out under the Kaizen banner where highly successful and involved Operatives participating heavily in the redesign of Cell Layout and
reappraisal of job design. The results, including reduced scrap, reduced rework levels, reductions in wasted floor space, Kanban systems, balanced flow assembly lines and reduced Work in Progress were encouraging and should have provided the impetus for a sustained and long term factory-wide improvement programme. However, while technical and engineering improvements have continued to a certain degree there has not been the fundamental shift in attitude and consequently culture which might have been expected. The projects that have been undertaken have more often involved the Cell Leader working with Production Engineers, the Cell Technician and Tool Setters rather than the Operatives themselves. This, it is felt, is a reflection of the failure by the Management to address the fundamental issues which actually represent the most challenging and, potentially, the most rewarding problems facing the Company. The adoption of Kaizen has, therefore, been in the style of an overlay onto the existing culture and as a reflex reaction to the threats from Japanese suppliers in particular. There has been little advancement, for example, in the attempts to push responsibility down and to enable and empower employees to solve their own problems and implement their own solutions. While some senior management is committed, including the Managing Director, as well as some middle managers, there is some degree of lip-service paid to the philosophy at all levels of the company. This is especially and most damagingly true on the Shop Floor. This it is felt, is the result of a combination of ignorance or misunderstanding of the basic principals and the tools available and barriers, or perceived barriers, to the solution of many deep rooted and on going problems. These obstacles are in the form of incompetence and/or lack of co-operation and indeed, at times, hostility on the part of other departments and support functions. These departments include Design, Quality Control, Maintenance, Tooling Services and Materials Supply.
The Unions.

The only blue collar union in evidence within the company is the GMBATU. The relationship between the Management and the Union is relatively convivial and a Joint Consultative Committee meets regularly to discuss a wide range of issues from current business prospects to issues of health and safety. Serious conflict is very rare and the management is anxious to be seen as even handed in the handling of disputed disciplinary action taken against Operatives by Cell Leaders which, along with day to day issues of health and safety and un-disputed disciplinary action, forms the majority of the contact between Union representatives and Cell Leaders.

Production Cells.

Production throughout the factory is based around the flow-line, cellular manufacturing concept. The Cells are classified according to either customer or customer and destination vehicle model. The factory is essentially divided into two, one half makes seat slides while the other half makes the frames and in some cases assembles slides from the slide cells onto the squab (or seat part of the frame). The Trim Shop finishes the only fully trimmed seats produced, those for the Land Rover Defender range.

The Slide Production Cells are as follows:

(i) Universal: MGR V8
    N936 (Nissan Primera).
    UT2/4 (Vauxhall Frontera 2-door and 4-door).
    Land Rover (Defender Series).

(ii) Nissan 909 (Nissan Patrol and Ford Maverick).

(iii) P700 (Volvo 800 Series).

(iv) S9000 (Saab 900 Series plus slides for Volvo 400 Seats).

(v) S900 (Saab 900 Series).

(vii) N906 (Nissan Micra).
The Seat Production Cells are as follows;

(i) Volvo 400 (Volvo 400 Series).

(ii) Range Rover (Series).

(iii) Rolls Royce (Silver Spirit III, Silver Spur III and Corniche IV).

(iv) Commercial Vehicle (Leyland/Daf, JCB and Land Rover Defender Series).

(v) Trim Shop (Land Rover Defender Series).

Generally cells work two shifts per day with each shift being 7.75 hours long. Some cells work days only (including Commercial Vehicle) and each day is 8 hours long.

For the purpose of this research only the Slide Cells were considered. This was mainly due to the fact that in order to produce a valid piece of research the volume of data to be collected and analysed and the systems to be studied had to be restricted to one half of the factory. The rationale behind this decision was two fold;

(i) The Performance Measurement System was found to be complex and far reaching in it's effects and by taking just one half of the factory it was felt that a valid model of system features and interaction and consequential behavioural cause and effect relationships could be established and assumed to be valid for the entire production system if required at a later stage.

(ii) Taking into account the limited time available for data collection and analysis prior to the second stage of research and the factors mentioned in (i) the maximum possible extent of the system was considered.

44
Of the Slide Cells all were considered except:

(i) Nissan 909.
(ii) Saab 900.

In both of these cases production did not start until during the initial stage of research and therefore the data available for these two cells over the initial period was severely restricted and deemed insufficient for valid analysis.

The initial period of data collection was forty weeks.

(4.5) Production Processes.

While each design of slide has a unique set of production operations associated with it there are several features of production which are common to all slides. A global description of the production sequence for the five cells considered would therefore read as follows:

(i) **Press Work.**

All non bought-out parts are initially formed on power presses. These vary from 40 ton to 500 ton capacity.

The tools used are generally of three kinds:

- Blanking
- Forming
- Progression.

The type of part produced in each way varies but generally the following applies:

- **Inners and Outers** - Blanked and Formed separately.
- **Brackets and Triggers** - Formed and Blanked on Progression Tooling.

The raw material is either hot or cold rolled steel which generally is
supplied to the presses as coils although lengths of strip are used in a few exceptional cases.

(ii) Fabrication.

At this stage any combination of three methods of fabrication are employed. The three methods are:

- Electric Arc Welding
- Resistance Spot Welding
- Spin or Press Riveting.

Generally brackets are riveted onto inner and outer sections with manual and robotic welding used for a wide variety of other applications.

(iii) Painting.

Once all fabrication is complete then the sub-assemblies are hung on jigs which in turn hang from an overhead conveyor mechanism which travels through all the cells and through the Paint Plant which coats the sub-assemblies with an even layer of black paint which is specified by all customers. Other parts such as triggers and trigger springs also have to be painted in the same way.

The cycle time for the Paint Plant is approximately two hours.

(iv) Assembly.

As with Fabrication the details of this stage vary considerably according to the product in question. Here again, however, there are some common features:

- All slide assemblies involve the inner
section running inside the outer section.

- All slide assemblies use steel balls placed between the inner and the outer in order to facilitate smooth running and stable behaviour of the assembly.

Generally four balls per assembly are used with two at each end.

- Trigger fitment is carried out ensuring that the trigger engages with the inner or the outer in a positive and consistent manner.

- All slide assemblies are required to 'run' smoothly with the resistance to travel between the inner and outer sections not exceeding a specified level. 'Running' is carried out manually or by a dedicated machine.

- All the assemblies are then packed into cases or pallets ready for despatch.

The above description is a gross over-simplification of the production process and is intended only as the briefest of overviews of what is actually a complex and various sequences of operations when the processes across the five cells are considered.

This concludes the introduction to Dunlop Cox, its culture, products and production processes. The next section deals with the Performance Measurement System as it impinges on the five cells under consideration.

The initial stage of this research is concerned primarily with the existing measurement of performance of the production activity within the company. Consequently it is from the viewpoint of Production Management in its broadest sense that the current Performance Measurement System will be considered. Within this context 'Performance' will be taken to mean any variable which is regularly accounted for and by whose behaviour against a criterion, formal or informal, the competence of the production system and/or those who manage and participate in it is judged.

(5.1) The Bonus or Labour Performance Indicator (LPI) System.

The LPI System, as it shall henceforth be referred to, is based on Standard Times which are allocated to each individual operation which is carried out on every component of every product. The calculation of these Standard Times is based on classical Work Study techniques of direct observation and timing of operations. Each operation is, therefore, assigned a Standard Minute Value or a time period within which one standard operation should be completed.

Standard Times are used in two forms by Cell Leaders. Generally the Standard Times for completed assemblies are used in the LPI calculation but occasionally (or regularly depending on the situation) Standard Times for individual operations are taken and multiplied by the number of times that the operation in question has been carried out on the cell over the working day. This usually occurs when the work is carried out for another cell in which case the calculation allows the Standard Hours worked on that product to be booked out to the customer Cell.
(5.1.1) The LPI Calculation.

Every morning the Cell Leader who is managing the morning shift calculates the LPI from the day before. Several pieces of information are required to make the calculation, this information is gleaned from two sources: Cell Records and the 'Plantime' or record of clocking times and hours worked for all hourly paid employees of the Cell. The LPI calculation is of a form common to many such systems:

\[ LPI = \frac{\text{Standard Hours Produced}}{\text{Hours Worked (Direct and Indirect)}} \]

Elements of the calculation such as Allocated Standard Hours, Normal Time Worked, Overtime Worked, Hours Booked in and out, Available Hours and Absenteeism levels together with the LPI value for the previous day are entered onto the resultant document, the Operating Report. A daily copy of the Operating Report goes to the Production Manager, Production Director and the Managing Director. The Report is added to each day until, at the end of each week (weeks run Sunday to Saturday), the LPI for the week is apparent.

Each Monday a copy of the Operating Report from the week before goes to the Management Accountant who checks the LPI calculation for the week using Cell Records of parts produced and their Standard Minute Values and records from the Wages Department which is responsible for the management of the computerised clocking system. Once the LPI value has been confirmed, with any mistakes corrected, then Directors and Senior Managers receive what is called the 'First Look' copy of the Cell Performances for the previous week. At this stage any last minute alteration to the LPI values and consequential bonus values allocated takes place.

Finally, on about Wednesday the sheet is produced showing the LPI values
achieved by each Cell in the factory over the previous week together with the bonus calculation.

The LPI was introduced into the company in 1986 and was intended to bring about the required large efficiency improvements. From a factory-wide average of LPI of around 45% in 1986 the average in 1992 was 70%. Progress to improve towards the goal of 80%, however, has been increasingly slow and little progress has been made since around 1990.

(5.1.2) The Bonus Calculation.

Each Cell is allocated a Start Point which is periodically updated. This Value is defined as being the minimum acceptable LPI value that the Cell can be allowed to perform at. The Start Point is updated according to recent Cell Performance at the discretion of the Managing Director. If the LPI value for a particular week falls below the Start Point then the Cell will earn no bonus for that week. For every point earned over the Start Point a Bonus of £1.39 is earned. If a LPI in excess of twenty points over the Start Point is achieved then a Bonus of £1.95 per point is earned. The Bonus is paid weekly to all non-staff employees (direct and indirect). consequently Cell Leaders do not receive the Bonus as such. However, following the 1993 Staff Wage Negotiations, Cell Leaders receive a small percentage of their Cell’s mean earned Bonus once a quarter.

An exception to the Bonus System occurs when a new Cell starts production. In order to allow for the inevitable teething problems until full production is established the Cell employees are paid the Bonus Factory Average. The Maintenance Department, Paint Plant, Receiving, Despatch and Stores all receive the Factory Average as a matter of course.

The LPI System is, therefore, the principle means of Performance Measurement within the company. However there are other factors which
impinge on the way that Production is managed and are used to gauge Cell Performances.

(5.2) Production Planning and Control.

A prime consideration when running a Cell has to be producing what the customer wants when he wants it. This is especially true when supplying the automotive industry which, more and more, demands Just In Time supply with less and less buffer stock. Slides produced for Nissan, for example, on an afternoon shift, leave the factory at 10pm and are being assembled into cars at Nissan's Sunderland plant by their night shift. In this environment the Production against Forecast deficit must be kept to a minimum as a priority.

There are, in fact, several versions of what the customer wants circulating in the factory at any one time:

(i) The Commercial Forecast: Prepared by the Sales and Marketing Function as part of the Company Strategy. This is a long-term plan. This information is generally not available to Cell Leaders.

(ii) Customer Schedule: Forecasts from the customer of their requirements over the short to medium term. Usually forecasts to about one or two months ahead. This information is available to Cell Leaders.

(iii) Production versus Forecast: Prepared by the Production Director. The report consists of the Forecast Sales for the week minus production to date. The report is up-dated daily and a weekly and quarterly version is produced. This information is not available to Cell Leaders as a matter of course but the Production Manager may, on occasion, discuss progress against forecast with the Cell Leader if
there is a shortfall.

(iv) Production Call: Prepared by the Production Manager on a weekly basis. This report, one per Cell, is passed to Cell Leaders at the beginning of every week and gives details of the customer requirements for each slide produced on the Cell. The Production Call is based on actual customer requirements but where such information is lacking or incomplete then the Production versus Forecast report contributes an effect. The Call is often updated. These updates are fairly common and may be due to a wide variety of factors.

(v) Direct Customer Contact: During any working day a customer may contact the company with immediate requirements for extra, less or a different mix of parts. This information is usually passed to Cell Leaders by the Production Manager, Despatch and Delivery Supervisor or, very occasionally, the customer will contact the Cell Leader direct although this usually occurs only when there is an immediate requirement outside of office hours.

Once the Cell Leader has details of the customer requirements then it is up to him to manage the scheduling and capacity of the Cell so as to provide the parts required at the time required and in the quantities required.

Raw material and bought out parts supplies are dealt with through the company's MRPII system and unless the Cell Leader alerts the Materials Supply Manager to a parts or material shortage then parts and materials are supplied to the Cell in accordance with the Customer Schedule. More recently, however, many bought-out items have been introduced onto a Kanban system which now operates across the majority of bought-out parts.
Inter and intra-cell Kanban systems are also in effect in many areas.

Apart from Production Efficiency, Delivery and Service the fourth major area of Performance Measurement is concerned with the Quality of the products.

(5.3) Quality Management and Control.

The task of ensuring that parts are produced according to the specification is the responsibility of the Cell Leader. The Cell Leader is aided in this by the Quality Control Department which assigns usually one Quality Technician permanently to each Cell. The Quality Technician is responsible for ensuring that gauging and measuring devices and equipment are being used in the correct way and that Quality Instructions are kept up to date and are adhered to at all times. The Quality Technician will also spot check any part or assembly on the Cell to determine whether it is in line with the specification. If there is any discrepancy then the Quality Technician is empowered to reject any material, parts or assemblies. Once this happens then the Cell Leader can do one or a combination of two things:

(i) Sort the affected parts or material into good and bad stock and use the good stock and scrap or re-work the bad stock.

(ii) Scrap all parts if re-work is not possible.

(iii) Apply for a Concession to use parts or assemblies which are not to the specification. The Concession must be passed off by the Design Department following comments by the Cell Leader, Production Manager, and Quality Technician.
A copy of the Rejection Slip which is completed by the Quality Technician goes to the Production Manager. The quantity rejected is at the discretion of the Quality Technician and is a reflection of the quantity of stock which is deemed to be affected by possible quality problems regardless of the actual number of defects found at the time or during any sorting operation.

The number of Rejections experienced by a Cell is a direct reflection on the ability of the Cell Leader to control the quality of the processes on his Cell.

Early in 1993 the company became accredited with BS 5750 Part 1. As a preparation for this and following it the Quality Control Department had established a Quality Audit for Production Cells which was designed, not to test the quality of the parts being produced but rather to test the adherence of the Cell to Systems of Quality Control the correct employment of which formed the major prerequisite to BS registration. The Audit also covers housekeeping and general aesthetic qualities of production areas. The Audit is carried out monthly by the Cell Quality Technician with the Cell Leader in attendance and a percentage mark is given on completion of the tour. All marks are published shortly afterwards together with a breakdown of the final score and details of the previous two scores. Copies of the report are displayed on notice boards and sent to the Production Manager and Director and the Managing Director. The minimum permissible score was increased from 80% to 90% in June 1993 and most Cells exceed this with regularity.

To summarise, in terms of Quality the performance of the Cell and its Leader is measured, primarily, in terms of numbers of Quality Rejections per nominal time period and the score achieved in the Cell Audit Value. The
only other direct reflection on the Quality Management of the Cell occurs when a Customer Complaint arises and this, obviously, is treated extremely seriously.

Since September 1993 the amount of scrap produced by each Cell has come under close scrutiny and the total weight scrapped by each Cell per week is plotted. Here the emphasis is largely on the Cell Leader to improve the situation with little or no involvement from the Quality Control Department.

This concludes the description of the Performance Measurement System at Dunlop Cox. The above provides sufficient detail to explain the Research Methodology employed, the results obtained and the conclusions drawn from Stage I of the research.
(6) Research Methodology.

The following describes the research undertaken in endeavouring to understand the functioning and effects of the Current Performance Measurement System. The aims were, in broad terms and with reference to the stated Objectives (Section 3), as follows:

(i) To identify the drivers at Cell Level.
(ii) To determine the relative influences, including perceived inter-relationships and behavioural consequences, of these drivers at Production Director, Production Manager, Cell Leader and Production Operative level.
(iii) To establish the degree of Goal Congruence vertically through the Production Function and horizontally at Cell Leader level with regard to the production drivers as well as to broader strategic issues.
(iv) To record, collate and plot values for the defined drivers over a forty week period in order to test the subjective and anecdotal evidence offered regarding driver identification, effects and inter-relationships.
(v) To offer an appraisal of the Current Performance Measurement System, to suggest areas for improvement and outline methods to facilitate further research through the testing of alternative systems from a Production viewpoint.

(6.1) Initial Appraisal.

The initial task in examining the Performance Measurement System was to identify the reports and the pieces of information therein which
related directly to the performance\textsuperscript{1} of individual Cells. The identification of the reports circulated at various levels was achieved through consultation with the Production Manager, Production Director, Finance Director, Personnel Manager and the Senior Quality Engineer. Simply by asking each of these individuals to list the reports which they produce or receive which relate to any aspect of the Cell performance the researcher was able to identify all pertinent reports. These reports are as follows;

(i) \textbf{Production Against Forecast Report:}
Produced by the Production Director, passed to Managing Director, Finance Director, Production Manager and Cell Leaders on occasion.

(ii) \textbf{Cell Profitability Analysis:}
Produced monthly by the Finance Director, passed to all Directors only. This is a detailed breakdown of all aspects of Cell finance.

(iii) \textbf{Standard Minute Values:}
Produced periodically by the Work Study Function, passed to the Managing Director, Production Director, Production Manager and Cell Leaders.

(iv) \textbf{Overtime Report:}
Produced by the Management Accountant, passed to the Managing, Production, Manufacturing Engineering and Finance Directors together with the Personnel and Production

\textsuperscript{1}Defined as the 'efficiency and effectiveness of action at a point in time' (Neely, A. 'Performance Measurement System Design - Theory and Practice Version 1.3' ACME Project Gr/H 21470, 1993, pg. 2.[22]
Managers.

(v) **Sales Analysis Report by Cell:**
Produced weekly by the Management Accountant and circulated as for (iv).

(vi) **Paint Rejection Analysis:**
Produced weekly by the Paint Plant Supervisor, passed to the Managing Director, Production Director, Production Manager and Cell Leaders.

(vii) **Cell Audit Report:**
Produced monthly by the Quality Control Department, passed to all Directors, the Production Manager, Cell Leaders and Notice Boards.

(viii) **Incentive Bonus Earned:**
Produced weekly by the Accounts/Wages Department. circulated as for (vii).

(ix) **Operating Report:**
Produced by Cell Leaders daily and weekly and passed to the Managing Director, Production Director and Production Manager.

(x) **Fault Analysis Report:**
Produced weekly by the Quality Control Department and passed to the Production Director, Finance Director, Production Manager and Cell Leaders.
(xi) **Fault Recurrence Chart:**
Ongoing record of the Fault Analysis Report. passed to the Managing Director, Production Director, Production Manager and Cell Leaders.

(xii) **Absenteeism Report:**
Produced monthly by the Personnel Manager and passed to the Managing Director, Production Director and Production Manager.

(xiii) **Safety Diary:**
Produced daily by Cell Leaders and passed to the Production Manager.

(xiv) **Cell Statistics:**
Produced weekly by the Finance Director, passed to the Managing Director, Production Director, Production Manager and Cell Leaders. Consists of summary figures from the Cell Profitability Analysis.

(xv) **Labour Calculation:**
Produced monthly by the Production Director, passed to the Managing Director and Production Manager. Details labour requirement for each Cell based on customer requirements and Standard Minute Values.

Copies of the above reports are found in Appendix A.
Three points arose from this initial task. Firstly, the volume of data produced daily, weekly and monthly which is either synthesised or circulated in its raw state is considerable and how much of it is produced as a matter of routine rather than necessity as well as how much of it is actually used to any great extent are issues outside of this research remit.

Secondly, a large proportion of the data is duplicated for inclusion in more than one report. In other cases, detailed facts and figures are condensed and re-circulated as different reports with greater or the same frequency as the parent report. Examples of this include such parent/daughter reports as the Cell Profitability Analysis/Cell Statistics, Fault Analysis Report/Fault Recurrence Chart, Daily Operating Report/Weekly Operating Report, Operating Report/Absenteeism Report/Production Against Forecast/Production Plan, Daily Production Against Forecast/Weekly Production Against Forecast (as well as the previously mentioned, multitude of Customer Requirement/Production Plan/Weekly and Daily Call change reports and updates of updates) etc.

Thirdly, while all of the information required for the generation of all reports originates on the Cell, very little of the synthesised information is fed back down to the Cell and Production Operators on particular. In fact only the LPI value, the Bonus earned, the Paint Plant Rejects and the Cell Statistics are passed back to the shop-floor on a regular basis.

Having identified these reports and the information contained in them the next stage was to determine the importance of each report and the information therein to the Cell and its Management. Firstly, however, it was necessary to narrow the field in terms of the information used by Production Management and therefore approach identification of the Cell drivers.
(6.2) Determination of the Production Drivers.

In order to begin to focus attention on the elements of the Performance Measurement System which actually affected the way that Production was managed the researcher questioned the Production Manager regarding the importance to him of the individual reports which he received on a regular basis. The reasons for initially questioning the Production Manager rather than the Cell Leaders or Production Operators for example were as follows:

(i) It was felt that the Production Manager (PM) could offer a broader view of the situation which was required at this early stage of the research than could his subordinates. Their contribution could be sought in detail at a later stage once a framework had been established (i.e. a preliminary list of drivers).

(ii) Being closer to the shop floor (in hierarchical terms) than the Production Director it was felt that the PM could offer a clearer insight into the effects of the current Performance Measurement System on shop floor behaviour.

(iii) As the prime facilitative actor in the Production Function the PM is best placed to offer a clear insight into the direction and aspirations of the shop floor through the collective feedback of his Cell Leaders.

(iv) The researcher, in his position as Cell Leader (Universal Cell) reported directly to the PM, and access to the PM, therefore, was readily attainable. Indeed, contact between the researcher and the PM was very frequent (several times daily), as it was with all the Cell Leaders reporting to the PM.

This questioning took the place of a semi-structured interview with each report considered in turn and the results fed back immediately to the
Production Manager for verification.

(6.2.1) Production Manager Viewpoint.

The results were as follows:

(i) **Cell Statistics.**

Looked at on receipt and then filed, referred to later on if specifically required to do so.

(ii) **Labour Calculation.**

Referred to constantly.

(iii) **Production Against Forecast.**

Referred to constantly.

(iv) **Cell Statistics.**

Had received only one copy of this when questioned.

(v) **Operating Report.**

Referred to constantly.

(vi) **Overtime Report.**

Looked at on receipt and then filed. Referred to later on if specifically required to do so.

(vii) **Sales Analysis Report by Cell.**

Looked at on receipt and then filed. Referred to later on if specifically requested to do so.
(viii) **Paint Rejection Analysis.**

If there appears to have been a high number of Paint Rejects then he questions the other Production Manager who is responsible for the Paint Plant. If further investigation is required then he talks to his Cell Leaders. Files if no problem.

(ix) **Cell Audit Report.**

Refers to and uses the results to help Cell Leaders to direct their attention towards areas where performance falls short of that required.

A point to note at this stage is that the above statements are taken at face value and it is assumed that what the respondent says he does and what he actually does are one and the same thing.

In addition to these points the following opinions of the Production Manager were noted.

The Production Manager (PM) believes that the Operating Report is the most accurate measure of Cell Performance which he receives. Along with the Production Against Forecast and the Cell Audit Report he believes that the Operating Report gives the information which most accurately reflects the state of the Cell. In addition, the PM believes that, by and large, when considering these three measures, it is not possible for one or more of the measures to have a poor result with the rest having a good result/s. In other words, all three aspects of performance are at a favourable, satisfactory or unfavourable level but never a mixture of levels across the measures, they all rise and fall together.

The PM believes that it is not possible to inflate the PI at the expense
of the Production Against Forecast. The Universal Cell is an exception since, due to the product variety there is an inherent flexibility in terms of possible labour movement within the Cell between products of differing Standard Minute Value and, therefore, differing benefit to the LPI/Bonus Calculation.

It is felt that, if the various measures considered on the Cell Audit Report are at a satisfactory level then the general level of Quality Management and Production Efficiency on the Cell is also likely to be at a satisfactory level. In addition Cell Reject Levels are usually reflected in the Cell Audit Value. This correlation is based on experience.

Referring specifically to the Production Against Forecast Report he first looks at the bottom line Sales Variance for each Cell. Next at the Sales Variance by Product and, where there is a shortfall, he looks at the variation between production and forecast in terms of Quantities. The figures given for Quantities are merely the conversion of the figures given for Sales and it is usually in terms of Production Volumes and not Sales that he will talk to Cell Leaders about any shortfall. Since it is the Sales Forecast which reflects the demands of the customer the PM believes that close control of this variable is an efficient way of satisfying the customer (this depends on the accuracy of the forecast figure and actual weekly customer requirements are often used in reality). The PM believes that most Cells, for most of the time, are operating just a little short in terms of capacity to fulfil the Production Call and in this way improved efficiency is constantly encouraged.

The flexibility of a multi-product Cell in particular means that where the Production Call for the day is fulfilled then labour should first be moved to other lines which are in need of extra hours to complete their Call and, secondly, be taken off production so working according to the proclaimed Just In Time philosophy with all of it's inherent benefits. However, since the LPI System is the principal Performance Measurement criterion, and
increased production usually means increased LPI, this is not always the case (this latter point is discussed further in Section 6.2.5). The PM believes, therefore, that in such cases, the LPI System contradicts the JIT philosophy. However, he also points out that such occasions are so rare that the importance and/or relevance of this argument is doubtful.

N.B. Over-production on any line on any one day has two effects at Cell level;

(i) Increases LPI (this relationship is considered later)

(ii) Produces excess stock/WIP to guard against the subsequent and frequent production downtime periods.

Because of this, over-production occurs whenever capacity and labour is available. While over-production of completed assemblies may or may not be rare there is often over-production of parts and sub-assemblies throughout the production process (this is based on the anecdotal evidence of the researcher).

With regard to the Operating Report the PM looks first at the Cumulative and then Daily Performance to find the level of Cell Efficiency. The Labour Performance (calculated in addition to the Total Performance and involving only Direct Labour) he suggests is important since the difference between this and the Overall Performance gives a measure of the Productive Activity of Indirect Labour. The other figure of interest to him is the value for the Overtime Hours worked.

Details of Absenteeism levels, which the PM finds on the Operating Report, are also of importance since they have direct bearing on output,
overtime working levels and may reflect the general morale or discipline of the Cell.

Therefore to summarise the findings of this, the second questioning of the Production Manager:

(i) The most important and accurate measure of Cell Performance is the Operating Report.
(ii) The Production Against Forecast and Cell Audit Value also give valuable indicators of the state of the Cell.
(iii) The above three measures rise and fall together and good or bad results in one are almost always reflected in the other two.
(iv) As far as customer satisfaction is concerned Sales Variance is what primarily interests the PM with Volume Variance used as a conversion for information exchange with Cell Leaders.
(v) The Cells are generally, run fairly efficiently with capacity and labour at a minimum.
(vi) The LPI System can lead to an undermining of the JIT Production System due to the desire of the Cell Leader to maximise the LPI.
(vii) As a rule Cells rarely over-produce.
(viii) The PM believes that it is important to have an idea of the contribution of Indirect Labour to production.
(ix) Levels of Absenteeism are of relevance to output, overtime working and Cell discipline and moral.

Based on this list five drivers were identified;

(i) Reject Levels
(ii) Production vs. Forecast
(iii) Labour Performance Indicator (LPI)
(iv) Absenteeism
(v) Cell Audit Value

While this list provides a valuable insight into the priorities of the Production Manager in seeking to influence the behaviour of his Cell Leaders it does not give any indication as to which, if any, is the overriding driver and what interaction there is, if any, between these. In short, what was required was a ranking of drivers.

(6.2.2) Production Manager Driver Ranking

In order to achieve this, a Questionnaire was devised which sought to clarify the situation. The design of the Questionnaire focused on the idea that each of the drivers is studied, for each Cell, every day by the Production Manager. If the value for one driver is poor for a day or a week then this would be the main target of the PM's attention for the following day or week. However, if two drivers had poor values for the same day or week and the PM were restricted to concentrating on only one of these in the following time period (which, of course is not the case) then his choice of single driver for attention should reflect his priority in terms of the two low driver performances. This, then, was the circumstance with which the Questionnaire confronted the PM. A set of drivers and corresponding values was devised with two poor driver values and the respondent asked to choose just one for attention in the following week. This was repeated thirty times, so covering all combinations of dual low driver values three times. The reason for presenting each combination three times was so that the repeatability of response could be gauged as well as the response itself. The other factor, subtly included, in the Questionnaire, was that of cause and effect relationships existing between drivers. For example low LPI may be tackled by reducing Reject Levels or Absenteeism, or both.
Once the Questionnaire had been completed then the analysis of the responses took place. Where one Driver was chosen in preference to another then the 'winning' Driver was allocated +1 and the 'losing' Driver -1.
**Figure 5: Production Manager Questionnaire.**

Look at each of the following statistics for a Cell over a period of weeks and for each week tick your main area of concern and target for correction in the following week. Each week's worth of data is unconnected to the next or the previous set.

It has been assumed that the following are good and bad scores respectively for each category:

<table>
<thead>
<tr>
<th>Category</th>
<th>GOOD</th>
<th>BAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>Cell Audit Value</td>
<td>90%</td>
<td>70%</td>
</tr>
<tr>
<td>Prod. vs. F'cast (success)</td>
<td>100%</td>
<td>70%</td>
</tr>
<tr>
<td>Reject Levels</td>
<td>0%</td>
<td>15%</td>
</tr>
<tr>
<td>Absenteeism</td>
<td>1%</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Choose only one statistic for each week.*

1. LPI 70%
   - Cell Audit Value 70%
   - Prodn. vs. Forecast (success) 100%
   - Reject Level 0%
   - Absenteeism 1%

2. LPI 80%
   - Cell Audit Value 70%
   - Prodn. vs. Forecast (success) 70%
   - Reject Level 0%
   - Absenteeism 1%
In this way it was possible to produce a 'league table' or ranking of the Drivers. The result was as follows:

1. Cell Audit Value. (Most Important)
2. Production vs. Forecast.
3. Reject Levels.
4. Absenteeism.
5. LPI. (Least Important)

In terms of the repeatability of response the Drivers at the extremes of the list were involved in the most consistent response (i.e. Cell Audit Value always 'won' no matter what the other low value was assigned to and LPI always 'lost' - both had 100% repeatability of response). Towards the middle of the list the response became less and less dependable. Bearing this in mind it was felt that in terms of drawing detailed conclusions from this ranking as it stood only the Cell Audit Value and the LPI could be taken as occupying wholly accurate and consistent rankings. In order to validate the conclusions of the Questionnaire it was necessary to feed back the results to the Production Manager and to ask for his comments on the findings.

(6.2.3) Production Manager Questionnaire Feedback.

The PM agreed with the general findings of the Questionnaire and, in particular, with the ranking of drivers at the extremes. The LPI ranking was a particularly interesting and illuminating result. According to the PM, the LPI is a reflection of the general state of the Cell. However, the four other drivers are all elements in the equation where the LPI is the result. All the other drivers must be at a satisfactory level before the LPI can also reach, and maintain, a satisfactory level. In this sense, therefore, the LPI is the most important driver in terms of the overall state and efficiency of the Cell.
while, simultaneously, being the least important in terms of actual Production Management since it is merely a measure derived from the direct measurement of all the other values. The PM also offered the point that only through the improvement of the direct, long-term variables (the other drivers) will long-term LPI improvement be achieved. This explains the apparent, but in reality non-existent, discrepancy between the results of the second discussion with the PM and the results of the Questionnaire.

The position of the Cell Audit Value reflected the PM’s opinion that this measure gave a strong and accurate indication of how well the Cell is managed in general terms as well as in terms of the specific categories covered in the Audit itself.

On the question of goal congruence between the PM and his Cell Leaders the PM stated that he believed that the Cell Leaders understood his priorities in terms of the drivers and re-affirmed that the LPI is the most regular topic of conversation between himself and the Cell Leaders. When questioned about the degree of response from his Cell Leaders when he asks them to concentrate on a particular driver the PM suggested that the actual level of resultant activity was very low. The possible reasons for this were:

(i) Ignorance of Cause and Effect relationships between drivers.
(ii) Defensiveness (including attachment to entrenched and outmoded attitudes and management style).
(iii) Lack of interest in, or fear of, change.

The PM was also questioned about the pressures on him from above (the Production Director) in an attempt to clarify the behaviour of driver identification and ranking between the levels. The PM stated that the following covered the majority of work-related conversation topics between
himself and his direct superior:

(i) Production problems (if any).
(ii) LPI (if it falls below the expected or acceptable level and/or periodically).
(iii) Production vs. Forecast (regularly).
(iv) Effective and efficient use of machinery and plant (the Managing Director takes a direct interest on occasion).
(v) Satisfaction of Customer delivery requirements.
(vi) Any major quality problems.

This concludes the determination of drivers and the effects on the behaviour of the Production Manager. In addition it provides a start point for the investigation of driver interaction, behavioural consequences and goal congruence from the viewpoint of the Production Director and Cell Leaders.

(6.2.4) Cell Leader Viewpoint.

In order to determine the opinions of Cell Leaders in relation to driver ranking, the use of information received and congruence between their own and the Production Manager's views a Questionnaire was devised which covered these points. The Questionnaire provided the framework for structured interviews which were completed with each Cell Leader in turn. An example of the Questionnaire is seen overleaf.
Figure 6: Cell Leader Questionnaire.

1. From this list of measures of Cell Performance choose the one which you consider to be the most important:

   (a) Reject Levels
   (b) Production vs. Forecast
   (c) PI
   (d) Absenteeism
   (e) Cell Audit Value

   Is this always the case?

2. Look again at this list and decide, on a scale of one to five, how important you think each one is and how important you think each one is to you and your superior.

<table>
<thead>
<tr>
<th>IMPORTANCE TO YOU</th>
<th>IMPORTANCE TO YOUR SUPERIOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Reject Levels</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Prodn. vs. Forecast</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>PI</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Absenteeism</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Cell Audit Value</td>
<td></td>
</tr>
</tbody>
</table>

3. Are there any other measures which you think are important?
4. Is there any information which you do not receive which you would find useful?

5. Is there any information which you receive which you do not consider to be important?

6. Here is the list of measures again. Please indicate which ones you consider to be short term measures and which are long term measures?

   (a) Reject Levels
   (b) Production vs. Forecast
   (c) PI
   (d) Absenteeism
   (e) Cell Audit Value

7. Could the information which you receive be communicated to you in a more effective or useful way?
In all six Cell Leaders were questioned, the Cells run by the respondents are all seat cells, as detailed in Section (4.4). The main results were as follows:

(1) The LPI was considered to be the most important single measure of Cell Performance by four of the respondents. One chose Production vs. Forecast and one chose Reject Levels. The list of drivers, previously identified through questioning the Production Manager, was confirmed by all the Cell Leaders to be complete.

(2) There appeared to be a high degree of congruence between Cell Leaders importance rating for each of the drivers and those which they perceive the Production Manager to have.

(3) All but one of the Cell Leaders gave the vast majority of drivers scores of four or five out of five for importance to both themselves and the Production Manager. The exception was Absenteeism for the PM which was allocated two by one Cell Leader and, in the same category, Cell Rejects to which another Cell Leader allocated three. In both instances their own rating was one point higher.

(4) Other measures suggested for inclusion in a list of drivers were:

- Individual Operator Performance (1 respondent)
- Scrap Levels (1 respondent)
Rework Levels (1 respondent)

Details of Tooling, Plant and Material Problems

(3 Respondents)

(Of the above information only Scrap Levels are currently reported in a formal way and these are total weights for the Cell and do not relate to the stage of production).

(5) Information relating to the points in (4) was identified as being useful information which, currently, is unavailable.

(6) On the question of information received which is not useful to Cell Leaders the following were identified:

(a) Paint Plant Rejections (5 respondents)
(b) Cell Statistics (2 respondents)

(7) On the question of identifying each driver as being long or short term, no pattern or common set of responses emerged.

(8) Communication of information within the company was found to be lacking generally. In particular between all support functions and departments and Cell Leaders. Three respondents suggested that Team Briefings would be more effective than the current multitude of memorandums.

N.B. Monthly Team Briefings were introduced into the Company eight months after the completion of this Questionnaire.
Because the Questionnaire, in effect, provided a framework for a structured interview which progressed into a general discussion once the major points had been satisfied. Further detail relating to the Cell Leader's perception of the performance measurement system also came to light through feedback and elaboration of the responses given:

The LPI value from the previous day is almost always discussed by the PM and the Cell Leader if it is below an acceptable value. If the LPI value is acceptable, or improved, then it is very rarely discussed.

The LPI is considered to be the main concern of the Production Manager and if the LPI is acceptable then no, or very little, attention is paid to other drivers. The exception here is where the Production vs. Forecast figure is poor and there is a risk of this affecting the customer. In this case satisfying customer demand becomes the prime objective. From the Cell Leader's point of view the first objective on any day is to satisfy the Production Call for that day, once this is achieved then maximisation of the LPI becomes a priority. The movement of labour or increased output of certain products, or both, helps to facilitate this.

An interesting feature of the Production Volume / LPI relationship is that if the Call is increased and overtime is increased to match this then the average LPI almost always increases when, in fact, it should remain unaffected by volume changes and only alter when the ratio of items produced to hours worked alters. It is generally felt that only through overtime, which is usually only sanctioned to increase production, can production downtime, of various sorts, be compensated for. In this way overtime may be used to hide inefficiencies within the system and also to guard against 'inevitable' future problems. This relationship has a cyclical feel about it where inefficient use of material, plant and labour leads to inefficient use of labour to compensate and so results in further sub-optimal
behaviour, and so on.

A final point to come across was the frustration which Cell Leaders feel when held accountable for factors which, while effecting the efficiency of the Cell, are out of their control. Examples of such factors are tooling, design and supplies problems.

This concludes the Summary of Cell Leader perceptions of the Performance Measurement System. The next section of the workforce to be questioned was the Production Operative.

(6.2.6) Production Operative Viewpoint.

In order to gauge the feelings of the shop-floor regarding Performance Measurement a direct approach was taken with the researcher talking to Operatives at their place of work. A cross section of Operatives was questioned, in all approximately 20% of the Slide Cell employees (equating to 50 people).

The views of Production Operatives regarding the system are much less intricate and various than those of the Cell Leaders or the Production Manager. The points raised are summarised as follows;

(i) The Bonus value (i.e. pounds and pence) is the prime concern of the Production Operative. The LPI Value from which it is derived is of secondary interest to most.

(ii) Many consider the Bonus System to be unfair in the following ways;

   (i) Major plant or production problems,
which are out of their control often
cause their Bonus to fall.

(ii) The Start point allocated to certain
Cells is felt to be too low so enabling
the employees of that Cell to attain
high bonus payments with comparatively
little effort.

(iii) The Bonus System fails to recognise the
achievements of individuals and often
poor performance by peers nullifies any
effort or achievement made by individuals.

Not one of the respondents was able to offer a suggestion for a practical
major modification to the current Bonus System which would help to nullify
any of the faults identified above.

N.B. As part of the 1995 Pay Claim the GMBATU has published, as its
main priority, the abolition of the current Bonus System in response
to its members views within the Company, no alternative is
suggested.
In reply the Management has undertaken to discuss possible
alternatives to the current system.

(6.2.7) Production Director Viewpoint.

Through two separate semi-structured interviews with the Production
Director (PD) the researcher was able to gain an appreciation of the PD's
views on the Performance Measurement System as well as the characteristics
of any broader, strategic considerations which may, or may not, impinge on
the behaviour and activity of the Production Manager and Cell Leaders.
He agreed in broad terms with the list of drivers and their ranking as described by the Production Manager and confirmed (although with different interpretation) by the Cell Leaders. In addition the PD offered some additional comments from his viewpoint. A summary of these views is as follows:

(i) There is no formal Mission Statement or Strategy of any sort, except for long term Marketing and Sales Strategies.

(ii) There is no non-financial strategy.

(iii) The attainment of goals laid out in the Yearly Profit Plan in the prime objective at Board level.

(iv) There are no non-financial goals laid out to achieve the Financial Strategy.

(v) All the information generated on the shop-floor and fed back through the hierarchy is geared towards feeding the Management Accounting System and that of BTR.

(vi) Only financial objectives, whether explicit or implicit, have any real effect on shop-floor activity.

(vii) Within his scope of responsibility the PD sees his prime concerns as being:

(a) Increase Productivity.

(b) Reduce Material Costs.

He sees the improvement of Profit (the bottom line figure) as being implicit in these.
The filtering down of Financial Objectives to the shop-floor with no conversion into non-financial objectives stifles Kaizen and the advancement of the company Culture.

The overall Strategic Objective of the company is to lead by design and to be a leader rather than a follower. Capital investment in the plant and machinery required to facilitate the efficient production of new designs is also seen as paramount.

The PD recognises that there is a need for change but offered no specific suggestions.

The PD confirmed that the current Bonus system has a life but whether it's ultimate replacement will involve monetary motivation is not clear.

The PD believes that the Cell Audit Value is of little relevance since it merely measures procedural correctness and does not relate directly to the quality of the assemblies produced.

It is possible for a Cell to have a high LPI but also have a totally unsatisfied customer.

There is pressure on the Production function at each month end to increase the sales figures for each Cell in order to improve the 'bottom line' for that month.

The speed of a Cell's response to a problem and its arrival at a
solution is thought to be a vital measure of performance which is not easy to quantify.

This concludes the summary of the behavioural and attitudinal features of the Performance Measurement System relating to the five identified drivers through the four levels of the Production Function hierarchy and across the Cell Leader level. The final part of the information gathering was concerned with the collection, collation and plotting of historical data which could then be used to test the assumptions and perceptions of the Production Director, Production Manager, Cell Leaders and Operators.

(6.3) Collection, Collation and Plotting of Historical Data.

In accordance with the agreed list of Cell drivers the following measures were recorded, weekly, for all five Slide Cells studied over a period of forty weeks;

(i) Cell Reject Levels (as a percentage of Total Production).

(ii) LPI (percentage).

(iii) Production vs. Forecast Sales (percentage success).

(iv) Production vs. Forecast Volume (percentage success).

(v) Cell Absenteeism (percentage hours).

(vi) Cell Audit Value (percentage).

The division of the Production vs. Forecast into separate Sales and Volume categories was a reflection of the Production Manager's stated reference to them in this way and suggested direct correlation between the two. By converting all measures to percentages which were not already in
this form allowed for all data to be plotted easily on one graph with Measurement Percentage along the y-axis and Week Number along the x-axis. Also direct comparison of any causal relationships and correlations would be facilitated in this way. The information required to plot the graphs was extracted from the reports and information sources used by the Production Director, Production Manager and Cell Leaders so as to ensure a common representation of the data.

After a period of twenty weeks five graphs were produced, one for each Cell, of Measurement Percentages against Week Number (Figures B1, B37, B55 and B68. These graphs were studied in order to identify any correlation between any of the driver values for each week, especially those suggested by the Production Manager and Cell Leaders. The results of this initial examination were unclear and inconclusive. Consequently x,y Scatter Graphs were produced for each Cell with a graph of every combination of drivers plotted one against the other to test for straight line correlation and therefore test directly the assumptions of the Production Manager and Cell Leaders.

After forty weeks the above exercise was repeated for each Cell (Appendix B). On this occasion the scatter graphs were, statistically speaking, twice as dependable as the twenty week graphs and therefore the forty week graphs were selected for further analysis. This analysis involved two stages:

(i) Visual appraisal of the graphs and any obvious correlation between driver variables.

(ii) The calculation of the Correlation Coefficient for every two variable combination for each Cell (fifteen combinations per Cell). The Pearson Calculation was employed here assuming the conventional 0.05 Significance Level. The Pearson Calculation was chosen for the following reasons:
Pearsons r is based on actual scores or data values whereas Spearman's rho (the other main correlation coefficient employed in statistical analysis) is based on rankings and such a method was not suitable in this case.

Pearsons r, while being more laborious to compute than Spearman's rho, does form the basis for a number of more sophisticated techniques. Such a facility would enable easy access to further statistical analysis should the subsequent research require it.

The 5% Significance Level was assumed in order to reduce as far as possible the possibility of making either a Type 1 Error (concluding a relationship between variables where there is none) or a Type 2 Error (concluding no relationship when, in fact, there is one). This level is assumed for all subsequent calculations.

(6.4) Analysis of Historical Data.

Cell Leaders were shown the Measurement Percentage vs. Week Number graphs for their Cells over the forty week period and asked for any comments on the results. These graphs are shown on the following five pages (Figures 7 - 11 inclusive). Few could offer explanations for individual peaks and troughs in the various driver categories but all could give broad reasons and causes for these and continued problems. These varied from Cell to Cell and are summarised below.

(i) Universal Cell: Various problems, most notably Tooling Repairs and sub-standard performance and problems associated with the design of parts.
(ii) **P 700:** Mainly Tooling problems, labour shortages and problems with the main Power Press which also serves other Cells.

(iii) **Saab 9000/Volvo 400:**
Mainly Tooling problems and downtime of Welding Robots which are the bottleneck of the Cell. (Keeps detailed records of downtime).

(iv) **R 17:** Any problems from Absenteeism to Tooling to Plant downtime severely effects the values for this Cell since it is comparatively very small having only six employees. (Universal, the largest, has approximately one hundred).

(v) **Nissan 906:** About 95% of the problems on this Cell are due to Plant and Machinery problems. The other 5% being split between Operator Error and others.
Figure 8: Measurement Percentage for all Measures for the Volvo 700 Cell for Weeks 1 to 40 inclusive.
Figure 9: Measurement Percentage for all Measures for the Saab 9000 / Volvo 400 Cell for Weeks 1 to 40 Inclusive.
Figure 10: Measurement Percentage for all Measures for the Rover 800 Cell for Weeks 1 to 40 inclusive.
Of greater significance to the research objectives, however, were the Correlation Coefficient values obtained for the data. The values fell into two distinct groups:

<table>
<thead>
<tr>
<th>GROUP 1</th>
<th>GROUP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficients &gt; 0.5</td>
<td>Coefficients &lt; 0.09</td>
</tr>
<tr>
<td>All sets of Production vs. of Forecast Sales</td>
<td>All other combinations of driver for all Cells</td>
</tr>
<tr>
<td>against Production vs. Forecast Volume.</td>
<td></td>
</tr>
</tbody>
</table>

Where a Coefficient \((r)\) of 1 indicates perfect Correlation between variables, a Coefficient of 0 indicates a totally random relationship and the value of \(r\) required to demonstrate correlation is 0.31.

Due to the fact that the two groups are so far apart in terms of correlation and that it can be legitimately assumed that additional data would not only lead to further entrenchment of this position but may also strengthen it and taking into account the additional variables in the form of production problems etc., whose effect becomes statistically less significant over time, the following conclusion may be drawn:

There is no significant correlation (positive or negative) existing between any of the identified Cell drivers with the exception of the Production vs. Forecast Sales Percentage Success and the Production vs. Forecast Volume Percentage Success for the five Slide Cells for the forty weeks from Week 1 to Week 40 inclusive, 1993.
Bearing in mind the close relationship between Volume and Sales the correlation which does occur is not unforeseen. An important to note is that the high correlation between these two measures does not prove in itself that changes in one variable cause changes in the second variable. In this case, however, by looking beyond the data to the circumstances surrounding it, it can be clearly seen that there is a very strong likelihood that this is the case. Conversely, the lack of any significant correlation in any of the other relationships does not prove that there is no relationship in these cases, only that the degree of linearity of the relationships is statistically insignificant and in those terms a relationship is unlikely given the confidence interval selected.

A repeat of the Correlation Coefficient calculations using a confidence interval of 0.1, for example, may have produced values of \( r \) closer to a level of significance. However, Group 2 had values of \( r \) so low and so far from the level required for significance (0.31) that a repeat of the test using a confidence interval of 10% (value of \( r \) for significance = 0.26) would have yielded the same conclusion. On this basis it is also demonstrated that neither Type 1 nor Type 2 Errors are present.

Therefore, to continue; the total lack of correlation between any of the other drivers contradicts some of the central assumptions made by the Production Manager and the Cell Leaders. In contrast to the diverse reasons behind the fluctuations within the various measures and across cells, the statistical analysis provides a unifying picture of the interactions between measures. This, therefore, obviates any requirement at this stage for direct consideration of factors such as cell size, peculiar or specific production problems, order levels etc. when testing the assumptions of the respondents with reference to the historical data. However, such factors do impinge on the behaviour of all respondents and it
is the nature of this response to supplementary factors (qualitative and quantitative) which determines the behaviour of the respondents and which, it can be argued, is shaped by the nature and makeup of the performance measurement system. Therefore, the behavioural consequences of the performance measurement system are represented, firstly, as any mismatch between perceived reality (human response) and actual reality (historical data), and secondly, as any differences in the understanding or interpretation of individual measures and the way in which they interact between and across the various levels of the production management hierarchy.

(7) Comparison of Perceived Driver Relationship Interaction and Historical Data over Forty Weeks.

The following is a summary of the findings of Stage I of the Research programme.

(7.1) Production Manager: Perceptions vs. Reality.

(a) In direct contrast to the beliefs of the Production Manager there is no direct correlation (positive relationship in this case) between the Cell Audit Value, Cell LPI Value and Production vs. Forecast Percentage Success for any Cell.

(b) There is no relationship between the Cell Audit Value and the level of Cell Rejects.

(c) There is frequent under and over production by every Cell according to the Production vs. Forecast figures which, in some cases fluctuate wildly in comparison to forecast. However, the continual
modification of production requirements in order to match customer requirements compared to the long-range, inflexible nature of the Production against Forecast report should be borne in mind when considering this result.

(d) There is no correlation between the two drivers identified as being the most important measures of Cell Performance: Cell LPI and the Production vs. Forecast Sales/Volume as was suggested by the Production Manager.

(e) Cell Leaders concentrate on the LPI in the belief that satisfaction of this, derived, measure is the ultimate goal and not, as the Production Manager believes, merely a measure of the state of all the other drivers operating within the Cell.

(f) The view of the Production Manager that the Cell Audit Value gives a good indication of the general performance of the Cell is the opposite of that held by the Production Director.

(7.2) Cell Leaders: Perceptions vs. Reality.

(a) A general misunderstanding of the LPI System believing that this is the ultimate measure by which their Cell, and their own ability to manage it effectively, is judged. This arises from the high degree of attention paid to it.

(b) Short term views held about the way in which performance is judged. Cell Leaders tend to work within a time frame of no more than two or three days. Time spent engaged in fire-fighting makes a
longer term view impractical with its benefits, though recognised, taking second place behind the short termism of the LPI System and the daily Production Call.

(c) Cell Leaders, like the Production Manager, believe that the drivers relate directly to one another and that there is correlation between some or all of them. This opinion is based on their experience of the system.

Cell Leaders, on the whole, understand well the views and priorities of the Production Manager, with the exception of the LPI System, see (a). Therefore, while the degree of goal congruence is relatively high in this sense, there is a significant mismatch in the understanding of the LPI System, which is the keystone of the current Performance Measurement System. This comes as a direct result of the apparently blinkered attention paid to the daily LPI Value and the myopic behaviour that this invokes. The attention paid to the LPI begins, or is continued, by the Production Director and this influences the behaviour of the Production Manager. This situation illustrates clearly that 'what you measure is what you get' and it can be argued that in order to change the way that people work one of the, if not the, surest way to achieve this is by manipulating the way that people are measured.

(7.3) Production Director: Perceptions vs. Reality.

Like the Production Manager, the Production Director recognises the need for change in the Performance Measurement System. He recognises that the current system encourages a myopic outlook and that the efforts with Kaizen to date have only begun to scratch the surface in terms of what it is actually possible to achieve. The lack of a clear solution or alternative
system prevents its replacement at the time of interview. It is unclear whether he believes there to be strong correlations between the Cell Drivers in the same way that the Production Manager and Cell Leaders do but he does recognise the strong influence that the LPI System has on the behaviour of those involved with Production Management at all levels. 

A particular mismatch of opinion regarding the Cell Audit exists where the Production Director regards it as virtually meaningless in terms of cell systems and control, the Production Manager regards it as being extremely meaningful and the Cell Leaders regard it with comparative indifference. In this case focus on the measure on the part of the Production Manager is clearly not translated into focus and action on the part of Cell Leaders except where direct and specific instructions are issued by the Production Manager. The reason for this is not clear although one possible explanation is that the day to day priorities of the Cell Leaders lie elsewhere and pressures of production do not allow for the consideration of longer term improvement requirements. This is supported through the results of the Cell Leader Questionnaire.
Summary of Stage I - Review of Initial Objectives.

In order summarise Stage I reference is made to the outline Aims of the Research as defined in Section 3:

(i) To examine and analyse the Performance Measurement System at Dunlop Cox Ltd. as it impinges on the Production function.

This, being the principal objective, is further defined by subsequent objectives and it's satisfaction being a measure of the satisfaction of the sum objectives of Stage I.

(ii) To identify the Production and Performance Drivers acting on the shop floor and any differences in the stated identity of these between individual actors at various levels.

This objective has clearly been met with the definition of the five main Performance Drivers and their ranking. In addition the goal congruence vertically through the Production function and horizontally has been shown to be high with universal acceptance of the findings although with differing interpretations. (Sections 6.2.3 and 6.2.4).

(iii) To examine relationships that exist between these Drivers as perceived at each level of the Production function hierarchy.

This objective has been satisfied through careful and rigorous analysis of Director, Manager and Cell Leader attitudes to and opinions about the performance measures in place and the system which
they constitute. The principal variations in opinion, the reasons behind these and the behavioural consequences which they invoke have been defined and described. (Sections 6.2.3/4/5/7).

(iv) To examine the actual measure of the Drivers over time and to identify the degree of mis-match between perceived and actual Driver inter-relationships.

This objective has been met through the thorough statistical analysis of historical data relating to the identified Drivers. Data from five cells over forty weeks has revealed a fundamental mis-match between the extent and nature of actual Driver interactions and those assumed at every hierarchical level (except for Production Operators where no such evaluation was possible). Satisfaction of this objective has also provided a reliable set of characteristics which may be realistically assumed to hold for those Slide Cells not included in Stage I (i.e. Nissan 909 and Saab 900) and which can also be used as a comparison with the results of any novel measure and/or system introductions during Stage II. (Section 6.4).

(v) To examine the degree of any mismatch in perceived Driver inter-relationships between various levels of the function hierarchy.

Satisfied as part of the outcome of previous objectives, see (iv).

(vi) To draw on the results of the above and use this as a basis for the development of alternative measures and/or systems which
will benefit the Company, the Production function and the Shop Floor.

As stated in the original objectives the above assumes that there are sub optimal elements or characteristics of the existing system. Clearly, the answers to other objectives indicate that there are a number of shortfalls in the existing system and the behavioural consequences which these have. Central to these are the following;

- **Difference in understanding of the role of the prime performance measure**, the Labour Performance Indicator, between management and the shop floor which in turn results in the adoption of a very short term view on the part of Cell Leaders in particular.

- **A lack of significant correlation between the majority of the main drivers**. This is at odds with the perceptions and opinions of all respondents from all levels. This indicates a system which is poorly understood, misleading and made up of measures which are largely unrelated and do not reflect a coherent manufacturing strategy.

- **A set of measures which are considered to be of limited relevance to the shop floor and which are dominated by the productivity measurement**.

- **The productivity measure encourages a myopic approach to shop floor management and control with the effect that longer term improvement activities are paid lip service only. The current system in no way drives change and the kaizen philosophy which the Company has stated it wishes to adopt in order to become a World**
Class supplier is stifled as a result.

- The current system is considered to be unfair by Production Operators who feel no sense of ownership of it and whose prime incentive is the weekly Bonus. There appears to be widespread appreciation of the longer term view and the aims of kaizen on the shop floor but no incentive to adopt the philosophy.

The Stage I results provide a picture of the existing Performance Measurement System in place at Dunlop Cox Ltd. They also provide evidence for the argument that fundamental changes are required if the company is to be proactively driven towards becoming a World Class supplier.

The next section presents, through a focused, second, literature survey the argument for change and, through this, provides an indication as to the most beneficial route. This is followed by a statement of Hypotheses which will be tested through the research content of Stage II.

In his book 'Total Quality Management' (1991) [18] John Oakland suggests that a production process (or any process) may be likened to what he calls, a 'Quality Chain'. The inferences are obvious. Each stage in the process is inescapably linked to the previous and the next. That there exists a series of customer/supplier relationships throughout the process and the quality of the final product is only as good as the weakest link in the 'chain'.

The difference between whether a company prospers or fails is increasingly dependent on the degree to which it does, or does not, satisfy the needs of it's existing and potential customers. The closest that any manufacturing organisation gets to its customer has to be where the internal customer/supplier relationship changes to the internal supplier/external customer relationship. This happens at the sharp end, on the shop floor. Every part of the organisation constitutes a 'link' in the chain and yet it is often on the production line or the cell where the difference between satisfying the ultimate customer, or not, is decided. It has already been recognised that for a company to set out along the route to becoming truly World Class it must first recognise that its success depends upon its manufacturing capability and on the recognition that manufacturing is, and should be used as, a competitive weapon [23].

Bearing this in mind it may be argued that the nature of Performance Measurement as it relates to and impinges on the shop floor is of vital importance to the academic or industrialist. With the increasing popularity of Just In Time manufacture suppliers are increasingly close to the customer in a number of respects and nowhere is closer to the customer than the production cell. The importance of sensitivity to customer requirements is seen as the 'overriding business pressure' of the 1990's [81] with some
advocating the development of business systems which are truly customer driven and requiring fundamental cultural change [82]. The central role of the customer is also represented in frameworks for performance measurement review. The Nolan Norton framework [83], for example, stresses that the starting point in improving a business is understanding how the customer views performance. Also recommended is the use of benchmarking with regard to World Class competitors. To ensure objectivity, the framework also recommends the use of third parties to actually collect the data and measure performance at the customer level [84]. As has been pointed out [85] the responsibility for customer care is too often vested in a single part of an organisation and is reflected in the performance standards only of that part of the organisation. Frequently it is marketing or sales. Such an approach fails to understand the full impact of customers on a business as a whole and on manufacturing in particular. This is especially damaging in situations, such as JIT supply, where the consequence of shortened lead times and much reduced supplier/customer buffer stock is that the responsibility for supplying the customer with what he wants when he wants it on a day by day or hour by hour basis has been pushed further and further down until, now, the individual production Operator has previously unimaginable responsibility in the World Class company. In the case of Nissan, for example, the assembly worker has total responsibility for the quality of the work he produces [86]. Canon of Japan has also progressed through allowing employees the authority to set goals and plan their own improvement activities (albeit within the constraints of the improvement targets at their 'level') [87]. This proviso of personal responsibility within a rigid control system is common to most versions of the 'Japanese philosophy' including the Toyota production system [88]. The widespread use of kaizen techniques by World Class companies has reportedly revolutionised the operation of many companies in the West
especially in the case of JIT suppliers [90,91], although definitive quantitative evidence of the attitudinal, behavioural and production related benefits of kaizen and quality circle participation has not been established to date [92].

Despite these changes accounting systems, management systems and performance measurement systems have remained unchanged and currently provide little or no assistance in managerial decision making [50,93] this is exactly the situation at Dunlop Cox Ltd.

For this reason Performance Measurement Systems on the shop floor which drive the business forwards towards the needs of its customers and the needs of the business are vitally important for both Dunlop Cox and other companies like it. The particular importance of JIT in the design of relevant Performance Measurement Systems has been the subject of attention for some time [65] and work continues to build the JIT philosophy into new frameworks. The Strategic work and that relating to Goal Congruence has, in many respects, established some cornerstones in Performance Measurement Research. The recognition that Management Accounting has to become more relevant to the needs of the business and must be driven by the Performance Measurement System and not the other way around has begun to pay dividends.

However, each piece of research to date contains the underlying assumption that formal implementation of a new performance measurement system is required, i.e. top down. There has been the suggestion that it may be more appropriate for the system to evolve naturally as the JIT operation expands [65], but this still assumes an imposed system. Some researchers [94] have advocated the use of managerial project teams which should;

(a) Identify and define the key performance criteria.
(b) Provide a focus for discussion of the new performance
measurement environment.

(c) Co-ordinate the implementation process.

(d) Provide any necessary education for affected managers.

(e) Support the initial stages of data collection for new measurements.

While such an approach may produce a more balanced and robust system of performance measurement there is one vital ingredient missing which is missing from all other performance measurement research - employee involvement.

It is now well established that employee involvement is an integral part of the way ahead for business [9,10,15,17,18,59,65,86,87,88,95] indeed the very culture of World Class companies is based around this concept. It seems only logical, then, that the design, development and operation of a new performance measurement system should not be inflicted on employees but rather carried out and truly 'owned' by them. The recent history of worker participation has been fraught with difficulties, especially in the U.K. [96]. Problems of demarcation and the caution of the shop floor in becoming involved with 'managerial' tasks of measurement and improvement planning has meant that only during the last ten years or so has real progress in terms of autonomy and teamwork have been achieved. It should be noted that autonomy is not what is experienced by Japanese workers in Japan, they have responsibility but no authority. Hoerr (1989) cites Haruo Shimada, an economics professor at Keio University in Tokyo, pointing out that in Japan;

'the team concept is not intended to increase workers' autonomy but to help them find out the problems in the production line so that no defective goods will be produced. In the US, workers tend to take participation as having a voice in all kinds of things that in
Japan are determined by management and engineers." [97]

In the West the use of techniques of the 80s' and early 90's such as Job Enrichment, Job Enlargement, Autonomous Work Groups etc. [98] have given way to the concept of Self Managing Teamwork [99] which advocates the almost total empowerment of work teams within manufacturing and service industry. Examples of such practice, however, are few and more research data is available on, the sometimes problematic, transplants of Japanese systems for continuous improvement into the West. The use of Nissan-type 'Green Areas' is one example where the attempted imposition of a culture change into a traditional heavy manufacturing company resulted in some initial disagreements with the Unions and considerable damage to the reputation of the concept within the company [100]. If introduced sensitively, however, Japanese style management systems of continual improvement and associated shop floor performance measures can be introduced with greater success [101]. What appears to be a central factor, therefore, in the success of such initiatives is the acceptance and ownership of the new measures at each level [102]. Only through the central involvement of those to be measured in the choice of measures and design and running of the measurement system will such ownership be developed and fundamental improvements and change be proactively driven.

For the shop floor the decades of being judged almost solely in terms of productivity have left their mark. The errors inherent in such practices are well known and yet their eradication promises to be infinitely more difficult than their definition. What is required in many cases, and at Dunlop Cox in particular, is not simply system or management change, but culture change. While almost every aspect of a World Class company involves employee empowerment the critical factor of Performance Measurement and its potential role in culture change seems to be exempt. Part of the reason for
this may be that moving from strategy to practice is seemingly much easier without employee involvement (Schuster et al., 1992). However, as Schuster [95] also points out, the success of the effort is greatly enhanced as a result of high quality employee involvement that matches the readiness of the organisation to make employee involvement work (or the organisation's willingness to change to a high involvement culture). The benefits of participative development of performance measures promises a far greater degree of understanding of the measures employed as well as a far better chance of meeting the agreed objectives [18]. Furthermore, only through the communication, participation and ownership discussed above can real, bottom-up, culture change be developed [103]. The task of culture change is a difficult and long term task if it is carried out correctly and very often direct confrontation with the entrenched values of the organisation will be necessary [104]. However, attacking the existing culture is not enough in itself. Indeed, deriding the behaviour patterns of subordinates while offering no alternative will result only in an entrenchment of traditional values and increased reticence. The facilitator of the culture change must offer an alternative way of operating in which the subordinates are empowered to meet and exceed the requirements of their customers [105].

The way to culture change, therefore, is a combination of clear strategy from the top and fundamental commitment to change from the bottom. In order to ensure that the shop floor is operating according to the strategy it is necessary to measure performance in terms of the key performance criteria defined by that strategy. The commitment to the measures and, therefore, the strategy comes through ownership of the measures employed.

The final part of this literature survey will briefly cover the use of goal setting and its behavioural consequences in terms of motivation and performance on the shop floor.
Research interest in the potential of Goal Setting for increasing motivation and performance has a long history. In 1974 Latham and Kinne carried out a study of pulp-wood logging operations in the U.S. where the performance of teams of men who had no performance goals communicated to them was compared with that of men who were made aware of a number of productivity targets, they state:

'The results indicated that producers who supervise their employees and set production goals have higher productivity than producers who supervise their men but do not set production goals.'

The study also found, however, that supervision was required in order that the men accept the goals assigned to them. On the question of feedback of performance the possible confounding effects of goal feedback with goal setting were considered minimal, since previous research had shown that knowledge of score alone does not lead to higher performance unless it is used to set goals. More recent research which suggests that feedback is essential in motivating the team contradicts this more narrow view. Significantly, however Latham and Kinne do conclude:

'Thus, in the process of discussing with the worker the nature of these (productivity) goals, the worker may acquire specific knowledge concerning his job tasks, their priorities, and the most effective methods that lead to their attainment.'

Further research by Latham into the effects of assigned and participative goal setting on performance and job satisfaction found that, while the most important factor in motivating employees was the setting of the goal, further improvements in performance were attained when
the subjects had participated in setting those goals. It was also found that other factors such as the attitude of the supervisor, incentive contingencies and intrinsic motivation from the task itself also played a part in facilitating acceptance of the goals and improved performance.

The motivational components of goal setting continued to be a focus of interest throughout subsequent years with the emphasis gradually shifting from Tayloristic type approaches which advocated the drawing up of rigid 'action plans' for employees to follow in order to attain their goals [109] to greater use of the work of Hertzberg [110] and the job enrichment approach. Umstot et al. (1976) conclude;

'Thus, the overall perspective suggests that job enrichment and goal setting can be combined without creating adverse effects and, in some cases, there may even be beneficial results.' [111]

By the mid eighties much more research had been carried out in the field and Tubbs (1986) was able to make the following conclusions pertinent to the key questions:

- The more difficult the goal set (while remaining achievable) the greater the levels of achievement.
- The more specific the goals the greater the possibility of achieving those goals.
- Participation in goal setting produces greater motivation to succeed and improved performance than where the goals are assigned to the group or individual. However, this point is less clear cut than others and the need for further research is highlighted.
- Feedback of results increases motivation and levels of performance over
similar situations where there is no feedback. Feedback also facilitates improved targeting of task improvement activities.

- The methodological design of research yields more reliable results when based on long term case studies than those based on laboratory experiments. [112]

With the basic advantages of goal setting established research in the late 80's and early 90's has begun to focus on the boundary conditions for the approach in an attempt to discover under what the conditions the approach can be most profitably employed. A significant finding of this research is that the setting of difficult individual goals may result in poorer performance than when a group goal (or even no goal) is set. It is important that, where an individual goal is set, that this goal, through its attainment, facilitates the attainment of the group goal [113]. The finding that team structures are more effective in terms of performance (within a goal-setting situation) is significant because it coincides with the entrenchment of the team approach in other research areas as discussed previously.

The most recent papers relating Goal Setting have developed the concept further in beginning to explore the problems of planning within groups in order to achieve participatively set goals [114]. The conclusions of this work seem to be that, in order to maintain group focus on the overall goals, it is necessary to keep those goals as straight forward and relevant as possible and for constant feedback of performance against those goals to be communicated to the group. The need for further empirical evidence in the area is also highlighted.

Recent research in to the use of Goal Charts for quality improvement has also illustrated the superiority of the group approach and the value of propagating shared values and objectives through the use of clear, specific goals [115]. This work also highlights the problems of using standard
control chart techniques for continuous improvement purposes. The answer proposed is the employment of a kind of 'gap analysis' [116]. usually employed in performance versus goals type analysis, to provide some visualisation of group performance against (in this case standard quality control) goals.

This literature survey has illustrated some gaps in the field of performance measurement research. To summarise;

- The role of performance measures in driving kaizen activities within the JIT manufacturing cell.
- Empirical evidence of the value of participative goal setting within a group situation.
- Empirical evidence of the behavioural and production related benefits of kaizen participation.
- Research into the behavioural consequences of performance measures.

Evidence relating to the use of autonomous groups in general is sparse mainly because it is inherently difficult to demonstrate beyond question that improvements in productivity or other performance measures are directly attributable to a 'soft' or 'woolly' change such as a move to group working or the autonomous adoption of kaizen. As Buchanan (1994) points out, the survival of the autonomous work group as a 'best practice' concept is questionable in the face of;

'a demonstrable lack of rigorous and strong supporting empirical evidence, and the invidious comparisons with Japanese manufacturing methods.' [117]
The evidence in support of the teams selecting their own performance measures and setting the goals against which their performance is to be judged is extremely sparse, mainly due to the threat of subjectivity of the measures so selected. However, as Muckler and Seven (1992) point out:

'The distinction between "objective" and "subjective" measurement is neither meaningful nor useful in human performance studies.' [118]

Therefore, when considering the choice of performance measurements which are 'scientifically valid' one must consider the blinkered approach of totally objective measurement against the fallibility of human subjectivity.

For Dunlop Cox, therefore, as well for Performance Measurement research, the next step has to be further investigation into the possibilities of allowing shop floor employees to develop their own Performance Measurement System against which they can gauge the degree of success of their Kaizen activities. In this way all the reported benefits of participation are realised, and drivers for continual improvement are introduced which do not exist under traditional accounting driven systems. In addition, the closeness of the customer to the JIT shop floor adds a new vitality and rigour to the system which evolves. The requirements of the customer should offer guidelines for goal setting with the whole system possessing the 'Loose-Tight' properties identified by Peters and Waterman [119].

This second literature survey, therefore, has revealed some considerable gaps in the field of performance measurement research and empirical research is certainly required in these (and other) areas. These gaps, combined with the situation of Dunlop Cox, help to define the hypotheses to be tested.
The remainder of the thesis is concerned with Stage II of the research: the continual monitoring of the existing measures, inclusion of a new set of imposed 'World Class' measures and the development of a Cell-based Performance Measurement System. First the Hypotheses to be tested are defined.
STAGE II Research.

(10) Statement of Hypotheses.

In relation to Dunlop Cox Ltd;

(i) The choice of Performance Criteria, setting of Goals and planning and actioning of Kaizen activities, when carried out by Cell operators, yields increased measures of ownership, understanding, relevance and commitment to the System and the improvements driven by it than are achieved under a traditional system or imposed World Class system.

(ii) Under the Cell generated system driver correlations are more defined and interrelationships better understood than under traditional and/or imposed systems.

(iii) The development of a Cell based Performance Measurement System which drives continuous improvement will yield more relevant results in terms of World Class criteria than does the existing system.

(iv) Through Kaizen activities driven by the Cell generated system real increases in Productivity (the basis for traditional systems) can be demonstrated.
Main Hypothesis

Through the utilisation of the knowledge and skills of Cell Operators it is possible to develop a Performance Measurement System with the following attributes:

- Consisting of Performance Criteria with associated goals and time scales which are directly relevant to the Customer of that particular manufacturing cell.

- With the full support and commitment of Cell Operators gained through their pivotal role in the design, management and operation of their system.

- Being essentially proactive and inherently flexible with the provision of a feedback loop for the continual re-evaluation of measures and redesign of the system by Cell Operators.

- Having the capacity to be linked directly to the Business Strategy and thus re-enforcing Goal Congruence.

Having stated the Hypotheses it is next necessary to describe the structure of the research designed to test these.
(11) Structure of Stage II Research.

The results achieved at this stage deal entirely with the existing system at Dunlop Cox. The details, characteristics and behavioural consequences of the system have been clarified to such a degree as to allow the legitimate manipulation of variables, recording of results, analysis of those results and, ultimately, the valid testing of the remaining Hypotheses.

It has been argued that a more appropriate Performance Measurement System would be one designed and run by the Cell employees and used to direct and monitor improvement activities. Therefore, the second stage of the research seeks to expand upon this notion and prove, or disprove, the superiority of the approach over the existing method and its inherent features. In addition a methodology for the implementation and running of a cell generated system is envisaged.

(11.1) Research and Control Groups

For the purpose of the second stage of the research two groups were identified:

(a) Research Group: Nissan 936 (Nissan Primera)

(b) Control Group: Nissan 909 (Nissan Terrano and Ford Maverick)
(11.1.1) Research Group Profile and Purpose.

The Research Group has the following composition:

Number of Members: 7 (5 Male, 2 Female)

Position of Members:
- Operator: 4
- Leading Hand/Operator: 2
- Tool setter: 1

Expertise of Members:
- Assembly only: 1
- Fabrication only: 1
- Presswork only: 2
- Assembly & Fabrication: 3

The members of the Research Group had all been working on the Nissan 936 (N936) Cell for at least six months. Three had been associated with the product for almost three years (since the start of production). Consequently there was a high degree of product knowledge and a high degree of familiarity with the manufacturing processes, although this expertise extended only as far as each Operator's particular work area or areas.

(a) Nissan 936 Cell Layout.

The layout of the Cell can be seen in Figure 12 and clearly is comprised of three areas:

(i) The Press Shop
(ii) Fabrication
(iii) Assembly
Figure 12: Floor Layout of the Nissan 936 Cell within the Universal Cell.

Note: The heavy black lines denote only the approximate boundaries of N936 activity. The majority of power presses employed in N936 are shown except for P302 and P303 which are located on the adjacent N909 Cell. (Figure 13).

Two Scrap bins referred to later in the text are marked 'S' and the Team Kaizen Board, also discussed later, is marked 'KB'.
The following brief description of the Cell relates to its operation prior to the start of the research and prior also, to the resultant Kaizen activities which, in some respects altered the workings of the N936 Cell. These changes will be outlined at a later stage.

(i) **Press Shop**

The Press shop differs from the other two areas in that the equipment here is not dedicated to the production of parts solely for the N936. Rather presswork for a variety of products takes place since the N936 is part of the Universal Cell which also serves five other customers. Therefore labour is moved around the press shop depending upon the requirements for each of the individual products. The presswork itself may be divided into two types;

(i) Blanking then Forming (for inner and outer sections)

(ii) Progression Tooling (for all brackets and triggers)

While there is certain flexibility in terms of which tools can be run in which presses there is some restriction due to the weight requirement of each tool, the feeding and stroking capabilities of individual presses and the clamping arrangements between tool and press. This means that certain items of plant may be identified as being related (though not solely) to N936 production. These are also shown on Figure 12.

Pressed parts generally fall into metal 'B-Pallets' which are then stored at the interface between Press and Fabrication and drawn on when required by Fabrication Operators. A daily stock check of pressed parts takes place and from this a daily Presswork schedule is drawn up by the Cell Leader or his Deputies. Coil steel is drawn directly from the Steel Stores prior to a run and the entire coil is generally run off.
(ii) **Fabrication Area.**

The Fabrication Area is basically divided into two lines. One line is involved with the fabrication of Inboard parts and the other with Outboard parts. The processes involved are those of spot welding, automatic arc welding and spin riveting. Sub-assemblies are produced according to a kanban system operating between Fabrication and Assembly.

Following fabrication all fabricated sub-assemblies are hung on jigs on the Paint Line to be painted. The paint process takes approximately two hours after which parts are decanted back into the wheeled trolleys which were filled in Fabrication and passed into the appropriate siding in the Assembly Area.

(iii) **Assembly Lines.**

The Assembly Area is made up of two C-shaped lines. One line produces Right Hand seats while the other produces Left Hand seats. The assembly process is made up of a sequence of manual operations. The sequence is as follows:

1. **Grease ball track of inner and outer.**
2. **Place inner inside outer.**
3. **Place two steel balls in each end of the slide assembly and dimple the ends of the outer to contain the balls. A Hare Press is used here.**
4. **'Run' the slide to check effort to travel and fit the trigger and trigger spring.**
5. **Fit one inboard and one outboard slide into the final fixture, fit the slide handle, wipe away excess grease, add date stamp and pack.**

The line is generally run with three Operators although one, two or
four are used at times depending on the situation. The most efficient number of Operators is three and the Standard number of completed assemblies per hour is thirty six.

The completed assemblies are packed into dedicated pallets, with each pallet holding twelve assemblies. Slides are delivered to the customer usually once per day according to the customer production schedule which is sent by facsimile every Friday for the following week.

(b) Cell Culture at the start of the Research.

The atmosphere within the Cell at the time that the research began was good with a definite feeling of 'team spirit' within the assembly area especially. The Cell had been performing fairly well although Bonus achievements had been fairly erratic and marginal over the previous few months. There was also a high degree of identification with product and the customer. The relatively close relationship with the customer (who fitted trim to the seats ready for despatch to Nissan, Sunderland) was largely borne out of the JIT relationship between customer and supplier. With a lead time of only a few hours delivery of the correct quantity of assemblies of acceptable quality was of paramount importance. Any quality problem found at the customer usually resulted in direct and immediate contact with the Cell Leader and, through him, Cell Operators. In addition the customer also rated Dunlop Cox against other suppliers in the same group, (a 'group' being a loose collection of companies supplying parts with some vaguely similar characteristics). The principal measures which the customer applied were delivery, service and quality. Delivery and Quality being under the control of the Cell with service relating to administration of orders etc. This relationship meant that the Cell had a good appreciation of the requirements of the customer.
A detailed analysis of employee attitudes is found in Section 12.1.

(c) Purpose of the Research Group

The purpose of the Research Group was as follows:

- To identify and develop, through a team approach, a set of Performance Criteria based on the needs of their Customer and the needs of the Cell. These Measures having goals and time scales associated with them.

- To record data relating to these measures and use this information to plan and control Kaizen activities.

- To constantly monitor the Performance Measures selected and modify, as necessary, the goals, time scales and Measures themselves.

- Through Kaizen activities, driven by the Performance Measurement System, to improve the performance of the cell in relation to the selected Measures.

- To test for the method of agreement, i.e. If X, then Y, and, consequently, test the remainder of the Hypotheses in conjunction with the Control Group results.

(d) Choice of Nissan 936 as the Research Group

Up until the time when the research began much of the Kaizen activity across the Universal Cell and throughout the company had dealt with major Cell re-layouts or with technically based problems which were usually worked on by technical staff and the Cell Leader and/or Deputies.

The establishment of major Kanban systems and c-shaped lines, for
example were highly visible projects which often had a high probability of success. Such projects did not require any major cultural change and while substantial benefits had been reaped in the past through such projects there had been no real attempt to maintain the early successes of kaizen activities by tackling more abstract and fundamental problems. Kaizen had been a bolt-on to the existing culture and the ongoing improvement nature of the approach had not been demonstrated. This may be due to the fact that as the individual problems get smaller so they become inherently more difficult to solve and the degree of knowledge within the company regarding the approach had reached a watershed at this point.

In the case of the N936 Cell the Assembly and Fabrication Areas had already been completely re-laid out as c-shaped lines with a kanban system connecting them. In addition the contents of the lines themselves, both on Assembly and Fabrication, had received considerable attention so that, at the time the research started, there was no obvious, large, kaizen project to undertake. The area required some kind of direction in order to plan and carry their improvements forward.

(11.1.2) Control Group Profile and Purpose.

Number of Members: 6 (all male)

Position of Members:  
- Operators: 4
- Leading Hand/Operator: 1
- Tool setter: 1

Expertise of Members:  
- Fabrication: 3
- Presswork: 3
Due to the nature and purpose of the Control Group only a brief description of the Cell and the Group is necessary.

(a) **Nissan 909 Cell Layout.**

The Nissan 909 differs from the Nissan 936 Cell in a few respects. The Cell is divided into two, the Press area and the Fabrication Area. In this case the slides are not assembled as such. The inner section is made of two halves which are spot welded together and contain the trigger and trigger lever. These are packed into one box while the outer sections are packed separately into another box. None of the parts are painted. Painting and final assembly takes place at the customer factory in Spain.

The layout of the Cell is shown in Figure 13 including the two Power Presses used. Plates are used in the forming of the inner section halves which takes place on P301. The halves are then loaded into pallets and left in storage until required by the Fabrication Area. The outer sections are Blanked and Formed on another Cell, the Volvo 700 Cell, and are delivered to the Nissan 909 Cell as and when required. On the N909 Cell a pierce and joggle operation is carried out on Power Press P240 prior to packing.

There are no kanban systems operating on the Cell and stock control is facilitated by physical stock checks which take place every morning.

The dimensional integrity of the finished sub-assemblies is very important since it is not until the parts reach Spain that any problems in Final Assembly are encountered. Consequently an elaborate CADAR Quality Control station is positioned in the Cell for regular use by Cell Members.

The Cell is under the control of the same Cell Leader as the Nissan 936 Cell.
(b) **Cell Culture at the Start of the Research.**

At the start of the research the morale on the Cell was at a fairly low ebb. There had been, over the previous three months, considerable quality problems. Most of these problems originated in the quality of the press tooling in P301 and this led to an erratic supply of parts to the Fabrication Area. As a consequence productivity had also suffered and the Cell had not reached their LPI Start Point and, therefore, not earned any Bonus for some time.

There had been very limited Kaizen activity in the Cell and there appeared to be no easy remedy to the tooling problems, indeed the squareness of the ram on the press had also been called into question. If proved to be wrong altering the ram would involve a considerable amount of work and disruption to the Cell.

The members of the Cell were fairly well acquainted with the product and the production processes although to a lesser extent than those Operators on the N936 Cell.

A detailed analysis of employee attitudes is found in Section 12.1.
Figure 13: Floor Layout of the Nissan 909 Cell.

Note: Only P301 (Inner Form) and P240 (Outer Joggle and Pierce) are used in 909 Presswork.

Outer sections go directly from P240 into a box and Inner sections from P301 to the two spot welders and then into boxes.
(c) **Purpose of the Control Group.**

The purpose of the Control Group was as follows:

- To record the data as that recorded for the Research Group so that this data may analysed and compared to that of the Research Group. (The exception being the Cell Generated Measures which, of course, would not be present within the Control Group).

- To observe changes in productivity and the other imposed measures over time as Kaizen activities proceeded in a more conventional way than on the concurrently running N936 Kaizen Team which formed the Research Group.

- To gauge any changes in employee attitude or moral over the time period of the research.

- To test for the method of difference, i.e. if not-X, then not-Y, and, therefore, test the remainder of the Hypotheses in conjunction with the Research Group results.

(d) **Choice of the Nissan 909 as the Control Group.**

The N909 Cell had several points in its favour as a choice for a Control Group:

- The Cell was under the control of the same Cell Leader as the N936 who was also the researcher. This meant that close control and observation of the Cell would be possible over the period of the research.
- While the production processes and organisation were different from the N936 Cell in several respects, the issues of quality and delivery were of comparable magnitude and importance. This may have been due to the fact that the ultimate customer for each Cell was the same.

- The number of Group members on the N909 Cell was almost identical to that on the N936 Cell.

- The Group members represented a fair cross section of ability and attitude as did those on the N936 Cell. This was based on the subjective opinion of the Cell Leader.

While the Groups were considered to be comparable in terms of size, makeup, processes etc., there were, of course, differences and this must be taken into account when reviewing the methodology employed and analysing any results.

The next step is to detail the methods of data collection and analysis for both Groups.

(11.2) Data Collection and Analysis.

The methods of data collection employed were different from those employed in Stage I of the research in so far as there were some different sets of data from different sources employed in Stage II.

Below are outlined the measures, information sources and methods of collection and analysis. Only the Research Group's new measures are not covered in detail, this will appear in Section 12.4.
The Research programme dictated that the existing Performance Measures (those analysed during Stage I) continued to be monitored so that direct comparisons and correlation's could be made in order to test the Hypotheses.

During the latter stages of Stage I, however, a new set of performance Measures was introduced by the management of the company. These measures, it was felt, would provide a yardstick against which progress to becoming 'World Class' could be gauged. Some of the measures were identical to some of the drivers identified in Stage I, some were variations on these, and some were new.

A notice board was erected at the front of each Cell for the display of the current data sheet or graph for each measure. Figure 14 below shows one such board. In this case that for the Nissan 909 Cell.

Figure 14: Nissan 909 Team Achievement Board
The following, therefore, is a list of all the measures either imposed by the company or identified as drivers during Stage I which continued to be monitored during Stage II for both the Nissan 936 and Nissan 909 Cells.

(i) **Drivers Identified in Stage I**

LPI (%): Recorded Daily and Weekly

Prodn. vs. Forecast Sales (%): Recorded Daily and Weekly

Prodn. vs. Forecast Volume (%): Recorded Daily and Weekly

Quality Rejects (%): Recorded Weekly

Quality Audit (%): Recorded Monthly

Absence (%): Recorded Daily and Weekly

(ii) **New Imposed Measures** ( * = Same measure occurs in (i))

Productivity (%): Recorded Daily and Weekly

Quality Status (%): Recorded Daily, Weekly and Monthly

(includes Rejects and Audit)

Attendance (%): Recorded Daily and Weekly

Customer Schedule

Achievement (%): Recorded Daily and Weekly
Production Scrap (%): Recorded Daily and Weekly

Safety Cost (pence per hour): Recorded Daily, Weekly and Monthly

Indirect Material Cost (£): Recorded Weekly and Monthly

Four of the New Imposed Measures which are not duplicated in the original driver list are worthy of note:

(i) Customer Schedule Achievement differs from the Production vs. Forecast Percentage Success in that it reflects the customers actual requirements for the week in question rather than the long term forecast produced by the Production Director for the purpose of internal medium/long-term planning. In this sense it is of greater relevance as a performance measure to the Cell, the customer and the Company.

(ii) Production Scrap became a factory-wide target for reduction during Stage I and was driven very strongly by the Managing Director. Production Scrap is the scrap other than that designed into the process by virtue of the positioning of blanks within sheet, strip or coil steel. It thus accounts for all other scrapped material including material used during destructive weld tests.

(iii) Safety Cost was introduced following a report by the Health and Safety Officer which quantified for the first time the cost to the Company of lost time due to work related injury or sickness. Claims against the Company relating to Repetitive Strain Injury
(RSI) and other Upper Limb Disorders (ULD) also prompted further investigation. A formula devised by the Health and Safety Officer which included lost production, ambulance fees etc. was used to calculate an average hourly cost for each Cell each month.

(iv) **Indirect Material Cost** covers the cost of consumable items used by a Cell during any week. Items such as weld tips, grease, hand tools, ceramic welding shrouds etc. were included, but not gloves.

In all cases it was the responsibility of the Cell Leader to ensure that all the graphs and tables on the board for his Cell were updated daily. An example of each of the graphs can be found in Appendix C.

The above measures were, therefore, collected and recorded weekly for both Groups in preparation for later analysis. As in Stage I data was collected and recorded for a period of forty weeks (weeks 40 to 80 inclusive).

Before analysing the data so collected it is necessary to detail the programme which the Research Group followed including examination of the group dynamics, behavioural implications, evolution and development of the new Performance Measurement System and the resultant Kaizen activities.

(12) **Chronological Examination and Analysis of the Research Group**

At the start of Stage II, as the collection of existing and imposed measures began it was necessary to gauge the attitude of shop-floor workers towards the Bonus system, Kaizen and the workings of the Company in general. Information regarding these aspects had been gleaned to some
extent during Stage I. However, much attention had been focused on the roles played by line, middle and upper management in driver identification and interaction and the Performance Measurement System in general with much less analysis of shop floor culture (except for the anecdotal evidence of the Researcher, Section 4.3). At the time such evidence had proved sufficient for the purpose of analysing the behavioural consequences of the existing Performance Measurement System. However, Stage II was to test Hypotheses which related much more to the shop floor and, indeed, to analyse the effects of a new Performance System actually originated, maintained and constructively used by the shop floor for the shop floor.

To this end, then, a Questionnaire was designed to gauge shop floor attitudes and provide an initial benchmark for the start of Stage II. This Questionnaire could be repeated after the Week 40-80 period and any changes or shifts in attitude noted.

(12.1) Initial Attitudinal Cell Questionnaire.

In essence the questions addressed the following points from the point of view of the Operator:

(i) Relative importance of the LPI and the Bonus.
(ii) Perceived relative importance of the LPI and Bonus to the Company.
(iii) Degree of appreciation of what the LPI is actually a measure of and how it is calculated.
(iv) Degree of understanding of how the Bonus payment is calculated from the LPI value.
(v) Measure of desire to understand the whole system better.
(vi) Ideas about other suitable measures of performance which may be important to the Company and/or the Operator and why.
(vii) Opinions on how fluctuations in alternative or additional suggested
measures may effect the LPI value achieved.

(viii) Opinions regarding the types of Performance Measures which may be important to Customers of the Company.

(ix) Degree of 'fairness' of the LPI system and ideas about how it could be altered if required.

(x) Opinions regarding the suitability and relevance of the LPI system in gauging the overall performance of a Cell.

(xi) Perception of degree of commonalty of aims and objectives between the Operators and Cell Supervision (Goal Congruence).

The Questionnaire was issued to all members of the Research and Control Groups as well as 17 Operators selected at random from other areas of the Universal Cell. In all 30 people were approached. This represented 50% of the people working in these areas. After the specified time period had elapsed 24 Questionnaires had been returned - 80% of the sample. Each question is shown below with a percentage of respondents choice of answer or brief summary of opinion as appropriate. Where a summary of opinion is given the Operators own words and phrases are used.

Initial Attitudinal Cell Questionnaire (including Results).

(1) The main Performance Measure in the Company is the LPI.

How important is the LPI of the Cell to you?

(a) Not important at all 0%
(b) Quite important 50%
(c) Very important 50%
(2) From the LPI the Bonus is calculated, how important is the Bonus to you?

(a) Not important at all 0%
(b) Quite important 50%
(c) Very important 50%

(3) How important do you think the Cell LPI is for the Company?

(a) Not important at all 0%
(b) Quite important 50%
(c) Very important 50%

(4) If your answer to (3) is (b) or (c), do you understand why the LPI is important to the Company?

(a) Yes 83%
(b) No 17%

(5) Do you understand how the LPI is calculated?

(a) Not at all 43%
(b) A little 29%
(c) Exactly 29%
(6) If your answer to (5) is (a) or (b), would you like to understand it better?

(a) Yes 100%
(b) No 0%

(7) Do you understand how the Bonus is calculated from the LPI?

(a) Not at all 43%
(b) A little 57%
(c) Exactly 0%

(8) If your answer to (7) is (a) or (b), would you like to understand it better?

(a) Yes 100%
(b) No 0%

(9) The LPI is really a measure of Productivity and Efficiency. Are there any other measures of Performance which you think may be important to the Company? Write down any you can think of.... (For example Quality might be one)

Quality, Delivery Reliability, Attendance, Machine Breakdown, Tool Breakdown, Communication, Continuous Improvement, Planned Maintenance, Training.
(10) Are any of the measures which you have written down of any importance to you?

(a) Yes 100%
(b) No 0%

(11) If your answer to (10) is Yes then write down which are important to you, how important to you and why.

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>HOW IMPORTANT</th>
<th>WHY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Very, Quite, Slightly)</td>
<td></td>
</tr>
</tbody>
</table>

The quality and quantity are important. If the Customer is happy it helps to show that we make a good quality product. It could help in the future with further orders, which in turn keeps us in work. If the quality is good it is easier to produce a good product and makes life easier. Kaizen is very important since there is always a better way to do things and planned maintenance would mean that machines would break down less.

N.B. This answer appears exactly as one respondent wrote it in the Questionnaire.

(12) How do you think the other Performance Measures which you have written down may affect the LPI of the Cell?

Better parts, Less Scrap, Build Faster, Less Breakdowns, Continual Improvement, Less bad work passed on to the
next stage, More P.I., More Money (for me and Company).

(13) What Performance Measures do you think are important to Customers of the Company?

Good Quality, Right Cost, Deliveries on Time, Value for Money, Right amount of Parts, Ability to build more at the drop of a hat.

(14) Do you think that the Bonus Scheme is a fair one?

(a) Yes 0%
(b) No 100%

(15) If your answer to (14) is No, how could it be made fairer?

By making smaller groups, so one group's performance does not affect a completely different group.

Everybody pulling their weight.

By making all the people work.

By splitting the Cell into groups i.e. Press, Fab, Assy.

Too many lazy people walking about with nothing to do for 8 hours, people in Press and Fab taking time - Assemblers rushing.
(16) Do you think that the LPI of the Cell is the best measure of overall Performance of the Cell?

(a) Yes 14%
(b) Not sure 29%
(c) No 57%

(17) If your answer to (16) is No, please explain your answer.

Because with the Cell P.I. it is easy to hide in the system undetected when individual performance is low. If split into teams everyone is involved on one particular job and if one member swings the lead the rest will notice.

Because you can work really hard and still seem to have a low Bonus, the effort does not justify the Bonus. The P.I. does not take into account other things going off on the Cell.

(18) Do you think that the priorities of Cell Leaders are the same as yours as far as the job is concerned or not?

(a) Priorities the same 66%
(b) Priorities different 33%

(19) If your answer to (18) is (b) then please explain why you think there is a difference.

None of the 33% of respondents chose to complete this question.
(12.1.1) Questionnaire Analysis

In answering the Questionnaire the respondents described their understanding of, and feelings about, the existing Performance Measurement System at Dunlop Cox. In addition opinions and understanding of the needs for continuous improvement were also demonstrated. The findings of the Questionnaire may be summarised thus;

- The LPI which the Cell achieves in any given week is either quite or very important to all of the respondents with 50% selecting each. Predictably the Bonus achieved is considered in exactly the same light by all respondents.

- Importance of the LPI to the Company, again, is considered quite important by 50% and very important by the other 50%.

- Despite the opinion that the LPI is of some importance to the Company 17% of respondents did not understand why it is important.

- A distinct lack of understanding of the system again manifested itself with regard to the actual calculation of the LPI where 43% had no understanding at all and 29% had only a vague idea.

- Of those with limited or no understanding of the LPI calculation all expressed a wish to gain a better appreciation.

- Ideas for alternative measures of performance were plentiful and demonstrated a widespread appreciation of the relevance of more fundamental measures which are also easier to grasp conceptually than the LPI because they can be related directly to real, physical, plant
and situations. These suggestions are borne out of the experience of the respondents.

- The depth of understanding of these more fundamental and causal factors is demonstrated by the articulated arguments which several of the respondents put forward. The degree of enthusiasm in answering this question demonstrates not only a good comprehension of the problems which can contribute to a poor LPI, (although the transfer mechanism is not clear to them), but also a high degree of potential in terms of continuous improvement by the respondents.

- Ideas about the measures which are important to the Customer are most eloquently described by respondents from the two Nissan areas and the answers given demonstrate a good grasp of their situation.

- All respondents believe that the Current Bonus scheme is an unfair one. This bears out the findings of the first Operator interviews (Section 4.3.4). A number of reasons for the unrest are sited but most revolve around feelings of unequal effort by Operators and inefficiency of some areas diluting the results of comparative efficiency in others.

N.B. It is widely known that across most Cells the Assembly areas generally perform most efficiently, followed by Fabrication and finally the Press Areas. This is due, to some extent to the decreasing possibility of quality problems as parts move through the Cell. In addition, the youngest, most skilled and motivated Operators are generally employed in the Assembly areas since firstly, the work tends to be more physically demanding than further back through the Cell and, secondly, the emphasis on quality and attention to detail has
historically, and of course erroneously, been firmly on the Assembly and, to a lesser extent, the Fabrication areas. This has been due, of course, to the fact that the detected quality problems have been found in these areas although they did not necessarily originate there. LPI maximisation on a daily basis also focuses on the assembly area since only finished assemblies are counted in the LPI calculation for the day.

- Smaller groups are suggested for the calculation of more specific LPI values. However, a return to an individual LPI system (a previous incarnation) was suggested by no-one. This is significant since it suggests a need for team rather than individual recognition of effort and achievement.

- Over half of the respondents do not believe that the LPI is the best measure of the overall Performance of the Cell while a further 29% are unsure and only 14% think that it is.

- Explanation of the above point is manifested in repetition of the arguments describing the unfair elements of the existing system. No respondent seems able to link the alternative relevant and important measures suggested by so many and the needs of the Customer, which are also well understood, with the need for a change in the current system.

- The degree of perceived Goal Congruence between Cell supervision and Operators appears to be fairly good with 66% believing the priorities of both groups to be the same. However, the unexplained lack of response to the invitation to the remaining 33% to explain a perceived
difference in priorities means that clarification of this issue (i.e. what is the degree of actual Goal Congruence) remains unresolved.

- Other than the greater appreciation of customer needs exhibited by respondents from both the Nissan 936 (Research) and Nissan 909 (Control) Groups no differentiating responses or trends appeared between respondents from different areas or in different positions.

The responses to the questionnaire provide a few useful guidelines in the formation and development of the Research Group. In short, the information gained regarding Operator perceptions and understanding of the current system as well as their views on any replacement, establishes the start point for the Group.

The sometimes hostile feelings which Operators from the Assembly area may feel towards Operators from the Press and, sometimes, Fabrication areas based around accusations of poor workmanship, inattention to detail, passing on faulty parts and poor work rates represent an important feature of the Cell culture and one which must either be resolved before or as the RG is established or which must be resolved as a function of the operation and aims and objectives of the Group. Poor communication between all areas may play a part here and should be resolved in a similar way.

A particularly important finding is that members of the Research Group (RG) have a good appreciation of Customer requirements, a basic understanding of the factors (drivers) whose fluctuation result in corresponding fluctuations in the overall LPI achieved and a basic dissatisfaction with the existing Performance Measurement System but do not recognise the potentially easy transfer from the existing system to an alternative one. This failure of lateral thinking defines the stage of development which the Group has reached.
Also, this analysis which includes the Control Group (CG) provides a basis for future comparison of Groups once the RG has progressed.

(12.2) Research Group Formation and Education.

In the first instance the Group members were approached individually in the Cell by the Cell Leader who asked whether they would be interested in participating in a Kaizen Team which would be specifically aligned to the Nissan 936 Cell. The idea, therefore, was to form a product rather than a process team (e.g. a Press Shop Team). The members were approached approximately two weeks after the completion of the Questionnaire (Section 12.1).

All members except one agreed immediately with the final one having reservations but agreeing to give it a try.

The first meeting, which lasted for around ninety minutes, was chaired by the Cell Leader and the points covered are listed below:

- The Team would deal only with the production of the Nissan 936 Seat from the delivery of coil steel to the Cell to the despatch of finished seats from final Assembly.

- The emphasis was placed on the continual improvement of the entire production process.

- The concept of the internal customer/supplier relationship was explained to the Group within the context of their particular situations within the Cell. The logic of this was readily understood and appreciated by all members.
• The drawbacks of the existing 'over the wall' production were outlined although everyone already had first hand experience of what these were. The ways in which these drawbacks manifested themselves were as follows:

(i) Very poor or non-existent communication between any of the three areas. Kanban links the Assembly and Fabrication areas but communication even at this interface is minimal.

(ii) Poor quality of parts which are sometimes passed onto the next stage of production. Increased communication, it was felt, would make people more aware of the consequences downstream of mistakes or errors of judgement made upstream.

(iii) Over and under production of parts in the Press area leading to excess WIP and therefore greater possibilities of errors being made and 'waste' (or inefficiency) being hidden rather than exposed and tackled.

It was agreed that progress had been made on improving quality performance, particularly with reference to the IHL measures, but that further improvements were certainly required. While less quality problems were being detected by the Customer there were still many careless mistakes being made in-house.

During the first meeting it was also recognised that, since there appeared to be no big project on which to focus and start the Group off that a different approach would have to be employed. The Group was
encouraged to think about ideas for future Kaizen activities in relation to solving some of their problems which they had already identified whether they be physical improvements or changes in the way that the Cell is run.

It was also suggested, by Group members, that the requirements of the Customer should be strongly represented when decisions about improvements were made and that factors such as delivery reliability and quality performance should form an integral part of any new scheme.

At the conclusion of the meeting the Cell Leader summarised what had been said and suggested that members should try to think of about five areas for improvement, related to internal or Customer needs or both, before the next meeting which was to be held one week from that time. These measures would then form the basis for a new set of Performance Measures for the Cell which would help the Group to identify areas requiring Kaizen activity.

The level of enthusiasm was high and the wish to make improvements was felt to be great, there was, however, a definite need for direction and purpose and it was envisaged that clarification of the key Performance Criteria by the Group would provide this.

(12.3) Election of the Team Leader.

The Cell Leader explained that, while he would continue to support and guide the Group, his role would become increasingly facilitative in nature as time went on and that the success or failure of the Group would depend very much on the members. The Group elected to choose their own Group Leader who would chair meetings, liaise with other departments and report on a regular basis to the Cell Leader on progress made, difficulties encountered etc.

The Group chose Mary Carroll, one of only two female members of the Group, to be the Leader. Mary had demonstrated a sound understanding
of the current situation and the need for improvement through her Questionnaire response and general conversation on the Cell. Her enthusiasm for change and wish for greater responsibility for herself made her, in many respects, the natural choice for leader of this Group.

Following the meeting the Cell Leader spoke to Mary at some length about the problems and challenges which the position of Group Leader may present. Not least the fact that she was a woman may lead to some hostility on the part of Operators from other areas of the Universal Cell who were not involved with the Group, although they had been informed as to what was happening. There still existed at this time the mistaken view in some quarters that Kaizen activities;

(i) Reduced the LPI earned by the Cell since people were involved in non-productive activities (despite the fact that all Kaizen hours could be taken out of the Bonus calculation every week, so in this sense it was beneficial since every hour taken out for every hour of Kaizen activity represented, by definition, 100% efficiency).

(ii) In the long term, improvements to the efficiency of the Cell meant that jobs would be lost. While the Company had, at the time when the Kaizen philosophy had been introduced, pledged that no one would lose their jobs directly as a result of Kaizen, the need for redundancies at times when the car market declined led to a suspicion in some minds that the losses would have been less had not improvements made previously led to increased labour efficiency in certain areas.

However, this view was a minority one and, as the Questionnaire (Section 12.1) had demonstrated, most employees recognised that continual
improvement was required if the Company was to remain competitive and therefore able to offer a degree of job security for the majority.

The fact that the Group had chosen its own Leader was, in itself, a significant departure from the norm as far as Kaizen Teams at Dunlop Cox in general were concerned. This initial and fundamental sign of autonomy for the Group aided in creating a sense of Team Identity. Other groups, led from the top and which were inherently paternalistic or even authoritative in nature had failed to generate this.

The Cell Leader told Mary that he was there to offer guidance and advice where required and that while he would remain very supportive it was his intention that she should grow in the role until she had gained such skills as to be a Leader of the Group in the true sense. The measure of her performance, therefore, would be the strength, motivation and effectiveness of the Group in fulfilling their self-defined objectives and in becoming a Team.

(12.4) Identification of Drivers.

At the second meeting of the RG there was a wide ranging discussion of the problem areas on the Cell and some suggestions as to how various specific problems and some less well defined ones could be solved. The realisation that the Press area was the least efficient section of the Cell and that it was the source of many quality problems led to the suggestion that a Kaizen Team specifically aimed at Press improvements would be required.

Problems with the consistency of dimensional accuracy of parts produced by certain press tools, the degree of functionality of parts produced to drawing, the possible inclusion of a Press/Fabrication Kanban system and the role which tools such as Single Minute Exchange of Die (SMED) could play were all discussed by the Group.

The Group Leader and the Cell Leader both suggested that some of
these issues would come within the realms of activity of the RG while others could be clarified through the measurement of the key Performance Criteria which the Group would choose. Once a clearer picture of the problems remaining had been gained then improvement activities aimed specifically at the Press area could be initiated.

It became clear during the second meeting that many of the members had given some thought to what they considered to be important to the Customer as well as what was important to them. There was general agreement that the needs of the external Customer must be of paramount importance with the improved operation of the internal interfaces being the means to achieve this.

The Group immediately agreed that one of their measures had to relate to the quality of the parts produced and so 'Quality' was the first measure to be selected for inclusion.

The question of communication was quickly identified as having important consequences as far as the overall performance of the Cell was concerned.

Improved communication between areas would;

(i) Lead to a consistent supply of parts to the next stage, especially between the Press and Fabrication areas (although this would later be formalised through the introduction of a Kanban system).

(ii) Improve the awareness of Group members as to the difficulties experienced by members in other areas of the Cell so that a greater appreciation of the entire production process could be perpetuated.

148
Help upstream Operators to appreciate the requirements of downstream Operators in terms of quality of parts. For example, a small burr on a hole produced at the pressing stage may seem insignificant to the Press Operator, the plug gauge used to check the hole may even pass through, but it may be that the Operator in the Fabrication area is be unable to pass a rivet shank through through the hole in preparation for the riveting operation. There had been cases where several thousand parts had had to be reworked prior to further use because of a simple misunderstanding, oversight or lack of knowledge on the part of an upstream Operator.

With fluctuating WIP levels between the Press and Fabrication areas and comparatively little stock at any time between the Fabrication and Assembly areas the discovery of a major quality problem often created major problems in terms of meeting the delivery requirements for that day.

Improved understanding of the work carried out in other areas, or even by a neighbour, would mean that, in the case of absenteeism, jobs could be more readily covered than at present.

Increased flexibility would mean that, eventually, Operators would have the confidence and ability to move to where they were required as dictated by Kanban systems. This would mean that, under normal circumstances the Cell Leader would no longer need to move and direct people according to his judgement with all the inherent possible inefficiencies.

A greater atmosphere of teamwork would be nurtured with everyone
aware of the requirements for that day, week or month and everyone pulling in the same direction.

Therefore, improved communication, it was felt, would benefit the Cell in almost every aspect of its operation and would also, crucially, provide the impetus and the cross fertilisation of ideas for dynamic and relevant improvement. The Cell could become more efficient and more versatile simply by becoming more cohesive with Operators being more appreciative of each others work.

It became obvious through the discussion that the way to drive the philosophy of communication with all its benefits was through some kind of Training Programme run by the Cell for the Cell. In this way Training became, probably, the central element of the new system since the Group came to the realisation that through this all other conceivable goals and objectives could be met. The way in which the Group had come to this realisation through using their own knowledge and experience did more to motivate them than any other single activity. The realisation that the problems which the Cell had, which had at first seemed convoluted and unrelated, were in fact all linked and that the solution was apparently so simple and that the Group had the capability to identify the essence of the problem and solve it was nothing short of a revelation to them.

This represented a major step in the Research. The Operators had, as individuals and as a Group, gone through a process of clarification and rationalisation of their ideas and experience. From the general conversations on the Cell between themselves and between them and the Cell Leader, through the Questionnaire and the first two meetings they had used a process of lateral thinking applied to their work environment. Through this they had identified the fact that there were certain cause and effect
relationships at work on the Cell and that control of certain central elements could effect the way that the whole Cell operated in all its minutia.

With the understanding of the cause and effect relationship between drivers came a greater awareness for the Group of what could be suitable measures to gauge the performance of the Cell. Along with 'Quality' and 'Training', therefore 'Customer Deliveries' was added as a third driver which would be fairly easy to measure. While the Group now appreciated that the reliability of deliveries was dependent upon a number of other factors it was considered to be so important to the Customer (and therefore to the Cell) that it had to be included.

The date for the next meeting was set (for one week hence) when finalising of the driver list would be completed and details such as frequency and methods of measurement would be discussed.

(12.5) Finalising Driver Identities and Setting Goals

With Group discussions having been in progress for some time it became increasingly important to finalise the new list of drivers as well as details of goals and time periods.

To add to Quality, Customer Deliveries and Training two more measures were selected which were considered to be of great importance to the Cell. These were Tool and Plant Downtime. These examples of waste had major effects on the running and efficiency of the Cell and it was felt that using Kaizen to reduce these would eliminate much of the inconvenience which often resulted. Also, as Kaizen continued and, as a result, inventory levels fell, the effect of a tool or major piece of plant going down would become increasingly acute.

The frequency of data collection and goals for each measure were
also discussed and finally a goal for each measure was decided upon. These are shown below;

<table>
<thead>
<tr>
<th>Measure</th>
<th>Frequency</th>
<th>Goal</th>
<th>Time scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>Weekly</td>
<td>75%</td>
<td>20 Weeks</td>
</tr>
<tr>
<td>Quality (Scrap &amp; Final Rejects)</td>
<td>Weekly</td>
<td>7%(Scrap)</td>
<td>0%(Rejects) 20 Weeks</td>
</tr>
<tr>
<td>Customer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliveries</td>
<td>Weekly</td>
<td>100%</td>
<td>20 Weeks</td>
</tr>
<tr>
<td>Tool &amp; Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtime</td>
<td>Weekly</td>
<td>0%</td>
<td>20 Weeks</td>
</tr>
</tbody>
</table>

It was decided that each measure would be recorded daily and then the total or mean for the week would be transferred to a master graph. The graphs would serve two purposes;

(i) They would serve as the prime reference source for the Group in the identification of areas requiring Kaizen activity;

(ii) They would be displayed on a Group Notice Board and so ensure that the activities, results and achievements of the Group could be seen by everyone. Considering the importance which the Group had attached to communication this aspect of the graphs was held to be of critical importance.

It was soon realised that each measure had to calculated and recorded
in a specific way and this had some effect upon the Goals identified. For example, Customer Deliveries could be a fairly simple percentage of success or failure with a Goal of 100% success; Training on the other hand was a little less straightforward. The definition of each measure and the reasons for the choice of individual goals is outlined below.

(12.5.1) Measure Definition.

(i) Customer Deliveries

This measure was the most straightforward to clarify. The facsimile received by the Cell every week detailing the Customer requirements for the following week formed the basis for the measure;

e.g. If the Call for Week 1 is 1000 seat sets and 900 are despatched then;

\[
\frac{900}{1000} = 90\%
\]

Percentage of Complete Deliveries = 90%

The goal had to be 100% for any given week so that while the time period of 20 weeks was specified for attainment of the goal this was more a question of achieving 100% complete deliveries 100% of the time rather than reaching that particular level after a period of twenty weeks. This feature was a function of the JIT relationship between the Cell and the Customer which meant that failure to deliver would have repercussions of a most serious and costly nature.

(ii) Percentage of Final Rejects and Scrap Parts.

Since it was felt that these two measures were in many ways related they were included on the same graph.
The figure for Quality Rejections was taken to reflect faults found at final Assembly only. Since through experience, the vast majority of quality problems were already built into the product when it reached Assembly, it was felt that the results of the continual pursuit of zero defects at every stage would be reflected by a reduction over time in the number of faulty parts found at the final Assembly stage. If more specific measurement of quality aspects further upstream were found to be necessary at a later stage then the measure could be modified to account for this. For the time being a peak on the graph (that is anything in excess of 0% rejections) would initiate an intense investigation and programme of action designed to ensure that that particular fault could never arise again.

The number of parts recorded as being reject would be the actual number found to be reject and not, as the Quality Control Department recorded it, the total number of suspect parts.

The figure for Scrap Parts was to include Production Scrap only, i.e. not webbing etc. which was designed into the process. It was felt that control and reduction of scrap levels would be a reflection of greater control of processes and increased repeatability of press tooling in particular. The goal of 7% scrap was arrived at from a knowledge of the levels of non-avoidable scrap present during normal production. Therefore the attainment of 7% total scrap would represent 0% Production Scrap.

Calculation examples for Rejections and Scrap Levels are shown below;

(a) Percentage of Rejected Parts.

e.g. If Total Production for Monday of Week 1 is 1000 seat sets and the Total Actual Rejects was 15 then the Percentage of Final Rejects for Monday was:
15 \times 100 = 1.5 \% \hspace{1cm} Final Rejects = 1.5 \%

1000

Or for the Week;

75 \times 100 = 1.5 \% \hspace{1cm} Final Rejects = 1.5 \%

5000

(b) Percentage of Scrap Parts.

e.g. If the Total Weight of Steel received into the Cell for Monday of Week 1 is 1000 kg and the Total Weight of scrap produced is 25kg then the Percentage of Scrap Parts for Monday is;

25 \times 100 = 2.5 \% \hspace{1cm} Scrap Parts = 2.5 \%

1000

Or for the Week;

125 \times 100 = 2.5 \% \hspace{1cm} Scrap Parts = 2.5 \%

5000

(iii) Percentage of Tool / Plant Downtime.

Due to the likely relationship between these two measures it was deemed logical to incorporate them both into the same graph. In devising the calculation it was decided by the group to assume zero inventory and one piece flow through the Cell. This meant that, according to the measurement, if one piece of plant or one tool went down then the whole Cell would stop...
production simultaneously. This, of course, is not the case, however, the assumption has two benefits:

(a) The multitude of variables which in reality determine the relative effect on production of equipment failure can be ignored for the sake of simplicity (at this stage at least).

(b) Zero inventory and one piece flow is the theoretical panacea of the Group and the Cell and the incorporation of changes in WIP levels or buffer stocks due to equipment failure is to build a measure of inefficiency in.

An example of the calculation devised is found below:

e.g. If for Monday of Week 1 there are 100 man hours worked on the Nissan 936 Cell. Also, one Press Tool is in the Toolroom for 5 hours and a Press is down for 1.5 hours then;

\[
\text{Percentage Downtime for the day} = \frac{5 + 1.5}{100} = 6.5 \%
\]

If totals for the week are:

Total Hours Worked = 500 hours
Press Tool Downtime = 24 hours
Plant Downtime = 6 hours
Then \( \frac{30}{500} = \text{Percentage of Tool/Plant Downtime} = 6\% \)

As can be seen this calculation also assumes that each man hour is used with 100% efficiency within the context specified. The goal specified was 0% Downtime.

(iv) **Percentage of Multi-Skilling.**

In line with the philosophy of the Group the term *Multi-Skilling* was chosen as a label for the training related measure. After some careful deliberation the Group arrived at the following definition of the measure;

e.g. There are 24 individual jobs on the Nissan 936 Cell.

Each person knows a percentage of these 24 jobs:

So, if Joe knows 14 jobs then his rateing is \( \frac{15}{24} = 62.5\% \)

For Week 1 if:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe knows</td>
</tr>
<tr>
<td>Mary knows</td>
</tr>
<tr>
<td>Graham knows</td>
</tr>
</tbody>
</table>

Then we add up the percentages and divide by the number of people;

\[
62.5 + 41.6 + 50 = 154.1
\]

\[
\frac{154.1}{3} = 51.4\% \quad \text{Percentage of Multi-Skilling} = 51.4\% 
\]
The number of jobs was arrived at by counting the number of discrete operations in the Fabrication and Assembly areas and by counting each individual pressed part produced in the Press area as an individual job. The rationale behind this was that each part has an individual Quality Instruction sheet, often individual gauges as well as some part or product specific 'knowledge' associated with it, only the Power Press used may be common to more than one part.

The goal of 75% Multi-Skilling was based on the opinion of the Group that it was not realistic to imagine that, at some point in time, every Operator would be fully competent to do every job on the Cell. A figure of 75% was considered more realistic. The fact that the goal selected aimed lower than that of many World Class companies was secondary to the importance of setting a goal at all at that point. Such a level of training (75%) was far beyond any level envisaged within the Company at the time and this goal, like all the others, would be, by definition, subject to revision in any event.

N.B. The suitability of the measures chosen, as well as their associated goals, was of secondary importance to the process which the RG had gone through in selecting them. The concern of the Research was not with the selection of a definitive set of World Class Performance Measures, rather in the method of selection, recording and use of the measures selected and the behavioural factors involved.

(12.6) Planning Data Collection, Recording and Analysis.

Once the measures had been decided upon the subsequent meeting
dealt with the issues of data collection, recording and analysis. Each measure required a particular piece or pieces of data for the relevant daily calculation to be made. It was decided that, during the last half hour of the morning shift (1330 - 1400), one or two designated members would collect the appropriate data, carry out the calculations and record the daily value. On the Friday of each week the cumulative values for each measure would be transferred onto the corresponding master graph on the same notice board.

Some of the data, however, was to be found in areas other than on the Cell itself. In particular in the Toolroom (for Tool Downtime), on the Maintenance Job Board (for Plant Downtime), in the Steel Stores computer (for each relevant type of steel delivered to the cell by weight) and from a forklift driver who dealt exclusively with the removal and tipping of scrap from all cells (for daily scrap weights). The dispersed nature of the information sources represented two areas of difficulty for the Group members:

(a) In many cases they were unfamiliar with the way in which the information was recorded and also with its location;

(b) They did not have the authority to enquire after or collect some of the information or to enter areas where some of it was recorded.

In order to overcome these problems the Cell Leader undertook to collect all the necessary data each day and record them on sheets which the Group formatted and leave these sheets in pockets attached to the notice board before the end of the shift. In this way only the task of collection would be removed from the area of responsibility of the RG members.

This, however, was only ever intended to be a temporary arrangement
since it was important that Group members should have complete ownership and control of the entire system. To this end the Cell Leader facilitated the collection of the information by the Operators in the following ways:

(a) Through taking the Operators to the various locations of the data sources and explaining how the appropriate data could be found amid the data for other Cells;

(b) Through explaining to people such as the Toolroom Manager, Steel Stores Supervisor and Maintenance Manager what the Group was doing and obtaining clearance for the members to have access to information as required.

As mentioned previously each piece of data was to be found at a particular location, in some cases in the possession of a particular individual. The records of Plant Downtime, for example, were found on the booking sheets outside the Maintenance Department. On these sheets the Cell Leader or Deputy from any Cell records a breakdown of a machine or a service required. The nature of the problem as well as time of breakdown/recording and repair all appear on the sheet. There are five sheets in use at any one time;

(a) Mechanical

(b) Electrical

(c) Lubrication

(d) Safety

(e) General Fabrication

An example of a Mechanical Sheet is found in Appendix D. As can be seen the members had to firstly select only breakdowns applying to the
Universal Cell. From this selection of breakdowns those applying only to plant and equipment used on the N936 Cell were recorded. In the case of Fabrication or Assembly equipment which is dedicated to N936 this was straightforward. However, Power Presses, which are often used for the production of parts for a multitude of products, had to be considered individually and knowledge about which tool was in use at the time of breakdown was often required in order to determine whether or not to include the downtime in the calculation for that particular day.

Information regarding steel issues to the Cell was obtained from the Steel Stores computer via the Steel Stores forklift driver. A list of all the steels used for the production of N936 parts was drawn up by the Cell Leader and this was used as a reference for recording steel issues.

The weight of scrap material taken daily from the Cell was easily obtained from the Scrap forklift driver as mentioned previously. This information, together with the steel issues, was used by the Steel Stores Supervisor to calculate a weekly value for scrap levels for each Cell (Figure A26) - in the same way that the RG did. Thus the RG was able to cross reference its weekly value with that produced by the Steel Stores Supervisor. This comparison resulted in some interesting trends in the published value - this is discussed in Section 17.

Records of tool downtime were obtained from Tool Repair Records kept in racks in the Toolroom (see Appendix E).

The value for complete deliveries was obtained with simple reference to the facsimile details for the day and the actual number of assemblies produced.

The value for Multi-Skilling was recorded daily with any training which had taken place being recorded on the daily sheet.

Each of the sheets produced by the Cell Leader allowed for recording of the data and calculation of the daily percentage which could then be
directly transferred onto the notice board (see Appendix F for sheets).

As the members became more experienced in the process of data collection, calculation and recording, the Cell Leader played less of a part. Once only members had begun to collect and decipher the data the Cell Leader simply checked calculations (at the request of the members) until, eventually, this too became unnecessary.

While the calculations for the daily measures had been kept as simple as possible many of the members had never had cause to carry out such calculations since school days. Consequently there was a learning curve involved with the re-acquisition of some simple mathematical skills. This, together with the new experience of searching for data and using it for some useful purpose served to motivate the members and in many cases increased feelings of self-esteem and competence which in turn benefited the RG as a whole. This is based on anecdotal evidence and no qualitative information is available to test the point.

(12.7) Group Dynamics - allocation of responsibilities.

As previously detailed, the RG had selected Mary Carroll as their Team Leader during their second meeting. This had been a fairly easy decision since Mary had taken on the role as unofficial Leader from the first instance. The remainder of the Group consisted of a cross section of personalities, much as any Group might. Some were very keen on the whole notion while others were more reticent. As the Group progressed, however, much of the reticence dispersed as members became more clear about the purpose of, and possibilities for, the Group.

The decisions about who should carry out the data collection were made soon after the new measures had been finalised. Initially Mary and her unofficial second in command, Graham Pilkington, should be 'trained' in the process. Once these had gained sufficient confidence they would show other
members where to look for the data and run through the calculation and recording elements until they, in turn, were fully trained. Gradually the Cell Leader would withdraw from the process until information retrieval and recording would be carried out exclusively by Group members who would continue to use the prepared daily data collection sheets. Eventually a rota system was envisaged. The RG agreed that involving everyone in the physical collection/calculation/recording process would have the following benefits;

(a) Every member would gain a complete appreciation of the implications which each of the new measures had on the overall performance of the Cell. This would result from a high degree of familiarity with the measures gained through close and regular contact with them.

(b) The progress of the Cell in reaching its' specified goals for each measure would be understood by everyone. A consistent appreciation of the position of the Cell in relation to the measures would aid the generation of appropriate ideas for improvement and keep everyone involved.

(c) All members would gain a greater appreciation of what happens not just in other areas of the Cell but other areas of the Company. Under normal circumstances few of the members would have cause to visit areas such as the Toolroom, Steel Stores or the Maintenance Department. This contact promised to enhance the notion of the internal customer/supplier relationship which they already understood from a Cell point of view. Such appreciation, it was envisaged, would enable the Group to come to informed and valid conclusions when dealing with
problems which involved interfaces with internal customers/suppliers and service departments.

(d) Operators coming together from different areas of the Cell near the end of a shift would, in itself, help to foster communication between areas of the Cell which, previously, had little contact. Shared experience in dealing with departments outside of the Cell as well as problems inside it would facilitate some cross fertilisation of ideas and help to strengthen the cohesion and development of the RG.

(12.8) The Kaizen Notice Board.

The Group decided to label the notice board the 'Nissan 936 Kaizen Team'. This title was chosen since it reflected the fact that the performance measures displayed on it were the drivers for the Kaizen activities which would drive the performance of the cell towards the displayed goals. The word 'Team' was chosen in preference to 'Group'.

The importance of the board meant that it's location was discussed at length. Finally, a central position between the Press and Fabrication areas was decided upon (see Figure 12). From various catalogues a half cork/half dry wipe board was selected. The cork half would be used to display the master graphs while the corresponding area on the white side would be divided up for the recording of the daily values for each measure. Figure 15 below shows the erected board in use.
The red pockets for storage of the daily collection sheets can just be seen below the board. The small white box was used to hold pens, rule, calculator etc. The board was ordered by the Cell Leader but the planning, construction of the supporting frame, erection and painting of the frame was all carried out entirely by Team members. This was their first project as a Team and there was a definite degree of pride attached to the board itself as well as the information which was subsequently to appear on it.

The erection of the board marked an important point in the Research. Once information started to appear then the effectiveness of the new measures in driving improvement could be tested. Because the board was not erected until Week 6 the recording of information on the graphs did not start until then either. For the sake of completeness, therefore, the Cell Leader found all the information necessary to complete the graphs from Week 1 up to and including Week 5.
As has already been explained the Cell Leader responsible for the Nissan 936 and Nissan 909 Cells was also the Researcher. This had several benefits from the point of view of the research:

- The operation of both Cells involved in the research was completely under the control of the Researcher.

- The Researcher had a good and established working relationship with all employees involved in the research.

- Being in the position of Cell Leader the Researcher had gained, over time, a deep and comprehensive understanding of the culture and internal workings, politics and nuances of the organisation which would not have been possible had the research been conducted by someone external to the Company.

There were, however, some considerations which had to be taken into account because of this position:

- Part of the requirement of the position of Cell Leader was to improve the operation and increase the efficiency of the Cell. The results of these ongoing efforts would have to be taken into account when analysing results brought about through the research.

- The natural desire of the Cell Leader to see the Cell improve and the Cell members develop had to be actively de-coupled from the thought processes and actions (especially interactions with Group members) associated with the research programme so as to minimise,
as far as possible, the effects of Subject-Experimenter Artefacts.
(This point is discussed in detail in Sections 26.2.4 and 26.2.5).

The role of the Researcher within the RG could best be described as coach and facilitator. When the RG was initially formed the Researcher began by introducing the concepts of internal customer/supplier relationships and talking about the needs of the Customer in relation to the performance of the Cell. In this a balance had to be struck between allowing the RG to function and develop with no input at all from the Researcher (in which case the Researcher would simply have been an observer with the degree of influence limited to the Hawthorne Effect) and spoon feeding the Group along the Researchers' preferred route. In the event the Researcher provided the Group with just enough information and knowledge to allow them to reach informed decisions. In fact, the members understood very well the two main factors of influence; the culture and workings of the Cell and the requirements of the Customer. As has been documented earlier the RG developed quickly to become an effective team able to put their personal experiences and knowledge into the broader context of the Cell as a customer and supplier. (Section 12).

During meetings the Researcher was able to judge the situation and encourage open discussion and contributions from all members of the Group. This was only made possible by the close working relationship which the Researcher had developed with the Group members. Once the meetings were underway the Researcher was able to act simply as a scribe contributing the occasional, loosely worded, suggestion designed to stimulate constructive argument.

During the early meetings the Researcher was able to draw out the more reticent or self conscious members of the Group and encourage them to put their opinion forward. After a period of around five weeks the RG
had developed into a fairly well balanced and cohesive group.

The Researcher also encouraged the idea that the N936 Cell could easily become the 'best' cell in the factory, producing seats of the highest quality with the greatest efficiency. Comparison with the Nissan 906 Cell was often a topic of conversation and, as time went on, the generally superior performance of the N936 when compared to the N906 was a source of much pride and satisfaction. This element of competition, cultivated by the Researcher (it had always been present anyway), served to make the Group even more cohesive and improved the general motivation and enthusiasm of the members.

Further detailed discussion of the role and influence of the Researcher appears in Section 26 which examines and evaluates all the methods of research employed.

The next step is to briefly discuss the activities of the Control Group (N909) during the period prior to the RG erecting their board and beginning the recording of their measures.

(14) Initial Progress of the Control Group.

While much attention had been focused on the RG, the CG had continued to function according to the prevailing culture in the rest of the Company. At the introduction of the new imposed measures the Cell Leader had made the Group aware of what each measure represented and the importance which the management of the Company placed on them. It was also made clear to them that through Kaizen activities many, if not all, of the problems which the cell undoubtedly suffered from could be gradually eliminated. Furthermore, the reduction of these problems would lead to improvements in many of the new imposed measures. This was the extent of
the communication between the Cell Leader and the Group regarding the
issue of performance measurement as an item, or in relation to continuous
improvement.

In terms of Kaizen activity on the cell there were a few obvious areas
which required improvement. These included;

- Inefficient production of formed parts from P301 and intermittent
  supply of parts to the Fabrication Area.
- Over and under production of many parts from the Press Area with
  regular periods of disruption for the Fabrication Area.
- Limited flexibility of Operators.
- Undependable quality of parts from the presses.
- Excessive tool change-over times, especially P301 (1/2 hour at best).

The Cell Leader suggested to the Group that a Kanban system between the
Press and Fabrication areas may eliminate many of the problems of control
and the identification and elimination of problems currently hidden by excess
inventory. Techniques such as SMED (Single Minute Exchange of Die) were
explained to the Group.

The CG was formed into a Kaizen Team which met under the
leadership of the Cell Leader. It was explained to the Group that the Cell
would be judged not only in terms of the LPI achieved but also with
reference to the other new imposed measures. The degree to which this
information was assimilated into the collective thinking of the Group is open
to discussion at a later stage. As has already been established, the pervading
measure of performance was the LPI and the degree to which the other new
imposed measures affected the behaviour or guided the activities of the CG,
given that the measures and their purpose were explained to the Group,
would become apparent during the analysis of historical data, (Section 16).

Thus the Control Group was left to run under the influence of the
existing performance measures, the new imposed measures and the underlying culture of the Company.

The role of the Cell Leader in the CG was very similar to that in the RG. There was, of course, one important difference. Within the CG there was no attention paid to the methods of performance measurement employed within the company. While it was clear to the Group that the purpose of carrying out improvement activities was to meet the various needs of the customer, the connection was never made between the needs of the customer and the many apparently unrelated problems which the Cell had. In short, the CG remained just short of the stage of development which the RG had reached prior to Stage II of the research.

The Kaizen activities which took place within the N909 Cell are briefly discussed in Section 19.

(15) Collection, Collation and Plotting of Historical Data II.

This aspect of the research activity followed an almost identical format to that followed during the analysis of the six existing measures for Weeks 1 - 40 (Stage I). In addition the New Imposed Measures, as described in Section 11.2, were recorded for the N936 and N909 Cells. Also the new Cell-Generated measures were recorded for the N936 Cell only.

As previously, the information sources used were those used by the management of the Company in assessing the performance of individual cells.

Data relating to the New Imposed Measures was obtained at the point of calculation; (i.e. as the Cell Leader calculated values for the New Imposed Measures for the N909 and N936 Cells on a daily or weekly basis he recorded the information twice, once for the graphs in the notice board at the front of the cell, and once for the research records).

Data relating to the Cell-Generated Measures of the RG was recorded...
at the end of each week once the RG had carried out the calculation and recorded the weekly value for each measure on the master graphs.

After the second forty week period (Weeks 41-80 inclusive) all three data sets were analysed. As before the measures were first plotted against time for each cell in order to gain an initial impression of any trends. Following this, again as before, each measure was plotted against each of the other measures in its' set in order to test for any correlation between measures; (again the Pearson Calculation was employed, Appendix L).

The following Section deals with the analysis of the data from Stage II of the research.

(16) Analysis of Historical Data II.

Appendices G, H, I, J and K contain all graphical results including all measurements over the second forty week period and scatter graphs for all measurement combinations (within sets) for the two cells. The Correlation Coefficient for every two variable combination is given on the appropriate graph. The following five pages show graphs of all measures for each category and each group (Research and Control) for weeks 41-80 inclusive. This is followed by the results in terms of degree of correlation between measures for each category.
Figure 16: Measurement Percentage for all Existing Measures for the Nissan 936 Cell for Weeks 41 to 80 inclusive.
Figure 17: Measurement Percentage for all Existing Measures for the Nissan 909 Cell
for Weeks 41 to 80 inclusive.
Figure 18: Measurement Percentage for all New Imposed Measures for the Nissan 936 Cell for Weeks 41 to 80 inclusive.
Figure 19: Measurement Percentage for all New Imposed Measures for the Nissan 909 Cell for Weeks 41 to 80 Inclusive.
Figure 20: Measurement Percentage for all New Measures for the Nissan 936 Cell for Weeks 41 to 80 Inclusive.
(16.1) Research Group - Existing Measures.

The graph showing all measures in this category over time and the single measure/time graphs (Appendix G) illustrate little in terms of trends or obvious correlation between variables. The correlation coefficients calculated bear this out and the results are very similar to those found for this data category in Stage 1;

GROUP 1

Coefficients = 1

Production vs. Forecast Sales
Forecast Sales against Production

GROUP 2

Coefficients <= 0.2

All other combinations of driver

vs. Forecast Volume

According to the 0.05 Significance Level there is no correlation between any Group 2 combinations (value of r required for significance = 0.31) but perfect correlation in the Group 1 combination. This division reflects exactly the findings of Stage 1.

(16.2) Control Group: Existing Measures

As for the RG Existing Measures the graphs of measure/time offer no obvious trends or relationships and this (Appendix H), again is born out in the correlation calculations;
The division of the two groups of data is clear as before. However, the Group 2 Correlation is higher than for the RG although it is still just short of the 0.31 value for significance. Since the N909 Cell was not included in Stage I due to insufficient data at the time this result supports the assumption that the data relating to this cell has much the same characteristics as that for all other cells examined in Stage I and is therefore a valid inclusion for Stage II.


In common with all previous data the measures displayed chronologically exhibit no clear relationships (Appendix 1) and again the correlation calculations quantify this. However the pattern of results is different from that seen previously:

GROUP 1

<table>
<thead>
<tr>
<th>Correlation = 1</th>
<th>Correlation &lt;= 0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production vs. Forecast</td>
<td>All other combinations of</td>
</tr>
<tr>
<td>Sales against Production</td>
<td>driver</td>
</tr>
<tr>
<td>vs. Forecast Volume</td>
<td></td>
</tr>
</tbody>
</table>

A notable difference between these results and previous ones is that there is no category exhibiting perfect correlation. While the constituents of Group 1
are not statistically significant they appear closer to being so than others to the extent where a specific mention seems appropriate.

Overall the degree of correlation for the imposed measures is lower than for the existing measures.

Where specific existing measures are replicated in the imposed measures then the correlation is, obviously, the same. Considering that only four of the imposed measures are novel in this sense it is predictable that the mean coefficient for the existing and imposed measures should be in the same range.

(16.4) Control Group: New Imposed Measures.

The division of coefficients, (Appendix J for graphical results), in this case matches the previous although the make up of the groups is at partial variance;

GROUP 1 GROUP 2
Correlation = 0.3 Correlation < 0.3
LPI vs. Customer Satisfaction All other combinations
and
LPI vs. Scrap Levels

of driver

All comments made regarding this category of RG results follow for the CG. Unless otherwise stated all subsequent sections refer to the Research Group and their activities.


As previously the chronological graphs (Appendix K) offer no immediate insight into measure interrelationships but the correlation values
quantify this. The value of $r$ required for significance is again 0.31.

<table>
<thead>
<tr>
<th>GROUP 1</th>
<th>GROUP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation = 0.3</td>
<td>Correlation &lt; 0.1</td>
</tr>
<tr>
<td>Scrap Levels vs. Tool/Plant Downtime</td>
<td>All other combinations</td>
</tr>
<tr>
<td>and</td>
<td>of driver</td>
</tr>
<tr>
<td>Scrap Levels vs. Customer Deliveries</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen there is no correlation between any of the selected measures and only two combinations approach the required value of $r$ for significance.

However, since many of the values of $r$ produced in this analysis are between the 0.26 value required for significance assuming a 0.1 Confidence Interval (as discussed in Section 6.4) and 0.3 then there is a possibility of the existence of a Type 2 Error in assuming a Confidence Interval of 0.05 in this case. The groups of data effected in this way are:

- Control Group: Existing Measures
- Research Group: New Imposed Measures
- Control Group: New Imposed Measures

Despite this no further statistical analysis is considered necessary. The reasons for this are as follows;

(i) All previous calculations have assumed the conventional 0.05 Confidence Interval.

(ii) There is considerable statistical evidence (from Stage 1) that there is no correlation between any of the Existing Measures for any cells (Section 6.4). Therefore, while some combinations of Existing Measures do exhibit correlation
between measures according to a 0.1 Confidence Interval, to draw such a conclusion would suggest a strong possibility of the existence of Type 1 Errors.

(iii) Of combinations of the New Imposed Measures which are not repeated among the Existing Measures (and so not included in the argument in (ii)) only Customer Schedule Achievement vs. Production Scrap exhibit values of r between 0.3 and 0.26 or -0.3 and -0.26 (Figures 116 and J16). These two sets of data represent a very small percentage of the total number of sets analysed in the research where no correlation was found. It is on this basis that the value of r for this relationship assuming the 0.05 Confidence Interval stands and it is assumed that there is no Type 2 Error.

Despite the lack of correlation there are a number of interesting features of the new measures which are exposed through the graphical and statistical analyses.

(16.5.1) New Group Measures: Detailed Measure Analysis and Discussion.

The lack of correlation between the measures devised by the RG is in contrast to the hypothesis which suggests increased correlation between these as opposed to the existing and imposed measures. Discussion of each of the measures in the light of the statistical results, however, may serve to clarify the results. Taking each measure individually:

(i) Multi-Skilling

The progress of the Multi-Skilling activities during Weeks 41 to 80 is a reflection of, in some ways, the culture of the cell. As can be seen from
Figure K2 the increases in the levels of multi-skilling takes the form of step increases during weeks 48 and 49 and 58 to 61 inclusive. Clearly the training of group members did not follow a regular plan or routine and was far more opportunistic in nature. The reasons behind this are discussed at a later stage. Additionally the step increase in multi-skilling value at week 60 from 39% to 48% was a result of a change in group membership at this time rather than training alone. This factor, also, is discussed at a later stage.

Of all the measures chosen by the RG multi-skilling is unusual in that variations in percentage are brought about not as a result of the effects of other measures acting directly on it but through a planned and predictable programme (in theory if not in practice). Conversely, changes in the level of multi-skilling could, conceivably, effect the values of other measures. While multi-skilling cannot be affected directly by a change in another measure or measures, however, there are likely to be other influences within the cell, which, when combined, affect the percentage of multi-skilling attained. In this way what could be termed the culture of the cell influences in a number of ways each measure individually and as a whole. Such a relationship may be unquantifiable as is but a clearer view is achieved through behavioural and statistical analysis combined.

This feature of the measure may only manifest itself in the way described when it is combined with the other measures as described previously and within the social and behavioural make up of the RG. Alteration of any external or internal factor or force may alter the precise nature of the relationship. Indeed, a different set of measures including multi-skilling may mean that increases in multi-skilling are brought about by certain movements in other measures but by means of a behavioural mechanism leading to a conscious manipulation of factors which result directly in the alteration of other measure values. That is, where a discrete and undesirable occurrence (e.g. a large rejection directly as a result of poor
training in a certain area) leads directly to immediate training to minimise the possibility of the same mistake being made again because of the same reason. This possible relationship was clearly identified by the RG as detailed earlier and was one reason for the inclusion of multi-skilling as a measure. During Stage II, however, neither this scenario, nor any where another measure directly drives a change in multi-skilling, ever arose. This may have been due to the state of development of the cell at the beginning of Stage II as well as its' subsequent development. This is discussed at a later stage.

Multi-skilling also differs from the other measures in that, under normal circumstances, the value will always rise over time. The exception to this could be when the composition of the group changes such that the overall skill level is reduced. All other measures fluctuate in response to other forces at work on the cell.

The points outlined above, in many ways, serve to explain the consistently low correlation coefficient achieved by any pair of measures where multi-skilling was one.

(ii) Customer Satisfaction.

The intense pressure on the cell to satisfy customer requirements on a daily basis may have meant that natural correlating (or non-correlating) relationships were stifled and/or negated as a consequence. Regardless of almost any other factor or the value of any other measure (existing, imposed or new) the delivery for each day had to be complete and on time; i.e. customer satisfaction had to be 100%.

Figure K5 shows the value for Complete Deliveries over time and a definite change in consistency appears to occur at week 56. This is in some ways misleading since at no point did the customer not get what was required. The changes in the shape of the graph were due to the following
Between Weeks 42 and 56 a value of 100% was recorded if the customer was supplied with all the slides required. This was irrespective of changes in the order during the week which sometimes occurred. From Week 57 onwards the facsimile from the previous Friday was used in the calculation of the weekly figure. Consequently from Week 57 to 80 variations in customer call appear as fluctuations in delivery success. Over a period of time the mean is still 100% since the Nissan build plan cannot be affected in anything but the shortest possible term by problems in upstream suppliers.

The alteration in the way that the measure was recorded was decided upon by the RG as it became clear that recording the weekly value as the result of a rolling comparison with forecast meant that the measure became impotent and in no way focused on areas for improvement. The change, it was thought, would mean that delivery data could be related more realistically to the other measures with a view to increasing the efficiency of the cell while always meeting the sometimes fluctuating demands of the customer. It should be noted that in all but two cases the fluctuations were relatively small.

(iii) Reject Levels.

The way that rejection levels were defined by the RG as the actual number of faulty parts rather than the number of suspect parts (as the Quality Control Department defined them) meant that the rejection levels recorded by the RG was in most cases even lower than that recorded by Quality Control and so used in the relevant calculations in the Existing and Imposed measures.
Figure K6 shows the reject levels against time and for 75% of the points the weekly value was 0%. As with Multi-Skilling and Complete Deliveries to some extent this very consistent performance means that the correlation coefficients involving Reject Levels are very low.

(iv) Scrap Levels

Scrap Levels on the cell was one of only two of the measures chosen which produced any marked fluctuation over time as Figure K3 shows. The large peaks at Weeks 46, 70 and 71 were largely due to human error exacerbated by inadequate training and attention to detail. Generally speaking around 85% of scrap is produced in the Press Shop. The largest amounts are usually inner or outer sections produced with inaccurate tolerances for example, or brackets and triggers produced with problems such as excessive burrs. It is fairly unusual for large numbers of defective parts to reach the Assembly stage undetected. This measure gave rise to some of the highest correlation coefficients although even these were insignificant.

(v) Tool/Plant Downtime.

Figure K4 shows Tool/Plant Downtime against time and illustrates an apparent sudden deterioration on control at Week 56. While some of this can be attributed to specific problems on the cell there appears to be no sufficiently rigorous explanation. None of the other measures exhibit any drastic change at this time (except for Complete Deliveries but for different reasons as outlined previously). The only additional factor which may have had an effect was that the current Cell Leader was moved onto another cell at Week 56 and a new Cell Leader took his place. A possibility is that lack of ability or training or some other factor on the part of the new Cell Leader led to this sudden loss of control but there is no data to support this or any
other theory.

The Tool/Plant Downtime values provide some of the highest correlation coefficients, especially when combined with Scrap Levels as previously mentioned but, again, these are not significant.

The lack of correlation between the new measures meant that the RG re-examined their measures with view to possible modification, Section 22.

(17) Resultant Kaizen Activities

One of the factors influencing the choice of measures was the idea that the data collected for each measure would give an indication as to the particular areas of activity which required some improvement. Indeed, this was the key concept driving the whole programme. Consequently, once the measures had been established and data began to be collected, the group then began to look for trends or signals in the data. However, as was to be revealed at a later stage by the statistical analysis, there was a conspicuous lack of correlation between any of the measures. At the time a simple visual analysis of the measure/time graphs was used to come to this conclusion. However, despite this lack of correlation, the graphs were effective in flagging up areas for improvement in the following ways:

(i) Over a fairly short period of time (within about the first six weeks) trends in various measures became apparent.

  e.g. Scrap Levels, after a peak in Week 46 began to fall.

  Tool/Plant Downtime also peaked in Week 46 but then regained a fairly low and consistent level.

The graphs appeared to illustrate fairly well the overall state of the cell in broad terms which were not always specific in terms of cause and effect relationships but did reflect 'how the cell was going'.
In some cases the presence of a peak or series of peaks on a graph flagged the need for immediate action of some kind.

E.g., Any Rejection on the cell prompted an immediate investigation, and formation and the implementation of a solution.

Depending on the magnitude or seriousness of the rejection the implementation of a solution sometimes took place on the same day as the rejection.

Occasionally two simultaneous peaks on separate graphs could be immediately associated with a particular instance.

E.g., The peaks at Week 46 in Scrap Levels and Tool/Plant Downtime can be attributed to a particular fault with a Press Tool which led to the production of a large number of scrap parts prior to detection and then downtime once the problem had been discovered and the job stopped while the tool was repaired (a broken punch in the tool leading to a missing hole in an inner section in this case).

In such instances the graphs, while being a retrospective record of events, served to increase general awareness of the problem and so reduce the likelihood of the same mistake being made in the future. In addition a practical measure or series of measures was often taken to prevent recurrence (in the case above the addition of a 'Care Point' to the Quality Instructions and the addition of electrical tool protection).

Peaks and troughs in the graphs in general served to illustrate the condition of the cell in relation to the measures. Group members
studied the graphs daily (even those not engaged in the data collection for that day) and, consequently, the general awareness of the progress of the drivers being measured and of the problems and successes around the cell was increased. This tended to lead to increased discussion about problems and possible solutions by members during the working day and not only during the kaizen meetings. In this way the graphs became a focal point for the group and the cell and the culture began to move forward (driven by failures almost as much as successes but, more than anything, by increased awareness and communication - as the group had predicted).

Specific analysis of attitudes to the measures and the development and use of them is found in Sections 20.2 and 21.

Increases in awareness and discussion of problems together with the definite signals for action from the graphs led to various kaizen activities throughout Stage II. Examples of these are as follows (see Figure 12 for location of plant and equipment mentioned);

(i) **Scrap Control**

Improving the control of scrap levels was part of the drive to reduce scrap levels across the cell. The first step was to gain an understanding of where the scrap was coming from, why it was being produced and what effects it was having. There was data available relating to the amount of scrap produced by the cell on a weekly basis provided by the Steel Stores Supervisor as detailed in Section 11.2. However, it was generally felt that figures produced were not always accurate and that separate recording of scrap (and comparison with the published data) would increase understanding of the problem within the cell. When the collection of data from the Steel Stores began it was found that the weekly figure calculated
by the group was always lower than that published by the Steel Stores. Following some investigation it appeared that scrap collected from cells was often left in pallets for two or three days before being tipped into a skip and the weight from each cell recorded (the group used scrap weights recorded especially for them immediately the scrap left the cell). The existing system led to two possible sources of error;

- Scrap was sometimes added to pallets while they were waiting to be tipped.
- The forklift driver would sometimes forget which pallet had come from which cell by the time he came to tip them.

Group members involved in data collection therefore resolved to question the Steel Stores Supervisor on a daily basis regarding discrepancies between the two sets of data. Over a period of time the two values for each week converged until they became, and remained, identical for the remainder of the research period. Figure 21 illustrates this convergence of data. This advance was, therefore, due simply to the increased attention paid to the issue of scrap levels.
Once the issue of scrap quantities had been clarified and the accuracy of published data improved the group began to look at ways of making scrap more visible on the cell and so make it easier to identify, control and, over time, reduce general levels.

Before the RG was formed the scrap produced in all areas of the cell was thrown into metal trolleys or, in the case of the press shop, pallets. These trolleys and pallets were often left until they were full and then tipped together into pallets to be taken off the cell. A breakdown of the scrap was produced but this was often produced retrospectively and its' accuracy was minimal. There was no real control of scrap, little attempt made to find the real causes of scrap and scrap parts would be found under benches, in all sorts of containers (usually unidentified) and in any dark hole that could be found.

The RG devised a scrap container, for the Assembly area initially, which sought to make scrap as visible as possible. The container consisted of a sloping tray on legs. The tray had low sides to restrict the amount of scrap which could be held. The tray was divided in two so that scrap left
hand assemblies were put in one half and right hand in the other. At the bottom of the tray, on each side, was a trap door which slid up to allow the scrap parts to slide out into a pallet positioned below at the appropriate time. Above each half of the tray was a scrap sheet on which anyone scrapping an assembly had to record the part name and number, the reason for scrapping and the quantity. This was produced under the existing system but, at the time, was for information only and was never used for analytical purposes. Twenty minutes before the end of each shift one of the assemblers would go through all of the scrapped assemblies and rework any that could be salvaged. The remainder would be tipped into a pallet and removed from the cell at the beginning of the following day. The tray was painted and placed in a strategic position in the assembly area. A similar tray was made for the fabrication area. The positions of the trays are marked on Figure 12.

This system succeeded in raising the profile of scrap in the two areas and the quantity of scrap produced in the areas reduced dramatically (by an average of 75% within three weeks of implementation). In addition the added control meant that problems, flagged by scrap parts, could be traced back to source and eliminated. This particular exercise contributed significantly to the attainment of two consecutive months of zero defects. The tighter control over parts (scrap and otherwise) which developed meant that any unidentified parts were scrapped to be later analysed. Gradually the housekeeping of the Cell improved until it reached a very high level and this, together with improvements in system generally on the cell gave it a reputation as one of the most efficient in the factory. The increases in the LPI achieved reflected this (see Section 18).

The overall scrap level for the cell, however, was reduced only by a small amount since the vast majority of the scrap was generated by the Press Shop. The fact that only a small proportion of the scrap produced was passed on to the Fabrication and Assembly areas (to be later detected there)
can be attributed to the general vigilance of the Quality Control Technician and Press Operators (although they often spotted problems when the tool had been running for some time and often it was Fabrication Operators who alerted others to problems). A further tray was therefore produced for use in the Press Area although the results from this began to appear after the data cut off point of Stage II.

(ii) Projection Welding of the nut to the DVC Bracket.

The peak which appears on the Reject/Time (Figure K6) graph at Week 58 was due to a problem with the above process. A fault with the electrode on the projection welder had caused excess spatter to be produced during the welding operation. This spatter had worked its way into the thread of the nut. When the completed seat is fitted into the car the seat is bolted to the floor pan using the DVC bracket by screwing a bolt through the DVC nut. Consequently spatter in the thread led to difficulties for the customer in assembling the seat into the car. Several dozen examples had been discovered by the customer when the alarm was raised at Dunlop Cox. While the fault was not a safety critical one the fact that it had escaped detection and had been passed on to the customer meant that it was treated very seriously.

Immediately the fault was discovered and reported (by the customer) a thread gauge was placed at the operation and a 100% check instigated. All WIP and stock was also checked (this is standard procedure in such a situation). The Cell Technician identified the source of the problem and replaced the worn electrode. Within two days a maintenance procedure had been initiated to prevent the continued use of over worn electrodes in the future. Once confidence in the process had been restored then the 100% check was reduced to once per hour. The problem never recurred.

This is just one example of immediate action to solve a problem.
which was not driven by the graph but by urgency to solve the problem and maintain supply. However, the fact that the information relating to the incident was recorded in detail is due to the activities of the RG. Thus a historical record is built up which can be used in the future as and when required.

It may also be argued that, while the graph itself did not drive the action, the data recorded on it did, albeit before it was recorded. Thus it should be appreciated that while the graphs are the visual representation of the system and the measures and while they serve to communicate, motivate and direct activity, it is the information behind them which is quintessential and drives the system.

(iii) DVC Nut Welding: Process Rationalisation and Redesign.

During the period of time when attention was focused on the DVC Nut Welding operation three members decided to investigate whether, through process redesign, the efficiency of the operation could be increased. The basic idea was to tie the welding and riveting operations together (originally these were discrete and sequential operations). Through redesign it was thought that one man could be freed up from the area. This would have two benefits;

(i) The efficiency of the stage and so the cell would be increased.
(ii) The change would contribute to the time available on a daily basis to carry out Multi-Skilling and other improvement activities.

The RG agreed that a three man team would be sufficient to carry out the work. Considerations had to be made regarding service requirements, costs (which had to be minimal) and safety requirements (the company Health and Safety Officer was consulted at the appropriate time). The plan which was
drawn up by the team and which details aspects of the current and the new layouts including timings appears as Appendix M.

(iv) Press/Fabrication Kanban.

A major project which was identified in the early stages of the RG was the need for a kanban system operating between the press and fabrication areas on the cell. Many of the problems associated with poor communication, less than perfect quality and efficiency in general would, it was felt, be remedied by such a system. The basis of the plan involved the use of a one card kanban system where a rack positioned at the end of a siding dedicated to holding a particular part would receive a kanban once it was removed from the full plastic box drawn by the fabrication area. The number of cards in all the racks would provide a guide for the press operators as to the optimum sequence of parts production at any one time. During Stage II the advanced planning stage was reached but no physical moves were made until after the Stage II cut off period. However, the action of planning the new system served (as in every other activity) to improve communication and understanding throughout the cell and so, to a large extent, achieve the goals associated with the physical completion and operation of the system.

While the kanban system was being planned other areas of activity associated with the press area were also underway. The introduction of Single Minute Exchange of Die (SMED), for example, was an inherent part of the cell development. It was recognised as means of aiding WIP reduction and shortening production runs from the excessive levels of the time and, therefore, as a support activity to the kanban development. Increasing Multi-Skilling in the press area enabling more operators to move around freely to where the work was, similarly, beginning to shift the culture of the area in a way which would make the introduction of kanban as painless as possible.
Appreciation of such cause and effect relationships and the sometimes abstract interdependencies between and within various parts of the cell grew within the RG over time so that the quality and validity of kaizen activities improved as a function of the shifting culture of the cell.

Through the activities outlined above, together with the innumerable smaller projects, the general performance of the cell improved rapidly. The rate of increase in the LPI, for example, was in excess of the physical completion of projects or even their planning. The involvement and autonomy felt by the RG together with the team building which took place constantly, formally and otherwise, meant that a sense of common purpose developed, guided by the new measures, and the energies of the cell began to be channelled in a constructive and productive way.

The following section outlines the changes in cell performance over Stage II with reference to specific measures.

(18) Changes in the Performance of the Nissan 936 Cell.

The pattern of performance relating to the New Group Measures has been discussed in Section 16.5.1 and repetition here is not necessary. However, analysis of performance relative to other existing and new imposed measures, and the LPI in particular, is important.

(18.1) Labour Efficiency Indicator (LPI).

The degree to which the activities on the cell and within the RG could be reflected in the LPI is a point identified in the hypotheses.

Over the first fifteen weeks of Stage II (Weeks 41 to 56 inclusive) the mean LPI for the cell increased from a mean for Stage I (Weeks 1 to 40) of
70.8% to 77%. In addition the LPI had exceeded 80% (a company wide target achieved only once before by the cell) on five consecutive weeks during that period (Weeks 52 - 56: 81, 80, 87, 89, 83 respectively). This meant that the cell achieved a mean of over 80% for the month.

However, from this point onwards LPI achievement declined (Figure G2) and the mean for all Stage II was 72.8%. The range of values achieved from Week 61 onwards resembles closely that achieved during Stage I. The reason behind this reversion may be related to a change in Cell Leader at Week 56. After this point the amount of time allocated to the RG for kaizen activities (especially Multi-Skilling) was reduced and this falling level of activity correlates with the period of erratic LPI achievement. Figure 22 below illustrates this.

Figure 22: The Relationship between Cell LPI (Including Kaizen Hours) and Percentage of Total Hours Booked to Kaizen for the Nissan 936 Cell for Weeks 41 to 80 Inclusive.

CORRELATION COEFFICIENT = 0.65

As can be seen the Correlation Coefficient in this relationship is 0.65 which suggests a positive relationship between the number of hours spent engaged in kaizen activity and the LPI achieved. The fact that the LPI values used for the above graph were themselves calculated with kaizen hours left in the total hours for each week and not booked out means that the relationship is
uncomplicated by the fact that merely booking hours out to kaizen can, in reality, artificially inflate the LPI for any particular week.

(18.2) Absenteeism.

Little in terms of trends can be deciphered from the value of Absenteeism during Stage II. Levels are, generally, very low considering the relatively small number of people included in the data. The mean for the period is 1% which compares with a company wide goal of 3% maximum. A continuing low absenteeism reflects a good level of morale and job satisfaction and while the data offers no further detail, the Attitudinal and Group Analysis Questionnaires together with historical information relating to RG development indicate improving conditions and, therefore, decreasing likelihood of anything other than minimal levels of absenteeism.

(18.3) Cost of Consumables.

The Cost of Consumables recorded during Stage II as part of the New Imposed Measures show a steep increase up to Week 52 followed by a more gradual increase and finally stabilisation. The factors behind this are unclear. The trend cannot be related to kaizen activity since a separate kaizen budget held by each of the two Production Managers was used for improvement costs.

(18.4) Cost of Accidents.

This measure shows no trend and again, the factors giving rise to the values are poorly understood. Clearly a poorly run cell with inadequate housekeeping and insufficient health and safety standards would present a greater risk to employees. This, however, is not the case within the N936 cell and the individual peaks are directly attributable to individual occurrences on the cell.
Changes in the Performance of the Nissan 909 Cell.

The kaizen activities which were carried out on the Nissan 909 Cell during Stage II reflected the areas of weakness listed in Section 11.1.2. The pattern of improvement activity followed a similar pattern as elsewhere in the factory. The group was led through each activity with much of the detailed planning remaining the responsibility of the Cell Leader and his Deputies. The scope of activity was limited by this to dealing with obvious and visible physical problems rather than tackling more fundamental ones. Examples of projects undertaken are:

- Re-layout of the CADAR gauging area
- Erection of a new parts identification board
- Planning of a Press/Fabrication Kanban System
- Development of improved spot welding fixtures.

While some activities may be broadly categorised with activities taking place on the N936 Cell the characteristics and detail do not compare. The levels of motivation and commitment to improve, the degree of understanding of customer requirements and system interactions and the development of teamwork to solve problems were infinitely greater within the RG. These points are borne out in the Final Cell Attitudinal Questionnaire (Section 20).

The increased differential in the culture of the two cells brought about by the development of the new performance measurement system is further demonstrated by the comparative performances of the two cells. Particular reference is again made to the LPI being the focus of the existing system with other measures mentioned with reference to the RG.
(19.1) Labour Efficiency Indicator (LPI).

Throughout Stage II the LPI of the cell displays erratic characteristics with no clear pattern emerging. The lack of any correlation of data quantifies this. Unlike the N936 data, there is no improvement with continuing kaizen activity and the range of values achieved is far greater than that for the N936 cell (34% for N909, 27% for N936).

It should be appreciated that the N909 cell was beset with some major problems (as mentioned previously) and that some of these affected production severely at times. However, the fact that over a period of forty weeks there was no noticeable improvement in the LPI (as there was with N936), gives a measure of the impotence of the kaizen taking place on the cell.

(19.2) Absenteeism.

As with the RG data the levels of Absenteeism within the CG present no obvious trend. However, unlike the RG data the mean for Stage II is well above the Company target for several weeks and the overall mean is only slightly lower at 2.6%.

The degree of morale on the cell is again illuminated further by the Final Cell Attitudinal Questionnaire.

(19.3) Other Existing and New Imposed Measures.

In broad terms the N909 cell showed little improvement in any measurement category during Stage II and the nature of the LPI during the period is, therefore, expected. The production problems, tackled on a day to day basis, precludes the longer term view provided by the measures of the RG.

As stated previously, there is no correlation between any of the measures acting on the N909 Cell. However, the main purpose of the CG
which was for comparison with the RG in the testing of the method of difference (If not X then not Y) and in this respect analysis is possible.

(20) Final Cell Attitudinal Questionnaire.

The second attitudinal questionnaire serves to compare the attitudes, morale and understanding of operators regarding the performance measurement system within the company. The questionnaire is identical to the first and was issued during Week 75. Clearly the answers given by members of the RG will be coloured by their experience of their own system as well as the existing and new imposed measures. Respondents from the CG will be affected by their experience of the existing and new imposed measures. In order to reflect this and aid direct comparison four answers are given to each question; one for the equivalent answer in the first questionnaire (F), one for the response of the Research Group (RG), one for the response of the Control Group (CG) and one for the other 17 respondents not aligned to either group (X).

(1) The main Performance Measure in the Company is the LPI.

How important is the LPI of the Cell to you?

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<th>F</th>
<th>RG</th>
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<tbody>
<tr>
<td>(a)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>(b)</td>
<td>50%</td>
<td>90%</td>
<td>65%</td>
<td>40%</td>
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<tr>
<td>(c)</td>
<td>50%</td>
<td>10%</td>
<td>35%</td>
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</table>
(2) From the LPI the Bonus is calculated, how important is the Bonus to you?

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<th>X</th>
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<tbody>
<tr>
<td>(a) Not important at all</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>(b) Quite important</td>
<td>50%</td>
<td>90%</td>
<td>65%</td>
<td>40%</td>
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<tr>
<td>(c) Very important</td>
<td>50%</td>
<td>10%</td>
<td>35%</td>
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(3) How important do you think the Cell LPI is for the Company?

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<th>X</th>
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<tbody>
<tr>
<td>(a) Not important at all</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>(b) Quite important</td>
<td>50%</td>
<td>30%</td>
<td>50%</td>
<td>45%</td>
</tr>
<tr>
<td>(c) Very important</td>
<td>50%</td>
<td>70%</td>
<td>50%</td>
<td>55%</td>
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(4) If your answer to (3) is (b) or (c), do you understand why the LPI is important to the Company?

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<tbody>
<tr>
<td>(a) Yes</td>
<td>83%</td>
<td>100%</td>
<td>90%</td>
<td>80%</td>
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<tr>
<td>(b) No</td>
<td>17%</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
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(5) Do you understand how the LPI is calculated?

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<tbody>
<tr>
<td>(a) Not at all</td>
<td>43%</td>
<td>0%</td>
<td>45%</td>
<td>40%</td>
</tr>
<tr>
<td>(b) A little</td>
<td>29%</td>
<td>20%</td>
<td>25%</td>
<td>35%</td>
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<tr>
<td>(c) Exactly</td>
<td>29%</td>
<td>80%</td>
<td>30%</td>
<td>25%</td>
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(6) If your answer to (5) is (a) or (b), would you like to understand it better?

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<tr>
<td>(a)</td>
<td>Yes</td>
<td>100%</td>
<td>100%</td>
<td>95%</td>
</tr>
<tr>
<td>(b)</td>
<td>No</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
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(7) Do you understand how the Bonus is calculated from the LPI?

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<tbody>
<tr>
<td>(a)</td>
<td>Not at all</td>
<td>43%</td>
<td>0%</td>
<td>30%</td>
</tr>
<tr>
<td>(b)</td>
<td>A little</td>
<td>57%</td>
<td>20%</td>
<td>65%</td>
</tr>
<tr>
<td>(c)</td>
<td>Exactly</td>
<td>0%</td>
<td>80%</td>
<td>5%</td>
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(8) If your answer to (7) is (a) or (b), would you like to understand it better?

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<tr>
<td>(a)</td>
<td>Yes</td>
<td>100%</td>
<td>100%</td>
<td>90%</td>
</tr>
<tr>
<td>(b)</td>
<td>No</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
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(N.B. For questions requiring a written response only the RG and CG answers are summarised.)

(9) The LPI is really a measure of Productivity and Efficiency. Are there any other measures of Performance which you think may be important to the Company?

RG

As above

(10) Are any of the measures which you have written down of any importance to you?

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<tr>
<td>(a)</td>
<td>Yes</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td>(b)</td>
<td>No</td>
<td>0%</td>
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(11) If your answer to (10) is Yes then write down which are important to you and why.

RG

We have to improve all the time if we are going to keep our customer happy. On the cell it is important that everyone knows what the customer wants so that we are all aiming for the same things. Our new measures give tell us where our performance needs improving and they make everyone aware of what is happening. By using our measures we have improved our LPI by increasing communication and teamwork.

CG

Kaizen can help to make life easier for us and to solve problems for our customer. We need to improve in these areas and by kanban systems so that the fabrication area can keep working.
(12) How do you think the other Performance Measures which you have written down may affect the LPI of the Cell?

RG
*By constantly improving in the areas that we measure the LPI will gradually improve. It may take a long time but the increase in bonus will last for longer. But if we stop doing kaizen then the bonus will fall again.*

CG
*We will only get more bonus if we make more slides with less men. We can't lose any more men with the problems that we've got and if we can't make more slides either then we won't get any more bonus. Kaizen on a Saturday morning is O.K. for those that get asked in but we don't get bonus anyway - so what's the point.*

(13) What Performance Measures do you think are important to Customers of the Company?

RG
*Complete Deliveries, Quality of parts, Right amount of parts, Competitive cost, Flexibility to alter build.*

CG
*Quality, Deliveries on time, the right price.*
(14) Do you think that the Bonus Scheme is a fair one?

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<tr>
<td>(a) Yes</td>
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<tr>
<td>(b) No</td>
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(15) If your answer to (14) is No, how could it be made fairer?

RG

*By making Nissan (936) a separate cell so that we get the credit for what we've done.*

CG

*By getting rid of it and paying an individual bonus like before.*

(16) Do you think that the LPI of the Cell is the best measure of overall Performance of the Cell?

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<tr>
<td>(a) Yes</td>
<td>14%</td>
<td>0%</td>
<td>10%</td>
<td>15%</td>
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<tr>
<td>(b) Not sure</td>
<td>29%</td>
<td>30%</td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>(c) No</td>
<td>57%</td>
<td>70%</td>
<td>60%</td>
<td>50%</td>
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(17) If your answer to (16) is No, please explain your answer.

RG

*The PI is not relevant to what the Customer wants. The Customer doesn't care whether we earn bonus or not so we should be measured on what is important to the Customer.*
If you improve things on the cell then the PI improves as well but most Cell Leaders just concentrate on the PI and so you might get bonus one week but not the next and the things important things to the Customer don't improve either. You can get a good PI but have loads of rejects or scrap in the same week.

CG

Because other cells have much easier work and less to do than we do so they don't have to work very hard to get loads of bonus. We have loads of quality and press problems and so we never will earn any bonus. The only people who get any extra are those who do kaizen on a Saturday morning, and it's always the same ones who get asked in.

(18) Do you think that the priorities of Cell Leaders are the same as yours as far as the job is concerned or not?

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<tbody>
<tr>
<td>(a) Priorities the same</td>
<td>66%</td>
<td>30%</td>
<td>70%</td>
<td>68%</td>
</tr>
<tr>
<td>(b) Priorities different</td>
<td>33%</td>
<td>70%</td>
<td>30%</td>
<td>32%</td>
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(19) If your answer to (18) is (b) then please explain why you think there is a difference:

RG

When we started our new team and started measuring our performance the Cell Leader wanted the same things we did but when our Cell Leader changed he wasn't so keen on kaizen
and didn't give us the time for the kaizen that we wanted to do. We don't get any time for training or any time off the lines, he says we'll get more bonus this way but we're getting less. We want to make the cell better and improve the PI that way but our Cell Leader just thinks about what the bonus will be for each day.

CG

No responses given.

(20.1) Final Attitudinal Questionnaire Results Analysis.

The responses to the second attitudinal questionnaire serve as a valuable comparison between the RG and CG and also give an indication of shifts in attitude and behaviour since the start of Stage II. The response to the questionnaire can be summarised as follows (Groups appear in order of magnitude of change in response pattern in each case);

- Importance of LPI to the respondent.
  
  RG; A marked decrease in importance but retaining at least some importance to everyone.
  
  CG; Slight decrease in importance, less pronounced than for RG
  
  X; Marginal increase in importance.

- Importance of Bonus to the respondent.

  As above.
- Importance of LPI to the Company.
  RG; A general increase in importance.
  X; Marginal increase in importance.
  CG; No change from Initial Questionnaire.

- Level of understanding of importance of LPI to the Company.
  RG; Marked increase in understanding (100% now understand).
  CG; Small increase in understanding.
  X; Negligible shift away from understanding.

- Level of understanding of how the LPI is calculated.
  RG; Marked increase in understanding.
  X; Minimal increase in understanding.
  CG; Negligible decrease in understanding.

- Desire to understand better the LPI calculation.
  CG; Small decrease (5% have no desire).
  RG; No change from Initial Questionnaire (100% desire).
  X; No change from Initial Questionnaire (100% desire).

- Level of understanding of how the Bonus is calculated from the LPI.
  RG; Marked increase in understanding (100% understand partially or completely).
  CG; Marginal increase in understanding.
  X; Negligible increase in understanding.

- Desire to understand the LPI to Bonus calculation better.
  CG; Small decrease (5% have no desire)
RG; No change from Initial Questionnaire (100% desire).

X; No change from Initial Questionnaire (100% desire).

(N.B. From this point only RG and CG responses are summarised since subsequent questions relate directly to the these groups only).

- Other measures of performance which are important to the Company.

RG
Listed their chosen Performance Measures.

CG
Using slightly different terminology from the RG the CG listed very similar measures.

- Importance to the respondent of measures identified above.

RG; No change from Initial Questionnaire (100% important).
CG; No change from Initial Questionnaire (100% important).

- Reasons for importance to the respondent of measures identified above.

RG; Stresses the importance of teamwork, shared objectives and meeting the needs of the Customer through continual improvement.

CG; Focus is on finding the solution to internal problems so that the effects of these problems are not passed on to the Customer.
- Opinions regarding the effects on the LPI of the cell of focusing attention on the measures identified above.

RG; Identifies the need to improve areas measured in order to achieve fundamental and lasting improvement in the LPI over a long period of time.

CG; Concentrates on the need to produce more standard hours using fewer man hours to increase LPI. Argues that labour must be retained in order to compensate for problems and meet build schedule and that an inability to increase productivity means that LPI improvement is not achievable. No recognition of any causal relationship between kaizen and long term efficiency improvement.

- Degree of Customer knowledge.

RG; Comprehensive appreciation of Customer needs.

CG; Valid appreciation of Customer needs focussed on Quality, Time and Cost. A less comprehensive list than the RG.

- Perceived 'fairness' of the existing Bonus Scheme.

RG; Same response as for Initial Questionnaire (100% unfair).

CG; Same response as for Initial Questionnaire (100% unfair).
- Ideas of how to make the existing scheme fairer.

  RG; Identifies a need for Group recognition.
  CG; Identifies a need for Individual recognition.

- Measure of suitability of the LPI as the best measure of overall performance.

  RG; Definite shift away from the LPI as the best measure.
  CG; Definite shift away from the LPI as the best measure.

- Explanation of the above response.

  RG; Stresses the lack of relevance of the LPI to Customer requirements. Identifies the myopic behaviour of some Cell Leaders in the pursuit of increased short term LPI at the expense of Customer requirements.
  CG; Stresses the disparity of Start Point between cells which means that the amount of effort put in by the cell members is not reflected in the LPI. Argues that inequality between cells in terms of quality problems and delivery pressure, for example, is not reflected in the LPI calculation.

- Degree of Goal Congruence between Operators and Cell Leaders.

  RG; A marked fall in perceived Goal Congruence since the Initial Questionnaire.
  CG; Perceived Goal Congruence almost unchanged since Initial Questionnaire.
• Explanation of above response.

RG; Describes the new measures as focusing everyone on improvements in line with stated goals achieved through kaizen and with the support of the first Cell Leader. Identifies a change in Cell Leader to one less committed to the new measures and to kaizen and more focused on short term LPI improvement with a marked fall in perceived Goal Congruence.

CG; No response.

The salient points arising from the second questionnaire illustrate the effects on understanding of the existing system, continuous improvement, customer focus and morale and culture which the new measures had on the Research Group. This is especially true when compared with the parallel progress of the Control Group. Discussion relates to the existing measurement system, any alternative measures and any attitude or culture change throughout the course of Stage II.

(20.2) Final Attitudinal Questionnaire Discussion and Conclusions.

A significant finding of the above questionnaire was that the importance of the LPI and the Bonus to individuals within the RG and CG fell during the course of Stage II. The change in attitude of the RG was particularly marked. However, an understanding of this shift is only brought about through consideration of other, related, results. For example, the increase in perceived importance to the Company of the LPI within the RG appears to contradict the previous result. This apparent variance can be explained with reference to the degree of understanding of the existing measures exhibited by each of the groups. The marked increase in
understanding on the part of the RG supported by later comments which place the existing measures in the context of the cell and the customer serve to clarify the situation.

Through the learning process which the RG experienced and which has been described earlier, there developed an appreciation of the fact that while the LPI does reflect the general state of the cell it is directly relevant to neither the internal workings of the cell nor the requirements of the customer. In addition, through involvement in the activities of the RG it may be argued that the motivation of respondents not only increased but was brought about, increasingly, through those activities and less by the LPI and the promise of Bonus payments. However, because of the activities of the RG the LPI did increase, rapidly in the early stages, and so the relationship is, at this stage, not clear cut. The Research Group Analysis Questionnaire (Section 21) seeks to clarify this point. The decrease in the importance of the LPI to the CG is far less in magnitude than that of the RG and the results of the questionnaire suggest that the reasons behind it are different. The general failure of the CG to achieve regular Bonus payments coupled with the quality and production problems appears to have led to a feeling of apathy within the Group regarding the LPI. The opinion that the problems on the cell are beyond the control of the CG and, indeed, the Cell Leader, appears to be predominant. As a consequence the importance of the LPI falls as it appears to be increasingly unattainable. The CG does not benefit from the enhanced education and understanding of the system which the RG develops over time and which may arguably have provided some direction and motivation for the group. The fact that the RG was so much more successful when measured in relation to the existing measures and compared with the CG adds weight to this argument. However, as already stated, the morale and the general operation of the N936 cell was in a more favourable state at the beginning of Stage II than was that of the N909 cell. Despite the
fact that the N909 cell had further to go than the N936 cell, however, it seems unlikely, given the magnitude of the RG successes, that this was a deciding factor in the creating the differential. While the problems of the N909 cell were generally greater than those of the N936 cell during the research period the lack of the ability or will to improve the LPI through fundamental analysis and attacking of the underlying problems, which would certainly have improved the situation to a point where only technical problems remained, serves to further differentiate the historical progress of the two cells (this is based on the direct experience of the researcher and there is no data to prove or disprove the assumption).

The effect of the New Imposed Measures on the behaviour of both groups appears to be negligible. In the case of neither group did the statistical analysis reveal any trend or interrelationships between measures and the lack of reference to them in the questionnaire gives the indication that they in no way drove the kaizen on either cell. The RG appears to have been driven primarily by their new measures and the CG by the LPI initially with it's declining influence being replaced by only individual and insular factors.

The attitudes towards kaizen on the two cells are also diametrically opposed with the commitment and enthusiasm of the RG increasing, at least over the first half of Stage II and the CG becoming increasingly sceptical about the concept. The appreciation of kaizen within the CG appears to be limited to the possibility of work on a Saturday morning and the extra overtime that this represents. This is in marked contrast to the balanced and considered view of the RG.

The question of changes in levels of goal congruence within the two groups provides an interesting comparison. In the case of the CG there appears to have been very little change in the perceived goal congruence over the period of the research. The lack of information giving reasons for
this makes factual analysis impossible. In the case of the RG, however, there is a definite deterioration in levels of perceived goal congruence. At face value this contradicts all preceding findings. However, the explanation which follows reinforces a previous conclusion reached regarding the progress of the RG following a change in Cell Leader (Section 18). The reduction in the time allocated for kaizen by the new Cell Leader together with the relative indifference to the new measures and their uses combined to reverse much of the progress made in terms of culture change during the first half of Stage II. As has already been shown, the falling number of man hours spent involved with kaizen activity correlates with a fall in the LPI of the cell and with a stagnation in measures such as Multi-Skilling (considered so central by the RG) and a decline in the importance of the measures generally on the cell. Anecdotal evidence suggests that while the information collection and recording continued up to and after the end of Stage II the fact that the information ceased to drive activity in the same way as previously meant that commitment to the new system and the group began to falter. The LPI became again the primary focus of the cell (through the Cell Leader) with the ramifications described in Stage I returning. The Questionnaire identifies the fact that the levels of goal congruence increased significantly in the early stages while the new measures directed and focused the cell but then deteriorated to a level below that defined at the beginning of Stage II as the new system deteriorated into a mere information gathering process.

Despite the fall off in kaizen activity and the general deterioration of the cell which occurred after the departure of the first Cell Leader, collection and recording of the data continued. After a period of time only three of the original group continued with the system although their commitment to the principals remained firm. Their continued activity in the face of apparent indifference on the part of other Operators and cell
supervision bears witness to their motivation and understanding of the
importance of the measures. In addition this obviates any argument that the
increased motivation within the cell was due wholly to a Hawthorne Effect
[80], although in the case of members who ceased activity this may,
obviously have been a contributory factor. This issue is covered in Section
23.

Most notable, however, was the development of new measures and
the detailed analysis of their own historical data which took place towards
and after the end of Stage II. This work is detailed in Section 22.

(21) Research Group Analysis Questionnaire.

A central element of this research are the behavioural implications
involved in the development of system such as the one described compared
to those of the existing, traditional, system. Also, as mentioned previously,
the Cell Leader was also the Researcher and, therefore, particular attention
had to be given to maintaining objectivity of approach. To these ends the
following questionnaire was devised to allow the members of the RG to
describe their feelings about and experience of their group, their measures,
kaizen and the way in which the Cell Leader had guided them through the
process. The questionnaire is of the Semantic Differential type. The results
are summerised in the same style below. The cross on each line represents
the mean response position for each question. After the Questionnaires had
been completed and returned the results were fed back to the respondents in
order to cross check the responses. The results are self explanatory.
However, in some cases further comment is required and such questions are
numbered 1,2 etc.
(1) The current Performance Measurement System in the Bonus System

Do you think that this system is:

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<tr>
<th>Fair</th>
<th>Unfair</th>
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<table>
<thead>
<tr>
<th>Easy to Understand</th>
<th>Hard to Understand</th>
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<th>Relevant to your Customer</th>
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<th>Relevant to Kaizen</th>
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<th>Achievable through your own efforts</th>
<th>Not achievable through your own efforts</th>
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(2) This question is trying to find out what effect, if any, the views and ideas of the Cell Leader had on the Team and its behaviour and what you think of the new System and the way it was created.

2

<table>
<thead>
<tr>
<th>C/L had pre-set</th>
<th>C/L had no pre-set ideas</th>
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<table>
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<tr>
<th>C/L had no ideas of what he wanted</th>
<th>C/L had no pre-set ideas</th>
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</table>
C/L ideas were stuck to from the start.

The whole Team worked together in the planning.

Team was totally committed right from the start.

Team got more committed as time went on.

You feel you own the System.

New System drives Kaizen.

C/L ideas were totally ignored by the Team.

One or two people made all the decisions.

Team never really wanted to do it.

Level of commitment never altered.

You feel no ownership at all.

System has no effect on kaizen.
Graphs motivate the Team

Graphs do not motivate

4

Graphs are the most important thing you do at work

Graphs are a pain in the neck

Since you started the Graphs the Bonus doesn't matter to you

The Bonus matters more than ever

The System is not affected no matter what C/L you have

The System is greatly affected by a change in C/L

5

The more Kaizen you do the less you think about the Bonus

The more Kaizen you do the more you think about the Bonus

The C/L made the whole thing happen

The Team made the whole thing happen
We want to develop new measures just as we are.

We owe it to ourselves to carry our C/L to carry on.

Good Kaizen helps us to earn Bonus. Kalzen does not help to earn Bonus.

C/L made fewer decisions as time went on.

(3) Imagine if the Bonus were paid according to your performance criteria e.g. scrap, multi-skilling etc. Do you think that such a system would be:

(Answers to Question 1 are marked (Y) for direct comparison)

Fair

Unfair

Easy to Understand

Difficult to Understand
Additional Comments

1: The response to the question reflects the response to a similar question in the Cell Attitudinal Questionnaires which illustrates an increase in the degree of understanding of the existing system on the part of the Research Group as a result of their activities. The result is a level of understanding of the existing system which is in excess of both Control Group members and others.

2: The mean response to the question relating to the perceived extent of Cell Leader preconception illustrates the controlled and objective role which the Cell Leader followed in guiding and educating the RG, especially in the early days of Stage II. This is discussed more fully in Section 26.

3: As with the previous point, the question relating to adherence to the ideas and ideals of the Cell Leader illustrates the fact that the
facilitative nature of the Researcher's approach meant that the Group felt a degree of ownership of the system and the principals behind it. But also that the ideas which the Researcher had were clearly an influencing factor (discussed further in Section 23).

As mentioned previously, the graphs were considered to be of great importance by the Group. However, there can be no doubt that, as time went on, the daily routine of data collection and recording, especially at the end of a busy shift, was at times a chore. Especially as the numbers directly involved began to decline. This is reflected in the response to this question. However, data collection was carried out religiously until the end of Stage II and beyond.

The response to the question regarding any shift in attention away from kaizen and towards the Bonus with increasing levels of kaizen activity appears, on first sight, to represent divided opinion within the Group. However, on feeding back the responses to the Group it appeared that the question had been interpreted in two different ways.

In the first case some respondents interpreted the question as it appears i.e. is attention focused more on kaizen and less on the Bonus as kaizen activity increases or vice versa. In this case all affected respondents decided that this was indeed the case.

The remainder of the respondents interpreted the question to be one relating increased kaizen activity with resultant increased Bonus payments. Therefore, a respondent marking the line to indicate that the more kaizen is carried out the more the Bonus is considered was demonstrating that the Bonus acts as a spur to drive kaizen once it is accepted and demonstrated that improvements increase long term Bonus payments i.e. one is always looking for improvements
to make with a view to increasing the Bonus. This is an important point since it demonstrates that the Bonus (and so the LPI) is a driver of continuous improvement - but only, it would appear, in the context of the RG culture.

The following Section deals with the activity of the Research Group towards the end of, and after, Stage II.

(22) **Further Research Group and Measurement Developments.**

As has been mentioned previously, particularly in the Final Attitudinal Questionnaire, there was a distinct decline in the degree of kaizen activity taking place on the N936 cell following the departure of the first Cell Leader. As a consequence the focus on the new measures and on the activities of the RG in general also declined to such an extent that only the three core members continued with the data collection and recording. The graphs, therefore ceased to drive kaizen in the way that they had previously (see Sections 18 and 20).

However, activity did continue. The Daily Data Collection Sheets, for example, were redesigned by one member to make the data collection process more efficient (Appendix N). Also, in line with the stated objective to develop new measures, (Research Group Analysis Questionnaire), the three core members began, at around Week 75, to examine the wealth of data which they had collected over the previous thirty weeks. The reasons for doing this were two fold;

(i) It had always been the understanding of the Group that the new measures as they had been initially defined were just that, initial definitions. The need to review the measures in terms of applicability,
ease of use, effectiveness etc. was understood from the start. However, it was not until Week 75 that a sufficient volume of historical data had been collected to allow for meaningful re-appraisal of the measures. Previous to this only informal discussion of the measures had taken place and while the need for change was apparent, the details were unclear.

(ii) As detailed in Section 16 analysis of the historical data at Week 80 showed no correlation between any of the new measures. As early as Week 60, however, it became apparent that direct cause and effect relationships between the measures, if they existed, were not being illustrated by the measures as they had been defined. The RG had suggested early (Section 12.2) that causal relationships did exist at some level between the measures which they had identified and, at the macro level, this was borne out by general improvements in the new measures resulting in a rapid increase in the LPI of the cell. The measures had succeeded in driving kaizen activities (Section 17) but only as far as individual measures were concerned. What was required, therefore, was a more detailed dissection of the measures chosen with the aim of exposing the causal relationships which the Group believed to be there.

As described previously (Section 16.5.1) a disturbing trend among the measures was the increasing and wildly fluctuating values for Tool/Plant Downtime. This had always been considered a vital measure for the cell since the practical implications of downtime of any sort were, frequently, very disruptive to the operation of the cell. As can be seen from Figure K4 Tool/Plant Downtime after Week 56 displayed the characteristics of being a
measure out of control.

Because of these factors the three core members decided to analyse the data which had been collected for this category over the previous thirty weeks.

In addition to the overall percentage value which had been recorded weekly on the graphs there was also a mass of information which had been collected from the Maintenance board and Tool Room records which gave details of individual tooling and equipment faults and had been collated and summarised to give the overall weekly value (Section 12.5.1). This raw data, it was envisaged, may provide a more precise insight into the characteristics of the waste area than had the broad brush approach of the existing measure definition.

(22.1) Tool and Plant Downtime Detailed Analysis.

An initial read through the records of the measure appeared to indicate that the largest category of downtime was that of Power Presses. The data was examined and the various elements of downtime ranked in order to verify this initial conclusion. The elements in this Pareto Analysis were Tool Downtime, Press Downtime and Other Plant Downtime. The result is seen in Figure 23 below.

The information sources for the historical appraisal of Press Downtime were:

(i) The Tool/Plant Downtime Graph
(ii) Tool/Plant Downtime Data Collection Sheets (Weeks 41-75inc.)
It should be noted that the value of 42% for Tool Downtime may be artificially high since the times used in the recording of data were lengths of total time spent by each tool in the Tool Room. This is not necessarily, the same time as the period actually spent working on the tool. Similarly, the values for Press and Other Plant Downtime are those times from the report time to the job finish time and do not necessarily reflect the length of time required to rectify the breakdown in each case. However, these two points combined mean that the relative percentages for each category can be assumed to be of sufficient accuracy for the purpose.

(22.1.1) Detailed Power Press Downtime Analysis.

The Pareto Analysis carried out by the core members confirmed their initial findings and they resolved to concentrate on Power Press Downtime. Their re-examination of the data involved allotting downtime to various Presses according to the information which had been recorded on the daily data collection sheets. In this way a matrix showing the total downtime for each press and categorised by fault was drawn up. This information was
then translated into graphical form. Three tiers of detail were developed from the data:

(i) Press versus Total Downtime for all Presses.
(ii) Fault versus Total Downtime for all Presses.
(iii) Fault versus Downtime for the worst Press as identified in (i).

The results are shown below.

Figure 24: Total Power Press Downtime by Press in descending order of utilisation for all products and the Nissan 936 Cell for Weeks 41 to 75 inclusive.
Through their analysis of the data and the resultant graphs the members were able to observe a number of interesting points, specifically:

**(i) Press versus Total Downtime for all Presses.**

- It appears to be the case that as Press utilisation increases so does downtime both in the case of the N936 data and the total values.
- Downtime related to N936 represents the vast majority of the Total downtime with minimal downtime attributable to times when parts for other products are being produced.

**(ii) Faults versus Total Downtime for all Presses;**

- By far the largest fault category in terms of hours of downtime was 'Oil Leak', closely followed by 'Conveyor Belt' and 'General Electrical'.
However, the values as they appear in Figure 25 require clarification.

'Oil Leak' - Because, once a low oil level or leak has been reported, there is often a considerable time lag before the fault is rectified. Times recorded on the daily sheets represent the total waiting time and not time taken for rectification.

'Conveyor Belt' - On at least two occasions where a damaged conveyor belt stopped the press a replacement belt had to ordered from outside.

(The high cost of such belts precludes their inclusion as a stock item). Actual fitment of a new belt takes between two and three hours only while waiting time can be as much as six times this.

'General Electrical' - On examining the maintenance records in detail the Group found a multitude of minor electrical repairs and maintenance which could not easily be categorised without producing an excessive number of categories. For this reason the General Electrical category was created. Further detail was available, however, should later analysis require it.

- In terms of the number of occurrences of the various fault categories 'Tool Sensing' recurred frequently with 75 occurrences over the 35 week period. However, only 20 hours of downtime are directly attributable to this suggesting that each downtime period in this case was relatively short.

'General Electrical', however, occurred 69 times representing 55 hours of downtime (0.8 hours per mean breakdown).

'Oil Leak' again features with 50 occurrences making it the third most frequent cause of downtime.
Using the data gathered for Figure 24 the Group established that P302 had the greatest amount of downtime for the period and, therefore, was to be the subject of further analysis. Figure 26 below shows the graphical results of this.

**Figure 26: Press Downtime versus Category of Fault with number of Occurrences per Fault for Press P302 for Weeks 41 to 75 inclusive.**

(iii) **Fault versus downtime for the worst Press as identified in (i) - Press P302;**

- As in the case of the Total Downtime figures the data for P302 revealed 'Oil Leak' as being the largest single category with 20 hours of downtime divided between only 5 occurrences (mean: 4 hrs each).
- The second largest category is Tool Sensing at 16 hours over 10 occurrences (mean: 1.6 hrs each) followed by Scrap Removal with 14 hours over 7 occurrences (mean: 2 hrs each).
- There was no downtime attributable to the Conveyor Motors.
- General Electrical again represented a large proportion of the total
downtime with other categories having comparatively minimal effect.

From these results the Group drew the following salient points regarding suitable initial targets for improvement.

(22.1.2) Power Press Downtime - Outline Improvement Plan.

Through the analysis above the core members identified the following features of the existing system as being primary causal factors in the high and fluctuating levels of Plant Downtime illustrated in the new measures;

(i) Poor response time from the Maintenance Department.

The long waiting times which inflated the downtime of presses particularly in the cases of Oil Leak and Conveyor could be reduced in the following ways:

- Ensure 16 hour cover for the Lubrication aspect of the Maintenance service. (This, currently, is not always the case and the ad hoc method of lubricant storage and marshalling means that Maintenance personnel other than those directly concerned with lubrication do not know, or will not find out, the location of a required oil when requested by the Cell).

- Arrange for replacement conveyors or repair kits to be held as stock items by the Maintenance Department (a detailed financial appraisal or Cost of Quality exercise may be required here).

- Poor response times generally have to be addressed by the Maintenance Department.
(ii) Lack of Preventative Maintenance.

Much of the downtime, it was felt, could be reduced or eliminated, through the adoption of a comprehensive preventative maintenance programme in the Press Area and across the Cell. The lubrication problems in particular, which give rise to a large proportion of the downtime, could readily be reduced through a planned lubrication programme in conjunction with the improvements outlined in (i).

The initial pieces of plant to benefit should be the presses with highest utilisation. The data collected suggests that as utilisation increases so does downtime (see Section 22.1.1). Figure 27 below shows that there is indeed a positive correlation between these two factors.

![Figure 27: The Relationship between total Press Uptime and total Press Downtime for the Nissan 936 Cell for weeks 41 to 75 inclusive. CORRELATION COEFFICIENT = 0.68](image)

The members also decided that the maintenance programme should be designed by the Group using analysis of data such as that for P302 and that as much of the routine work as possible should be carried out by cell members. In this way a new 'Press Team' would arise from the activities of
the original Kaizen Team and would be driven by a new set of detailed measures related specifically to Plant Downtime. The measures suggested were:

(i) **Maintenance Response Time**
Applicable to internal (Cell) activity, including Technician repairs, as well as Maintenance Department activities.

(ii) **Plant Downtime (by Press)**
Measurement of the four worst presses at any one time with emphasis shifting once individual presses improved to certain level i.e. through ongoing Pareto Analysis.

(iii) **Mean Tool Changeover Time**
With the emphasis on continual reduction using SMED as a tool to drive the improvements. The reduction of batch sizes and WIP being the underlying goal.

(iv) **Scrap Level**
A detailed daily analysis of all scrap produced in the Press Area with the emphasis on rapid elimination of causes and the implementation of permanent preventative measures (as already in place in the Assembly and Fabrication areas).

(v) **Multi-Skilling**
A greater degree of detail than in the existing measure (which would remain for the whole Cell) and with direct linkage to the other Downtime measures so that all of the learning and development driven by them could be immediately incorporated into the collective
knowledge and culture of the Press Area and the Cell.

This is the stage of development which the Research Group reached by Week 80 and the end of Stage II of the research. The process which the RG went through over the second forty weeks and the problems and successes which they had experienced serve to test the hypotheses on which this research is based. A summary of the research and the salient findings is therefore applicable at this point. This summary will form the basis for the proposal of a framework and outline methodology for the development of a cell-based performance measurement system intended to drive improvement activities in similar situations as that found at Dunlop Cox Ltd.
Summary of Research.

This summary will briefly review the key findings of Stage I of the research followed by a review and discussion of the hypotheses postulated and tested in Stage II. The salient points of this discussion will then form the basis of a framework for the implementation of a cell-based performance measurement system applicable to a Just In Time, high volume, small batch environment such as that at Dunlop Cox.

(23.1) Review of Stage I.

Detailed analysis of the objectives and findings of Stage I is not necessary here; a summary may be found in Section 8. The following points, however, which arose from Stage I, describe the salient characteristics of the existing system as they impinge upon the behaviour of those production personnel questioned as well as the quantitative reality of the situation.

- There are five performance drivers at work under the existing system as identified by the Production Manager and confirmed by the Production Director. In order of importance these are:

  - Cell Audit Value. (Most Important)
  - Production vs. Forecast
  - Reject Levels
  - Absenteeism
  - Labour Performance Indicator (Least Important)

The Cell Leaders largely concur with the above with one significant exception. The LPI is considered to be of greatest importance by the Cell Leaders because they believe that the Production Manager also believes it to be the most important. This discrepancy is brought
about because;

(a) The Production Manager believes that the LPI gives an accurate reflection of the general status of the Cell as defined by the other direct measures. Through long term improvement of the other direct measures the derived LPI will also improve. Consequently, the direct measures should be the focus on the cell with the LPI reflecting this.

But, being under pressure from above to maximise the LPI on a short term basis, the short term is the focus of attention when talking to his Cell Leaders on a daily basis. This is reflected not only in short term maximisation of the LPI on the part of the Cell Leaders but also in a fire fighting mentality which effects the culture of the company.

(b) The Cell Leaders, realising that the LPI is the daily focus from above, concentrate on maximising this on a daily or weekly basis. This is achieved through moving labour within or between cells with the aim of producing as many slides as possible with high standard times, maximising machine and labour utilisation and through creative booking of labour hours to kaizen or other 'non productive' activity. This myopic approach leads to sub-optimal management of the cells and, in particular, a neglect of kaizen activity including training etc.

- The Production Manager and Cell Leaders believe there to be marked inter-relationships between all of the drivers identified above. In particular anecdotal evidence suggests correlation between;

(a) LPI
However, statistical analysis of historical data revealed no such correlation. Indeed, only sales and volume as defined by the Production vs. Forecast measure revealed a significant correlation of any kind (positive correlation in this case).

- A key finding of Stage I is that the existing performance measures in no way drive improvement activity on the shop floor and, as a consequence, do not contribute to the stated goal of the Company to become a World Class supplier. The behavioural consequences of the existing system have been shown to directly inhibit kaizen activity and culture change in the organisation.

- Finally, the Cell Operators feel no ownership of the existing system and regard the measures employed, in particular the LPI, as being beyond their influence.

The findings of Stage I, summarised above, provided the ground rules on which to propose any alternative measures and/or system. A detailed understanding of the existing system and the behavioural consequences invoked as a result was clearly required to provide direction and meaning to the experimental Stage II. The characteristics of the existing system established through the statistical analysis could be used as a start point and comparison for any data generated at a later stage. The continued collection and analysis of data relating to the five existing drivers, together with the inclusion of the newly imposed 'world class' measures further supported many of the conclusions reached during Stage I and outlined above.

Finally, the understanding of the forces shaping the characteristics of
the cells and their management coupled with the critical role of the shop
floor in shaping a World Class company served as the prime focus for Stage
II and the development of a Cell based Performance Measurement System.
A set of Hypotheses was established whose testing, it was intended, would
serve to compare the features of the existing system with one developed and
used by the shop floor to direct and drive their kaizen activities.

(23.2) Review and Discussion of Stage II.

Stage II of this research can be described as the stage of
and being carried out in the style of 'Action Research' as described by
Easterby-Smith et al (1991) [1]. The researcher, as part of the research and
part of his job, was involved in modifying the characteristics of the subject
(i.e. the Cell and those who worked on it). This being the principal
objective of any management position or task means that replication of the
process (or of the best parts of it) is readily achievable. Transferability of
the findings is a topic considered at a later stage however. Reference to the
hypotheses, which were postulated at the end of Stage I and which provided
the direction and framework for Stage II, and the discussion of the relevant
findings in each case will provide a conclusion to the Experimental Stage.
All Hypotheses relate specifically to Dunlop Cox Ltd.

**Hypothesis 1:** The choice of Performance Criteria, setting of
Goals and planning and actioning of Kaizen
activities, when carried out by Cell Operators,
yields increased measures of ownership,
understanding, relevance and commitment to the
System than are achieved under a traditional system
or imposed World Class system.
This hypothesis considers the types of behavioural consequences which can be expected from the development of a system such as that created and used by the Research Group. Specifically issues of understanding of, commitment to, relevance of and feelings of ownership for the new system as compared with the existing or the New Imposed systems are dealt with. The evidence strongly suggests that this hypothesis is proven correct.

**Evidence:** The principal sources of evidence to support this hypothesis are:

(i) Initial and Final Cell Attitudinal Questionnaires
    (Sections 12.1 and 20)

(ii) Research Group Analysis Questionnaire
    (Section 21)

Detailed analysis and discussion of the Cell Attitudinal Questionnaires appears in Sections 12.1.1 and 20.2 and repetition is not necessary here. Suffice it to say that all conclusions are in support of the above Hypothesis.

The Research Group Analysis Questionnaire is similarly analysed in detail previously, in Section 21. Again the conclusions support the hypothesis.

**Hypothesis 2:** Under the Cell Generated System driver correlations are more defined and inter-relationships better understood than under traditional and/or imposed systems.

The evidence relating to the second hypothesis is equivocal in some respects and, as a result, only partial proof is attainable.
Evidence: (i) Initial and Final Cell Attitudinal Questionnaires (Sections 12.1 and 20)  
(ii) Stages I and II Statistical Analyses (Sections 6.4 and 16)  
(iii) Chronological Examination and Analysis of the Research Group (Section 12)

The lack of correlation between drivers identified under the existing system was considered to be a significant fault in the measures employed (Section 8) and the cell generated measures were expected to correlate with one another to a much greater degree. This would offer a clearer view of the mechanics of the cell and, therefore, a greater degree of control over the factors influencing its performance. However, in the event the degree of correlation among these measures was even lower than that for both the existing and new imposed measures. At this level, therefore, the hypothesis is disproved. However, despite this result the Research Group maintained that there was correlation between their measures and suggested that more detailed measures may begin to expose this. The validity of this view was supported through the increased understanding of both measure inter-relationships and the way that control of the salient factors on the cell could fundamentally effect the overall performance of the cell in terms of the cell measures and the LPI (Section 12). (The new imposed measures, in so far as they differed from the existing measures, had minimal effect in the decision making process or, indeed, any aspect of the Research or Control Group activity). The analysis of press downtime (Section 22.1.1), however, produced only one correlation; downtime vs. utilisation. While this result was useful in establishing a rule for future Pareto analysis it did not serve to provide any inter-measure correlation.
In the absence of quantitative evidence and with no direct qualitative evidence only anecdotal evidence and assumption remain. In Section 16.5.1 which provides an analysis of the statistical examination of the data it is suggested that, because of the advanced state of the N936 cell and its good performance in terms of complete deliveries and reject levels in particular, that correlations which might have occurred between similar measures in less advanced cells do not appear. This, in turn, suggests that either more specific measures or less developed cells would produce correlations under similar circumstances.

Also, group drivers which performed less well (e.g. scrap and downtime) did exhibit increased correlation when paired together, although this correlation was still statistically insignificant.

According to the direct knowledge and experience of the cell on the part of Group members and the Researcher, it seems likely that correlations do exist between the new measures but that the system, at this stage, is insufficiently sensitive to decipher them among the plethora of factors acting within the cell.

A final point which is relevant to this hypothesis is that the Research Group progressed well and achieved outstanding results without explicit correlation between measures and it was not until the Group had developed to a stage where further, directed, improvement required more detailed information that the question of the need of correlation between measures was again raised in earnest. Again the lack of correlation did not hinder the identification of the major causes of press downtime, the worst presses and the formulation of an action plan to improve the situation and new measures for further control.

Therefore, the whole necessity for correlation between drivers is called into question. The only conclusion which can be reached here is that, while correlations between measures would be beneficial to a new
performance measurement system in so far as providing a clear and coherent model of the manufacturing system is concerned, the lack of correlations is not shown to be detrimental to the general performance, advancement and improvement of that system. Further research into this particular aspect is required in order to clarify the situation.

**Hypothesis 3:** *The development of a Performance Measurement System which drives continuous improvement will yield more relevant results in terms of World Class criteria than does the existing system.*

**Evidence:**

(i) Production Director Viewpoint
   (Section 6.2.7)

(ii) Initial and Final Cell Attitudinal Questionnaires
   (Sections 12.1 and 20)

(iii) Chronological Examination and Analysis of the Research Group
   (Section 12)

(iv) Resultant Kaizen Activity
   (Section 17)

In answering this hypothesis it is first necessary to define what we mean by 'relevant results' and 'World Class criteria' in terms of Dunlop Cox Ltd. and the Research.

The first assumption made here is that becoming 'World Class' is a good thing and something which Dunlop Cox wishes to do. Through the course of the research it became clear that this is a primary goal of the company. However, while it is the stated aim of the New Imposed Measures to drive the shop floor towards World Class status, the Company's
definition of what 'World Class' means is unclear. Section 6.2.7 which details the questioning of the Production Director reveals a lack of any kind of mission statement, manufacturing strategy definition or non financial goals or performance measures at Board Level. The lack of such direction suggests that the primarily (or exclusively) financial goals of BTR are what really drive the system. The whole thrust of Stage I supports this. However, it has to be assumed that the stated aim of becoming World Class is genuine (whatever interpretation respondents place on the term). In the absence of a clear definition from the Company it is necessary to turn to the literature for clarification. Section 9 argues for a different approach to performance measurement within the Company which will drive the production function towards those criteria identified as being World Class. There have been many interpretations of this broad term which was first coined by Schonberger (1986) and discussion of this is found in Section 9. In terms of this research the definition of World Class, therefore, is simply those characteristics required by the Customer, in this case IHL and Nissan. This is because, as stated in Section 12.5.1, the principal concern was with the process which the Research Group went through in selecting and using their measures rather than with the absolute validity of the measures themselves. It is also true, however, that the Group had a sound appreciation of customer requirements at the start of Stage II (Section 12.1.1) and that these requirements reflected many of the widely known attributes of the World Class company. It was not until near the end of Stage II that the core members of the Research Group began to seriously re examine their measures with a view to modification (Section 22).

The issue of relevance, then, is tied to the process which the Research Group went through in determining their measures. The measures were relevant to the Group, since they had chosen them. They were relevant to the customer in so far as the Group appreciated the requirements of the
customer. Finally, they were relevant to World Class goals in so far that the requirements of the customer reflected those World Class goals.

Having established that the measures are relevant, as defined above, it follows also that the results of the measures are relevant. The kaizen activity which was driven by the measures, being, by definition, relevant to those measures, was also relevant to World Class criteria.

This being the case, the above hypothesis, which argues for a set of measures which are not necessarily of absolute, but of comparative, relevance is clearly proven correct.

Finally, the effectiveness of these measures in driving relevant kaizen activity is also proven correct through the details provided of resultant activity and the outcome of this in terms of the cell generated performance criteria (Section 16.5.1).

**Hypothesis 4:** Through kaizen activities driven by the Cell Generated System real increases in Productivity (the basis of the traditional system) can be demonstrated.

**Evidence:**

(i) Historical Data - Changes in Performance of the Nissan 936 Cell (Section 16).

(ii) Initial and Final Cell Attitudinal Questionnaires (Section 12.1 and 20).

Analysis of the historical data for weeks 41 to 80 inclusive shows a marked increase in the mean LPI over the first fifteen weeks of 6.2% for the N936 Cell. Furthermore, on five consecutive weeks values of over 80% were achieved (Section 18.1). This performance represented by far the best in the history of the cell. From Week 56 onwards, however, the LPI level
fell to such a degree that from Week 61 onwards the productivity achieved closely resembled that recorded for the Cell during Stage I. Therefore, while the data from the first fifteen weeks appears to prove the hypothesis there are two points to answer;

(a) How is the change at Week 56 onwards explained in the context of the Research?

and; (b) Could any other factors have caused a marked improvement in the LPI during the first fifteen weeks of Stage II?

As discussed in Section 18.1 there is no clear answer to the question of the Week 56 change. The only major occurrence on the cell was a change of Cell Leader where the Researcher was moved to another cell and replaced on the Universal Cell (and so the N936 and N909 Cells). The comparative lack of commitment to kaizen or the Research Group and its activities on the part of the new Cell Leader (see Final Cell Attitudinal Questionnaire, Section 20), however, offers the clearest possible reason. Also, it appears from the data that the marked decline in time spent on kaizen activity after the departure of the Researcher correlates directly with the falling levels of the LPI (see Figure 22). The effect of the removal from the cell of the Researcher and his being replaced with someone less committed to the Group and their System provides some interesting points which are used in Section 25 to add validity to the proposed implementation framework.

The question of other possible factors resulting in the marked increase in LPI is answered through reference to the Initial and Final Attitudinal Questionnaires. Here the increase and subsequent decline in the LPI is linked explicitly with the Research Group activities under the Researcher followed by the arrival of the second Cell Leader and the
resultant falloff in activity. In addition there is no evidence of any sort to suggest any other factor which could have resulted in the LPI profile during Stage II.

Therefore, in summary, the activities driven by the Cell Generated System did bring about marked increases in the LPI. Also, these increases can be shown to have no other cause than the development and use of the Cell Generated System with all its practical and behavioural consequences. Furthermore, the degree of productivity improvement brought about in this way is closely related to the amount of time spent on kaizen activity coupled with the general attitude and abilities of the Cell Leader in place.

Main Hypothesis: Through the utilisation of the knowledge and skills of Cell Operators it is possible to develop a Performance Measurement System with the following attributes:

- Consisting of Performance Criteria with associated goals and time scales which are directly relevant to the Customer of that particular manufacturing cell.

- With the full support and commitment of Cell Operators gained through their pivotal role in the design, management and operation of their system.

- Being essentially proactive and inherently flexible with the provision of a feedback loop for the continual re-evaluation of measures and redesign of the System by Cell
Operators.

- Having the capacity to be linked directly to the Business Strategy and thus re-enforcing Goal Congruence.

Some elements of the above hypothesis are tested through the testing of the previous hypotheses. In particular, the first element of the Main Hypothesis which relates to the relevance of the new measures with their goals and time scales is covered by the testing of Hypothesis 3. The remainder of the Main Hypothesis, however, requires specific comment. As previously there are several sources of evidence to refer to in testing the hypothesis.

Evidence:

(a) Initial and Final Cell Attitudinal Questionnaires (Sections 12.1 and 20).

(b) Chronological Examination and Analysis of Research Group (Section 12).

(c) Research Group Analysis Questionnaire (Section 21).

(d) Further Research Group and Measurement Developments (Section 22).

The question of whether the cell generated system had the full support and commitment of the Cell Operators involved cannot be answered with absolute certainty. The Researcher was also their direct superior and while every effort was made to maximise the autonomy of the Group and maintain a facilitative, coaching role on the part of the Researcher the
question of expectancy bias coupled with psychosocial effects must be addressed.

This point, which relates to the validity of the research, is discussed in detail in Section 26. While, at this point, only the evidence as it stands can be sited, this does serve to validate the research methodology.

The Chronological Examination and Analysis of Research Group Activity suggests that while there was some reticence on the part of one or two members in the early stages this quickly disappeared to be replaced with general enthusiasm for the Group and its' purpose. This is borne out through the comparative responses to the Initial and Final Cell Attitudinal Questionnaires which, as detailed previously, can be used to attribute the rapid improvements in cell performance to the activities of the Research Group.

A detailed postcriptive analysis of member attitudes to the Group and the role of the Researcher is provided by the Research Group Analysis Questionnaire. While the responses represent the general view, the range of responses in each case was relatively narrow. In summary the levels of commitment to the Group increased over time with senses of ownership and teamwork developing also. The results of the questionnaire suggest that the Researcher succeeded in maintaining a largely facilitative role with the members feeling ultimately responsible for the activities and results of the Group. However, the falloff in activity which occurred during Stage II indicates a continuum of commitment to the Group with only those who were most enthusiastic continuing with the work as far as they could despite the indifferent attitude of the new Cell Leader. The commitment of this critical mass is further illustrated through the development of refined measures towards the end of Stage II.

In summary, while the full support and commitment of all members cannot be proven beyond question, the evidence suggests that the vast
majority (if not all) were keen to be involved in the Group, be associated with the Group and for the Group to continue and succeed. This, however, is very much a function of the attitude of the Cell Leader in place and only the most committed will remain sufficiently motivated to continue when practical as well as vocal support is withdrawn. Despite such provisos analysis of responses from the Control Group illustrates that from a comparative viewpoint levels of commitment and support are far greater when a performance measurement system is developed and implemented bottom up than when it is imposed top down.

The third element of the Main Hypothesis which proposes the idea of a proactive, flexible system with the provision of a feedback loop for measure re-evaluation is tested with reference to the Further Research Group and Measurement Developments. During the research there was no real consideration given to the mechanism for the periodic re-examination of measures. This was primarily because attention was focused on the definition of the initial measures and their use. Had the initial measures proved not to be useful in the early stages then a feedback loop may have been considered earlier. Also, it was not until around Week 75 that sufficient data had been amassed to carry out a realistic reappraisal of the downtime measure which appeared to be the largest waste area at the time. However, as previously stated, it had always been the intention of the Group to continually appraise and develop their measures and the ways of using them. In this sense, the proactive attribute suggested in the Main Hypothesis relates to the measures themselves as well as to the proactive kaizen activities driven by them (Section 17).

To summarise this point; while there was no formal feedback loop in place within the system (as with the Existing and New Imposed Systems), there was the fundamental understanding within the Group that the
measures and the system as it stood should be as much a target of kaizen as any other aspect of the cell (unlike the Existing and New Imposed Systems). The formalisation of a feedback loop with input from the customer is a feature of the proposed framework and guidelines (Section 22).

Finally, the element of the Main Hypothesis which suggests that the system has the capacity to be linked directly to the Business Strategy thus re-enforcing (or introducing) Goal Congruence has not been directly tested in the course of this research. There are three reasons for this;

(a) There is no defined Business Strategy in place at Dunlop Cox at the time of writing against which the cell generated system and measures can be judged.

(b) The focus of the research was increasingly on the cell and the shop floor in general. The volume of work involved in meeting the objectives of Stage I and testing the hypotheses of Stage II precluded the detailed analysis required to test this final point.

(c) The attitude of the management of the company was that the Researcher and therefore the research should be confined, as far as possible to the cell in question. The investigation of broader issues was limited in this way.

However, it is possible to comment on the likely use of such a system in conjunction with the Business Strategy through reference to the Final Cell Attitudinal Questionnaire. The question related to goal congruence existing between the Researcher and Operators and between Operators themselves provides evidence to suggest that the definition and use of the new key performance criteria served to increase the level of goal congruence within the cell to a large extent. This is supported by the fact
that when active support for the project ceased (change of Cell Leader), then the level of goal congruence fell markedly.

Consequently it seems logical to assume that, had the measures chosen by the Group directly supported a Business Strategy, there would have been a high level of goal congruence between the board room and the shop floor (this assumes a complete system at work through all aspects and levels of the company). This, of course, is in direct contrast to the existing situation. The N936 Cell with the new system in place (and before Week 56) can be used as a model to illustrate the effect which such a system could have on the entire production function. Assuming the validity of the measures chosen by the Group, the Business Strategy, and therefore the key performance criteria for each intervening hierarchical level, could be defined by those measures. In this way absolute relevance to the needs of the customer is assured both in terms of measures used at every level and of the Business Strategy. Furthermore the whole organisation is guided by a strategy which is driven by the customer through the shop floor. Such a system would ensure that the capacity of manufacturing to become the key competitive weapon in a company like Dunlop Cox is realised.

A point worthy of mention at this point is that a company operating in this way may be open to the criticism that, through being so intensely customer focused, it is concentrating on defending its customer base and having few prospective features and so a weakened position in terms of long term survival. However, it is also true that a company whose customer is acknowledged as being of world class status will be pulled up to the level of that customer (as Nissan is continually doing with Dunlop Cox and all of its suppliers). This means that the supplier moves into an increasingly strong position in terms of acquiring fresh business. In the case of Dunlop Cox, for example, their successful partnership with Nissan in particular has resulted in the promise of new business supplying the Toyota plant in Derbyshire.
Conversely, if the manufacturer supplies companies with low or sub-world class requirements then the customer will not drive the supplier to continually improve. In such cases the argument for using competitive benchmarking as an aid to measure definition is strong. The degree to which customer focus strengthens or weakens the prospective features of a company, therefore, is very much a feature of the quality of the customer. This in no way detracts from the value of customer focus as demonstrated through this research, rather it suggests the possibility of focusing on the most demanding customers in the market in order to make the company increasingly competitive.

This concludes the discussion of the hypotheses proposed and, therefore, the summary of the research findings. The knowledge gained from this research represents a valid addition to performance measurement research and a valuable guide for other researchers and industrialists considering the best approach to a new performance measurement system. It is now possible to formulate the findings into a framework which can be used for implementing similar systems in other situations. However, prior to this, it is necessary to briefly comment on the transferability of the findings.

(24) Transferability of Results

The scepticism which is often felt towards the case study in management research in particular largely rests on the view that generalising from the results of one study is not possible [3]. Drawing on the work of Mitchell (1983)[121] and Yin (1984)[122], Bryman (1988) argues that case studies should instead be:

'evaluated in terms of the adequacy of the theoretical inferences that are generated. The aim is not to infer the findings from a sample to a population, but to engender patterns and linkages of theoretical importance.' [123].

252
It is thus of great importance to pay attention to the question of the
degree of logical inference which it is possible to draw from the results of
any study based research [120].

The value of the project as a piece of action research can be judged in
terms of the work done within the investigated situation. The degree to
which the findings of that research can be transferred to 'similar' situations
is, therefore, a function of the validity of theoretical inference. One way to
test this validity is through the analysis of other, similar, environments i.e.
through questionnaire, interview or, ideally, duplicated or follow-on
research. In the case of this research, however, only data relating to slide
cells other than the Universal (including N936) and N909 was tested. This
testing formed part of Stage I and the establishment of the characteristics of
the existing system, but not Stage II, the experimental stage. This means
that only findings from within this project can be sited as evidence for
transferability. Before identifying these findings it is first necessary to define
what is meant by a similar situation in this case. It is felt that the research is
of sufficient strength to logically suggest patterns and linkages as being
applicable to the following range of situations. In ascending order;

(a) All Slide Cells within Dunlop Cox
(b) All Cells within Dunlop Cox
(c) Manufacturing companies with the following characteristics;
   - Cellular manufacturing organisation
   - Small batch, high volume, manufacture to forecast (JIT)
   - Traditional, financially controlled, management systems
(a) **All Slide Cells within Dunlop Cox**

The results of Stage I are sited here. These results demonstrate a relatively homogeneous organisation segment in terms of product, processes, culture, management control, performance measurement (and its behavioural consequences) and culture. In addition the relative breadth of the project (at 40% of all Slide Cells and approximately 40% of all Slide Cell Operators) guarantees transferability on this scale.

(b) **All Cells within Dunlop Cox**

As in the case of (a) the results of Stage I support transferability on this scale and for the reasons outlined above. This level of transferability is an important one since it broadens the applicability of the findings to the whole of the production function analysed.

(c) **Manufacturing Companies with the salient characteristics of Dunlop Cox Ltd.**

The transferability of the research findings to manufacturing companies other than Dunlop Cox is a useful qualification for the research. Despite the increased abstraction from the research situation the argument for this degree of transferability is a logical one.

Each of the characteristics identified in (c) has certain aims, objectives, theories and common features associated with it. These are best illustrated with reference to the term 'world class manufacturing' [17]. As stated previously in this work, the term is a very broad one but will include the following:

- a new approach to product quality
- just in time production techniques
- change in the way that the workforce is managed
Other definitions of World Class Manufacturing (WCM) suggest that it is simply another term to describe Just In Time manufacture [61]. This implies cellular manufacturing and the use of kanban, poke yoke, SMED and many other techniques employed on the N936 cell. The functioning of a manufacturing cell within a JIT environment has many distinctive characteristics. Some of these are as follows;

- Related to a particular product/customer
- Many internal customer/supplier interfaces
- Multi-process
- Multi-skilled workforce
- High degree of autonomy
  etc.

It can be seen that these characteristics and others which are generally related to JIT cellular environments are ones which were the focus of attention for the Research Group. Additionally, small batch sizes, high volumes and manufacture according to forecast are features which are often coupled within a JIT environment.

It can be argued, therefore, that the situation of the N936 cell within such a manufacturing scenario and the focusing of the Groups' performance measurement system on the features and characteristics common to such a scenario means that the research findings are readily transferable to any company operating under similar conditions. Most likely to conform to the stereotype is the first or second tier automotive component supplier which is planning to employ performance measurement for world class
manufacturing.

This will include a great many who, like Dunlop Cox, have financially driven management control systems which are derived by the management accounting function and have little to offer the production function and the shop floor.
In order to draw directly on some of the more detailed aspects of the case study the proposed model and guidelines will be based around the stereotypical manufacturing environment which was identified in Section 24 and also describes the salient features of the production function at Dunlop Cox. To reiterate these are:

- Cellular manufacturing organisation (single product focus cells)
- Just In Time Manufacture
- Small batch, high volume, manufacture to forecast

For the sake of simplicity this scenario will be referred to as Type A in further discussion.

(25.1) A Contingent Approach to Driving Improvement.

Contingency Theory as applied to the design of organisations is based around the concept that the characteristics of management structure and control should be contingent upon the task in hand, the people involved and the surrounding environment [124]. This is in contrast to the Classical and Human relations approaches which Walter Bennis (1959) defined as being 'organisations without people' and 'people without organisations' respectively [125].

It has long been recognised that the complexity of organisational design precludes the universal applicability of more prescriptive approaches [126,127] and that taking a broader view of the world (including outside influences such as the customer and market) will yield more and not less
robust organisational designs. Contingency theory provides the facility to identify (and sometimes quantify) internal and external forces at work and the resulting forms which the organisation will be pulled towards thus facilitating a flexible and dynamic definition of organisational design and characteristics.

In the field of performance measurement research also there has been a shift away from the prescriptive and highly formalised management accounting systems towards a more balanced approach which also takes account of internal and external forces through the application of non-financial as well as financial measures (Section 2). The profile of such a performance measurement system will be contingent upon the situation of the organisation including its' history, internal politics and management style. Research has also shown, however, that through taking the decision process to as close to the customer as possible, and, at the same time, minimising the inter-hierarchical interference in new measure development, it is possible to rapidly develop and implement new measures which are largely unencumbered by internal political or historical forces. Such measures will override (in terms of behavioural consequence and, therefore, actions) existing highly formalised and prescriptive performance measurement systems [128].

As stated previously, the aim of this project was never to define an absolute list of world class performance criteria. Rather it was to examine the process of development of a new system and set of measures by the shop floor which was contingent on their situation and which would drive improvement activities. Comparison of the new system with existing and new imposed systems has shown that considerable benefits can be gained through such an approach, perhaps most notably, when judged in terms of the existing financial driver, the Labour Performance Indicator.

In summary, a framework for the implementation of a cell based
performance measurement system should be based on the premise that the measures chosen and, at a deeper level, the system configuration and operation defined, are contingent upon the needs of the cell, the goals of the business and, most importantly, the needs of the customer. The requirements of suppliers to the subject company are also becoming increasingly important with the increase of inter-company kanban systems and other, wider issues, of supply chain management.

Performance measures, therefore, are Contingent upon the relative characteristics and strengths of:

- Customer requirements
- Internal requirements
- Supplier requirements

with customer requirements being key and defining the framework for all other requirement categories. All requirements, therefore, will provide direction and drive towards improvements to the cell which are relevant to the customer requirements, thereby closing the loop and creating, what Hampden-Turner (1990) calls, a Virtuous Circle. [105]

(25.2) Optimising the Measure Driven Cycle

It is apparent that, within a given performance measurement system, there are various cause and effect relationships in place which are driven by the system and which ensure that the measures employed become a self fulfilling prophecy (i.e. you get what you measure). The link between cause and effect in this case is the behavioural consequence both of the measure, and of the system as a whole. Using this principal it is possible to map the progress of cause and effect relationships through a cycle. Below is a
Measure Driven Cycle for a Type A company operating under a traditional, accounting driven, system, such as that at Dunlop Cox. This, then, represents the Cycle prior to the change process.

**Figure 28: The Introverted Measure Driven Cycle**

This model illustrates the essence of the Introverted Measure Driven Cycle where the behavioural implications of non-customer focussed measures drive the culture of the organisation away from world class performance criteria and the requirements of the customer.

Despite previous reference to a Virtuous Circle, the above does not necessarily represent a Vicious Circle at the level depicted. This is because
opposite sides of the circle do not represent opposing 'horns' of a dilemma. Rather than producing a system in tension which is never resolved, the Introverted Measure Driven Cycle produces an often highly balanced and stable one. In this case it is the sub-optimal behavioural implications of the system which stifle improvement and drive the culture along a receding helix away from resolution of the internal performance measurement system with the demands of customer and market.

Through the development of a Cell Based Performance Measurement System it becomes possible to incorporate those customer needs into the cycle. Again behavioural implications link the cause and effect relationships but this time the cycle becomes a proactive and dynamic one. Once the culture has moved far enough away from the introverted initial state then the customer becomes the focus and non-financial measures increasingly drive the shop floor along the path of continual improvement.

Below, therefore, is an Optimised Measure Driven Cycle. As before the model represents a highly stable and balanced system. In this case, however, the energy of the cycle is translated into shaping the operation of the shop floor into a system which meets the requirements of the customer (and ultimately, therefore, the financial measures of the Introverted Cycle) instead of focusing explicitly and exclusively on the principal financial driver as it impinges on the cell.
While the above clearly focuses on the individual cell the model can also be used to represent an entire organisation where world class performance criteria and, therefore, customer requirements define the Business and Manufacturing Strategies. In this case the measures are adapted to be relevant to each hierarchical level while a clear link between strategy and the shop floor is assured though a strategy definition in terms of direct measures of service to the customer. Such goal congruence means that the benefits of local autonomy can be maximised and cell based entrepreneurial flair (or deviance from the norm) will not detract from the central mission of the organisation. Such a characteristic is defined by Peters and Waterman (1987) who discuss the 'Loose-Tight properties' of successful companies such as 3M.[119]
At this highest level the concept of the Virtuous Circle is relevant. Indeed, the example used to illustrate the concept serves also the clarify the point made above. Hampden-Turner uses his model to contrast the cultural typologies of Roger Harrison (1972) and Charles Handy (1978) [80] where two sets of dilemmas or opposing forces are held together, through reconciliation, in a Virtuous Circle.

![Diagram of the Virtuous Circle]

**Figure 30: The Virtuous Circle. (taken from 'Corporate Culture - from vicious to virtuous circles.' Hampden-Turner, (1990)).**

Using this example within the context of the Measure Driven Cycle the continual development and improvement of the measures and cell systems brought about by those individual cells is captured and serves to develop the entire performance measurement system and, consequently, the business. The concept of the shop floor having the capability, responsibility and authority to directly shape the performance measurement system of a
company in this way represents a significant advance in terms of individual and group responsibility. It serves to complement the level of responsibility in terms of performance measurement which is apparent in relation to product quality, for example, within the majority of world class organisations.

There are, of course, influences other than those of the customer at work in the development of a new performance measurement system. In particular the interests of shareholders (including holding companies such as BTR) and the City are of great concern to the directors of companies. In many cases the attainment of 'bottom line' figures such as profit, return on capital employed etc. are of overriding and paramount importance to large financial institutions. However, it is also true that in many cases, the methods which individual companies employ in order to meet the requirements of holding companies (and certainly smaller shareholders) are devolved down to company or business unit level. In such cases a translation mechanism between the external financial reporting requirements of the holding company and the City and the internal performance measurement system is required. However, the ease with which non-financial measures can be translated into hard financial data is open to question and surely the subject of future research.

While, this research offers an example where non financial, customer focused measures resulted in considerable gains in terms of the existing traditional measure (LPI), the financial justification of non-financial measures (especially within the short time frames common to traditional management accounting) and of investments prescribed by non financial measures will continue to be a source of debate.

Having presented a theoretical model which will underlie the practical framework for the development of a Cell Based Performance Measurement System the next stage is to detail that framework including guidelines for the
successful implementation of a self sustaining system.

(25.3) A Model and Guidelines for Implementation.

The cyclical nature of the behavioural implications of performance measurement systems as discussed above means that the provision of a feedback loop for the continual re-appraisal and improvement of measures is made relatively uncomplicated. The most suitable way to represent the sequence of actions required in the implementation of a cell generated performance measurement system is through the use of a flowchart. However, prior to this it is necessary to classify the two distinct scenarios which the facilitator may encounter regarding the choice of appropriate measures by the Group. It has been shown [129] that where knowledge of customer requirements is good the Group is likely to select measures which are highly congruent with the requirements of the customer. However, it may equally be the case that the appreciation of customer requirements will be insufficient to select valid measures. The question of what is 'valid' is best answered by the customer and so direct customer input would be favoured here. The second scenario demands a modification to the implementation flowchart as is illustrated below.
The terms in brackets at each stage describe the quality of the process at that point and indicate that sound progress to the next stage is possible. The second scenario depicts the situation at the other end of a continuum where the degree of customer knowledge is minimal at best.
In this situation kaizen activity is initiated and driven by the sub optimal measures while an education and training input is initiated in order to lead to the definition of a more suitable set of measures. This initial set is then refined after input from the customer and introduced at the measure review.
(which is initiated as soon as the refined set is ready). If a review decides that the existing measures are still acceptable then this is fed back into the kaizen activity. If the set requires modification then new measures are identified and these are either fed into the kaizen activity or to the training entity as appropriate.

It is possible to combine the Expert and Novice Measurement Frameworks to form a Contingent Measurement Framework which can be used whatever the characteristics of the Group in terms of customer appreciation.

**Figure 33: The Contingent Measurement Framework**
The Contingent Measurement Framework can be used to formalise the development of a Group at any point along the knowledge continuum through a simple flowchart. Two feedback loops are employed for the input of existing measures either back into the Kaizen Start/Restart activity box or the Identify Measures process box. A description of the actions and activities associated with each entity in the flowchart will clarify the mechanism. What follows is not a detailed breakdown of each activity or process appearing in the framework. Only sufficient detail is provided at this point to describe the basic operation of the model.

(i) Identify Measures

Using input from the customer and from within the cell the Group seeks to identify those key performance criteria which will drive the cell towards the requirements of the customer. Once these criteria have been identified then suitable goals and time scales for achievement of those goals are also defined. A review period for the measures may also be set at this stage (although not necessarily). Information from the review of existing measures also contributes to the process. Initially this input will be a review of the advantages and disadvantages of the measures currently employed and the system in which they are configured. Later, information from reviews of cell generated measures will form this input.

(ii) Kaizen Start/Restart

Once measure definition is complete then this information serves to trigger the kaizen activity on the cell. Once the measures are set then the cell is provided with a direction and a target for its improvement activities. As the title of the activity suggests, this can either represent the initial kaizen project (not necessarily driven by optimal
measures - see later comments on OK/NOK prompts) or the redirection of general kaizen activity following an amendment to the performance measures which has been confirmed in the preceding 'Identify Measures' process.

(iii) Review Measures

The periodic review of measures is crucial to the success of the system and this can either take the form of a rigorous timetable or a more rule of thumb approach where the data is examined over a period of time and only when a pattern begins to emerge, or some other indicator appears, does a formal review take place. One input to the process will be measures which have been defined by the Group and already used to drive kaizen activity in one way or another. In all but one case these input measures (α) will be 'valid' ones. At the start up of the system invalid measures may be used to initiate kaizen activity and in this case it will be these which are reviewed. This aspect of operation is discussed in detail at a later stage. The second input (β) to the process will be from the 'Refine Measures' process and will only occur when invalid measures have been processed through the 'Education and Training' process and are ready to be reviewed prior to input to the 'Identify Measures' process (if the measures are still held to be invalid and complete reappraisal is required) or the 'Kaizen Start/Restart' activity if they have been validated. Therefore, the output from this process feeds back either into the Kaizen Start/Restart activity if the measure/s is/are found to still be relevant or into the Identify Measures activity if some amendment is considered necessary.
Education and Training

This procedure is followed in the case of 'invalid' measures being defined by the Group. The cause of this invalidity will be either, insufficient knowledge of customer requirements, or of cell characteristics. (Cell characteristics in this case are taken to mean any feature of the operation of the cell). A clarification of the term 'invalid' appears at a later stage. Input from the customer will support the process while the output will be a heightened level of awareness and training in the relevant issues which form the input to the 'Refine Measures' process.

Refine Measures

This process differs from the 'Review Measures' process in that it is concerned with the refinement of sub optimal measures initially chosen by the Group. Input from the 'Education and Training' process will serve to enrich the process and increase the chances of a valid measure or set of measures being defined for input to the 'Review Measures' process.

(25.3.1) Definition of Measure Validity

Within the context of this research the definition of what is a valid measure as chosen by the Group is made with reference to customer requirements. If the measure reflects an aspect of the service required by the customer then the measure is valid. However, there are two provisos to add;

This assumes that customer appreciation on the part of the Group/Company is at a sufficient level to accurately interpret what the customer wants. If this is not the case then direct customer involvement becomes imperative. Initial assessment of Group
appreciation obviates the possibility of choosing invalid measures and
is best carried out by a representative from the customer company.

(ii) A customer involved with the process may not entirely see the
relevance of measures chosen by the Group which pertain to internal
cell factors and operating characteristics. Assuming that these
measures are indeed valid from the point of view of the cell, and
therefore the customer, then the logic of the relationship should be
explained to that customer.

(25.3.2) The Role of Validation

Validation within the model described is a continual process which
ensures the continuing applicability and relevance of the measures in place.
With reference to the Contingent Measurement Framework validation only
takes place, in a formal sense, during the Identify Measures and Review
Measures processes. There will, of course, be a continual review and
discussion of the measures in place throughout the normal working day and
it may be profitable to capture the salient points arising from these informal
conversations during a brief daily meeting/briefing for example (although the
astute Cell Leader will be continually listening to and acting on suggestions
and ideas from his cell members).

Formal validation may involve an individual measure, a selection of
measures, all measures or the entire system as applicable.

(25.3.3) Using Invalid Measures to Drive Kalzen.

The Contingent Measurement Framework includes two OK/NOK
decision points where the validity of measures is assessed. The first occurs
at the Identify Measures process and the second at the Review Measures
process. A description of how these decisions feed into the next part of the
The flowchart has already been given. However, the case of the invalid (or NOK) measures driving the Kaizen Start/Restart activity requires clarification.

This situation will only occur once, at the inception of the system. At this point it is likely that partially (or totally) invalid measures will be selected by the Group, especially where appreciation of customer requirements is low. However, it is preferable to allow these initial measures to begin to drive kaizen while Education and Training is carried out and prior to production of the β measure set for the following reasons:

(i) In order to continue the motivation of the Group and encourage enthusiasm it is preferable to maintain some momentum in the process and not to introduce a pause in progress while the imperfections of the measures which the Group has chosen are analysed.

(ii) Some measures are better than no measures and, in many cases, where there have previously been no drivers for kaizen it is infinitely preferable to demonstrate some practical improvements on the cell. Group members will usually be keen to start some practical kaizen and, in the early stages, encouraging this without provisos is important for morale and facilitator credibility as well as the learning process. As a practical guide, if an Operator asks the Cell Leader if he/she may make some improvement on the cell (whether it be painting the floor or designing a kanban system) then, as long as all safety requirements have been met, the activity should be allowed and actively supported.

In the early stages it is more important to encourage the generation of ideas, the growth of confidence and enthusiasm and pride in the cell and the improvements carried out than to insist upon absolutely
valid measures and resultant activities. It is preferable, therefore, to allow Group members to make sub-optimal decisions and carry out sub-optimal activities in the early stages than to allow only those activities which the Cell Leader considers to be valid. For the Cell Leader to unofficially select the Group Performance Measures in this way undermines the whole philosophy of the approach and represents a kind of lip service paid to the concept which will be immediately obvious to the Group.

(25.3.4) The Choice of Initial Project

Where the initial project for the Group is an obvious one (a major physical re-layout for example) then this can be used as a launch for the Group. The benefits are likely to be large, the changes visual and communication of the improvements will be easy. It must be remembered, however, that the new measures must drive the Group and not the obvious (and often easy) improvements. It is vital that the new measures are chosen first and it is these which direct the Group towards the initial project. Where the direction for initial improvement is not immediately clear then the following points must be noted:

(i) The initial project (and indeed all projects) should be as small and focused as possible. No project should be allowed to mushroom.

(ii) The initial project must have a high probability of success (even guaranteed) to ensure motivation of the Group. To this end the specific goals of the project must be clear and concise.

(iii) The results of the project should be publicised as widely as possible. Recognition drives commitment.
The initial project should be quickly followed up with a second. There is often the temptation to allow the momentum to fall away after the first big success. This results in a disillusionment within the Group which can prove fatal to the system.

It may be that the most effective initial project is the selection of the measures themselves (as in the case of the N936 Cell). In this case the communication of the project was facilitated through the Team Kaizen Board and proved very effective in motivating and directing the Team.

(25.3.5) Role of the Cell Leader.

Of key importance to the success of a Cell Generated Performance Measurement System is the role played by the Cell Leader. The system demands that the Group is afforded real autonomy and that the Cell Leader is primarily the facilitator for the Groups' activities as well as the day to day operation of the Cell. Valuable characteristics of the Cell Leader will include the following:

- While offering guidance and support the Cell Leader must strike a balance between suggestion and direction.
- A good knowledge of the personalities and abilities of the members is important in helping the Group to capitalise on the skills available. This is also important in guiding the Group or Team Leader who may not have previous experience of leadership.
- Effective liaison with other cells and supply functions is important where the Groups' activities interface with outside areas. In some cases links across functional boundaries cannot be initiated by Cell members (in the early stages at least) and this is important in ensuring the rigour and validity of the Cell System.
In an organisation where a traditional, financially driven, performance measurement system is in place with all the behavioural consequences which this may have, the Cell Leader must act as an umbrella or shield to his Cell. Sub optimal behavioural consequences initiated in middle management, for example, must not be allowed to cascade onto the shop floor, they have to be blocked and absorbed by the Cell Leader. In this way drives to increase productivity are translated by the Cell Leader into a form relevant to the measures of the Cell and the functioning of the Group. In an organisation employing a customer driven performance measurement system where goal congruence is high, then the requirement for this characteristic is reduced.

As the Group develops the Cell Leader must have the ability to yield an increasing degree of control and responsibility to the Group. The more mature the Group becomes the less need will it have of a facilitative or parent figure.

The most important point here is that the role of the Cell Leader in the successful initiation and perpetuation of a Cell Generated Performance Measurement System is absolutely key. In the same way that, in the past, the success or failure of TQM has been said to rest with First Line Supervision [18], so the success or failure of measure driven continuous improvement rests with the Cell Leader. It is the responsibility of the management of a company to ensure that the Cell Leaders in place have sufficient knowledge, training and man management skills to effectively guide their cells through the process of measure definition, system set up and ongoing improvement. Senior management cannot impose a culture of continuous improvement on the shop floor (or any other part of the organisation) it has to be bred and nurtured from the bottom up. Relevant, customer driven measures will drive and direct kaizen but only the Cell Leader can make it work. [130].
Examination and Evaluation of Methods of Research Employed.

This section is a critique of the research methodology employed. The analysis is carried out at three levels;

(a) Primary Level (general structure and framework).
(b) Secondary Level (philosophical considerations)
(c) Tertiary Level (appraisal of tools employed)

Primary Level: General Structure and Framework.

Section I discusses the philosophical options available when carrying out behavioural research. In addition an outline plan is described which forms the framework of the research. As stated, this project is best described as a piece of action research according to the definition by Easterby-Smith et al (1991) [1].

The early definition of Research Objectives provided a rough framework for the project and established the boundaries of enquiry. The Descriptive Enquiry (analysis of the existing performance measurement system and determination of driver identity and perceived interaction) and the subsequent Relational Enquiry (analysis of actual driver interactions and effects) served as a basis for the final stage, the Experimental Enquiry. Only at the completion of Stage I of the research could a set of Hypotheses be posed which provided direction to Stage II.

This basic framework of the research reflects the priority attached to a phenomenological viewpoint when carrying out behavioural research. However, as Wass and Wells (1994) point out;

'Although we adopt a critical stance towards positivist methods, this is not to say that we reject them completely. These methods, like
any others, are relevant when used at the appropriate level, i.e., to answer the specific questions in the specific research setting chosen by the researcher.' [3].

The point is that in developing an 'interpretative understanding of human action' it is important to base conclusions on the real perceptions and viewpoints of the subjects. This requirement means that the basic requirement of a positivist approach which requires the scientific analysis and verification (or falsification) of an a priori hypothesis is essentially rejected. It is a central requirement of behavioural research, therefore, that one firstly understands the meaning of observed phenomena (especially in participant observation) so that one can ask the right questions (i.e. pose pertinent hypotheses). Otherwise there is bound to be a very real danger that meanings, as understood by the subjects of the research, are missed or worse still, 'The verifier may find that the speculative theory has nothing to do with his evidence, unless he forces a connection' [120].

Similar problems can arise through the use of questionnaires where a genuine understanding of the social situation and cultural background for the research has not been attained prior to designing the questions.

A further guard against 'blinkering' is to delay any in depth literature survey until after a relatively broad brush investigation has taken place. In this way, also, objectivity is encouraged. Such a method was employed in this research where only a general literature survey was conducted initially in order to loosely define the remit and aims of the research. It was not until after Stage I that sufficient understanding of the situation had been established so that a detailed and very focused literature survey could be carried out which would form the basis for testing the newly posed hypotheses.

This process of increasing focus meant that the project could be
tightly controlled and directed with no risk of the remit mushrooming, as it
could easily have done when researching in such an area. However, there
was also the recognition that, in order to effectively capture the spread of
issues and factors pertaining to the situation, it would be necessary to pose
hypotheses which reflected this diversity. To this end the hypotheses sought
to;

(a) Clarify the quantitative effects of the Cell Generated Measures
    in relation to the existing system as described in Stage I and
    the performance of the Control Group.

(b) Describe the main advantages and disadvantages of the
    approach of the Research Group and the progress which they
    made in terms of continuous improvement and general
    performance.

(c) To provide the practical answers and guidelines which would
    be required when initiating a similar system elsewhere.

In these terms the overall structuring of the research succeeded in its
aims. A rigorous and controlled approach is especially important in action
research generally and behavioural research in particular. The importance of
maintaining objectivity was also recognised early and this element of the
philosophical considerations is of key concern in the evaluation of the
methodology employed.

(26.2) Secondary Level: Philosophical Considerations.

The fundamental subjectivity of an approach where the researcher is
the change agent coupled with a situation where a great many variables
(indeed the very culture of the company at large) are outside of the
researchers control means that the rigour of the methodology is of enhanced
importance in determining the validity of the research. The following represent the major factors in the situation of the research and the methodology employed which, potentially, are areas of systematic error and, therefore, weakness:

- Immersion of the researcher in the experimental situation: possible lack of objectivity.
- Hierarchically defined superiority of the researcher over the subjects: possibility of expectancy bias on the part of the researcher affecting the behaviour of subjects and outcome of the research (Role Motivation).
- Degree of influence of the behaviour of the researcher on the behaviour of the subjects (Psychosocial effects)

The possible lack of objectivity of the research is the thread which runs through all of the above points. The control which the Researcher had over the subjects and their situation, the possibility of expectancy bias leading to the hypotheses posed becoming self-fulfilling prophecies and the central role of the researcher in the change process are all factors which threaten objectivity.

However, this risk was recognised early in the research (Section 1) and this realisation led to the inclusion of more positivist type elements in the methodology. Not least among these was the statistical analysis of historical data which was central in the examination of the existing measures and the analysis and appraisal of the new measures. The hard data provided ensured that, whatever the effects of the subject-experimenter relationship, the effects on the performance of the cell of the changes made could be clearly defined.

The issues relating to the interactional errors, however, are less clearly resolved. Through consideration of the various subject-experimenter
artefacts defined in the Behavioural Research literature it is possible to
firstly categorise the possible systematic errors present and then describe
firstly how these were countered and, secondly, the possible effects which
they may have had.

(26.2.1) Defining Systematic Error

Systematic errors can be contrasted to Random errors, which are
defined as the effects of uncontrolled variables that cannot be specifically
identified, but are 'self-cancelling' [4]. Systematic errors are those which are
directly attributable to uncontrolled variables which are not 'self cancelling'.
Such systematic errors can apply to the effects of the subject, the
experimenter, or the relationship between them and are termed to be
noninteractional or interactional. Before considering these specifically,
however, it is first necessary to briefly define the errors which are
attributable to the attitude of the subject to the research and the researcher.

(26.2.2) Types of Role Motivations.

There are three main types of role which a subject might assume;

(a) Good Subject: excessively sensitive and accommodating to
the experimenter's implicit wishes and expectations for the
experimental outcome.

(b) Evaluation Apprehension: the subject is fearful of being
judged and apprehensive that their performance will be
judged unfavourably and modifies their behaviour to suit.

(c) Negativistic Subject: fundamentally uncooperative and
even hostile, does everything possible to sabotage the
experiment.

Clearly each of these modes of behaviour must be avoided if possible so that
the subjects respond to the research in a 'naturally positive way'. This was achieved primarily through the approach of the researcher. In the first instance each potential group member was asked whether or not he/she would be interested in participating. After the researcher had outlined what the main aim of the Group would be the subject was able to make a decision whether to be involved or not. While the research aspect of the project was made clear to each subject it was also explained that the main aim of the Group would be continuous improvement of the cell. The fact that all those approached agreed to participate, however, may be due to the fact that that they were behaving as Good Subjects. However, three factors make this possibility less likely:

(a) The attitude of the researcher was deliberately non-persuasive. To coerce or pressure people into participating would have introduced error into the research and undermined any attempts to build a team which would actively want to improve the cell.

(b) By minimising the emphasis on the research side of the project while maximising the emphasis on improving the cell performance in terms of customer requirements the researcher was able to clearly identify and monitor those elements of the experimental outcome on which the subjects would focus if they behaved as Good Subjects. Therefore, in making the aim of the Group explicit from the outset the possibility of misinterpretation and/or deliberate adherence to any implicit wishes (or subject perception of them) was much reduced.

(c) The time scale of the project was fairly long (Stage I: 40 weeks; Stage II: 40 weeks) and the possibility of Good Subjects maintaining any facade or pretence of co-operation and enthusiasm every day over
such a period is minimal. Any other co-operation and enthusiasm must, by definition, be genuine and brought about by factors other than role motivations.

The explicit initial description of the purpose of the Group coupled with the good working relationship existing between the researcher and subjects made the possibility of any Evaluation Apprehension minimal. Where it did exist within individuals it was quickly eliminated through the rapid evolution of the team and the increasing control which that team developed in relation to the performance measures against which they were to be judged.

Because the motivation to make changes was high from the start there appeared to be no Negativistic Subjects within the Group.

While such anecdotal reasoning provides a useful basis in testing for systematic error there is clearly a need for more concrete evidence and this is provided through the various questionnaires employed. Of particular relevance is the Research Group Analysis Questionnaire (Section 21). This is referred to in detail at a later stage.

(26.2.3) Noninteractional Experimenter Effects

There are three main systematic errors in this category;

(a) Observer Effect: where the act of observation effects the results observed.

(b) Interpreter Effect: where the experimenter's interpretation of experimental data is biased or erroneous in some way.

(c) Intentional Effect: where experimental results are deliberately modified in order to fit a desired outcome or pattern.

Each of these effects operate without the researcher influencing the
subject's actual response. The only measure to be taken in response to these effects is simply to be aware of their possible existence. In no instance was any kind of Observer Effect noted during the research. It should be noted, however, that another kind of observation effect, the Hawthorne effect, which does effect subject response, was noted. This is discussed later.

The role of any Interpreter Effect is worthy of consideration. Much of the research is punctuated with interpretations of data and other situational information. An example of this is the interpretation of correlation coefficients between drivers. While there is a definitive point where correlation starts and finishes (according to the significance level selected) the grouping of sets of data into different levels of non-correlation is purely judgmental and open to criticism. In this case, however, the results of all the correlation coefficient calculations gave definitive groupings in terms of correlation and non-correlation and so any Interpreter Effect was of minimal consequence.

The selection of significance level followed convention of identifying 0.05 as the Confidence Interval [131, 132]. Further discussion of this point appears in Sections 6.4 and 16.

The other main area of possible contamination was that involving the interpretation of questionnaire responses. While every effort was made in the design of the questions to minimise the degree of interpretation required (including quantifying responses where possible and using semantic differential types) there was always some reflection and interpretation of responses required in order to extract the salient points which would feed into the following part of the research. The danger here was that erroneous inferences drawn from one questionnaire response would be fed into the next stage of the research so invalidating that. In this way the errors would have been cumulative and difficult to trace if detected at all. In order to minimise the chances of this each respondent was approached after the questionnaire
had been completed and the results analysed so that the conclusions drawn from their response could be fed back to them for validation. In this way the validity of the analysis did not rest solely on questionnaire design and administration but was cross referenced at every opportunity. This approach meant that the subject's interpretation of the questions was also clarified (in the Production Manager Questionnaire this aspect too was included as part of the questionnaire structure through the repetition of questions to facilitate cross referencing of results and assessment of response repeatability in driver ranking).

The question of Intentional Effect is addressed in a similar way to that of Interpreter Effect. The constant cross referencing of questionnaire results and feedback of conclusions to subjects can be offered in partial defence. Additionally, the quantitative and testable characteristics of statistical analysis means that the intentional manipulation of this data is less likely than that of 'softer' or more phenomenological based evidence. Finally, the answers to the Final Cell Attitudinal Questionnaire, many of which feature direct facsimiles of subject responses, confirm many of the overall conclusions of the research (indeed the responses themselves form the basis of many conclusions) and add to the integrity of the project.

(26.2.4) Interactional Experimenter Effects.

There are three main types of Interactional Experimenter Effects;

(a) Biosocial Effects: differences in subject response due to the sex, age or race of the researcher.

(b) Psychosocial Effects: differences in subject response due to the personality/characteristics or social/hierarchical status of the researcher.

(c) Situational Effects: differences in subject response due to
the experience of the researcher, the degree of familiarity with
the subjects etc.

In terms of any Biosocial Effects in the research (or either of the
other two types of effect) it is not possible to categorically prove that there
were no effects on subject response. To do so would require identical
projects to be carried out by other researchers of the same and differing
social types.

Only the experience of the researcher in this case can be offered. The
sex of the researcher is unlikely to have been a major factor influencing the
results of the research. During the course of the research as well as in the
everyday running of the Cell (in the capacity of Cell Leader) the researcher
aimed always to treat female members of the cell in the same way that he did
male members. The fact that the Team Leader was a woman is not relevant
since it was the Team (not the researcher) who elected her to the position
(note that the Team also included another woman and that the election of
the Leader was unanimous). In terms of the age or race of the researcher
there is no evidence available to prove or disprove that these factors
effected the research in any way.

The same is not true of Psychosocial Effects. The attitudes and
behaviour of the researcher undoubtedly contributed substantially to the
outcome of the research. This is borne out through the responses given in
the Final Cell Attitudinal Questionnaire which details the sudden decline of
activity, motivation and morale with the departure of the researcher and his
replacement with another Cell Leader. However, rather than weakening the
research, through making this particular psychosocial effect explicit (made
possible through the change in Cell Leader), it is possible to define a factor
in the system implementation (Cell Leader characteristics) which determines
the success or failure of the system; i.e. success is contingent upon Cell
Leader characteristics. This element of the results is found in Section 21 which gives guidelines for implementation elsewhere. Similarly, the social/hierarchical status of the researcher is specifically identified as a critical factor in the success of the system through the identification of the Cell Leader or Line Manager as the key to the success of any such system.

The role of Situational Effects is less clear. Certainly the high degree of familiarity which the Researcher had with the subjects was a positive influence in developing the system but no further conclusions can be drawn.

The overriding point relating to Interactional Effects is that, since the research described is a case study, any extrapolation of the findings to other situations must be carried out with caution. However, as has already been argued, the potential transferability of the findings is considerable and, as the findings are removed further and further from the research situation, so the literal assessment of any Interactional Effects becomes less valid until only awareness of their possible existence is realistic.

(26.2.5) Bias and Objectivity.

When conducting any research which relies heavily upon participant observation it is necessary to recognise early the reflexive nature of all such research. Because the researcher is part of the social world which is being studied it is impossible to detach oneself from it and there must, therefore, be some effect on the outcome of the social situation under consideration. This is especially true in the case of action research where the researcher is also a participant. Experimenter Expectancy Effect [4] is defined by behavioural researchers as being an interactional effect in which the progress and results of research are biased in some way because of the expectations of the researcher. There are two widely recognised approaches to combating this problem. The first is concentrate on mimimising the bias inherent in questions etc. while the second is to be aware of potential bias but
concentrate rather on the possible effects which this bias may have on the research [133]. As Wass and Wells (1994) point out;

'...we feel that while one must acknowledge the possibility that the presence of the researcher will contaminate the data one must seek to understand the nature of this impact and attempt to keep it to a minimum wherever possible.' [3]

The question of possible bias in this research was one which was incorporated into the methodology from the outset. Major factors in the minimisation of bias were the lengthy period of the research, the tabula rasa basis of Stage I and the multiple information sources and personnel consulted prior to the formulation of the hypotheses. As Becker (1970) notes;

'the field worker typically gathers his data over an extended period of time, in a variety of situations, using several different ways of getting at the questions he is interested in, all of these reducing the danger of bias. Because he observes over a long time, he finds it hard to ignore the mass of information supporting an appropriate hypothesis he may neither have expected or desired...' [134].

The maintenance of objectivity during Stage II, as has already been explained, was achieved through the careful design of questionnaires and feedback of results (minimising bias) and also through the Research Group Analysis Questionnaire which provided all subjects with the opportunity of reflecting on the role of the researcher (understanding the effects of any bias).

This questionnaire was completed at the end of Stage II when the new Cell
Leader was in place and the subjects were no longer answerable in any way to the researcher.

The results of this questionnaire appear in Section 21 and suggest that the researcher did not influence the behaviour or progress of the Group beyond the initial training and suggestion of system configuration (i.e. customer focused measures used to drive kaizen). As well as being in concordance with the stated aims of the researcher to be primarily facilitative in nature and so encourage a sense of 'ownership' on the part of the Group, this suggests that the experimental objectivity of the research was maintained in similar proportions. The bias caused by the presence of the researcher was, therefore, minimised as far as possible. However, the influence of the researcher in initiating and encouraging the Group (e.g. coaching the Team Leader, allowing time for multi-skiHing, liaising with other departments etc.) was clearly central, (including some Hawthorne type effect). What is important is that the nature and effects of this involvement are clearly understood and actually form part of the overall results of the project.

Finally, the extensive use of statistical data throughout the project provided a thread of positivism (and high objectivity) which can be used to link every stage of the research. However, while the majority of experimental techniques employed were of a phenomenological type and based around ethnography, these served to flesh out the understanding of the situation in a way which purely positivist methods could never achieve, and which are necessary as a basis for realistic positivist analysis in behavioural research. The expectancy bias, impact of the observer and threats to objectivity, which are all unavoidable in such research, were recognised, minimised as far as possible and fully explored and analysed at every stage of the investigation.

The final section briefly discusses the research tools employed.
(26.3) Tertiary Level: appraisal of tools employed.

There were four main research tools employed within the project described here;

(i) Correlation Statistics
(ii) Semi-Structured Interview
(iii) Questionnaire
(iv) Participant Observation

The use of diverse techniques served to validate and test information collected from different sources regarding the performance measurement system within the company (e.g. perceived versus actual driver interrelationships) and to maximise on the volume of relevant data collected. Such use of quantitative as well as qualitative methods is known as methodological triangulation [135] and means that the research does not become 'method bound' [136].

Taking each tool in turn;

(26.3.1) Correlation Statistics

As stated previously, the statistical analysis of historical data provided a strongly objective element to the research and served as a vital yardstick against which to judge the anecdotal evidence gleaned from the qualitative methods. The use of the correlation coefficient in particular provided information about degrees of interrelationship between measures and was used at every stage of the research. While there are computer packages available which calculate coefficients all calculations in this research were carried out manually. Although this was extremely time consuming it did mean that a level of understanding of the data and
relationships between measures developed which was beyond a simple quantitative value. Consequently, while it was the quantitative result which fed into the following stage of the research in each case, it was possible to discuss the results more fully as a result of the increased understanding. Such a detailed perception was especially valuable in suggesting reasons for high levels of non-correlation between cell generated measures when the opposite had been expected. However, while correlations between data sets are defined by this method a significant level of correlation does not, in itself, define a causal relationship. In order to do this one must look beyond the data to the circumstances surrounding it. Input from qualitative methods facilitated this.

(26.3.2) Semi-structured Interview.

This method of investigation was used twice during the project. Once for the initial interview with the Production Manager and once with the Production Director. In both cases a list of, fairly loosely worded, questions was drawn up prior to the interview and used, by the researcher, as a framework for him (the researcher) to refer to. Jones (1985) suggests that a useful method to employ in the semi-structured interview is to base the interview framework around a ‘topic guide’ which can be deviated from, if required, as the interview develops and preferable lines of enquiry begin to emerge [137]. This was the approach used in both of the semi structured interviews. In this way, also, the degree of structuring can be modified, at the discretion of the interviewer, as the interview develops. A similar approach was used for the initial interviews with quality, financial and other support personnel in the information flow analysis, although these interviews were a good deal less structured than the two described in more detail.

While the basic aim of each of the interviews was the same (i.e. to gain further insight into the perceived functioning of the existing
performance measurement system) the specific requirements of each differed. The Production Director interview served as an additional perspective on the picture while the Production Manager interview served as a lead into more detailed questioning through a questionnaire.

Because the researcher knew the Production Manager and Director fairly well the issues of obtaining trust and social interaction [1] did not feature heavily in interview planning. However, the minimising of bias in the questions as a result of preconceptions on the part of the researcher was an issue which required some attention. The researcher could not assume, for example, that the interviewee would respond in certain ways to basic questions and so omit them from the interview process. The result was that some of the questions asked by the researcher seemed rather obvious to the interviewees bearing in mind the researchers position in, and experience of, the company. In order to combat the threat of bias in the questions posed or interpretation of the answers given much use was made of the technique of reflecting back the answer just given. In this way the point is clarified and bias is reduced.

As has already been stated, the results of the interview with the Production Manager fed directly into a detailed questionnaire. Having identified the key performance criteria as perceived by the PM the following questionnaire sought to produce a ranking of those drivers using a variation on a technique known as the Critical Incident Technique.

(26.3.3) Questionnaire.

The questionnaire referred to above used the Critical Incident Technique as a '...procedure for collecting direct observations of human behaviour in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles' [138]. The use of the technique in conjunction with interviews is widespread among
qualitative researchers and its inherent objectivity lends added rigour and depth to the results of the initial interview [1]. Such was the experience of the researcher in this case where a novel design of questionnaire involving repeated 'critical incident' situations built, in effect, a data base of human response to an everyday management dilemma.

Other questionnaires employed were less complex. The two Cell Attitudinal Questionnaires, for example, used a combination of YES/NO type questions with more open ended ones. Initial questions were deliberately straight forward and requiring of little effort with later questions becoming more involved and requiring additional thought once the confidence and interest of the respondent had been gained. By using the same questionnaire, with mostly the same respondents, at the beginning and end of Stage II, a direct comparison over time of attitudes and behavioural consequences of performance measures was possible. As previously stated, objectivity was maintained through awareness of the need to minimise bias in designing the questions and reflecting back the results of the questionnaires to respondents. This use of questionnaires proved invaluable in distilling and clarifying the views and beliefs of cell members and served, also, as a supplement to the quantitative information provided by the statistical analysis.

The final questionnaire, the Research Group Analysis Questionnaire, provided the opportunity for the Group to feedback to the researcher, in a structured way, their feelings about the project in general as well as the role of the researcher. In addition to providing an additional behavioural comparison of the existing and cell generated systems, this questionnaire also gave an indication of the degree and nature of any bias on the part of the researcher as perceived by the subjects. The use of a semantic differential design meant that the questions were easy to answer and the results clear and straightforward.
Participant Observation.

This mode of investigation was in effect almost constantly and much of the information gained simply through watching, listening and talking with cell members served to shape and direct the more formalised methods of information retrieval and analysis detailed above. The volume of information gleaned through frequent informal conversations on the shop floor, for example, was too large to be recorded in detail in anecdotal form. This nebulous data was captured, however, through the questionnaires and interviews described. Other knowledge gained by the researcher through his own experience and immersion in the situation, while not being detailed explicitly, served to add weight to the guidelines for implementation elsewhere, for example.

Not only the subjects but the researcher also was a participant and the observations of the researcher made by the subjects and communicated to him formally (through questionnaire etc.) as well as informally served to enrich the learning experience which the researcher went through in carrying out this research and running the cells under his leadership.
(26.4) Critique Summary

The threat of bias and subjectivity in the research is focused on three main areas;

(a) Research Type
(b) The Researcher Effect
(c) Selection of Research Groups

(a) Research Type

The research methodology is based around the concept of 'action research' which seeks an understanding of a system or situation through changing it and the researcher being immersed in that change process. Using this as a backdrop the obvious threats to objectivity posed by the ethnographic nature of the project were countered using methodological triangulation. This involved a combination of 'quasi-experimental' analysis of the two Groups and quantitative statistical analysis of the historical data.

This combination of methods two distinct advantages over more 'pure' forms in this case;

- Exclusive focus on positivist type methods would give a blinkered and incomplete view of a complex and multifaceted situation.
- Exclusive focus on phenomenological type methods would not provide the degree of objectivity required to produce a rigorous piece of research and would limit transferability of outcomes.

By augmenting qualitative methods such as questionnaires with statistical analysis it was possible to identify and take into account sources of subjectivity while maintaining a thread of objectivity through the research.
(b) The Researcher Effect

The effect of the Researcher on the results obtained was a key consideration in the methodology. In the event the role of the Researcher proved to be central in determining the results of the project. The apparent subjectivity of this situation was taken account of and rationalised in the following ways;

- Through sections of the Initial, Final and Research Group questionnaires which addressed the point of Cell Leader/Research influence specifically. The responses from these were used to test for type and degree of object-experimenter artefacts as detailed in the literature.
- Through the removal of the Researcher from the cell half way through Stage II and his replacement. This allowed the explicit testing of the effect of management style on the degrees of kaizen activity and the effectiveness of this activity in driving performance improvement.

The combination of these points led to a clear definition of the Cell Leader role in the process which not only served to further validate the methodology but also augment the proposed implementation framework and guidelines.

(c) Selection of Research and Control Groups

The reasons for the selection of the RG and CG have already been given and to summarise the reasons for their selection were two fold;

- Both cells are under the control of the Researcher and so continual contact and monitoring is facilitated in this way.

Both cells are similar in terms of processes, product and customer requirements.

The differences which did exist between the cells was addressed through the methodology as discussed earlier. What is open to question, however,
is whether the research would have been more objective had the groups been under the control of another Cell Leader. In some respects this may be the case. The absence of any object-experimenter artefacts would have simplified the justification of the methodology and validation of the results much more easy. However, it is felt that the dual position of Cell Leader / Researcher served to increase the value of the research in the following ways;

- The close working contact which the Researcher had with the cell personnel meant that a far greater insight into cell personalities, politics and culture was possible than if the research been carried out in other areas.

- A major element of the research output was concerned with the key role of the Cell Leader in forming and guiding his team. This included many aspects of management style and team/leader interaction. Such detail would have been much more fragmented in an alternative situation. Through making explicit the subjectivity of the situation the research is able to provide a practical guide to others. A more objective design, in this case, would have yielded results of less practical benefit with fewer of the potential pitfalls of system introduction detailed.
Prior to outlining the implications of this project for further research in the area it is necessary, first, to summarise the findings of the research.

(27.1) The Salient Findings

This research represents a contribution to the field of performance measurement in general and the behavioural implications of such in particular. The following points are central to that contribution;

In relation to Dunlop Cox Ltd.:

- It is possible to identify those measures of performance in effect on the shop floor and within cells.
- The measures identified can be regarded as drivers in terms of their effects on the operation and culture of the cell and the production function as a whole.
- There exists a severe lack of congruence between understanding of the prime, accounting based, driver on the part of the Production Manager and Cell Leaders.
- The prime driver (LPI) has fundamental behavioural consequences in terms of Cell Leader attitudes towards continuous improvement activities on the cells.
- The performance measurement system in effect within the company does not drive continuous improvement on the cell, indeed, it acts as a barrier to kaizen and advancement of the company culture.
- There exists, within the production function, the misconception that there are strong correlations between the various drivers identified and that these correlations are of sufficient reliability to enhance control and improvement of production activities.
- The existing performance measurement system, and the LPI in particular,
is considered unfair by production operators and little sense of ownership or even understanding of the system is felt.

Additionally and in relation to Dunlop Cox and other organisations as discussed in Section 24;

- Shop floor employees have a good understanding of the problems existing in the management and operation of their production cell.
- Cell members have a good understanding and appreciation of the requirements of their customer (especially where the degree of customer contact is relatively high and requirements are relatively stringent).
- Shop floor employees are generally eager to make changes to the operation of the cell in order to improve the performance of the cell in terms of both customer and internal requirements.
- Given adequate encouragement and support, cell members will readily formulate new performance measures with realistic goals and time scales associated with them.
- The performance measures so formulated are effective in driving and directing continuous improvement activities where the existing measures are not thus demonstrating some of the benefits of participative goal setting.
- The use of such new measures to drive kaizen results in, initially, rapid improvements in cell performance both in terms of the new, non financial measures and the existing traditional and accounting based measures.
- Such measures will not, necessarily, correlate with one another although his would not appear, at least in the early stages, not to hinder rapid improvements.
- As improvements progress and the waste to be eliminated decreases then increasingly focused measures are required in order to facilitate further
improvement.

- The active encouragement and support of the Cell Leader is vital to the long term success and advancement of the group associated with the new measures.
- The motivation of employees brought about through the development of such measures is as effective in improving cell performance as the physical changes prescribed.

The above points cover a broad spectrum of aspects relating to the behavioural implications of performance measures. They also help to identify several avenues of investigation which must be followed in order to improve our understanding of performance measurement. These areas for future research are briefly discussed in the final section.

(27.2) Specific points arising from the Research.

(i) Correlation between measures.

During the early stages of the research there was the assumption that, in order for a set of performance measures to drive a production function in a predefined and predictable direction, it was necessary for those measures to be linearly related to one another to some extent. Indeed, the lack of correlation between measures under the existing system was considered to be almost as much of a weakness of the measures as the mistaken belief that there were such a relationships. Subsequent developments of the Research Group, however, where considerable improvements were made within a very focused system but with no apparent correlation between measures, calls into question the need for linear relationships between measures. Further research is required in order to examine in detail the relationship between degrees of correlation and degrees of improvement. Such investigation,
however, will not be easy since the multivariate nature of any manufacturing situation (especially when considering behavioural implications) will call into question the reliability of comparisons between different experimental groups in such a case. It may be that a longitudinal study of a single situation may reveal more with, as is suggested in the text, increased degrees of correlation emerging as the areas of waste decrease and increasingly focused measures are implemented.

(ii) **Issues relating to Supply Chain management.**

Many world class manufacturers actively develop quality and control systems which are closely aligned to those of their suppliers. In some cases the systems of customer and supplier are actually one and the same. This type of increasing integration has also begun to influence the performance measures employed by some supplier companies. The development of performance measurement systems which are shared by customer and supplier, or even supplier chain, is an area worthy of further investigation. The degree to which the explicit requirements of a customer in terms of detailed, operational, performance measures should override the authority of shop floor employees to devise their own measures and the behavioural implications of such developments is an area requiring further work.

(iii) **Internal Translation Mechanisms**

Much research is required, also, into the possible mechanisms by which internal non-financial and financial measures can be linked and equated with one another (if, indeed, equation is necessary). Also, the ways in which the output of non-financial internal measurement systems can be coupled to the financial measures of holding companies and the City is an area where virtually no empirical research has been carried out. While there
are individual case study examples in progress there has, to date, been no proposal of a widely applicable translation mechanism. It may be that, because each company is different, there can be no widely applicable system. In any case further work is required.

(iv) Behavioural Implications of Performance Measures in non-JIT environments.

Due to the popularity of the JIT philosophy and its increasingly widespread use much research attention has been focused on the effects and effectiveness of performance measures in JIT situations. This is increasingly true as time emerges as a pre-eminent factor in business success. However, there are also many situations where JIT is not practised. The use of performance measures in job-shop environments, for example, has received some attention [139] but not in terms of the behavioural implications of performance measures. Such investigation would test whether the findings of this research are applicable to non-JIT situations. Finally, the role which performance measurement could have as a vehicle to JIT implementation and the culture change required is an area where valuable research could be carried out.


Initial studies suggest that many of the problems inherent in developing performance measures which drive continuous improvement in manufacturing and service/financial organisations are common [140]. In general, service industries, however, have been slow to adopt many of the practices which are well known to manufacturers and which could benefit them (TQM in the National Health Service for example). The role which performance measurement could have in driving change through its
behavioural consequences as applied to non-manufacturing situations (including Local Government and the Civil Service), therefore, promises to be a huge area of potential research activity.

(vi) **Bottom-Up propagation of Customer Focused Performance Measurement Systems**

The propagation up the organisation of such systems as that developed in this research promises deep rooted goal congruence and a focused business. Further investigation is required into the process of developing a customer focused system where there is a definite business and manufacturing strategy in place which may or may not be congruent with the requirements of the shop floor and/or the customer. In cases where strategy and measurement requirements are at odds there may well be a trade-off between satisfying the demands of shareholders for example, realised via the strategy, and the longer term need to continually improve and remain competitive.

Central to this and points made previously is the importance of a sound understanding of the behavioural implications of performance measures. Such understanding facilitates the efficient exploitation of Japanese business practices with the added dimension of a truly empowered and proactive workforce [141].
Overview of the Research

This, final, section will provide an outline of the following with respect to the research project:

(i) Basic assumptions.
(ii) Research output and contribution to the field.
(iii) Critique of the research method employed.
(iv) Summary of further work.

(i) Basic assumptions

The basic assumptions made within the project can be summarised as follows:

(a) That, in the analysis of systems, the questionnaires and interviews employed were as free from bias on the part of the researcher as possible.
(b) That the response of the Production Manager, Cell Leaders and Operators, was a true reflection of their understanding of, and attitudes towards, the existing, imposed and new systems; i.e. what they said was what they meant.
(c) That the choice of 5% as the Confidence Interval for the calculations of Correlation Coefficient reduced as far as possible the chance of making a Type 1 error without increasing the possibility of making a Type 2 error.
(d) Correlation between performance measures is a prerequisite of a controlled system which will successfully drive continuous improvement.
(e) The system developed could be applied to an entire organisation with bottom up/top down contribution to business strategy review and formulation.
(f) The system developed could be employed in non JIT manufacturing environment or in a service organisation with equal effectiveness.
(ii) **Research Output and Contribution to the Field.**

The output of the research summarised in the following statements;

(i) Without clear communication of goals and an understanding of the behavioural consequences of performance measures between levels of the organisation it is not possible for the shop floor to drive effective, long term, improvements.

(ii) Where a group productivity bonus system is in place longer term measures and goals become neglected.

(iii) In order to effectively drive continuous improvement it is necessary to facilitate the choice of measures and administration of the system by those to whom the measures will be applied.

(iv) Such a system produces more rapid and sustained improvement in terms of customer focused measures and labour efficiency and productivity than do traditional, implemented, systems.

(iv) There are two key elements in the successful development and operation of a cell-generated performance measurement system;

- Training and Education of the Cell Leader and Operators
- Open, coaching and progressive management style on the part of the Cell Leader.

(v) The translation of a system which exclusively supports the existing management accounting function into one which drives the production cell towards the requirements of the customer is illustrated by the Introverted and Optimised Measure Driven Cycles.

(vi) The process of measurement selection, training, customer input, kaizen and measurement review can be formalised as the Contingent Measurement Framework. This framework can be used in any situation approximate to that described in the research.
(iii) Critique of the Research Method employed.

(i) The research employed can be termed as being 'action research' in that the best way to understand the system was to change it and take part in that change process.

(ii) The methodology employed a technique known as 'methodological triangulation' which involves several different techniques (qualitative and quantitative) to examine the same phenomenon over a period of time.

(iii) The techniques employed involved the use of positivist (objective) techniques such as statistical analysis and phenomenological (subjective) techniques such as interview and participant observation. This approach ensured a good understanding of a subjective research situation augmented by the thread of objective research methods to maintain rigour.

(iii) The immersion of the researcher in the situation and the hierarchical relationship of the researcher with the subjects provided the greatest threat of bias in the research. This risk was recognised and overcome by understanding and quantifying (as far as possible) the effects of the presence of the Researcher (as Cell Leader) on the project.

(iv) The other main threat to objectivity was the comparison of the Control and Research Groups in terms of altered performance, education, morale etc. where their initial states were different in a number of ways and where different management styles applied to the Groups was possible. This element was handled through the use of questionnaires at the start and end of the research and the analysis of relative rather than absolute comparison of performance changes over time between the Groups.
(iv) Summary of Further Work

(a) Investigation into the necessity of correlation between performance measures intended to drive continuous improvement activities.

(b) Taking the concept of cell-generated systems into the area of supply chain management.

(c) Investigation into possible translation between financial and operational measures within manufacturing companies taking account of new measures such as Economic Value Added.

(d) The relationship between performance measurement and change management within non-manufacturing organisations.

(e) Investigation into systemising the bottom up contribution of the shop floor in issues of strategy formulation.
References


