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Technology, labour markets and the organisation of technical work: CADCAM in Australia

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University of Wollongong

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Technology, Labour Markets and the Organisation of Technical Work: CADCAM in Australia

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR of PHILOSOPHY

From

UNIVERSITY of WOLLONGONG

by

Paul William Blake Hyland


Department of Science, Technology and Society

1999
DECLARATION

I Paul W. B. Hyland declare that this thesis submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the department of Science and Technology Studies, University of Wollongong is wholly my own work unless otherwise referenced and acknowledged. This document has not been submitted for qualifications at any other academic institution.

Paul W. B. Hyland
21 October 2000
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ABBREVIATIONS

ACADS The Association for Computer Aided Design Limited
ACTU Australian Council of Trade Unions
AFMEPKIU Automotive, Food, Metals, Engineering, printing and Kindred Industries Union
AMT Advanced Manufacturing Technology
AWIRS Australian Workplace Industrial Relations Survey
BCA Business Council of Australia
CAD Computer aided design
CADD computer aided draughting and design
CADCAM Computer aided design/Computer aided manufacturing
CAE Computer aided engineering
CAM computer aided manufacturing
CAPP computer aided production planning
CIM Computer integrated manufacturing
CNC computer numerical control
CPU central processing unit
CRT Cathode ray tube
DAC Design Augmented by Computers
DNC distributed numerical control
FEA Finite Element Analysis
FMS Flexible Manufacturing Systems
GM General Motors
GUI Graphical User Interface
IBM International Business Machines
IGES Initial Graphics Exchange Specifications
IRC Industrial Relations Commission
LAN Local area network
MIT Michigan Institute of Technology
MRP Manufacturing Resource Planning
MTIA Metal Trades Industry Association
NC numerical control
OLE Object Linking and Embedding
PC Personal Computer
QA Quality Assurance
PDM product data management systems
PDMS production database management system
RDMS Relational Database Management System.
SME small to medium enterprises
TAFE Technical and Further Education
TQC Total Quality Control
VSAP Vehicle Structural Analysis Program

Abbreviations
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SYNOPSIS

The number of technical workers in the workforce in all economies is increasing. In developed economies such as Australia they play a significant role in the process of production. The increasing use of advanced manufacturing technologies (AMT) such as computer aided design/computer aided manufacturing (CADCAM) has the potential to significantly impact on the jobs of workers in areas such as engineering, design, draughting and production. This thesis examines the position of technical workers and some of the changes to their work that have occurred as CADCAM has been implemented and developed. The labour process, labour market and class-consciousness literature provides the framework for this research. The research set out to determine if employers or employees have used advanced manufacturing technologies such as CADCAM to alter the power relationships and work of technical workers in Australian labour markets? This thesis has challenged the view that it is in the best interest of employers to deskill and displace skilled labour and replace them with unskilled labour. The empirical findings in this thesis support the view that technical workers in Australia using CADCAM are engineering and trades people who have used their knowledge and skills to become CADCAM users. The data also supports the view that in the main technical workers have relatively secure jobs with good status and prestige. Technical workers have used their knowledge of the design and production processes to ensure that their jobs are located in a secure tier of the primary segment of an internal labour market. Finally technical workers have a contradictory class position, but currently they are more closely aligned to their traditional roots in the working class than to the middle class.
CHAPTER ONE

Introduction

This thesis examines the nature and characteristics of the jobs of technical workers using computer aided design/computer aided manufacturing (CADCAM) in Australian manufacturing industries. In doing so, the assumption¹ that management aims to deskill workers and increase management's control over the production process using technology, is challenged. The ability of technical workers and trades people to protect their jobs through a variety of mechanisms such as craft regulation and exclusions practices is too often ignored. Some craft workers such as print workers, eventually failed in their efforts to protect their jobs from the onslaught of computer-based technologies after lengthy struggles. But not all workers have failed and it may be the case that some workers have been able to use technology to protect their jobs. Workers are not only able to protect their jobs and working conditions for long periods of time from attacks by employers, but if they are proactive, they can improve the status of their jobs and their working conditions. To protect and improve the status of their jobs workers need to develop strategies that will alter the balance of power in their favour. In analysing the nature and characteristics of jobs this study aims to determine if workers and employers value the jobs of technical workers using CADCAM. That is, how are CADCAM users' jobs regarded by employers and employees? Are the CADCAM users' jobs skilled, with good status and working conditions, or have these jobs been deskillled, devalued and marginalised and is this the result of the introduction

¹See Braveman (1974) for a detailed argument on deskillling
of particular technological configurations? In conducting such an analysis it is necessary to examine the core issues of how labour markets are structured: What actions can workers take to make themselves and their jobs valued and what process determines who is allocated a particular job within a labour market?

This study begins by looking at how work is organised by capital and labour in a general sense. The interactions between capital and labour are a complex mixture of events and activities. (see Braverman 1974, Burawoy 1979, Child 1987, Edwards 1979 and Freidman 1977) While originally capital and labour were a partnership in the production process, this has altered over time with changes in the social, economic and technological framework. Changes in social, economic and technological conditions bring about new problems and possibilities for employers in organising the labour process. Similarly these changes bring about new problems and opportunities for workers and the unions that "represent" their "interests". The changes in conditions do not by themselves determine the content and structure of labour markets, rather they can and do result in changes to jobs. As jobs alter, or in some cases disappear, the balance of power between different actors such as employers, employer organisations, employees and labour associations will determine how the structure of the labour market is changed. If there is an increase in the demand for labour and shortage of supply, then the balance of power will shift in favour of the workers. If through the introduction of technologies, or altering product demand, there is an oversupply of labour the power balance favours employers. The reorganisation of work has profound
implications for workers, as old jobs disappear and in some cases new jobs emerge. For workers the question of how they can maintain a job, or be allocated a new one, is central to maintaining their position and status in the labour market. An understanding of the characteristic of jobs: their allocation, employment conditions, recruitment and training practices, career structures, and worker mobility can be gained from researching labour market, labour process and industrial relations.

In its simplest form a labour market is a construct that is used to explain the exchange of labour for other goods, services or money. The primary function of the labour market is the allocation of labour to jobs (for a description of labour markets see Whitfield 1987). In conventional labour markets it is assumed that there is competition among workers for jobs and between employers for workers, and the price paid by employers and accepted by workers will in the main be determined by the laws of supply and demand. However, it has been argued\(^2\) that the labour market is not a true market in as much as there are restrictions on supply and demand for labour. For example, in developing countries such as Australia, workers unable or unwilling to enter the labour market may be entitled to social security payments which leads to what some may regard as a market distortion. For this, and other reasons, different models have been constructed in order to explain how labour markets operate in the real world; where governments can, and do, intervene and other agents such as trade unions and employer organisations act to influence supply and demand. There are different models discussed by Whitfield

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\(^2\) See Appelbaum (1979) and others for discussions of labour markets
(1987) of labour markets including the wage competition model, flexible wage model, rigid wage model, implicit contract theory, dual labour market theory and labour market segmentation theory (see also Villa 1986). An examination of these theories and models reveals that labour market segmentation theory is most suited to Australian conditions as it is based on three propositions. These are: first that technology plays a central role in segmentation, second that class conflict and the role played by employers in controlling labour leads to segmentation, and finally trade unions play an active role in the process of labour market segmentation. If trade unions play an active role in the segmentation of labour markets, they must believe that it is in the interest of workers who they represent to have segmented labour markets Blandy and Richardson (1984) provide a useful discussion of the role of trade unions.

Traditional labour market theory is inadequate for sociological analysis because it is contradicted by what is actually happening at the organisational or firm level (see Doeringer and Piore 1971, 1979 and Osterman 1984, Thurow 1975). Also it ignores, or does not address, the organisation of the labour process, that is the process through which labour power is consumed. To understand the process of labour allocation, that is who gets what jobs, it is necessary to discuss employers’ policies and tactics at the firm level. Such a discussion leads to an analysis of the labour process. The process of allocation of workers within a firm is the outcome of a set of intertwined processes. These processes include recruitment, selection for training and promotion, and reward and recognition systems. For example, who bears the cost of training is important in

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3 See Villa (1986,16) for details of labour market segmentation in manufacturing.
determining job allocation. If workers are able to bear the cost of training and employers need to recruit trained workers and do not wish to bear the training costs, then only those workers who are trained will be recruited. So the employer can only recruit from a pool of trained workers and has little discretion in who can be employed. But this discriminates against the most disadvantaged workers who can not afford to pay for training. This has the effect of creating a secondary labour market of untrained workers.

The labour process literature, particularly since Braverman's work, has been dominated by arguments that management, in order to exercise more control over the process of production, is deskilling workers, separating them from the production process and creating new divisions between groups of workers. A large body of evidence (in the works of Cooley 1980, Berg 1981, Gorz 1976, Nichols 1980 and Noble 1979) has been accumulated to demonstrate that technologies such as automation and robotics have been successfully used by management to deskill production workers. So it is argued that other technologies such as advanced manufacturing technologies (AMT) will be used to deskill technical workers and eventually remove them entirely from the production process. Perhaps contrary to this argument the technological literature promotes information technologies such as CADCAM and appears to put forward the case that AMT are merely new tools that will save a manufacturing sector in decline. Similarly much of the management literature that examines the implications of technological change takes a simplistic view of AMT and claims many benefits. These include increasing productivity, reducing lead times and increasing the range of
customised products that can be manufactured in small batches to meet customers needs. CADCAM\textsuperscript{4} is representative of AMT and has been identified as a potential tool to be used in the deskilling of technical workers. Potentially, according to writers such as Cooley (1980), CADCAM could be used by skilled engineers to design a component and then manufacture it on an automated multi functional mill without any inputs from technical workers, tradesmen or production workers. This assumes that engineers have all the skills and resources needed to do the job and other workers would be unable or unwilling to oppose this process. Labour process theorists have downplayed the role of workers in opposing management’s attempts to control the process of production and they assume that workers have nothing to gain from, nor do they wish to have, new divisions created between groups of workers that may undermine class consciousness. This appears to ignore the actions of craftsmen who, in establishing a craft grouping, are creating divisions to protect their artisanal knowledge and skills from other workers.

Labour market segmentation theory, as discussed by Doeringer and Piore (1971), Edwards (1979) and later Osterman (1984), provides an alternative view of the divisions and inequalities among workers, compared to the views debated in the labour process literature. Although both bodies of literature reveal inadequacies, they are not mutually exclusive. A clearer picture of the processes taking place within internal labour markets can be derived from examining both bodies of literature. Much of the labour process and labour market segmentation literature examines the organisation of work in North America and Europe. Within the Australian context neither body of literature has

\textsuperscript{4} The potential for CADCAM to be used to deskill workers is dealt with in greater detail in chapter three.
focused on the role of workers and other actors such as unions and governments, and how they shape labour markets and the organisation of technical work. There has been, however, significant research on disadvantaged groups in the secondary labour market.

In order to understand the processes that determine labour market structures an analysis of industrial relations theory within a national context must be carried out. Industrial relations theory attempts to explain the interaction of employers, workers, trade unions and other actors who wish to influence labour market structures. However, according to Child (1986) and Thompson (1985), the actions of management and employees are constrained by existing social, economic and technological conditions. At the same time, a feedback loop exists, for social, economic and technological conditions are affected by the outcomes of the interplay between employers, workers, trade unions and other actors. If workers are not prepared to negotiate changes in work practices and conditions that allow an employer to improve productivity, reduce cost or improve the quality of a product, then it will not sell in the market place and the organisation will go out of business and there will be job losses. If the increased unemployment puts pressure on other workers this will eventually have social and economic effects.

This thesis examines and challenges some of the arguments concerning technical workers and technology put forward by labour process researchers. The examination is carried out within the framework of labour market segmentation theory, as proposed by Doeringer and Piore (1971). This is based on the assumption that the labour process does not operate in isolation, rather it operates within internal labour markets. If the labour process is altered in significant ways then this will have an impact on the structure of the labour market. It is within an internal labour market structure that
workers in an organisation compete for jobs usually on the basis of merit or seniority or a combination of both.

A formal description of how parts of internal labour markets are structured in Australian firms can be found in awards and enterprise agreements. The current system of awards, enterprise agreements and workplace contracts have evolved out of an industrial relation system that is unique to Australia. An analysis of Job Classification Structures contained in awards and enterprise agreements reveals that in a formal sense, internal labour markets consist of several segments. While an examination of documents such as awards and enterprise agreements establishes the formal structures, further empirical work needs to be carried out to determine if the formal description is an accurate description of the characteristics of jobs and segments within Australian firms using CADCAM.

**Approaches to the Research**

In order to gain a better understanding of the jobs of technical workers using AMT, two approaches were undertaken. Firstly, a literature review was undertaken to identify explanations of labour markets and then a review of findings on the implications of introducing AMT in the workplace was also carried out. The review of labour process and labour market literature revealed that few studies had been conducted that examined who was using AMT and how AMT such as CADCAM had altered the organisation of work. There appeared to be a lack of empirical analysis about exactly what changes had occurred to jobs of technical workers since the introduction of AMT. This review revealed there had been no survey research carried out on Australian manufacturers
using CADCAM that examined how work was organised and who was using CADCAM. Furthermore no detailed interviews had been conducted of CADCAM users to establish the impact of CADCAM on their jobs and to ascertain how their work had altered since the introduction of CADCAM.

After the initial literature review, a series of site visits and interviews were conducted to gain an understanding of the context of CAD and CADCAM in manufacturing companies in Sydney. Following the site visits a more detailed review of the literature was conducted. To collect primary data from around Australia on CADCAM a mail questionnaire was used, principally because of the wide geographic area to be covered. The survey was piloted on a small number of companies in NSW and Victoria and modified before being mailed out to the selected sample. Following the survey, a series of site visits and interviews were conducted to clarify issues raised in the questionnaire. As the focus of the survey was on work organisation and any changes that had occurred as a result of firms introducing AMT, such as CADCAM, it was decided to conduct the interviews some time after the survey. In conducting the interviews both CADCAM users and managers were interviewed to compare the perceptions of both groups. A detailed description and justification of the methodologies are presented in chapter seven.

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5 A study by Badham (1989) had described the technologies in use and how they were configured and organised.
Research problem and propositions

The research problem under investigation is: Have employers or employees used advanced manufacturing technologies such as CADCAM to alter the power relationships and work of technical workers in Australian labour markets?

In examining this problem the research sets out to determine the extent to which Awards and Enterprise Agreements describe the structure and segments of internal labour markets in Australia? If awards and enterprise agreements describe internal labour markets, can it be shown that these internal labour markets are segmented? In other words, to what extent do the typologies identified by labour market theorists such as Doeringer and Piore (1971), Edwards (1979) or Osterman (1984) describe internal labour market segments in Australia? And to what extent do these typologies adequately account for the position of Australian technical workers using CADCAM? Lastly, to what extent has CADCAM and the nature of CADCAM work enabled either workers or management to shape work processes and influence the relationships of technical workers within internal labour markets in Australia?

Structure of the thesis

Chapter two investigates how and why models of labour markets differ and examines the work of Doeringer and Piore (1971) Edwards (1979) Piore (1978) and Whitfield (1987) and others. The investigation seeks to find a model of the labour market that allows for the constraining influences of factors such as social, technological and economic conditions and the role of workers and their unions in structuring the labour market within the Australian context. In examining labour market segmentation theory this chapter seeks to provide an explanation of how labour markets are structured and
discusses several views on why management would wish to divide or segment labour. This discussion provides an introduction to the next chapter that examines the division of labour from the labour process perspective. Within labour market segmentation theory technology plays a central role in the structuring of the labour market segments. Technology specificity enables employers to keep workers within firms, as their skills are not readily transferable. The role of technology and different technological configurations detailed in chapter four is a major factor in considering CADCAM and how management has used it to influence the jobs of technical workers. It has been argued that different configurations of technologies such as CADCAM, are more likely to be used by management to monitor and control workers. This chapter puts forward three models of segmented labour markets that may be applicable to the Australian labour market. The characteristics used to describe the segments within these models are used in the survey of CADCAM users analysed in chapter seven.

In chapter three, an analysis of the debates about aspects of work and technology in the labour process literature, produces a richer understanding of what occurs within segments of internal labour markets and at the boundaries between segments. In examining the interactions between workers and the technologies in use it is apparent that in attempting to gain access to a particular technology, or in opposing the introduction of a technology, workers may come into conflict with their employers and other groups of workers. A detailed analysis of changes in work organisation and developments in manufacturing technologies can be found in the labour process literature. Chapter three will briefly examine the ideas put forward by Braverman (1974) and others that seek to describe and explain the changes which have taken place in manufacturing industries in developed economies. This chapter will analyse some of
the strategies that labour process theorists maintain employers have used, such as the division of labour, deskilling, and the introduction of technology to maintain their control over the labour process. Labour process researchers such as Cooley (1980) overemphasise the success of strategies such as these to alter the organisation of work and to assert, or increase, capital's control over the labour process. Labour process theory provides a useful approach and framework that can provide a better understanding of the microprocesses resulting in labour market structures.

Chapter four begins by exposing some of the problems associated with a discussion of technical work or technical workers. In exploring the approaches of the labour process literature to technical workers it is apparent that many of the studies, such as Carchedi (1977), Gorz (1976) and Mallet (1975) are concerned with issues of technical workers and class. These issues are explored briefly as they provide an explanation of the emerging conflict between technical and nontechnical workers. Yet another body of labour processes literature has proposed that technical workers will eventually be deskilled by the introduction of advanced manufacturing technologies such as CADCAM. While CADCAM can potentially be used to monitor control and deskill the jobs of technical workers there appears to be little empirical evidence to support this proposition. In defining technical work, and technical workers, problems are encountered (see Barley and Orr 1997). So it is proposed in this chapter that it is necessary to firstly define them within a national context then at an industry level. Within the Australian context awards and enterprise agreements contain definitions of technical work and descriptions of the jobs of technical workers. They also describe the skills and qualifications technical workers need to operate CADCAM. So to understand technical workers and CADCAM users in the Australian context it is necessary to have
an understanding of awards and the award making process. Chapter four presents a historical view of the development of awards within Australia's conciliation and arbitration system and will analyse characteristic awards to demonstrate the way in which particular labour markets are segmented. The analysis of awards and enterprise agreements will reveal if there are restrictions on entry into jobs and if the segments are similar to those described by researchers such as Doeringer and Piore (1971) or Osterman (1984). This thesis argues that existing theories do not fully explain the place of technical workers in internal labour markets; and how workers have played a role in shaping labour markets.

Chapter five links together the key features of the initial literature review. Then it examines the critical aspects of the theories put forward and draws them together in a theoretical framework. This chapter briefly introduces the reasons for linking the theory to the technology and leads into the empirical chapters and concluding chapter.

Chapter six begins by defining CADCAM and several similar AMT. A brief historical overview of the development of CADCAM is provided to place the current systems in context. The current status of CADCAM, as outlined by writers such as Chasen (1996), describes a complex array of systems and possible configurations. The competition among the suppliers of software and hardware means that no one system completely dominates the market. In some industries such as aerospace, particular software may be dominant. In recent years there has been significant improvements in PCs and this has lead to an increase in the use of low-end CAD packages. With an increase in the use of CAD and CADCAM across the manufacturing sector there is currently a shortage of skilled users. While this shortage exists CADCAM users can be confident that their
jobs are valued and secure. However, there is also an increase in the user-friendliness of systems, which means that it may require less skill than current systems. If it requires less skills to operate the system then this will potentially open up the labour market segment to less skilled users.

Chapter seven describes the research methodology and justifies the use of a survey and interviews to collect data. The subsequent parts of this chapter begin by describing the respondents to the survey and the hardware and software used. The remainder of the chapter examines the job characteristics of CADCAM users and describes the dominant characteristics. The chapter examines the possibility of relationships between job characteristics and technological configuration of hardware and software. The analysis shows that both hardware and software configurations are independent of any job characteristic. This chapter reveals that while there are job characteristics that are common to the majority of CADCAM users they do not fit exactly any of the typologies used by Doeringer and Piore, Piore, Edwards or Osterman to describe labour market segments.

In chapter eight the results of the interviews are analysed. The goal of the interviews was to shed more light on the characteristics of jobs of CADCAM users and to establish why it is important for CADCAM users: to work as part of a team, to be able to work unsupervised, to use their initiative, to solve problems and make decisions. Also interviewees were asked why “on the job” training was important and to identify how CADCAM users learned in the absence of formal on the job training. The survey revealed that the majority of CADCAM users were from a trade or engineering background. The interviews asked if this was still the case and why these technical
workers were CADCAM users. To determine if CADCAM was being used in some way by management to exercise direct or a more subtle control, CADCAM users were asked about how their work was monitored and controlled, and managers were asked about how they monitored work and measured CADCAM user performance. Users and managers were also asked about structures such as parts libraries, access levels and the ability of users to alter or customise the system, as this can provide indications of a more subtle level of control. Workers were also asked how their job had changed, to determine if the technology was being used by management to alter jobs, or if workers were modifying their jobs. Questions were also asked about the hardware and software configuration because analysis of results from the survey indicated that there is no substantial difference between the job characteristics of workers using different hardware and software configurations. This was done to determine if a particular hardware or software was being used to ensure technology specificity and restrict the career paths of CADCAM users. The flexibility and transparency of the system is important if management is using the technology as a control mechanism. An inflexible system where workers are unable to access a wide range of data and the work of other workers is indicative of a system where management is attempting to control, and restrict the tasks of employees.

Finally, chapter nine draws together the findings from the survey and interviews and relates these findings to the literature covered in the early chapters. It is clear that technical workers in Australia are able to readily access jobs as CADCAM users. CADCAM user's jobs are located in what can be regarded as an upper tier of the primary segment of the labour market. Engineering, operations and trades personnel regard CADCAM users' jobs within such a tier as desirable “white collar “ jobs with
status. As yet management has made little, or no attempt, to use CADCAM to monitor, control or deskill technical workers. The choice of system and its configuration appears to be based more on cost and “userfriendliness” than any other factors. Perhaps within the Australian context, the size of firms using CADCAM is such that there is no need to use or develop systems that allow for remote monitoring and control, that can be carried out directly by managers.

**Conclusion**

This thesis demonstrates the need to consider a diverse range of factors when examining how jobs are allocated and the potential impact of using a particular technology on jobs and workers. While the final choice of a technology is in the hands of management, how the technology is used and who uses it, is influenced by many forces. Workers can, and do, identify jobs that they see as being desirable and of high status. Workers have several paths open to them to be allocated a job and workers individually, or as a group, can take action to gain access to jobs and protect their jobs and their status.
CHAPTER TWO

Labour Markets

Introduction

This chapter examines labour market models and theories to identify an explanatory model that can be used to analyse the processes and outcomes within the Australian labour market. The model as noted in the introduction needs to take into account the influences of social and technological factors as well as economic conditions. At the same time the model must allow for the actions of workers and their unions in seeking to influence the structure of the labour market. The model also needs to be able to incorporate aspects of labour process research identified later in this chapter. An understanding of the different labour market models is necessary to determine which model of labour markets is most useful to an examination of technical workers and job allocation.

The supply of workers and the skills that workers need or possess varies considerably and can be influenced by factors both inside and outside of their control. The skills, which workers possess and those employers need, has significant impact on the supply and demand for labour. The variation in the demand and supply of labour operates within a labour market. The traditional view of labour supply and demand is that it operates as a free market. In a free labour market capitalists buy labour in the same way as they do any commodity (Kaufman 1988, 157). As the demand for labour increases, capitalists have to pay more for labour, if the demand for labour decreases, then the price paid for it will also decrease. Labour market theories have been modified to take into account the variations that appear from time to time and alternate models are put
forward to explain constraints such as lack of competition in the labour markets. Labour market theories and models all attempt to explain the availability, price and the allocation of labour, but few of these models allow for the activities of the state in structuring labour markets.

**Labour market theories**

Labour market theories include the neoclassical free market, dual markets and segmented markets. While many labour economists would argue that economic and technological considerations are crucial in the structuring of labour markets they are not the only factors that need to be considered. To understand why all labour markets are not the same in structure and to understand the role of employees in structuring labour markets, we need to examine the custom, cultures, conditions and characteristics within markets. Labour markets are not fixed, employees and employers are changing the positions of workers within the labour market and jobs are disappearing and new jobs emerging. The processes that allow these changes to take place alter policies in areas such as recruitment, promotion and training. The balance of power between employers and employees determines who has the greatest say in how labour markets are structured. The structure of the labour market within a firm, and the organisation of the labour process of that firm, will determine how jobs are allocated and who allocates them.

**Wage Competition Model**

The traditional view of labour markets, based on Adam Smith, is the flexible wage model. This model applies to jobs within firms and jobs across firms.
Whitfield (1987, 38-40) maintains that the main feature of the flexible wage model is that changes in the supply and demand for labour result in adjustments to wages. Others including Hicks (1963) Joll, McKenna, McNabb and Shorey (1983) support this view. As a result this model is termed the wage competition model. The wage competition model is based on the concept that employers always try to minimise their wages bill and pay only as much as they need to, to attract workers. Also this model assumes that workers can easily move from low paying jobs to jobs with high levels of remuneration. The market is said to be in a state of allocative efficiency when employers can minimise their wages bill and employees can obtain the highest wages that their skills will allow.

A major difficulty with this model is that it assumes that voluntary unemployment is eradicated as workers can reduce the wage level they are prepared to accept to obtain a job. While this may be the case in some industries such as the clothing industry where “out workers” are paid paltry sums for piecework; it does not apply across the board. In developed counties such as Australia there are minimum wages set by legislation and workers are unwilling and often unable to accept wages under the minimum level. This model also fails to take into account social security systems. When a government establishes a social security system that pays workers unemployment benefits then workers will not work for payments that provide a lower wage and benefits than that available through the social security safety net. The wage competition model is based on the assumption that employers will replace expensive labour with cheap labour. However, there is evidence that all employers can

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6 Brosnan et al (1995, 669) argues that a welfare system sustains labour market segmentation.
not take advantage of high unemployment levels to reduce the wages of their workers or replace them with cheaper labour. Blandy and Richardson (1984, 437) maintain that this is in part due to the activities of trade unions that distort the market. The basic wage competition model fails to take into account intervention by other parties such as governments. In Australia the activities of employers’ organisations and trade unions affect the structure of the labour market. The intervention of conciliation and arbitration tribunals in Australia can disturb the wage competition model particularly when the tribunals intervene in negotiations between employers and employees. The activities of employer’s organisations, trade unions and conciliation and arbitration tribunals in Australia have a major impact on the labour market. If these groups impact on the market in a major way then they need to be included in the theory, rather than being considered after the model has been constructed.

**Implicit Contract Theory**

One theory, according to Whitfield (1987) that attempts to explain why employers do not sack workers and replace them with cheaper labour; and why workers are prepared to acquire skills and do not consider working for less than the reservation wage is the implicit contract theory. The key assumption underlying the implicit contract theory is that it is riskier for workers to invest in acquiring skills than it is for employers to invest in physical resources. To encourage workers to acquire skills, employers offer workers a guarantee in return for some reduction in real wages. Employers guarantee a set wage regardless of changes in the demand for labour. This idea has been extended to cover employment conditions other than wages. The implicit contract covers a wide range of matters including physical working conditions, hours, penalty rates, hiring and firing mechanisms and training. The contract is a result of negotiations, often informal, between employers and employees and forms part of the culture and custom of the firm.
The important aspect of the contract is that the agreement is implicit, unlike industrial awards in Australia where the contract is explicit and detailed. Implicit contracts depend almost solely on trust between employers and employees. As employers are often unable to guarantee job security, or even the ongoing success of their own business, implicit contract theory provides a weak model.

**Rigid wage models**

There is considerable support for the wage competition model and there have been several attempts to modify it to suit particular labour markets. According to Whitfield (1987, 44) there is a growing number of economists who do not support the model. Those such as Villa (1986) who do not support the model maintain that because the real world labour markets operate in a completely different manner to the wage competition model it cannot be used as a starting point. Whitfield (1987, 44) maintains that using the wage competition model as a starting point introduces major distortions into the analysis of labour markets. Rather than use the wage competition model, labour economists have developed rigid wage models. The rigid wage model is based on the assumption that wages are highly constrained and do not act to balance the effects of labour supply and demand. The rigid wage model also takes into account non-economic factors such as, the structure of jobs and the behaviour of workers. Two main variants of the model have been developed, they are: Thurow's (1975) job competition model and the dual labour market hypothesis.
Job competition model

The job competition model argues that workers do not compete for jobs and wages on an equal footing. The model maintains that workers compete on the basis of their background characteristics, including their education level, gender, ethnicity, age and physical attributes. Whitfield (1987, 45) argues that the reason according to Thurow that workers are selected on this basis is because most skills are gained on the job. In selecting on the basis of background characteristics employers are attempting to minimise training costs. This model is based on the assumption that workers require skills to carry out the tasks that make up their jobs. To acquire these skills workers need to take part in training programs and these training programs impose constraints on employers. In particular, employers are unlikely to replace trained worker with untrained workers because they would then have to bear the cost of training the new worker. Assuming that there may be large pools of unemployed prepared to replace skilled workers in existing jobs, it is not in the best interest of employers to replace them as they would have to pay the cost of retraining. When selecting workers on the basis of their background characteristics employers rank the employment pool creating employment ladders. This ranking, based on the perceived cost of training workers, creates queues of workers waiting to get on training ladders. The first worker in the queue is the one who the employer believes would have the lowest training cost.

In larger firms employers prefer to hire lower level classifications that require the least training. The reason for this is employers believe that skills are best acquired on the job and that establishing career or skills paths within the firm increases the motivation levels of incumbent workers. To ensure that workers will pass information to one another and teach each other new skills, management, according to Thurow, needs to
inhibit wage and employment competition. In Thurow's model Whitfield (1987, 45) maintains that there is minimal wage competition and employment competition is restricted by controlling job opportunities.

Job opportunities depend upon what Whitfield (1987, 45) refers to as the distribution of knowledge, the sociology of wage determination and the allocation of training costs. The distribution of knowledge affects the degree to which employers can alter the production process and the organisation of work. If the production process consists of skilled jobs with the knowledge distributed amongst workers, it is difficult to alter the production process without the active involvement of workers, as many Australian firms discover when they attempt multiskilling. If, however, the production process consists of unskilled jobs requiring little or no knowledge then management can alter it easily and replace workers who object to any changes with workers from the pool of unemployed labour. The sociology of wage determination is based on the idea that the job preferences of workers are interdependent and that their income or wage expectation is relative rather than absolute. Workers expect people doing the same job to be paid the same wage and workers in similar jobs, or part of a team, or workgroup, would expect to receive the same wage as other members of the group. If employers are to motivate workers and gain their cooperation then they have to pay wages which the employees consider are just. If an employer offers a job at a wage which workers consider too low then no one with the necessary skills will apply for it, as it would be viewed by the group as being disloyal. At the same time the group would not believe it

\footnote{Multiskilling in Australian manufacturing industry is when a worker is trained in the operation of several machines or processes so that the worker can either operate multiple machines at the same time or rotate from one machine to another. Trades persons have also been multiskilled for example when they complete a dual trade certificate so that they can be qualified as say an electrical trades person and a fitter and turner, in cases such as this the trades person would be able to carry out the work of an electrician and fitter and turner.}
was just to receive too high a wage for a particular job. Who bears the cost of training has a large impact on the distribution of job opportunities available. Workers who cannot, or will not, bear the cost of training have restricted job opportunities. If employers are prepared to bear the cost of training they can exercise control over entry, into and progression within, the labour market and can determine who will, or will not, have access to jobs, training and progression.

**Dual labour markets**

In an attempt to explain some of the difficulties associated with competitive wage models of the labour market, the dual labour market theory has evolved, based mainly on the work of Doeringer and Piore (1971). The dual labour market consists of two distinct sectors in which the behaviour of employers and employees varies in fundamentally different ways. The market is divided into a primary and secondary sector. Jobs in the primary sector are characterised by high wages, good working conditions, stable employment patterns, career paths and equity in the administration of work rules. Secondary sector jobs are characterised by low pay, poor working conditions, high staff turnover and arbitrary and inconsistent administration of work rules. The dual labour market according to Villa (1986, 13) is a theoretical construct based on three interrelated hypotheses. First, there are two sectors in the national labour market, the primary sector with the good jobs and the secondary sector with the poor jobs. Second, the entry mechanisms and wage determination processes differ between the two sectors, and mobility between sectors is restricted and traps workers in the secondary sector. The dual labour market theory according to Doeringer and Piore
(1985) evolved as a hypothesis to explain how urban labour markets were structured in the USA in the late 1960s and early 1970s. The theory developed around the idea of an internal labour market. The idea of internal labour markets was introduced by Kerr in (1954) and Dunlop in (1966) and they can be regarded as administrative units or enterprise markets. Within these markets the price and allocation functions of the market take place within the organisation rather than outside of the firm. Workers in the internal market are protected from the vagaries of the external market where the payment and allocation of labour depends upon economic variables. Doeringer and Piore (1971) maintain that the main protective mechanisms are restrictions on entry and the possibility of mobility within the internal market. Internal labour markets are governed by a rigid set of rules that have developed over time and are based on customary practice. These rules determine who is eligible to move into given jobs and how the decision is made. The rules also relate to career ladders. The career ladders define precisely the movement of workers within the firm, movement up the ladder results in better jobs with improved wages and conditions. The basis of wage determination is a set of rules that apply to a family of jobs. A firm typically has several families of jobs. Each family has its own ports of entry, career ladders and wage system. While some rules apply to specific families, other rules are common across the organisation. These rules usually deal with procedural justice, job rights and job security. Within the dual labour market the primary sector consist of a series of internal markets characterised by a stable workforce. On the other hand Rubery (1978) and

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8 Curtain (1993, 14) argues that dual labour market theory relies on a special case that is the USA’s external labour market which he maintains is highly flexible and much larger than Australia’s labour market.

9 The career ladders put forward by Doeringer and Piore (1971) have many similarities to job classification structures. That is workers can enter a internal labour market at the lowest level then move up the classification structure as they gain in experience, skills and qualifications.
Wilkinson (1983) claim the secondary sector consists of those jobs that lack a formal structure, or distinct job description, and this sector is characterised by instability of jobs and workers.

Villa (1986) argues that while critics of dual labour market theory concede that it partly explains behaviour previously neglected by neo-classical theorists, it is viewed as an oversimplification of the labour market. The major problem is the dichotomy between good jobs and bad jobs. It can be argued according to Norris (1983, 110) that there is a job continuum ranging from good to bad moving through indifferent jobs. Although the theory suggests that technology is the major factor in determining the range of available jobs, there is no precise mechanism for allocating jobs to a particular sector. The criteria used to allocate jobs are usually the level of wages and a vague notion of occupational prestige or status. Villa (1986, 15) maintains that dual labour market theory raises more questions than it answers. Further, Villa claims the main questions raised are: Why do labour market structures differ, how are jobs allocated, are workers able to move between sectors and do the categories assist in analysing labour market structures in the real world? In attempting to answer these questions it becomes apparent that a dual labour market model cannot explain (and does not provide sufficient categories), to explain the complexity of the Australian labour market. Labour market segmentation is based on different hypotheses that in part explain job allocation mechanisms and the labour market structure.

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10 For a detailed examination of dualist models see Peck (1989, 125-126), one of Peck's main criticism is that dualist models fail to take into account the role of the State. In Australian labour markets the State has had a significant impact on shaping the structure and nature of labour markets.

11 In contrast to this continuum Flatau and Lewis (1993) identified segments and clusters and while the segments could be regarded as moving from unqualified jobs to highly qualified jobs there is no clear dichotomy between good and bad jobs.
Labour market segmentation

In an effort to be more explanatory than the dual labour market theory, the idea of labour market segmentation has evolved. However, as Orr (1997) points out, any examination of labour market segmentation is complicated by the fact that several variations of the theory exist. This analysis will only consider institutional approaches and is not concerned with neoclassical approaches. It is argued a range of factors interact to produce segmentation. These include the rise of monopoly capitalism, the emergence of a dual industrial structure, labour control tactics, product markets, technology, labour market institutions, the actions of workers organisations, the ideological and social context of production, the structuring of labour supply, discrimination and government policies. This is too complex an array of factors to examine in detail. The thesis will concentrate on those factors that may be regarded as having significant impacts on the jobs of technical workers.

Labour market segmentation is based on three propositions according to Villa (1986, 16). The first proposition emphasises the role of technology in structuring labour markets. The key to this proposition is that firm specific technologies can be used to tie workers to a particular technology and a particular firm. But employers using such a tactic may have to tie workers to the firm by offering higher wages and other privileges. The second, which is based in radical analysis, concentrates on class conflict and the efforts of employers to control the labour process. This proposition is based on the argument that employers develop a segmented labour market to separate workers in

13 The issue of control and the labour process is dealt with in more detail in chapter three.
desirable jobs from workers in poor jobs. This reduces the possibility of workers unifying and developing class consciousness and uniting in a class struggle for better pay and conditions for all workers\textsuperscript{14}. The third proposition emphasises the role of workers and their unions in the process of labour market segmentation. As unions have been traditionally craft based - all electricians for example belong to the Electrical Trades Union - then these organisations will act to defend jobs for their members. In defending the jobs of their members, unions try to control part of the labour market by establishing barriers to entry which leads to segmentation.

In examining the role of technology two main cases are argued. The first is closely related to dual labour market theory and argues that in selecting complex technologies firms will then need skilled, trained employees. Villa (1986, 16) maintains that if management is to meet this need they must be prepared to ensure a stable workforce by offering high wages and good working conditions. The second case supported by Norris (1983, 108) argues that a dual economy exists, the core firms are oligopolistic, have high capital-to-labour ratios, use sophisticated technology and as a result the firms require skilled workers. To meet their needs the firm bears the cost of on-the-job training of skilled, supervisory and technical workers. The peripheral firms are low technology firms that do not need well-trained skilled workers. Both these cases would suggest that technology has a role in influencing the structure of a labour market, but neither cases shows why firms select specific or general technologies. Technology by itself has little influence over the labour process and the structure of internal labour

\textsuperscript{14} In Flatau and Lewis (1993, 290) they found that non-professional workers such as technical and tradesmen and women viewed themselves as closer to unskilled and semi-skilled workers than they were to professionals and managers.

The radical hypothesis puts forward the idea that the evolution of the factory system has resulted in conflict\textsuperscript{15} between capital and labour. Internal labour markets are viewed by radical economists as a mechanism that allows management to divide or segment labour. For example, Edwards (1979) and Gordon (1972) argue that segmentation is a strategy that enables capital to control the labour process. Segments in the main are homogenous groups\textsuperscript{16} that Edwards (1979) claims are easier to influence than heterogeneous groups. In dividing workers into segments and restricting mobility, management is reducing the possibility of the development of class-consciousness and class struggle. Another approach supported by Edwards (1979, 171) and Kahn (1975) focuses on the active role of workers. In particular the role of unions in protecting the jobs of their members. With changes in economic, technological and market conditions, unions have developed strategies in response to these changes. Many of these changes result in increased competition for existing jobs\textsuperscript{17}. To reduce the competition for jobs workers need to have a say in job allocation policies. Workers involvement in the control of labour supply results in segmentation in the labour market because the strategies advantage one group and further marginalise others.

\textsuperscript{15} Fevre (1991, 890) maintains that conflict is built into the system of production as capitalist exploit workers by paying them less than the value of their labour.

\textsuperscript{16} Flatau and Lewis (1993) argue that their segments are not homogenous groups and there are significant differences between workers in all of their segments.

\textsuperscript{17} Fevre (1991, 112) points out that it can be argued that internal labour markets have the effect of changing the conflict from between capital and labour to conflict between workers.
In linking together these propositions, labour market segmentation provides a theoretical construct that can be used to analyse job allocation strategies and labour market structures. Labour market segmentation does not seek a single explanation of the labour market; rather it is a multi causal explanation. Peck (1989,125) maintains that while the main tendencies for segmentation can be traced to market uncertainty, changing product market conditions and technological factors and control strategies, other factors have been identified as playing a role. These other factors include the actions of the state and the collective struggle of trade unions. The interaction between economic, social, technological and institutional factors needs to be investigated to explain the functioning of labour markets. Doeringer and Piore (1971) provide the basic framework for understanding segmentation, although as they admit their work on labour market segmentation has evolved and is still evolving. However, in examining the work on labour market segmentation, the early work of Doeringer and Piore (1971) is an excellent starting point.

In examining the origins of internal labour markets it is useful to look at the forces which produce them and the rules which govern them. Doeringer and Piore (1971, 13) maintain that internal labour markets are generated by three factors, skill specificity, on-the-job training and customary laws. In discussing skill specificity Doeringer and Piore (1971, 13-17) also look at job specificity and technology specificity. The main reason for this is that management usually makes decisions about job structures and types of technologies rather than types of skills. In examining skill specificity it is necessary to

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18 The role of the State and trade unions will be examined in more detail in chapter four.
19 Doeringer and Piore (1984) in their second edition suggest that all labour markets are evolving.
distinguish between specific and general skills. Although the terms specific and general represent a range of skills, the term specific as used by Doeringer and Piore (1971) is a skill that is unique to a single job within one organisation. On the other hand a general skill can be used in a range of jobs, or in several enterprises. The main effect of skill specificity in internal labour markets is it increases the level of training cost borne by the employer and also the proportion of training cost to the employer increases. The reasons for this are relatively simple. As a skill becomes more specific it is less prevalent in the labour market. Skills, which are less prevalent cost more as economies of scale in training, cannot be realised. Also there is little incentive for employees to bear the cost of gaining specific skills, as workers are unable to utilise them elsewhere in other organisations. However it is in the best interest of employers to train employees in specific skills. Employees with specific skills are tied to the firm and by training employees in specific skills employers are assured of a supply of skills that they need. Also training, recruitment and labour market turnover are affected by skill specificity. Highly specific skills reduce employee turnover because they do not enhance workers employment opportunities outside a particular organisation. This increases the employer's willingness to accept the cost of training that can be offset against a decrease in turnover costs. Skill specificity also increases recruitment costs. Specific skills do not lend themselves to broad-based recruitment and screening techniques.

20 Curtain (1993, 14) argues that it has been demonstrated that firms broad and unspecific skills as well as specific functional skills. Also Porter (1990:593) argues that trained employees do not leave their employers in large numbers if the employers are prepared to invest in their personnel.

21 Curtain (1993:13) maintains that it is a misconception that general, nonspecific skills promote labour turnover.
While skill specificity is a major determinant in the generation and operation of an internal labour market, job specificity is also important. The two concepts differ in that a specific job may consist of a particular set of general skills. That is the set of skills is unique to the job in a particular firm. These skills could be general skills elsewhere but the combination of the skills would make the job unique. However, as Doeringer and Piore (1971, 15) point out, every job will require some specific skills; that is regardless of the job, the tasks undertaken become easier once the worker becomes familiar with the working environment. At managerial level skills can be specific. For example, if a manager is part of a team, then the skills required to work with a team in one enterprise are not identical to the skills required to work with a different team in another enterprise.

Technology, like jobs, requires skills of varying degrees of specificity. The technology itself does not impart specificity to skills. In working with a particular technology operators become more skilled, or are able to produce more goods or better quality goods, or both, after becoming familiar with the technology. In most cases the technology may be a machine or a process, but usually it is both. As far as machines are concerned Doeringer and Piore (1971,16) suggest that the greater the variety of tasks a machine is designed to perform, the less efficient it tends to be in carrying out any one of them. So if an organisation wishes to reduce cost there is a tendency for technology to become more specific to improve efficiency. It is not unusual for operatives and supervisors to carry out unauthorised modifications to improve the efficiency of equipment. Also most technologies tend to develop their own idiosyncrasies which operatives are able to cope with. These alterations and idiosyncrasies provide workers with unique knowledge and skills concerning the technology and its operation. So the
skills needed to operate the plant become the possession of the workers in the internal labour market. In this way the employees increase the importance of a stable internal labour force.

In examining how workers acquire skills, particularly specific skills we need to consider industry training. The largest proportion of skills utilised in carrying out a job is gained through on-the-job training. It is on-the-job training that enables workers to acquire skills that are specific to their jobs. However, Doeringer and Piore (1971, 18) maintain that on-the-job training is less important to professional and managerial staff who have acquired formal educational certification. This is particularly true when the formal certification outweighs the importance of on-the-job training. A great deal of training occurs informally. Often workers learn by doing and it is assumed that workers who have 'survived' have the necessary skills for a job. In some organisations training is part of the promotion structure so that a worker who is skilled at a lower level will be promoted to the next level. A more detailed explanation of training and promotion is examined in chapter four. Although training varies in different enterprises it can consist of three elements. Firstly, it occurs during the production process by trial and error. Secondly, it can be formalised, when an experienced worker deliberately demonstrates tasks to a less experienced worker. Finally, it can be viewed as a continuous readjustment of tasks. In this readjustment the experienced operative assigns tasks to a novice and as the novice demonstrates mastery they are assigned more complex or skilled tasks. While the novice performs the task the experienced worker supervises but does not carry out the task until the novice moves onto the more complex task. During each of these training situations job designations are maintained.
Custom is the third major factor identified by Doeringer and Piore (1971, 22) that relates to internal labour markets. Custom in a workplace is unwritten rules that govern any aspect of work or relationships at work. These rules are based on precedent and past practice. To establish custom it is necessary that the workforce is a relatively stable and thus social groups or communities can form. It can be shown that it may be in the best interest of management and workers to establish stable communities. As customary rules are enforced on an informal basis they may gradually become more rigid. As the customary laws gather force they will exercise a great deal of influence over internal wage structures and organisational structures. If workers fail to adhere to customary rules then either supervisors or fellow workers may discipline them. If management breaks customary rules, or attempts to change them without consultation, then workers may retaliate. Retaliation can vary in degree from go-slow campaigns to industrial sabotage and strike action.

Doeringer and Piore (1971) argue that custom is essentially a passive phenomenon. Doeringer and Piore (1971, 25) maintain that when economic conditions are stable and there is no conflict between management and workers, custom may not even be recognised as exerting any pressure. To a certain extent management, particularly shop floor supervisors, are tied to custom. As these supervisors are part of the shopfloor community they belong to that group and have helped to establish customary rules. If they fail to follow customary rules they face abuse, hostility and social ostracism. Essentially, custom is learned on the job and aspects are drawn from the wider community. It is established by the repetition of acceptable behaviour. New customs can be introduced when the group deems the behaviour is acceptable.
Garnsey *et al* (1985, 49) argues that custom which evolves within an organisation is strongly influenced by social groupings or units. Custom is historically based and the employment structure of firms, whether they are segmented or not, usually alters as the firm evolves. Firms become locked into given pay and working conditions. These conditions are usually modified on a regular basis but are rarely altered dramatically. When firms undergo dramatic reorganisation it is usually because of external factors. The gradual evolutionary changes that occur within firms are usually the result of interaction between groups. In altering pay and conditions, employers as Garnsey *et al* (1985, 49) points out, need to be aware of the firm as a social unit. Productivity requires the efficient interaction of employees. Effective productivity is not the result of new or better technology alone, it requires co-operative interaction from the employees involved with the technology.

Not all custom is unique to a particular firm or enterprise. Custom outside of enterprises also effects labour markets. According to Buchanan and Callus (1993) the behaviour and practices of unions and employers groups are regulated by informal rules and the application of these customs is central in determining wage rates and wage movements in Australia. Doeringer and Piore (1971) argue that some customs are imported from the wider community. Even when establishing a greenfields site there may be certain customs which management cannot violate. Some procedures, such as considering seniority when introducing redundancies, may be widely accepted outside a firm and may be very difficult to change. There is a cultural component to custom so

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22 Custom can even prescribe which workers are expected to get particular jobs. If as Brosnan *et al* (1995, 692) suggest that when disadvantaged groups are constrained in occupational choice this results in a community expectation that certain social groups will only be able to work in a limited set of occupations.
that some customs may be more prevalent within certain communities. The cultural component has as its basis group homogeneity. Homogeneous work groups will facilitate the development of custom. Also the stability of groups will help custom based on habit and past practice to become established. Finally, it is useful to note that on-the-job training reinforces custom. As skills and knowledge are passed from one worker to the next they induct workers into the customs of the workplace. Many skills and habits required to successfully carry out tasks are customs and are controlled by customary law. In the same way the group uses training and custom to reinforce job rules and internal wage determination.

Custom does not only play a role in determining the structure of labour markets, it also impacts upon who is, or is not, employed in the first place. As Fevre (1991, 68) points out, even if a worker finds a job that suits them the employer has to determine if they want that person for the job. In deciding if a particular worker is the right person for a job an employer takes into account a wide range of factors. These include: do they have the required skills, are they able to undertake all the tasks involved in the job and will they fit in with the other workers. Often in deciding who gets a job or not the final selection comes down to determining if this is the type of person who is usually employed by the firm. Once a worker has a job within a particular firm they will choose to stay in that job and at that firm for a variety of reasons. The reasons a worker chooses a job or chooses to stay in a job may include: working conditions, pay and intangible factors such as are the people friendly, is the employer fair and approachable.

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23 For a discussion of the social aspects of work and labour markets see Fevre (1991).
So that who gets and keeps a job is not easily quantified and how jobs are allocated is a complex matter.

In their early work Doeringer and Piore (1971, 28) suggest that workers and the trade union movement place a positive value on internal labour markets. This is reflected in workers' acceptance of lower earnings to ensure stable employment in these markets. Casual labourers and sub-contractors receive, in many instances, a higher hourly rate than permanent staff. In internal labour markets workers are also prepared to accept a lower wage or salary at ports of entry as they are usually guaranteed increased payments with promotion. There are three areas where workers benefit in internal labour markets. The first and the most obvious benefits to workers are job security and opportunity for advancement. Workers see internal labour markets guaranteeing them a long term, secure income. In periods of recession workers in internal labour markets are prepared to accept sizeable reductions in real wages and salaries to ensure job security. This has been demonstrated in recent years in Australia when trade unions representing the majority of workers in internal labour markets have agreed to wage freezes and small wage rises. Industries with strong seasonal and cyclical fluctuations will also be prepared to accept relatively lower wages in internal labour markets. The workforce also views internal labour markets as a means of ensuring equity and due process. Equity and due process has a value placed on it by workers, but it is difficult to quantify.

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24 Althauser and Kalleberg (1981), according to Fevre (1991, 101) suggest that workers value internal labour market as it provides them with access to almost all the jobs in a particular firm.

25 This was also demonstrated in the 1991 dispute between the ACTU and SPC fruit cannery. In this case workers actually accepted a cut in wage rates to ensure a reduction in job losses and long term employment for experienced 'senior' workers.
A major problem with internal labour markets is resistance to change. The major impediment to change identified by Doeringer and Piore (1971, 32-34) is customary law. Customary law determines what is right and just in an organisation and any forced change will be viewed as unjust and wrong. As well, change is constrained by skill specificity and on-the-job training; these both empower the skilled worker. When skills are specific the knowledge of a skilled worker is essential for effective training. So there is an incentive for workers to undermine the training process when they want to influence the supply of trained labour. This may occur when wages are determined by the availability of skilled workers. Wage rigidity and job security are necessary in plants where training occurs on an informal basis. This helps to ensure that workers will pass their skills and knowledge onto other workers around them. The internal labour market can be partially insulated from change in two other ways. One, which is used by craft unions such as printing and mining unions, is restriction upon entry. Another used by clerical and administrative staff, is seniority. In this case senior staff are guaranteed precedence in employment and promotion and is indifferent to staff entering the internal labour market after them.

Much of the work done on internal labour markets comes from firms that are unionised. It is the union movement that has enabled customary law to be formalised. Any attempt to alter custom, which has been ratified in Australia into award agreements, will result in economic reprisal or the threat of industrial action. However, trade unions provide a communication channel which allows management to negotiate with all union members.

26 The unwillingness of workers and some employers to alter internal labour markets in response to global competition resulted in pressure being brought to bear on the Australian Federal government in the late 1980s and early 1990 to change the industrial relations system. For a detailed discussion of these changes see Griffin and Teicher (1997).
This enables management to negotiate changes to customary rules in an orderly fashion. It is important to realise that local unions will often wish to negotiate change but are prevented from doing so by national executives, or other bodies in Australia, such as the ACTU. Also it can be the case that the union officers support changes but workers in an enterprise refuse to go along with the advice of their union officials. Unions may act to maintain the standard of living, or the relative wage levels of the majority of workers, at the expense of one or two smaller firms and their workers.

Technical workers\textsuperscript{27}, that is workers involved in the design, organisation and supervision of the production process, have been able to ensure that they have secure jobs within the internal labour markets. While there is evidence put forward by Dickson (1981) Windschuttle (1983) and Gill (1985) that management has replaced skilled workers on the factory floor with unskilled workers using automated technologies, there is little evidence if any of technical workers being displaced by technology. Rather there is evidence that skilled tradesmen displaced from the factory floor have been able to use their knowledge of the production process to acquire the knowledge and skills necessary to operate advanced manufacturing technologies, and in doing so have become technical workers in their own right. The empirical research in this thesis will determine the background of workers using CADCAM. If professional engineers are displacing technical workers, or if there is a change in recruitment practices, this may indicate that CADCAM is being used by employers to exert greater control over the production process by using CADCAM.

\textsuperscript{27} Technical workers will be discussed in greater detail in chapter three. Technical workers are not easily defined and there has been a great deal of debate about the nature of technical work.
The most widely accepted model of segmented labour markets was put forward by Doeringer and Piore (1971). However, other models and modifications need to be examined, including those put forward by Piore (1978), Edwards (1979) and Osterman (1984). The main features of Doeringer and Piore's (1971) model are that the internal labour market can be divided into two segments, a primary and secondary segment. The main features of these segments are summarised in Table 2.1.

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<td>High wages</td>
<td>Low Wages</td>
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<tr>
<td>Good working conditions and benefits</td>
<td>Poor working conditions and benefits</td>
</tr>
<tr>
<td>Employment stability</td>
<td>High labour turnover</td>
</tr>
<tr>
<td>Promotion structures</td>
<td>Little chance of promotion</td>
</tr>
<tr>
<td>Equity and due process in work rules</td>
<td>Arbitrary and inconsistent supervision</td>
</tr>
</tbody>
</table>

Table 2.1: Doeringer and Piore's Characteristics of Internal Labour Markets

The difficulty with this model is that it is very limited. While most technical workers would be located in the primary segment, they would not all experience the same working conditions or have the same promotion structures and career paths available to them. This model puts forward a simple dichotomy of good and bad jobs and does not fit the range of jobs found in Australian industries. Through the activities of the trade union movement and as a result of government regulations most jobs in Australia would be located within a primary sector. The few jobs located in the secondary sector would be seasonal jobs in the rural sector where there is arbitrary and inconsistent supervision, piece work, high labour turnover and poor working conditions, (although it could be argued that some jobs such as shearing can have relatively high wages).
Piore (1978) proposed a similar model that partly overcomes some of these difficulties. Piore (1978) maintained that the primary segment could be subdivided into an upper tier and a lower tier. The upper tier is not shackled by elaborate work rules and exhibits many of the characteristics of self-regulating work groups proposed by socio-technical systems theorists. The main features of Piore’s model are summarised in Table 2.2.

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Tier</strong></td>
<td><strong>Lower Tier</strong></td>
</tr>
<tr>
<td>Absence of elaborate work rules</td>
<td>Elaborate work rules</td>
</tr>
<tr>
<td>Internalised code of behaviour</td>
<td>Formal administrative procedures</td>
</tr>
<tr>
<td>Varied conditions allowing initiative and creativity</td>
<td>Personalised relationships between workers and supervisors</td>
</tr>
<tr>
<td>Low skilled poorly paid</td>
<td>Lack of linkages to other jobs</td>
</tr>
</tbody>
</table>

Table 2.2 Piore’s Model of Internal Labour Markets

Piore’s model is more flexible than the original model proposed by Doeringer and Piore in that it allows for a variety of working conditions. In this model the upper tier can be regarded as a professional/managerial elite. The model, as the terminology suggests, is a hierarchical one with promotion involving movement from secondary to lower tier to upper tier as well as vertically within each segment. However, this may not be the case and empirical evidence is needed to more clearly delineate how the tiers are structured and how workers can move between segments. While this model has moved away from a simply dichotomy of good and bad jobs it appears to place hard barriers between segments. With a model such as this there does not appear to be a mechanism for workers in the secondary segment to move to the primary segment. In Australian internal labour markets a worker may start off in a secondary job but if the have, or are
prepared, to gain skills and qualifications, it is relatively simply for them to move into a better job in the primary segment when vacancies appear.

In an effort to explain how segments consist of cross-cutting and overlapping divisions, Edwards (1979) put forward the idea of three segments that he termed the secondary market, subordinate primary market and the independent primary market. The segments differ according to the jobs within each segment. The main characteristics of jobs and segments of Edwards (1979, 178) model are summarised in Table 2.3.

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent</td>
<td>Subordinate</td>
</tr>
<tr>
<td>Supervisory, technical and specialised administrative jobs Includes craft and professionals Jobs allow for initiative and creativity Career ladders present Require external accredited training</td>
<td>Mainly unionised mass production jobs Assembly and fabrication, retailing and clerical Repetitive, boring, routine, often machine paced Little training, few skills Workers have little control over the job</td>
</tr>
</tbody>
</table>

Table 2.3 Characteristics of Segments in Edwards’ Labour Market Model

Edwards maintains that while skills, training, education, experience and technical characteristics can influence the structure of the labour market, he emphasises that these operate within a given system of control. The system of control will determine how the labour market is segmented. In arguing this he posits: simple control produces secondary labour markets, technical control results in subordinate primary markets and bureaucratic control leads to independent primary markets. Edwards model has many of the features and characteristics of segments in manufacturing industries in Australia.
where there is typically a clear division between unskilled labourers, who would be located in a secondary segment, and skilled production workers, who would form the basis of a subordinate primary segment. Where this model falls down is in the independent primary segment. In this segment Edwards has put both trades and professionals jobs, but there is a very clear divide between these two groups of workers. This model fails to distinguish between technical and trade workers, which is problematic in labour markets where there are a growing number of technical and scientific jobs.

Another model, which does not have a hierarchical structure, is Osterman’s (1984) model. Osterman puts forward three segments: the craft, industrial and secondary segments. The main features of the segments are outlined in Table 2.4.

<table>
<thead>
<tr>
<th>Craft</th>
<th>Industrial</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loyalty to skill and</td>
<td>Limited ports of entry</td>
<td>Few opportunities for</td>
</tr>
<tr>
<td>profession rather than</td>
<td>Progress along well</td>
<td>advancement</td>
</tr>
<tr>
<td>firm</td>
<td>defined career ladders</td>
<td>low skilled, poorly paid</td>
</tr>
<tr>
<td>Non-specific skills</td>
<td>Well defined rules and</td>
<td>Lack linkages to other</td>
</tr>
<tr>
<td>Highly mobile workforce</td>
<td>procedures cover job</td>
<td>jobs</td>
</tr>
<tr>
<td></td>
<td>security</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training provided by</td>
<td></td>
</tr>
<tr>
<td></td>
<td>employer</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.4 Characteristics of segments in Osterman’s Model

Osterman’s model has many similarities to Edwards’s model although he does not use a primary segment and the underlying basis for the segments are different. Like Edwards, Osterman puts trades and professional jobs in the same segment and fails to take into account technical workers. It is the emergence of a growing number of technical workers that has blurred the boundary between trade and professional work. In
attempting to simplify or limit the number of segments, most authors have lost sight of the fact that an internal labour market can be divided into many segments\textsuperscript{28}. Rather than describing different markets, Edwards (1979), Piore (1978) and Osterman (1984) describe segments of the same market or segments in different internal labour markets. Also labour markets are not fixed, nor are the segments within an internal labour market fixed. As the external environment changes\textsuperscript{29} either by developing new technologies, changes in the workforce, alterations to government policies, removal of tariff barriers or deregulation of monetary policy will all influence in some way the structure of internal labour markets. How management and workers respond to changes in the external environment has the potential to significantly influence the size and structure of an internal labour market. The movement to a global marketplace where companies can rapidly relocate an operation, or outsource any part of an operation, will alter how labour markets operate. However, it is no longer just companies who are internationally mobile. Firms throughout the world eagerly seek workers, particularly those with highly valued skills. Also with the expansion of information technology there is no need for a firm to locate all its functions in the one city, state or country. In fact many companies can see benefits for locating their design department in Europe or the USA and locating their manufacturing operation in Asia. Although firms and workers are increasingly mobile, the availability of skills restricts the movement of firms that are dependent upon specific skills, such as programmers or CADCAM users. Firms dependent on CADCAM users would be unable to move to low cost locations where

\textsuperscript{28} For a comprehensive examination of the segments and occupational clusters in labour markets in Australia see Flatau and Lewis (1993, 293).

\textsuperscript{29} Fevre (1991, 111-112) points out that several writers including Lazonick, (1978) and Rubery (1978) argued that workers are able to maintain control in spite of changes to technology or in work organisation.
there were no CADCAM users unless they could tempt CADCAM users to relocate with them.

**Conclusion**

Labour market segmentation theory provides a satisfactory alternative to orthodox economic models of labour markets\textsuperscript{30}. However, the taxonomies put forward by theorists such as Piore, Edwards and Osterman are inadequate to take into account the changing nature of labour markets in Australia. As Flatau and Lewis (1993) point out, in Australia occupations can be divided into a complex array of segments and clusters within segments. With changes occurring in government policies the nature and structure of both internal and external labour markets are being altered\textsuperscript{31}. As Osterman (1994) suggests; to understand the workings of internal labour markets a broader perspective needs to be considered. Such a perspective needs to take into account the operation of the labour process and the outcome of a labour market (Refer to Figure one). It is within the labour process that internal pressures interact to determine employer’s strategies and the labour market position of workers.

The nature and structure of segmented labour markets in Australia differs from those in Europe and the USA where most on the work on labour market segmentation has been done. While in the USA and Europe there are large internal labour markets consisting of a variety of segments, such vast enterprises with twenty thousand plus employees are very rare in Australia, particularly in manufacturing.

\textsuperscript{30} this is argued in Brosnan et al (1995)

\textsuperscript{31} For an analysis of the changing nature of work in Australia see James, Veit and Wright (1997).
However, segmentation, (except in very small enterprises) can occur. This segmentation occurs as a result of the interplay between labour market outcomes and labour market processes as depicted in figure one. This thesis is focused on technical workers using CADCAM in the manufacturing sector. The majority of manufacturing firms have a clear and distinct division of labour. Within manufacturing firms there are employees who operate the equipment that manufactures the final product and then there are non-operational employees. At the same time it needs to be recognised that within most firms there are some employees who can not be easily placed in one of these two divisions. Within the operational segment there are usually workers, or groups of workers, that are restricted to specific jobs or tasks. For example, in most firms an electrician is required to disconnect and maintain a major piece of equipment, such as mill which is electrically driven. If the firm does not employ an electrician then a subcontractor is employed to carry out the task. In many firms tradesmen and women will not operate production machinery as they regard it as outside their job description and beneath their status. Machine operators, unless appropriately trained are not allowed to carry out periodic maintenance activities. Therefore it can be seen that the tasks and jobs of workers depends upon a range of factors including the size of the workforce, the training, qualifications and skills of the workers and how the work is organised.

In medium to large firms using CADCAM there is a clear division between tradesmen and women and non-trades qualified employees on the factory floor. At the non-

32 In examining manufacturing firms this thesis excludes small or very small firms with less than ten employees or owner operator enterprises where the owners are involved in all process and outcomes.
operational level other divisions would occur but based on slightly different criteria. At its simplest level there would be a division between managers and non-managerial employees\textsuperscript{33}. Such a division may be difficult to sustain in many medium sized firms where clerical/administrative staff carry out managerial tasks. Non-managerial employees can be subdivided into technical and clerical/administrative employees. Technical employees in large organisations are subdivided into professional/technical employees and technicians or technical workers. As the groups or clusters are subdivided it becomes increasingly difficult to clearly differentiate between workers. In most workplaces groupings would be based firstly on job classification and then on qualifications.

\textsuperscript{33} See Flatau and Lewis (1993) for their description of job segments and clusters in Australia
Workers' position in the labour market is determined by

Specific job allocated to worker

Jobs are located within

Labour market structure

<table>
<thead>
<tr>
<th>Labour market processes</th>
<th>Labour market outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work organisation</td>
<td>Division of labour</td>
</tr>
<tr>
<td>Classification systems</td>
<td>Grading structure</td>
</tr>
<tr>
<td>Internal allocation</td>
<td>Reporting structure</td>
</tr>
<tr>
<td>practices</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>Composition of labour</td>
</tr>
<tr>
<td>Promotion</td>
<td>force</td>
</tr>
<tr>
<td>Recruitment</td>
<td>Skills and trades</td>
</tr>
<tr>
<td>Pay determination</td>
<td>Career patterns</td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
</tr>
</tbody>
</table>

Labour market structure

Social and Economic Factors
Technological Factors
Industrial Relations Systems

Constraints on the labour process influencing labour market structure

Figure 2.1 Job Allocation and Labour Market Structure
The composition of the labour force plays a crucial role in determining the labour market structure and how workers view their jobs and the jobs of their fellow workers. For example, a university qualified engineer would perceive him or herself as being different, perhaps even superior, to clerks and trades people even though at times they may carry out identical tasks. Even within the same occupational discipline, where there is a trades qualified engineer and a university qualified engineer, they may both experience major differences in pay, working conditions, career paths and opportunities for promotion. Yet at the same time, they could be required to carry out identical tasks. It may not always be the better formally qualified worker who gets the best pay and conditions.

So while skills, training, and classification systems may play a dominant role in determining the internal labour market structure, it is possible that one or two other factors can affect an individual worker's position in the internal labour market. Although the structure of the internal labour market is determined by internal factors these factors are moderated by external influences. Most internal labour markets can do little to influence the nature of external factors and events such as the development of new technologies, changes to industrial relations laws. Yet as will be discussed in greater detail in chapter four, the industrial relations system has significant effects on pay determination, grading structures, training processes and job classifications structures. Also new technologies can dramatically alter skill requirements, training needs, the composition of the labour force and even reporting requirements. Similarly, as shown in figure one, social and economic factors play a role in shaping internal labour markets. With increasing globalisation of markets some companies can readily move their operations from locations experiencing economic difficulties or social
turmoil to a more stable location offering better economic conditions. Similarly, individual workers are now more prepared and able to move from one location to another if they can see it will benefit them in the long term.

Economic factors combined with technological factors play a significant role in determining which technology a company can afford to acquire and when they acquire them. These combined with internal factors such as the characteristics of the workforce and the need for and availability of training also have an effect on the introduction and implementation of technologies. If a technology requires specific skills to operate it, or maintain it, and these are not available, then it is highly unlikely that a risk adverse company would introduce it to their operations. On the other hand, a company who could afford to purchase the technology but not train employees to use and maintain it would fail to achieve the full benefits of introducing the new technology.

Once a job is located within a particular segment of a market it is difficult for it to move to another segment unless a major change occurs to the tasks carried out within that job, or to the qualifications required to gain entry to the job. Any model or theory of labour markets must be flexible enough to allow for changes in external and internal conditions. As with all markets, demand and supply factors will play a role in determining the structure of the labour market. Large monopolistic firms will have a greater impact on the labour market than small firms as they will have a greater demand for labour. To ensure their demand for labour, either skilled or unskilled, is met they

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34 However it is more difficult for unskilled or poorly skilled workers and workers with dependent families to easily move to new locations.
are able to establish internal labour markets and structure them in ways that enables them to exercise greater control, increase divisions and differentiation among workers and increase the fragmentation of work groups. On the supply side, the activities of organised labour through the trade union movement exert a substantial influence on the structure of internal labour markets. Trade unions, by defending the jobs of their members against the incursions of other non-members, seek to maximise the position, status and secure of the jobs covered by a union. In doing so trade unions have played a major role in maintaining and extending the employment opportunities of their members. At the same time their actions have produced factions and segments within labour markets. To understand how internal and external factors can influence supply and demand conditions, which in turn impact upon the structure of internal labour markets, it is necessary to examine the labour process and the class-consciousness of workers. In examining the labour process it is possible to identify how factors that operate within the labour process lead to segmentation. While an examination of class-consciousness will provide a perspective of how wider social factors alter workers perceptions of their jobs and positions within the labour market.

36 See Peck (1989, 130) who argues that some workers in the primary sector have not only defended and maintained their employment opportunities but they have managed through the actions of their labour organisations to extend their job opportunities.
CHAPTER THREE

The Labor Process

Introduction

While labour market theories and models provide partial explanations of the exchange, availability, price and allocation of labour they do not attempt to explain the mechanism that influence the allocation of labour and the organisation of work within firms. Labour process theory is based on extensive analysis of the use made of labour within the production process. An examination of the theoretical approaches to the labour process debate provides a better understanding of how particular jobs are allocated to workers and what and who influences the process of job allocation. The labour process literature also examines the mechanisms that are available to workers and employers in their efforts to exert control over work organisation. Although much of the labour process literature describes European and North American experience it still has significance for Australian workers and employers. This chapter will deal mainly with the dominant European and North American literature and examine other research as it relates to the labour process in Australia.

Any discussion of the labour process and how technology has been used by capital to alter the jobs of workers begins with the work of Braverman (1974). Braverman has

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37 The labour process debate in Australia has not been as vigorous as the European and North American debate although labour process theory has played a significant role in some critiques such as the feminist discourse on employment.

38 Smith and Thompson (1998,569-571) maintain that it is essential that we are cautious in trying to find common or typical features of the labour process that matches a particular country. They point out that local labour market conditions override any international or even national features. Also that local factors and labour markets are most important in shaping the labour process within factories supports this. The local Australian conditions will be dealt with in greater detailing chapter four.
had a lasting influence on the labour process debate.\textsuperscript{39} This chapter will examine the development of key theoretical approaches to the labour process debate and link them to labour market theory. In analysing the labour process debate three main areas will be considered: Braverman’s work and some of its weaknesses, the deskilling debate and issues relating to information technologies such as CADCAM, and organisational design and technological configurations.

**Theoretical approaches to the labour process debate**

Labour process theory focuses on the micro-level. It provides a different and richer picture of what is happening to workers and their jobs than the macroanalysis of labour market theory. It is not necessary to present a historical account of the works of Marx, Weber and Durkheim to gain an understanding of the labour process debate. As Thompson (1985) explains although their work is important and their influence strong, they were not specialists, but dealt in wider general theories of class and society. Capital has attempted over the years to organise production in such a way as to minimise the relationship of workers to the production process. In attempting to divorce workers from control over the production process, management has sought to use technology to both dominate and to replace workers. According to Child (1987, 245) there is a widely held view\textsuperscript{40} that information technology based microelectronics will have revolutionary implications for the nature of work. As information technology has developed throughout the 1970s and 1980s, there has been a resurgence of interest in the debate on the labour process and how these technologies may be used to alter the labour process.

\textsuperscript{39} Foster. (1994, 40) points out that Braverman is still one of the most influential and widely cited authors on the labour process.\textsuperscript{40} Ehrensal (1995) believes information technology can not be neutral but increases rationalisation and control.
While much of the debate has centred on Braverman's (1974) work "Labor and Monopoly Capital", others such as Freidman (1977), Edwards (1979) and Burawoy (1979) have made significant contributions. At the same time the works of Gorz (1976), Zimbalist (1979), Berg (1981), Nichols (1980) and Noble (1979) have added to the debate. While the development of manufacturing technologies may have had some indirect influence on the renewed interest in the labour process it was mainly a result of the apparent increase in work place conflict. In the middle of the 1960s Thompson (1985) suggests that it was not only a quantitative increase in conflict but that there was a notable qualitative shift in workers' demands. Pizzorno (1978 vol. l:xi) found that there was a distinct shift in issues away from wages towards quality of working life issues, such as control, piece work, authority relationships, hierarchies and job upgrading. It was not only the number and issues in dispute that were altering, but also the personnel. Developments such as these led writers such as Mallet (1975a) to put forward the idea of a new working class. Initially the debate centred on the idea that a new class could emerge, for many this was a radical departure from Marx's idea of a homogeneous unified working class in conflict with capital. These early debates were inconclusive because they focussed on whether some technical and professional workers where part of the proletariat or part of capital. The significance of the debate lies in the ideas that were re-awakened rather than the conclusions that were reached.

Gorz (1976 VII) argues that the renewed interest in Marxist theories drew attention to the capitalist division of labour as a source of alienation. In a similar vein Edwards

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41 For a more detailed discussion see Fevre (1991)
42 Barley (1996) argues that technical workers and technicians can still be seen as a challenge to existing class structures.
43 Kiechel (1993) maintains that technical workers do not fit into accepted structures in hierarchical organisations
44 Smith and Thompson (1998, 556) claim that there is increasing pressure on technical and professional workers to produce outcomes, and they are expected to meet targets and follow standard processes and procedures. This leads to a reduction in the use of discretion in decision making and an increase in managerial control.
(1979) maintains that the labour process is an arena of class conflict. However, for Marx's work and ideas to take root again, a new framework of the labour process needed to be applied to recent developments in industry. It is Braverman, according to Thompson (1985) who has the distinction of doing this by taking a fresh look at skills, technology and work organisation. Braverman was one of the first to apply Marx's theory to the labour process. Thompson (1985) lists three aspects of Marx's work that Braverman has emphasised. The first is the transformation of labour, in this process capital transforms and controls labour to realise fully the potential of purchased labour power. The second is the production process, which alters social relations and imposes the will of employers. The third is the classic technical division of labour where work is subdivided into simple routine tasks. This subdivision can lead to deskilling so that cheaper unskilled labour can then be employed in place of skilled labour. It is argued by Foster (1994) that deskilling reduces labour costs by reducing the amount of skilled labour required, increasing managerial control and making workers interchangeable with other workers or replaceable by machines.

Braverman and Monopoly Capital

Braverman saw new technology in the service of capital, providing increased possibilities for deskilling. New technology provides management with improved tools and techniques of control; Edwards (1979) calls this technical control. This need by management to have precise control over each component of the production process has as its basis the work of Frederick Winslow Taylor. Braverman is not alone in his perspective on Taylor's work; others, including Marglin (1976) argue that employers have used Taylor's principles of scientific management to recast the partnership of capital and labour. However, not all employers seek to control every aspect of
production. In introducing a particular technology such as scheduling software an employer may increase his control over the pace of work and the production process, but it may not have been his initial aim. In the case of scheduling software the employer may have been trying to improve his on-time delivery and as an unexpected consequences ends up exerting greater direct control. Braverman argues that Taylorism\(^45\) is a qualitative change in production in that it separates the conception of a task from its execution. It is the subdivision of labour that enables capital to exercise greater control over the labour process. However, Braverman (1974,136) points out that Taylorism was opposed strongly by the trade union movement and was not capable of transforming the whole labour process. None the less, adherents of Taylorism have used new technologies to extend the division of labour. It has been claimed that what management had been unable to achieve through discipline and organisational change they have succeeded in doing by the introduction of specific technologies. However, it needs to be substantiated that management has deliberately set out to control the labour process through the subdivision of labour. As Child (1987, 253) suggests, management can choose whether to introduce technology that builds on existing skills or it can select a technology that is a means of degrading skills. This is also supported by Noble (1979, 323) who, unlike Braverman, supports his findings from extensive research in manufacturing plants. Noble found in visits to twenty four plants that in almost every case management had tried, but not necessarily succeeded, in deskilling the shop floor by transferring control to a programming office. As different components of work are mechanised there is a trend to reduce the skill of workers. Thompson (1985) claims that

\(^45\) Burns (1998) argues that conceptual skills were transferred from workers to technical experts.
regardless of the type of mechanisation examined by the different theorists, there is a general theme of deskilling as an essential component of the capitalist labour process.

While there is some agreement between labour process theorists that new technologies are introduced to deskill the workers, others including Blauner (1964), Goldthorpe, Lockwood et al (1968) and more recently Adler (1988) argue that the reverse may also be true. This argument maintains that as some workers experience a decrease in skills, others experience an increase in skills. In the early stages of the introduction of new technologies a small group of workers enhance their skills as they learn to operate the new machines. However, a study by Nichols and Beynon (1977), found that once the system is on line and running smoothly the work becomes less skilled. What appears to occur, according to Thompson (1985) is a cyclical effect where the group which initially gains skills is subjected to sub-specialisation as the machinery becomes more complex and they then lose some of their skills. The issue of the evolution of skills is of critical importance and empirical evidence is needed to support or refute the view that skills are cyclical in nature. This thesis will examine empirical data in chapters seven and eight that may determine if skill gains and losses are cyclical in nature.

**Skills and Deskilling**

Braverman's main contribution to labour process theory is his extension of Marx's work by linking the capitalist labour process to a theoretical model of the class structure.

46 See Meiksin (1994) for arguments that support the relevancy of Braverman.

47 Osterman (1995), maintains that the tendency in the 1990s is for an increased demand for skill. Likewise Barley (1996) sees unskilled manufacturing jobs disappearing and an upskilling in technical jobs. This still does not adequately establish if there is a transfer or re-allocation of skill or an overall reduction in skill.

48 A difficulty with this point of view is it is limited to machine operators and does not consider other workers who may not operate machines or workers who do not consider themselves to be machine operators.
In doing this Braverman touches on what Thompson (1985) sees as the two main areas of debate in labour process theory: deskillning and managerial control. In studies by the Brighton Labour Process Group (1977, 16) they found that deskillning existed in tasks that were intended to achieve cheapness, replaceability, maximum speed, and standardisation. The researchers also specified what deskillning involved: the replacement of skilled workers by machines or machinists, the division and sub-division of tasks with any skills being allocated to a few specialists, and the fragmentation of the remaining semi-skilled or skilled tasks. While this group has presented one definition of deskillning, one of the problems perceived by Thompson (1985) and others, for the deskillning thesis is that there is a lack of systematic definitions of skill within the literature\textsuperscript{49}. Even Braverman fails to define skill; perhaps for this reason many critiques of deskillning have ended up being attacks on terminology, confusing skills with training and dexterity.

Yet to understand the implications of technology on the labour process and work organisation it is necessary to have an acceptable definition of skill. Agnew, Forrester, Hassard and Procter (1997,318-319) put forward a model developed by Rolfe (1990) that is useful. They maintain that skill can be measured in terms of technical complexity and discretion or autonomy. Each of these components can be refined in terms of sub-components. Technical complexity can be measured in terms of the complexity of the task, knowledge of the product or process and finally range and variety of tasks carried out. Discretion or autonomy is measure in terms of level of supervision, amount of control the worker can exert over work organisation and the scope for individuals to

\textsuperscript{49} For comments on skill and problems defining skill see Meiksins (1994)
make decisions. Smith and Thompson (1998.566) maintain that within a societal model of the labour process autonomy is not simply the ability to make decisions, or work without direct supervision, but includes how to organise work and retain social interaction. Using Rolfe's (1990) model components of skill can be altered and this can be regarded as either deskill or the re-allocation of skill. But for complete deskill to occur one component would have to be completely removed. So if a worker was able to exercise discretion in the organisation of tasks and that discretion is removed completely then the job has been deskill. Similarly if a job has been technically complex and information technology is used to handle all the complexity and the worker simply becomes a machine minder then his or her job has been deskill. However changes such as these assume that while jobs are being destroyed the workers are passively standing by and accepting it, and making no effort to acquire other skills and exercise discretion in other ways.

An important aspect to consider when examining the deskill thesis is that it is anchored in the tradition of craft industries. Craft production is important because craftsmen were able to use their craft skills to exercise control over their work. Writers such as Montgomery (1976), Hinton (1973) and Stone (1973) stress this aspect of craftwork. They include industrial craftsmen such as iron and steelworkers and miners and maintain that they were able to regulate their hours, pace of work and wages. Using their ownership of the means of production they maintained their control over the labour process50.

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50 Although a historical examination of coal miners in Scotland during the Industrial Revolution and in the gold mines of South Africa today would not support this view. It was only after long and bitter struggles that miners had any say in the organisation of their work in the mines.
Much of this control has vanished with the introduction of new technologies, such as the continuous miner and the automated processing of iron and steel. These types of mechanisation have deskillled the workers and handed control of much of the labour process to management, but as Fevre (1991) points out it has also improved the working conditions and safety of workers and increased the productivity of operations. However, as Thompson (1985) notes, the process involved in deskillling has not been a gradual and unrelenting decline, rather it has been a long and uneven process. Crafts such as carpentry and printing have undergone fluctuating periods of deskillling with the introduction of new technologies. Zimbalist (1979) traces these waves of deskillling in his work on the printing industry. With the advent of the computer Zimbalist (1979, 108) claims that the last vestiges of craft tradition were destroyed. It could be argued that with this final act of deskillling, management as a tool of capital, had removed all control of the printing process from the workers. In doing this they enabled owners such as Rupert Murdoch to establish his plant at Wopping and crush the British printing unions.

A widely expressed criticism of the deskillling of craft workers and artisans is that it presents a romantic view of workers and crafts\(^{51}\). This view argues that craft workers made up only a small percentage of the total work force. More (1982), Putnam (1978) claim that the theory idealises the range of conceptual and manual tasks carried out in the production process. However, this criticism does not stand up against the evidence in works such as Zimbalist’s (1979) which outlines the levels of skill, knowledge and control exercised by craft workers in a large range of industries. A frequent criticism of

\(^{51}\) Meiksins (1994) addresses some of the criticism levelled at Braverman
Braverman that is often put forward is his omission of worker resistance\textsuperscript{52}. It is not only craft workers who are degraded by the development of new forms of work organisation, other semi-skilled and unskilled works are also at risk. It is usually the unskilled who are the first to be displaced by new technologies. Craft workers according to Freidman (1977) have access to a number of mechanisms, which enable them to effectively resist and counteract the deskilling process. Freidman (1977) argues that one of the key methods of resistance is social exclusion. Zimbalist (1979) presents a good example of social exclusion in the printing industry where the foreman was a member of the union and able to hire and fire workers, so he was able to exclude non-craft workers from the printing shop. Although craft workers initially headed opposition to the reorganisation of the labour process, unions of semi-skilled and unskilled workers soon joined the fray. As both Freidman (1977) and Nichols and Beynon (1977) show, it has been the collective struggle of non-craft workers that has been the distinguishing characteristic of the class struggle in the twentieth century.

A different criticism raised by Rubery (1978) is the absence \textsuperscript{53} of a theory of wage and price determination in studies such as Braverman's. Braverman's critique relies upon the view of Marx and Babbage that by dividing the craft into unskilled tasks, capital can reduce labour cost by employing cheaper unskilled labour for each task\textsuperscript{54}. An analysis of the interrelationships that exist in shifts in the labour market reveals systemic or external shifts in the size and nature of the labour market. Labour process theorists have

\textsuperscript{52} Meiksins (1994,51) addresses this criticism
\textsuperscript{53} Meiksins (1994,52) accepts that criticisms of Braverman are legitimate and have resulted in useful modifications to his work.
\textsuperscript{54} This is based upon the assumption that cheaper unskilled labour can carry out simplified tasks using available technologies. It also ignores our fails to explain why manufacturers regularly experience shortages of skilled labour. If it is in management's interest to displace skilled labour it is reasonable to assume that by displacing skilled labour there would be an excess not a shortage of skilled labour.
largely ignored the importance of changes in labour market structures. There are two types of systemic shifts; industrial shifts which relate to new products and processes, and cyclical shifts which relate to overall patterns of economic activity. Industrial shifts occur when new products or process are introduced, for example the development of the digital watch had massive effects on labour markets in Switzerland. This occurred because watch manufacturers attempted to maintain a craft tradition and failed to compete with the emerging Japanese manufacturers. When they did compete in the digital watch market they were successful only after they completely re-organised the process of mass manufacturing watches. Internal or occupational shifts that occur within the workplace, or internal labour market, correspond to the changes dealt with by Braverman. There has been little change in the percentage of skilled craft workers in the workforce, rather their position within the labour markets has altered. In his view as part of an industry deskills workers by introducing new products or processes, these skilled workers are able to move to other areas or segments or other industries or other jobs within the same firm. While deskillng usually occurs in large dynamic industries, many marginal sectors are maintained using traditional methods. This is the case in Switzerland where the craft tradition of hand assembling watches has survived but in greatly reduced numbers. Furthermore Thompson (1991,189) maintains that the deskillng thesis failed to take into account a range of intervening factors including worker resistance and the size and structure of firms.

The size and structure of firms plays a significant role in Australia, as there are few firms with more than one thousand employees. The large monopolistic firm typical of

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55 Labour market structures have a significant implication for the labour process as the structure of the labour market can determine how a range of technological, social and economic factors can influence the labour process.
some European and American industries does not exist in Australia. Thus many of the processes and work organisational structures of large international firms do not exist in Australian factories. Also size is a factor when considering the need for systems of control. In a small factory or workshop with less than fifty employees the owner can monitor the flow of work by walking round and observing the workers. In situations such as this it may not be necessary to use technology to monitor and control workers.

In this analysis there is a need to make a distinction between deskilled workers and deskilled jobs. The introduction of technology can result in a reduction in the skills needed to operate new technologies such as CNC tools and mills. In instances such as these the jobs of machinists are deskilled but if the machinists is able and willing to change jobs they may not lose any skills. It may also be the case that a machinist operating an advanced manufacturing technology is required to carry out preventative maintenance as they are no longer needed to constantly monitor a single machine. If this occurs then the machinist may loose skills needed to operate one machine and acquire new maintenance skills. As machines and systems become more complex, tradespersons maintaining such complex technologies can be trained in new skills needed to maintain and repair the new technology. It may also be the case that tradespersons who are unable, or unwilling, to be retrained are displaced from their jobs and replaced by skilled technicians or technical workers. This analysis will seek to determine if technicians and technical workers are more likely to be retrained

56 Burns (1998) maintains that the introduction of AMT has lead to an increasing reliance on skilled workers.
57 Barley (1996) points out that AMT informed machine operators work making it more abstract, symbolic and focussed on instrumentation.
58 For an analysis of changes to jobs and skill and computerisation see Burris (1998).
tradespersons or are they an emerging group with totally new skills displacing tradesmen and women.

Thompson (1985) argues that the growth of new industries, technologies and products does create new skills and in the short term these new skills may hide the real effect of the changes in work organisation. The real effect of changes in work organisation is the erosion of skills. This erosion of skills has weakened the position of many skilled workers. In this weakened position workers no longer compete against management, rather, they compete with fellow workers for the few remaining secure jobs. As Rubery (1978) points out to differentiate themselves from competitors, workers must attempt to control aspects of the internal labour markets in order to maximise their position. These aspects include apprenticeships, promotions by seniority, redundancy on a “last in first out” basis and restrictive practices and demarcations. If workers are able to gain some of the control lost through the breakdown of the craft system they may be able to compensate for loss of skills. Rubery (1978) suggests that particular attention needs to be paid to internal markets because the growth of internal markets can counteract the impact of skill degradation and workers can use tradition, custom and other constraints to ensure that they maintain their position within an internal labour market. So, to fully understand how workers can use internal labour market structures to protect their jobs, we need to link the labour process to labour market segmentation theory.

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59 Child (1984, 27) discusses the nature of deskill and suggested that while it is relatively simple to deskill jobs with high levels of specialisation and low levels of discretion jobs with high levels of discretion or low levels of specialisation are much more difficult to deskill.

60 Ehrensal (1995) argues that in the 1990s in the USA white collar workers have had their secure positions within internal labour markets eroded.
Other markets, which can play a role in the labour process, are the product markets. As the product markets change Kelly (1982) shows that firms respond to these changes. These responses can result in specialisation, new technologies or redundancies that can effect the organisation of the labour process. The rapid changes in market demand has seen manufacturers, particularly of electrical goods, move away from large scale production lines to small batch production. An example of this is mobile phones where manufacturers are producing customised mobile phone to customer specifications and delivering them to the customer within forty eight hours, effectively producing single unit batches. Similarly in the clothing industry Levi will produce a tailor-made pair of fashion jeans to fit an individual customer. The move to small scale batch production has increased the need for multiskilled workers who can move between jobs and carry out a larger number of tasks. Machine operators in most plants are required to operate a range of machinery and equipment rather than specialise in one machine. Thompson and McHugh (1991,209-210) argue that multiskilling requires an increased in workers’ knowledge, which if we accept Rolfe’s (1990) view of skill, would mean they are increasing rather than decreasing their skills. This move away from ‘Fordism’, combined with pressure from product and labour markets has, according to Thompson (1985), produced certain trends including outwork\textsuperscript{61}, decentralised production and work humanisation\textsuperscript{62}. There has also been an increasing trend to establish new plants in developing countries with cheap unskilled docile labour. If new plants are established in developed countries such as the USA, they are often established in states that have had a tradition of anti-unionism rather than the traditional locations. Both these

\textsuperscript{61} Outworking had not increased significantly in Australia according to the AWIRS study Callus \textit{et al} (1991). Although it had increased in some industries such as the textile and clothing industry

\textsuperscript{62} Work humanisation puts the worker rather than the machine as the focus for work organisation. This is discussed in detail by Cooley (1981)
strategies can appear to be a response to new product markets in emerging areas, but they really enable firms to exercise increasing control over the labour process by moving their operations to locations where workers are relatively powerless.

It would appear that work organisation undergoes cyclic periods of deskilling and worker resistance. It has been pointed out that crafts and skilled trades have been smashed by mechanisation and deskilling many times yet they have been revived and continue to resist domination and extinction. Braverman appears to ignore the cycles and is deterministic in his view that technological change will inevitably shape work organisation. In Elger’s (1979, 64) view Braverman is over reliant on evidence derived from management concerning skills and control. Supporters of Braverman, such as Zimbalist (1979), also tend to argue the inevitability of deskilling and that in the long term in industries such as printing, worker resistance is ineffective. The confusion arises from the belief that workers need to retain skills to ensure control over jobs. In cases where craft labour has been deskillled and replaced by semi-skilled workers, Rubery (1978) found that they were still able to exercise control over the production process. As Nichols and Beynon (1977) point out skill is not essential to control. Thompson (19865) takes this view a step further when he claims "that no amount of deskilling or mechanisation can lead to the complete domination of capital over labour". While it can be argued that capital has been unsuccessful in completely deskillling workers and establishing control over all aspects of the labour process, capital has attempted to dramatically alter power relationships and work organisation. In some countries capital has used technology and other internal factors to alter power

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63 Although as was argued earlier by supporters of Braverman’s view see Foster (1994) the dominant tendency and central imperative of management is to deskill.
relationships. In Australia, at present, capital has enlisted the Federal government’s support to alter power relationships by dramatically changing industrial relations legislation.

**New Technology and Work Organisation**

New technologies and work organisation provide opportunities for capital to impose greater technical control over labour. In recent years the development of computer based technologies such as computer integrated manufacturing has increased the possibility of management controlling the whole production process. In Shaiken's (1979) study of automation it is suggested that the computer is the weapon that management will use to "slam" the workers. Until current developments in computer technology, the wide scale use of extensive automation has been limited by technical and at times economic factors. Improvements in microprocessors have removed from workers the discretion that Palloix (1976) observed they were able to exercise over production. If the tendency was universal and has continued then there is a need to produce empirical evidence to demonstrate that this has occurred in Australia. This combined with a downturn in the worldwide economy has lead to a restructuring of work organisation particularly in developed countries. In an attempt to compete with low wage economies many firms have attempted to replace high cost labour with low cost technology. In an effort to reduce costs firms are installing sophisticated labour displacing technologies. In contrast to Meiksins (1994) and Foster (1994), Thompson (1985) claims that it would be a mistake to argue that the main purpose of these technologies was to deskill workers.

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64 Osterman (1995) maintains that High Performance Work Organisations will need considerable increases in skills.
Rather the major drive has been for companies to maximise profit by reducing costs, usually labour costs. Technologies such as direct numerical control (DNC) and numerical control (NC) are being replaced by computer numerical control (CNC) which is able to do away with machinists and replace them with cheaper machine minders. At the same time the machines can be programmed by supervisors doing away with specialist programmers. An important change that has occurred with the introduction of advanced manufacturing technologies is that they impinge upon the jobs of technical and professional workers who were once seen as part of management. As Shaiken (1979, 33) points out, initially management removed control of AMT from the workers, then the loss of skills and control flowed on to engineering workers. Even design workers were at risk as Thompson (1985) points out system such as CAD (computer aided design) effects the technical jobs of draughtsmen. Cooley (1980, 29) is even more scathing in his criticism of CAD claiming that it embodies Taylorism and leads to the fragmentation of design skills and loss of an overview of the design process.

It can be demonstrated that advanced manufacturing technologies can be used to increase the power of capital and can help it to restructure the labour process. However Thompson (1985) argues that checks and restraints exist that can limit this power. In countries such as Australia these check and balances are written into formal agreements between management and workers. In these agreements employers must consult workers before introducing new technologies. If employers are to obtain benefits from introducing technologies they need to negotiate any changes in working

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65 Delbridge and Lowe, (1997) point out that the advent of some technologies has seen more control being exercised by supervisors rather than less as proposed by Braverman
66 This view is reinforced by Ehrensal (1995)
67 For details of possible restructuring see Burns (1998).
conditions and the tasks of workers before the technology is introduced. During periods of technological change new skills are developed\textsuperscript{68} and there is a tendency towards polarisation. This polarisation results in a segmented labour market that sees a minority of highly trained and well rewarded workers and a majority of low skilled and less well paid workers. It will be argued below that this polarisation has occurred in some Australian firms using CADCAM. Another limiting factor is the position and actions of the trade union movement. While the trade union movement is potentially able to exert considerable influence over the introduction of new technologies it has been remarkably unsuccessful. This can be put down to what Jones (1982) sees as unions uncritical view of technology and its short term attitude to either maintaining jobs or gaining the best possible redundancy packages for members. To effectively influence the type and direction of new technologies trade unions need to become pro-active. Trade unions have tended to react to technologies after their introduction by management. Even when unions have negotiated new technology agreements they have, according to Manwaring (1981), been unsuccessful in gaining an equitable share of benefits for their members. When trade unions negotiate new technology agreements they usually attempt to insert a clause that forces management to notify them of any new technologies that are to be introduced. Most of these clauses including those in the Australian Telecom agreement, (Mathews 1986) allow for consultation. However the final decisions about the technology remains with management. As Gill (1985, 128) points out unless trade unions take the initiative with new technology they will be unable to shape it or determine its direction. However, if workers can develop strategies

\textsuperscript{68} Alsene (1994) argues a case for the broadening and enrichment of jobs.
that enable them to limit and control access to new technologies, they will be able to 
exercise a degree of control over the technology.

It is important who shapes technology and determines which technology is to be 
introduced. There is a forceful argument put forward by Freidman (1977), that not only 
is deskilling not inherent in a technology but there is more than one technological 
direction under capitalism\(^\text{69}\). Studies such as Bosquet (1980) have shown that when it 
suits them firms will introduce work organisation involving job enrichment and job 
enlargement. This view is supported by research such as Wilkinson (1983), Buchanan 
and Boddy (1983) and Wall Clegg and Kemp (1987) which found that management has 
significant choices available to them when selecting and implementing new technology. 
Management can select technologies that will improve the quality of work life and 
allows workers to work at their own pace, or they can select technologies that pace and 
monitor workers' outputs. Capital will even introduce work humanisation programs 
when it is in its best interests. The key focus of management according to Thompson 
(1985) is control of the labour process. Freidman (1977) has demonstrated that when 
given the choice between direct control and responsible autonomy, capital will 
invariably select direct control. Noble (1979) reinforces this point in his description of 
the choice between record-playback technology and numerical control. In this instance 
capital selected the numerical control because it removed control from labour and 
embodied it in management.

\(^{69}\) Osterman (1995) believes that many authors wrongly assume that once technology is in place the outcome deskilling is 
preordained.
It needs to be understood that it is in the interest of capital to control the labour process, just as it is in the workers' interest to control the process. To assert as Braverman does that employers will always be served by deskilling workers is to ignore the possibility put forward by Freidman (1978) that there are times when in its own economic interests capital prefers not to deskill labour. There is an increasing realisation among managers of knowledge intensive industries that a highly skilled workforce provides a competitive advantage. If industries in developed economies are to successful compete with those in low cost developing economies they need to make the most of a skilled workforce.

Braverman's approach, according to Thompson (1985), is unilinear and one-dimensional. What capital seeks is to maximise profit by the most effective and efficient utilisation of the means of production, including labour. If the drive for profit means workers are deskilled then what is at issue in the long term is how will this effect work organisation. Thompson (1985) discusses the impact of deskilling on all workers, not just craft workers and points out that workers' perceptions are important. If a new technology improves a worker's job and enables a worker to exercise more responsibility, while it may require less of one skill, it may be better for the worker in the long term. If workers perceive their jobs have been degraded by being unable to use traditional skills then a problem exists, however, for an unskilled worker to take on a responsible job of supervising technical machinery there is a net improvement in their job. As suggested earlier in this chapter a major difficulty exists in people's perception of skills as there is no simple tool or technique that can objectively measure every workers' skill level. Deciding if a job or worker has been degraded involves a subjective rather than an objective judgment. While for some, word processing may appear to be a mindless and boring task, for others it may be a challenging and important job. Braverman's main achievement is not exposing the real battle between
labour and capital, rather by initiating and stimulating debate he has considerably increased our understanding of the nature of work.

Organisational design and technology

The reason that firms experience problems with employees is usually a result of poor organisation and communication. The way in which an organisation is designed or evolves will, according to Child (1986, 5), determine job design, career paths and the speed at which new technologies are introduced. Some studies have found that limited organisational knowledge would slow the diffusion of microelectronic technology and the awakening of its potential effect. However, it is usually management that initiates the introduction of new technologies\textsuperscript{70}. Child (1986, 248) argues that management has the dominant influence over which technology is introduced and how it is applied. Management's philosophy plays a role in deciding to introduce a technology. In examining the relationship between new technology and organisational design Child (1987) examines four relevant areas: strategic purpose, employment and job design, integration and control, and the role and structure of management\textsuperscript{71}.

The reasons given for introducing new technologies usually involve cost reductions related to reliability, compactness, speed of operation, accuracy and low energy consumption. Management may have other strategic reasons for introducing new technology, including increased flexibility, improvement in quality or increased control and integration. Child (1987, 249) puts forward three main possibilities for cost

\textsuperscript{70} Alsene (1994) argues that it is not the technology alone that impacts on the enterprise but many interrelated factors that relate to workers and management.

\textsuperscript{71} Barley (1996) points out that many analysis of work have glossed over issues such as these and in doing so may have overlooked crucial factors.
reduction rather than the technical improvements mentioned above. The first cost reduction dealt with extensively by Gill (1985), Windschuttle (1983) and Freeman et al (1982) is reductions in the workforce. There are various estimates of the number of job losses due to new technology. In manufacturing industries there have been reductions in the workforce as a result of introducing word processors, computer numerical control machines and automated processing. Although all job losses are not directly related to the introduction of new technologies, some firms introduce technologies such as robots to displace workers. In other cases new technology can be substituted for increases in the workforce by increasing throughput without a corresponding growth in staffing. Information technology can be used to improve the efficient allocation of staff by monitoring staff. Data collected can be used to roster staff on when the workload is greatest and roster staff off when demand is slack. This is often the case in supermarkets and fast food restaurants that monitor sales to determine when additional part-time sales staff is required.

Information technology such as barcoding can also be used to reduce costs by providing rapid access to detailed information on stock levels, patterns and usage. An example cited by Child (1987, 249) is in automotive sales where dealers linked together can effectively exchange parts and models. This allows dealers to reduce the variable cost of running their business and save money by carrying smaller inventories. There can also be some staff reductions or savings because there is an automatic transfer of stock data, which is usually cheaper than manual transfers. A claim made by system suppliers is that computer aided manufacturing (CAM) systems can improve quality and reduce errors. It is claimed that CAM improves precision and unlike human workers is not subject to fatigue. Adler (1988, 61-62) claims that when CAM is used in conjunction
with CAD there is a reduction in lead times, a reduction in the design cycle and improvements in assembly-time. These improvements can help reduce the overall cost of a product.

The real cost benefit of CADCAM is its ability to increase the flexibility of a plant. The computer programming of equipment is suitable for a small batch production and enables far faster change over from one production run to the next. Rumelt (1981, 7) claims that CADCAM avoids the need for large production runs. When linked to a database with automated facilities for specifying parts the necessity of holding large quantities of spare components within a firm is significantly diminished. From management's point of view, Child (1987, 250) suggests, that new technology provides the opportunity to run a range of production items through a single facility with minimum cost and disruption when changing from one product to another. The need for increased flexibility is a strategic requirement that is being emphasised more and more, it can reduce costs by decreasing capital investment and managerial overheads.

There has been an increase in the market demand for quality products, which has resulted in awareness that companies need to develop quality improvement strategies. With the development of quality management systems such as Total Quality Control (TQC) and Quality Assurance (QA) firms often require improvements in the provision of information. According to Child (1987, 251) new technology can provide high quality information rapidly as well as ensuring that design and manufacturing specifications are precise. When information needs to be transferred several times and it can be done electronically this reduces the chance of transposing errors that occur in manual transfers. Information technology can be used to integrate information from a
variety of sources. To improve and even increase its control and integration processes, management may use technology to collect data automatically. In Japan, information is collected automatically using a range of technologies including closed circuit television, voice recordings and bar coding. A Japanese company has developed a program called Neo-Kiazen which automatically analyses data collected from remote sources. The collection of data in this way permits the accurate monitoring of all stages in the production process and increases management's control over the process. Child (1987, 251) suggests that microelectronic technology enhances integration because of its capability to accumulate a range of information and to bring together individuals separated physically. Thompson and McHugh (1991, 209) point out that computer-based flexible manufacturing systems operate more effectively if there is a high level of cooperation and flexibility amongst workers. It is also more effective when workers are knowledgeable and make decisions rather than being mindless operatives. Microelectronic technology can link individuals by means of teletext, word processors, e-mail, and audio and audio-visual teleconferencing which allows direct interactive communication at reduced cost.

The introduction of new technology and changes to employment patterns has had an impact on job design and reward systems. However, it is not only new technology that has brought about these changes. Child (1987, 252) lists three non-technological factors that are an integral part of these changes. They are: management's philosophy on employment levels, management's view of skills and the division of labour, and the

72 It is unreasonable to regard management as a homogenous group with identical beliefs and philosophies. (See Wood and Kelly 1982) It is also difficult to accept Braverman's view that management has no problem implementing its decisions.
influence and strength of the resistance of workers and their representatives. The issue of employment levels is extremely complex because it is linked to environmental factors outside of individual firms. However there appears to be a trend amongst users of new technology towards labour saving technology. These policies of cost reduction, by decreasing labour costs combined with particular technologies, can have considerable impact on employment patterns and job content.

There are instances where new technology has increased the skills of workers. Child (1987, 253) maintains that new technology, by completely displacing jobs, results in an overall loss of skills. In other cases workers may lose craft skills and acquire new skills of a qualitatively different kind. As mentioned earlier a choice clearly exists, to either introduce new technology that enhances and builds upon skills or to use new technology as a means of degrading skills. As Wilkinson (1982, 40) concludes there is no logic in technology that sees tasks become more mundane, nor is it the technology that requires improved skills or provides more fulfilling and satisfying work. The choice of technology rests in the hands of management, which technology is introduced will depend upon management’s overall strategy and policies. It is management's policy that will, in part, determine how the labour force is to be segmented.

The reason an organisation chooses one philosophy of employment instead of another is generally a political and social issue rather than simply a technical issue. In adopting a particular employment policy, Child (1987, 257) identified four contingencies that organisations need to consider. They are: the amount of non-programmable skill needed to complete task, the degree of personal service in the job, the unpredictability of the tasks involved in the job; and, the results of technology failure. Overall, if the
work requires human skills and flexibility, so that it is in the best interest of the company to employ a human labour force then it will. In circumstances where some human attributes can be replaced by new technologies, workers who possess flexible skills and are able to handle unpredictable situations will be in demand. Indeed skilled workers may be in a much stronger bargaining position if they are able to operate in a highly mechanised environment. Similarly if managers consider workers to be highly skilled they may be less likely to be antagonistic towards them as they value their skills and perceive them to be strategically important to their business. However, managers’ and workers’ attitudes, expectations and perceptions are according to Smith and Thompson (1998,565) partially determined by cultural, social and historical factors as well as their education and training. These issues will be examined in more detail in chapter four, particularly the historical development of industrial relations in Australia which has played a major role in structuring labour markets.

The technology increasingly used in the integration and control of an organisation is information technology. It can facilitate integration by improving information access and dissemination, and allows instantaneous communication between groups and individuals in an organisation. Also, information technology can be used to unify physical and analytical control information. These three characteristics of information technology increase its usefulness in the integration of an organisation. At the same time information technology has potential to increase managerial control. The three aspects identified by Child (1987, 258) include firstly, a faster and more exact knowledge of systems operation and outcomes. Secondly, it replaces the imprecise actions of workers and finally it unifies all control systems allowing a more comprehensive and balanced assessment of performance. The main outcome of the
unification of control, combined with the integration and simplification of organisational activities and structures will be an alteration in the structure of the workforce. This alteration will most probably result in a reduction in middle management, a net loss of staff in support roles and a small highly skilled technical staff at the strategic level, what is referred to as a flat organisational structure or a lean organisation.

Employment policy, which aims at establishing a small highly skilled staff of senior managers and specialist technicians within a primary sector of an internal labour market, is based on recentralisation. Child (1987,261) argues that in Britain most organisations are placing the majority of employees into the secondary segment of the internal labour market or into the external labour market. Organisations have been successful in doing this because they have chosen appropriate information technologies. These technologies allow the recentralising of decision making by integrating data and simplifying its presentation. A major problem with centralised decision making is that it runs counter to many behavioural science views about motivating people by allowing them to assume responsibility for the tasks they are required to perform. Although new microelectronic technology is being introduced in many organisations the rate of diffusion and the changes within firms are not uniform. There is evidence to suggest that new technology does not result in major changes. Bjorn-Andersen et al (1979) and Robey (1977) found that changes subsequent to the introduction of computer technology were minimal. Although it could be argued that technologies introduced in the late eighties are more sophisticated and will have a greater impact on organisational design.
While management appears to be trying to create a more flexible workplace by locating the majority of workers in the secondary segment of the internal labour market and contracting workers from the external labour market, workers are able to oppose these trends. Studies such as the Australian Workplace Industrial Relations Survey (AWIRS) have shown that there has been no real increase in the number of workers in secondary or external labour markets in Australia. Although anecdotal evidence suggests that managers are employing more part-time and casual workers in recent years, this appears to be in response to unfair dismissal legislation rather than as a strategy to increase the number of workers in secondary labour markets. It is extremely difficult for individual workers to resist change. In unionised workplaces, groups of workers can actively oppose changes to work organisation and restructuring of the factory floor. As Child (1987) points out, it is management who decides which technology will be put in place, but groups of workers can exert considerable influence over management and their decisions. Thompson and McHugh (1991,336) define a group as "a collection or coalition of people who interact meaningfully in the pursuit of common goals or objectives." Yet not all groups of workers are in conflict with management and oppose management’s decisions. As Burawoy (1979) points out some workers can actually create the conditions of consent and establish a consensual view that supports management. In many circumstances groups of workers may believe that it is in their long-term interest to support management’s view. In some cases workers in an effort to maintain the group and a consensual position may harness peer pressure to identify and punish deviations from the groups view or position. However, management is not always able to implement changes without consulting employees. Matthews (1986)

73 See Thompson and Ackroyd (1996) for a discussion of the role of groups in organisations.
describes how some unions in Australia have managed to ensure that employers consult with workers before introducing new technologies.

Also many unions have managed to insert into their Industrial awards the right to negotiate any major changes in work organisations.

**Conclusion**

In examining employers organisational strategies Grimshaw and Rubery (1998,201) contend that the relationship between organisational structures dealt with by labour process theory and labour market forces have not been effectively incorporated into an institutional approach that can be used to explain the changing nature of jobs and work. The dichotomies drawn between capital and labour, working and middle class, internal and external labour markets, primary and secondary segments establish polarised frameworks that do not allow for the dynamic nature of work organisation. Grimshaw and Rubery (1998,213) have adapted Osterman’s (1994) three rings model (see figure one) of labour market structures to explain how “internal and external competitive pressures mutually interact to shape employer strategy and the labour market position of employees.” Grimshaw and Rubery (1998,217). Models such as Villa’s (1986) also show the complexity of the relationships between organisational design and technology. As can bee seen in figure one the structure of a firm’s internal labour market is shaped by several factors including the process of labour consumption. This model shows that the external labour market factors influence the structure of internal labour markets.

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74 Villa (1986) presents a complex and multilayer model of job allocation practices incorporating labour process theory labour market theory and industrial relations perspectives.
This is particularly true in Australia and will be examined in greater detail in chapter four.

Firm Custom and Practice
Norms
Wage differentials
Insider-outsider relations
Social relations

Internal Market
Labour
Structure

Performance
Supply and demand for labour
Technological change
Mimicry

External Labour Market
Social security system
Minimum wage
Unemployment
Equal employment policies
Industrial relations policies

Adapted from Grimshaw and Rubery (1998)

Figure 3.1 Linking Internal and External labour Markets

The effect of social security systems and industrial relations legislation plays a significant role in how internal labour markets are structured. Technological change has had many impacts on internal labour markets as Allen (1977) argues that computer technology has removed many of the physical distinctions between jobs. In a factory; designers, clerical staff and machine operators may all need to operate a PC, but the
work they do using the technology is significant different. Not only is the work different but the knowledge and skills required vary considerably.

A machine operator monitoring a PC controlling a mill needs different skills to a word process operator designing a company brochure and both use different knowledge and skills to a designer programming a new shape using CAD on a workstation. On the surface they all appear to being similar jobs. Grimshaw and Rubery’s (1998) model also takes into account the social relations and norms within a firm. It is often the break down in social relations which cause workers to leave a firm, but technologies and the pace of work can have significant impacts on social relationships.

Although much of the debate that arose out of Braverman’s work has focused on deskilling, the subject of his work was the changing structure of the working class and how it has changed.” Braverman (1974). Many of the labour process researchers have focused on the deskilling debate and continue to argue that the dominant tendency in manufacturing jobs is still deskilling. However there is a growing alternative view that AMT have increased the need for skilled workers and workers using AMT require more skills75. In focusing on the labour process in isolation there is a tendency to over emphasise the success of capital’s use of a range of tactics to control workers and the process of production76. There has also been a tendency to generalise the use of tactics such as deskilling and the sub-division of labour across all firms, regardless of their size.

75 Foster (1994, 11) maintains that there is enormous pressure to conform to what he terms the orthodox view that technology has raised the demand for skills responsibility and knowledge.
76 See Meiksins (1994, 52) who agrees that the tendency is still deskilling but many agree otherwise.
or location. While there is an increasing globalisation of labour markets, there are still significant differences between countries and even within countries.

Rather than make broad generalisations about what is occurring across organisations there is a need to consider what is happening at the enterprise levels, as all business organisations are not the same. Just as workers are not a single homogeneous group, both managers and owners differ. They differ in their management philosophy, their views on skills and the division of labour and their attitudes towards workers and unions. It is not always the case as Foster (1994) asserts that the goal of management is to minimise the cost of labour by paying as little as possible for skill and at the same time making workers work as intensively as possible. While some managers prefer passive unquestioning employees who leave their brains and abilities at the factory gate, others seek out, value and reward independent, skilled creative workers. However to understand what is happening at the enterprise level or within the "factory regime" the labour process needs to be regarded as part of a larger interactive system. The system is made up of a variety of factors and conditions, these include technological, socio-economic, cultural and industrial relations factors.

This chapter has examined the claims and arguments put forward by labour process theorists. The analysis rejects the proposition that the dominant tendency in internal labour markets in developing economies is deskilling. In particular the idea that technical workers are simply deskilled by the introduction of AMT is challenged. Furthermore the argument that production workers, craft workers, and tradespeople

77 Some evidence of management paying more than they have to, can be found in the use of overaward payments see Morehead et al (1997)
have lost their jobs to a technological elite must be questioned. An analysis of job distribution data reveals that while some manufacturing jobs are in decline, others in technical areas are growing. Australian manufacturers trying to compete with emerging economies in Asia have to be “smarter” and reduce their costs. Cost reductions may mean that they replace expensive production workers with flexible manufacturing systems, but these systems need skilled employees to program and maintain them. It will be determined in chapter seven using empirical data, if any of the displaced workers are now operating complex technologies such as CADCAM. In chapter four it will be argued that unlike the technical workers in much of the labour process literature, Australian workers in a highly centralised industrial relations system have through the activities of unions maintained a secure labour market. Within firms workers are able to exert considerable influence and employ a range of tactics to protect technical jobs.

CHAPTER FOUR

Technical Workers and Industrial Relations in Australia

Introduction

The emergence of a growing pool of technicians and technical workers in industries of advanced economies has stimulated discussion concerning their position within existing class structures. In examining the class debate it is apparent that neither Marxist nor Weberian analyses of class adequately provide for the fluctuating location of technical workers. The class debate shows that in attempting to explain the position of technical workers there is a need for a complex class model rather than a simplistic model. The more complex picture of class that emerges from examining technical workers location has many similarities to the segments described in the labour market literature. The analysis of class provides a deeper understanding of the complex hierarchies of authority and control within enterprises. However, analyses of class structure and workers position which are at least partly based on loyalty to fellow workers or class-consciousness are too simplistic. Class position and structures are the result of a complex array of influences and interactions. Class analysis according to Carchedi (1977,23) must consider not only the economic structure of a society but also the political and ideological structures. All these structures exist within a historical framework, and any examination is being done at a particular stage in the development of a capitalist society.

This chapter will examine the class analysis literature that deals with the position of technical workers. The simplistic descriptions of class will be challenged as they fail to
adequately provide for the position of technical workers. In analysing the nature of technical work and the position of technical workers it will be shown that this needs to be done within a national and industrial context. This thesis seeks to explain how class-consciousness is moderated and influenced by actors other than workers, managers and employers. It will be argued that within the Australian context, governments and the agencies of governments, such as industrial relations legislation, have had a major influence on class relationships in Australia. It will also be argued that over the last one hundred years Australia has evolved a unique industrial relations system. This system by advocating and providing for the compulsory intervention by industrial relations tribunals has reduced the ability of employers to exploit the working class. These tribunals have also had a moderating effect on the efforts of workers to dominate and control the processes of production. So the political structures have had significant influence on the class-consciousness of Australian workers.

This chapter begins by presenting some of the issues associated with a discussion of technical workers and class. These issues are explored as they provide an explanation of the emerging conflict between technical and non-technical workers. The predominantly European literature on class is unable to present a clear view of technical workers. This lack of clarity stems both from the contradictory views of class and the contradictory roles of technical workers. Within the Australian context awards and enterprise agreements contain definitions of technical work and descriptions of the jobs of technical workers. They also describe the skills and qualifications technical workers need to operate CADCAM. So to understand technical workers and CADCAM users in the Australian context it is necessary to have an understanding of awards and the award making process. This chapter presents an overview of the development of awards
within Australia's conciliation and arbitration system and analyses characteristic awards and enterprise agreements to determine the way in which some internal labour markets are segmented. After establishing that internal labour markets are segmented it will be demonstrated that existing class analysis does not fully explain the place of technical workers in internal labour markets and how workers have played a role in shaping labour markets.

**Technical workers and the labour process**

Technical workers, as defined in the labour process literature, are engaged in a wide range of jobs. In attempting to explain the term "technical" Smith (1987,2) includes: graduates; professionally qualified workers; specialised manual workers; and groups engaged in design, development, planning, production, maintenance and post-production functions. The difficulty with such a description is that it encompasses too many workers and does not clearly differentiate technical workers from other workers such as professionals and production workers. Similarly Barley and Orr (1997) maintain that it is difficult to define technical work and explain how it differs from other types of work. They put forward three perspectives on technical work. The first perspective views technical work as working on a complex technology as in maintenance, or working with a complex technology. The second view suggests that the type of knowledge it requires would distinguish technical work from other work. That is technical work is work that requires workers to understand and utilise an abstract body of knowledge. The third approach is to view all work that requires skilled practice as

79 This perspective is supported by Barlow (1967) and Hull (1986).
having a technical component- technical work differs from other work in degree only. The greater the skilled practice needed the more technical the work. However Barley and Orr (1997) reject these three perspectives preferring another view of technical work. In their view technical work can be defined within a loose grouping of attributes. Although some instances of technical work may not have all the attributes they maintain that all technical work will have a majority of attributes. The four traits they propose are:

“a) the centrality of complex technology to the work, b) the importance of contextual knowledge and skill, c) the importance of theories of abstract representations of phenomena, and d)the existence of a community of practice that serves as a distributed repository for knowledge of relevance to practitioners.” Barley and Orr (1997)

The problem with this definition is that it fails to distinguish between professionals and technicians and between “hands on work” and “knowledge” work.

In Australia technical workers as defined in awards are mainly involved in product and process design, production planning and the maintenance of the manufacturing processes. Traditionally, in Australia at least, these workers have been classified as trade persons, designers, engineering associates, draughtsmen and planners. Changes in the production process and the introduction of advanced manufacturing technologies such as CADCAM result in alterations to the technical division of labour. These changes mean that draughtsmen are not restricted to drawing plans but are expected to have significant input into the design and technical specification of a product. In some organisations engineers now produce complete technical drawings using CAD rather than using draughtsmen to complete drawings for them. These changes make it difficult to clearly identify where some technical workers and their jobs are located. What is
occurring is a blurring of tasks and responsibilities and who does what varies from firm to firm. Furthermore the authority structure within organisations has been varied so that there is considerable overlap between the functions of trades persons, associate engineers, engineers and draughtsmen. As a result of changes such as these a debate on the position of technical workers has occurred. Much of this debate has centred on the location of technical workers within a class analysis. This debate has attempted to explain the relationship between technical workers and management and between technical workers and production workers in terms of a class structure.\(^{80}\)

**Class and Technical Workers**

Attempts to locate technical workers within a class structure will encounter difficulties. Technical workers as a group of white-collar workers\(^{81}\) appear to vacillate within the system between management and wage labour. That is they act at times in supervisory or control capacities and can be viewed by production workers as part of management and at other times they are part of the production process and work on the shopfloor. Davis and Cousins (1975) argued that class-consciousness depends upon the militancy, strengths and weaknesses of workers in the labour market. When there is an increase in militancy for the working class, there is a corresponding increase in the militancy of white-collar workers. It is during these periods that technical workers have formed organisational and political links, generally through the union movement, with manual workers. The links between technical and manual workers are easily established, as

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\(^{80}\) Boreham (1991) views class structures as an analytical concept that provides a limitation on the availability of choices and decisions that can be made by individuals or groups of employees.

\(^{81}\) See Carter (1985) for further discussion.
many technical workers are manual workers who have been promoted from the factory floor. Smith (1987) suggests that during these periods it is difficult to sustain a fixed view of technical workers as part of management as they become 'reluctant militants'.

Within the Australian context, technical workers may not be reluctant militants as they come from a manual or trades background, many technical workers would regard themselves as being closely aligned to workers rather than part of management.

The rising militancy of white-collared workers during the 1960s saw the development of a new working class thesis. This thesis proposes that technological change, associated with the introduction of advanced manufacturing technologies, brought about a redefinition of the working class. The leading figure who coined the phrase the new working class was Serge Mallet. He argued that a qualitative change had occurred in the structure of the working class. Mallet criticised what he saw as the traditional Marxist view that working class was restricted to manual waged production workers. Although it appears that Mallet (1975) was unclear about the exact composition of the new working class, he did include technicians, researchers and skilled workers. In Mallet's view automation was a major factor in altering the composition of the working class. A benefit for employers was the multiskilling effect which was possible according to Mallet (1975, 14) because skills were not acquired through an elite educational establishment. This in turn led to increased mobility between shop floor and office that in turn resulted in changes to the technical divisions between technical workers, engineers and manual workers.

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82 Whalley and Barley (1997) go further when they maintain that engineers jealously guard their positions and are rarely willing to unite with manual workers to bargain collectively preferring to improve their own status by siding with management (Crawford 1989, Whalley 1986).

83 See Whitston (1997) for details.
The new working class thesis put forward by Mallet views advanced manufacturing technologies as a means of stimulating advanced forms of class-consciousness.

Smith (1987, 23) argues that Mallet saw that the changes to work and jobs occurring in advanced industries enabled different forms of work organisation to be introduced. The important role that the new working class thesis plays is that it focuses on changes taking place in the awareness of technical workers. Mallet's importance is that he supports the view that technical workers identified more with the working class and moved away from the middle-class. However, Mallet has been widely criticised for his technological determinism in viewing AMT as having an active role in stimulating class-consciousness. According to Smith (1987, 25) different factors impinge upon the consciousness of engineers and technicians. It is important to consider differences in the training and background of engineers and technicians when commenting upon their class-consciousness. Engineers and technicians who are recruited from a trades background and trained in the non-university sector can be expected to be more closely aligned to the working class than those with university qualifications and little or no experience on the factory floor.

Mallet's work suffers from his technological determinism and his unsupported belief that automation enables workers to grasp an overview of the production process. In contrast the work of Salaman (1981) showed that advanced process technologies, in general, downgraded workers skills. Other studies such as Smith, Child and

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84 The works of Low-Beer (1978) and Greenbaum (1979) supports the general thrust of his thesis.
85 The down grading of skills in Australian labour markets is not apparent in research carried out by the Reserve Bank of Australia. See Debelle and Swann (1998).
Rowlinson (1987) and Nichols and Beynon (1977) contradict Mallet’s view and indicate that automation still produces fragmentation and division of labour.

While Mallet's view has remained relatively constant since 1963 when he published his book 'La nouvelle classe ouvriere'; the ideas of Gorz have undergone several changes. Unlike Mallet, Gorz\textsuperscript{86} is more theoretical and bases his work on conjectures and a certain amount of crystal ball gazing. In the 1960s Gorz was strongly influenced by the new working class thesis. He argued that a central feature of advanced economies was the progressive alteration to the position of educated and qualified labour. This can either be as a result of qualified labour being displaced from management jobs or the need for production jobs to have qualified labour. With the increasing need for multi-skilled employees who can operate and maintain a wide range of plant and equipment there has been a tendency in some Australian enterprises to employ production workers with trade qualifications and displace semi-skilled production workers. Unlike Gorz and Mallet, Carchedi (1977) argues that the new middle class is undergoing a process of 'proletarianization'. He maintains that the process has two components, the first is the devaluation of skilled labour and the second is an increase in the “time during which the function of the collective worker is performed” (Carchedi 1977,9). So Carchedi argues that skilled workers such as technical workers have their work reduced to an unskilled level and more of their times is spent in productive labour and less on control and supervisory activities. As a result Carchedi (1977,197) concludes that technicians or technical workers can be divided into two groups. The upper group is a technical elite and the larger, lower group has undergone a process of devaluation of their labour.

\textsuperscript{86} For a discussion of Gorz and Mallet's work see Smith (1987,28)
power. He takes this division a step further by claiming that stratification can occur within the groups depending upon the level of devaluation\(^87\). So he views the majority of technical workers as part of the working class. However, Gorz (1967) like Cooley, argues that technical workers are ideologically rather than structurally a part of the working class. Gorz changed his position in the 1980s, with the growing fragmentation of labour under the impact of a global crisis. Changes to the structure of the workforce and increasingly flexible work patterns make class-wide transformations structurally impossible. Basically capital has the upper hand because labour cannot easily overcome the structural divisions introduced by capital. Furthermore the growing diversity and internationalisation of capital industries weakens the position of labour.

The importance of Gorz (1967, 106) lies in his belief that technical workers need to be aware that capital views them as wage earners, paid for a piece of work that is only good if it is profitable. Also the basis of their expertise, that is creativity and workmanship, are incompatible with profitability. While Mallet failed to stress it, Gorz claims that the work performed by technical workers is becoming increasingly routinised and their skills and abilities, although changing, are progressively under-utilised\(^88\). During the 1960s Gorz believed that technical labour would form part of the working class. This was reversed in the 1970s, when Gorz (1971) (1976) identifies technical workers as a part of the division of labour separate from the working class. In fact he sees the language, techniques and jargon of technical workers as part of a management subculture. Like Mallet there is a strong element of technological

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\(^87\) Carchedi (1977,197) maintains designers and draughtsmen have had their work completely proletarianized.

\(^88\) This view is criticised in more recent works such as Barley (1996).
determinism in Gorz's writing. In the 1980s Gorz (1982, 72) suggested that all industrial work has been deskillled by capital. In this view he has been, according to Smith (1987, 36), an inspiration to writers such as Cooley. However, this view has not been supported by extensive empirical studies and it is difficult, as noted in chapter three, to view all workers as belonging to a single homogenous group because of the different positions of workers and the hierarchies that exist within enterprises.

Unlike Gorz, there is no doubt in Braverman's (1974, 403) mind that technical or intermediate employees are part of the working class. However, Braverman has been criticised by Thompson (1983) and Burawoy (1985) for his view of capital as an omnipotent force that succeeds in controlling labour. As far as technical workers are concerned Braverman (1975, 405) fails to come to terms with the issue of class position. He sees class as a continuum, with engineers, acting on behalf of management, near the capital end and the draughtsmen and technicians at the working class end. The major difficulty that occurs with this view is the fluid nature of workers' position along the continuum, but given the changing nature of work this view can be sustained. In some industries engineers may be able to exercise the political, economic and managerial prerogatives of capital, while in others they may be unable to exert control or authority and would move towards the working class end of the spectrum. Initially Braverman appears to be unambiguous in his views but he claims later in his work (1974, 443) that by monopolising technical knowledge and helping to deskill manual workers, scientific, technical and engineering staff have isolated themselves from manual workers. It is argued by Smith (1987, 41) that the reality is different to that presented by Braverman.
Smith argues that technical workers are not actively involved in deskilling, that they are forced by capital to work in the interest of management.89

**Job Design**

Cooley (1972) advocates a view of technical workers that is similar to Braverman's. He argues that there is a choice as to the way work and technology can be designed. The choice is basically that work and technology can be designed to control the labour process or it can enhance the labour process by allowing the worker greater freedom. Cooley (1980) has supported the critique that maintains there are ways to design jobs so that the skills of manual workers are enhanced and links between conception and production are maintained.90 Furthermore, Cooley (1980) argues that advanced manufacturing technologies such as CADCAM have the potential to deskill elite technical workers such as engineers. Although Cooley supports the deskilling thesis his analysis differs from Braverman's on one major point. Cooley claims that it is possible to redirect technology and job design so that skills are developed and enhanced. What Cooley (1981, 110) emphasises in his work is the need to challenge power structures in society. Workers, technical and manual, can and should have a say in which technologies are introduced into the workplace. The most important aspect of Cooley's analysis is that his challenge to what Rosenberg (1981) called the 'engineering paradigm' that sees technical workers isolated from other workers by hierarchical

89 This view fails to take into account that it may be in the interest of technical workers to deskill non-technical workers. In deskilling other workers technical workers may be able to make their own jobs more secure.

90 Carchedi (1987) is vigorous in his arguments that computers and computer-based technologies are a tool of capital but they can be used by workers to resist capitalist domination.
structures and elitism. However it is the case that workers form their own elitist, hierarchical structures. Within the manufacturing process in Australian factories, labourers are at the bottom of the scale then there are production workers and machine operators, next there are tradespeople. Even within trades there is a ranking. For example, an electrician would be regarded as superior in status to a fitter and turner, who would be regarded as superior to a welder. Part of this hierarchy is based on training, but part is also based on the nature of the work, skill level and task done by different employees.

When technicians are involved in supervision or management of fellow workers they can be seen to be acting in the interest of capital. Smith (1987, 53) regards as an empirical rather than a theoretical question the identification of whether technicians perform managerial tasks. Poulantzas (1975, 239-40) believes that by the very nature of their work technical workers are politically aligned to capital. An ideological basis for class distinction is based on the separation between mental and manual labour.

Poulantzas incorporates the work of Gorz (1976) in arguing that mental labour which occupies technical workers enables them to dominate and control manual workers. However in dominating or controlling workers they may be acting in their own interest rather than as the tool of capital. While Poulantzas’ view may fit the Western European system it was, according to Smith (1987, 56) widely criticised as contradictory in countries such as Australia where technical workers are unionised and

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91 In chapter seven empirical evidence will be presented to determine the nature of technical work.
92 It will be argued later that within segmented labour markets workers both technical and non-technical use a variety of tactics to protect their jobs.
share collective structures with manual workers. It is also important to consider the historical context of class in non-European countries such as Australia and the USA. In Australia, most workers would not regard conflict between workers and employers as having its origins in class struggle. Workers would regard employers as equals and we see the struggle as an economic struggle for wages or a greater share of company profits.

While new working class and new middle class models draw on Marxist writing, Weberian writing has divided workers into classes on the basis of market capacities or skills. Other writers, including Abercrombie and Urry (1983), have attempted to combine the works of Marx and Weber, in reviewing the position of technical workers. A viewpoint put forward by Wright (1977) maintains that class relations in capitalist societies were determined by three control mechanisms: the control over labour power, the control of the physical means of production and the control of resources and investments. Although Nichols (1980, 8) argues that this point of view is not new, what was new according to Smith (1987, 61) was the way Wright used this classification. While Wright saw capitalist society polarised on the basis of possession and ownership into capitalist and working class, he claimed the middle class controlled the means of production and investment and resource allocation. However, this view disregards knowledge as resource in the production process.

93 While technical workers may be in the same union as manual workers they may still compete with manual workers for better pay and conditions.
94 Studies such as Keefe and Potosky (1997) found no evidence in the USA to support the emergence of a new class or new class system. Rather they suggested that there is an increasing stratification of labour and technicians are located at the bottom end of a technical hierarchy.
95 Similarly workers are divided in job classifications on the basis of skill and this is dealt with below in more detail.
96 Hindess (1987,72) argues that the emergence of the new middle class thesis has seen a convergence in Marxist and Weberian approaches.
97 Braverman argued that work was degraded because workers in industrialised settings were no longer in control of the conception and production of goods. Also they could not control the pace of work as that was determined by management and finally they no longer owned either the place or the tools of production.
If knowledge is regarded as a resource and there is an increasing emphasis on knowledge in the management literature, then workers who capture and control knowledge of the production process can exert a significant influence over the process of production. Most importantly Wright acknowledged the contradictory nature of all class positions, arguing there is never a clear cut division of labour. To overcome this Wright allocated workers, such as technical workers, into two distinct locations. These contradictory locations place some technical workers into a technocrat grouping where they have limited autonomy over some aspects of their work. He also places some technicians into semi-autonomous groupings closer to the working class than technocrats. Gorz (1982) also argues that because of their knowledge technical workers have a superior position in the workplace. Unlike Gorz (1982) who argues that this knowledge is useless Koch (1977) maintain that technical workers superior position is based on abstract knowledge acquired in the formal education system.

Eventually, Wright (1985) developed a fragmented class map. This map consisted of groups of wage labourers, semi-credentialed workers, supervisors, experts and non-managers, non-owners and owners. Smith (1987, 64) claims that the map fits Marx's picture of an infinite subdivision of classes. Wright's groupings are based on ownership and skills. He has been criticised by Smith (1987, 65) for his view of skills, Smith maintains that Wright sees skills as a basis for exploitation of workers by capital.

98 In this he has a similar approach to Carchedi (1977,196)
99 A different view is put forward by Touraine (1971) who assigns technical workers to a new middle class because of their links to management.
100 While formal education is an important source of knowledge workers can acquire knowledge on the job and can use this knowledge to exercise significant control over the production and design processes.
101 This sub-division does not alter the antagonistic relationship between capital and labour but allows for different classes of labour.
Wright suggests that by claiming skill allowances trade unions are helping capital to further exploit the unskilled. In this way technical workers assist capital to exploit non-technical workers. In claiming this Wright is ignoring the political and ideological links that exist between trade unions and the representatives of technical workers. This view also does not take into account the role of trade unions in ensuring all workers have access to competency based training. Trade unions in Australia have established agreements with employers that ensures all workers gain access to training and can be rewarded for gaining skills through on the job training. Also Wright, according to Smith (1987, 66) has failed to examine the social construction of skill as well as the dynamics between manual craftsmen and technicians and the solidarity and cooperation of the trade union movement. A further element that is often ignored is that technical workers can be promoted from the ranks of tradespeople and from the factory floor. From a class perspective a technical workers may align themselves with workers on the factory floor, but in terms of wages and conditions is aligned to other technical and professional workers. Smith seems to ignore the conflict that exists between different unions and even groups of workers covered by the same union. Sometimes ties between trades are stronger than ties within a union.

Boreman (1991) maintains that the class debate does not restrict the social membership categories of an individual but he maintains it has clouded the issue of where workers are located. Also the class debate confuses many of the issues which workers experience daily. Workers are not a single grouping or class and workers' positions change during their work life. In focusing on a class position the conflict between

102 The recruitment and training of technical workers is examined in detail in chapter six.
groups of workers is seen as secondary to the conflict between capital and labour. In taking a simplistic view of class and class struggle the day to day nature of the relationships between workers is easily overlooked. Also in attempting to develop a general statement of worker’s class or location it is easy to ignore national and industrial differences. Allen (1977,70) points out that all capitalist societies have undergone profound changes in the structure of their workforce. The changes in the methods of production, manufacturing technologies, and ownership of the production process have all impacted upon workers, their class consciousness and social groupings. The responses of workers and the wider society to these changes differ from country to country as each has had its own unique experiences. There does appear to be some similarities within developed economies and in industries that have introduced advanced manufacturing technologies. However, these similarities are tempered by national and regional differences. In explaining the position of technical workers in industries using AMT it appears to be necessary to develop segmented or stratified structures that allow for a range of skills and locations. The responses of a society are dependent upon the historical context of the development of capitalism within that country. Australia is no exception and to understand the current position of technical workers it is necessary to consider the role of actors other than employers and employees. The following section examines the actors such as trade unions, employers associations and governments in determining the position of technical workers in Australia. The usefulness of the class debate to this study is that it reveals the need to examine the role and position of technical workers at an enterprise level and exposes the problems associated with treating all technical workers as a single cohesive group. The main problem with the class analysis literature is it focuses on the conflict between capital and labour and fails to examine in detail the conflict between groups of workers.
Technical Workers in Australia

An understanding of the position of technical workers in Australia requires knowledge of labour markets and industrial relations, in particular industrial awards and enterprise agreements. As mentioned in chapter two, groups other than employers and workers influence Australian labour markets. The governments, both State and Federal, can intervene both directly and indirectly to influence the structure of labour markets and the allocation of jobs within labour markets. Australia's unique system of compulsory arbitration and conciliation ensures that industrial relations tribunals, both State and Federal can and do influence the structure of internal and external labour markets. These tribunals hand down industrial agreements or awards that dictate the wages and conditions of workers within an industry. The matters covered in an award are wide ranging and usually exceed what would be covered by an employment contract. The provisions of awards in effect describe how a particular internal labour market will be segmented. For example the Aerospace Technologies Of Australia Pty Ltd 1987(1) Award effective 1990, describes three generic trade streams as well as technical, professional, administrative and supervisory vocational fields and a general non-trade area. In describing the technical field the Award in effect defines technical workers as those involved in:

Production planning including scheduling, method engineering, estimating, materials handling, production control, etc.

Laboratory work, non-destructive testing, design and development work, (e.g., prototypes, models, specifications) in both product and process areas, quality control/assurance and like work.

Design draughting and like work.
Technical support including diagnostics, programming and like work. (Award F110 Appendix A 1991)

Awards influence the wages and conditions of all workers including salaried staff not covered by the award, because an award establishes the minimum standards of wages and conditions within an enterprise or industry.

**Industrial Relations and Technical Work**

While definitions such as these provide a simplified description of technical work, a better understanding of the position of technical workers in Australia can be gathered from examining the system of industrial awards that have developed through the compulsory conciliation and arbitration system. The beginning of compulsory conciliation and arbitration in Australia was a result of the great strikes of the 1890s. After the great strikes Australian governments chose to impose penalties on those unions who took part in strikes and other forms of direct action. The penalties for industrial action were contained in government regulations relating to compulsory conciliation and arbitration. Prior to the compulsory system New South Wales, Victoria and South Australia had tried unsuccessfully to negotiate through a voluntary system of conciliation, but this system failed because employers refused to use it. Although unions were initially opposed to a compulsory system they eventually supported it after they saw the benefits to unions of the compulsory system in New Zealand. Although the Commonwealth government enacted the original Commonwealth Conciliation and Arbitration Act in 1904, it only applied to industrial disputes which occurred in more than one state. Each state also had its own system of conciliation and arbitration. Despite differences across the system they can be loosely classified into three groups. The first category is the 'curial' system that includes the Commonwealth, Queensland
and Western Australia. Each of these have commissions empowered with arbitration functions and courts for judicial functions. The second grouping consists of Victoria and Tasmania. These two states originally had less formal tripartite wages or industrial boards system. Victoria in 1979 replaced the wages board and Industrial Appeals Court with a single system. New South Wales and South Australia make up the third category which consist of a formal conciliation and arbitration commission and a less formal tripartite conciliation committee.

In accepting the need for compulsory arbitration we are seeing a reflection of what Hill (1987, 181) calls a 'national character'. Although Hill maintains it is impossible to define exactly a national character, he describes three dimensions that he believes influenced the formation of industrial relations legislation. The first of Hill's (1987, 180-182) dimension is the concept of mateship and egalitarianism that is a mutual support mechanism that ensures that we look out for one another and ensure equal treatment. The second dimension is exhibited in an apparent disdain for success and down playing of achievement. Australian workers are as good as their bosses and will not defer to their employers. These beliefs see workers claiming that Australia as a society is free of class, caste and racial divisions and that all workers should have equal opportunities and conditions. The third dimension is one based on the notion of fair play. This is exhibited in determining wage rates. The criteria used; capacity to pay, comparative wage justice, and a basic living wage are the determinants of the wage fixing system based on equity and fairness. The system has to appear to be fair and

103Although it is not being suggested that all Australians hold these views they have been expressed freely for over a century and are part of an Australian character. Unlike some societies Australian workers are not socially separated. Allen (1977:71)
equitable to employers as well as employees. If employers can pay more, then workers can still negotiate over award payments. The national character based on mateship, egalitarianism, equal opportunity, equity and fairness should lend itself to an unsegmented labour market where the majority of workers share the same or very similar conditions and wages. This is not the case, however, as can be seen when examining the system of awards.

Although the processes involved in making awards differ between states, and between states and the Federal government, the principles involved are similar. It is useful to consider the similarities in the processes and principles rather than concentrate on differences. The following section will examine the Federal system.

The Conciliation and Arbitration Act of 1904 which established the Australian Conciliation and Arbitration Commission has been altered by various governments. In 1988 the Australian Parliament passed the Industrial Relations Act 1988 which replaced the Australian Conciliation and Arbitration Commission. The Specialised Federal Industrial Tribunals was replaced with another independent body, the Australian Industrial Relations Commission (IRC). The role of the Commission is essentially the same, that is it must act to prevent or settle industrial disputes by conciliation and when necessary arbitration. In fulfilling this role the Commission can make awards, consent awards and certified agreements. The basic difference between Federal and State awards is that Federal awards cover parties involved in interstate matters. That is if an industry such as the transport industry employs workers in more than one state, such as Victoria and New South Wales, then they will need Federal coverage so that workers are covered by the same conditions in both states.
Award making is central to the Australia Industrial relations system. Awards, unlike many employment contracts, are extremely comprehensive. The comprehensive nature of awards enables them to be used by workers and employers as the major determinant of how an internal labour market operates. As well as setting out the minimum rates of pay for each occupational classification, it also contains rates to be paid for additional work, shift allowances, unpleasant conditions (including dust, water, height and extremes of temperature). Awards also lay down standard hours of work, meal breaks, rotation of duties, allowances, and leave entitlements including holidays, bereavement, sick, maternity, paternity and special leave. Awards stipulate whether workers can be employed weekly, daily, permanent or casual, part-time or full-time and conditions on abandoning or terminating employment. Awards also prescribe the nature and extent of facilities such as first-aid or medical, canteen facilities, facilities for boiling water for meals and washing and sanitary conveniences. More importantly awards set out the rights of unions to enter and inspect premises, the rights of employers to stand down employees and contain 'bans clauses' and procedures for settling disputes. The coverage and content of awards can be gauged from Appendix(3) which shows the material covered in a Metal Industry Award\textsuperscript{104}.

**Industrial Awards and Internal Labour Markets**

To understand how awards operate and the effects they have on the way labour markets are structured it is useful to understand the types of awards and how awards are made. Employer groups are always complaining about the number of awards that are in force

\textsuperscript{104} The Federal Government is reducing the number of matters dealt with in awards as they believe the rigidity of awards decreases labour market flexibility.
in a particular enterprise and this has, in the past been used to justified the current move to enterprise agreement\textsuperscript{105}. In most industries the bulk of workers are covered by one award and this is referred to as an industry award, because the job classifications covered by the award are found in one industry. Examples of industry awards include Pastoral Award, Timber Industry Award Graphic Arts Award and Transport Workers Award. The majority of awards tend to be craft or occupationally based rather than industry based. So that in a workplace employing over a thousand employees, the vast bulk of manual workers are covered by the Metal Trades Awards. Other workers would be covered by Craft Union Awards and other awards such as Carpenters and Joiners Award, Plumbers and Gasfitters Award, Professional Engineers Award and the Clerks (General) Award. Some workers in the administration area may not be covered directly by awards. However, the conditions and wages will be similar to, or exceed, workers with equal status. What tends to happen is when an engineer is employed in a purely managerial role he or she would expect (or in some cases negotiate) better wages and conditions than engineers within the enterprise or industry. There would also be an expectation that if the conditions of employment were not as good as fellow engineers in relation to for example, hours of work, annual leave or allowances, then this would be compensated for by a larger salary or other benefits such as a car, expense account or a share package. In this way awards influence the pay and conditions of workers not covered by awards.

Within an award\textsuperscript{106} there is rarely a single pay scale because most awards cover more than one job classification. In establishing variable rates of pay, awards are recognising

\textsuperscript{105} The claim that workplaces are covered by too many awards is not supported by the work of Callus et al (1991)

\textsuperscript{106} For a description of the process of award making see Deery and Ploughman (1991) or Sappey and Winter (1992)
the need to compensate workers for skills or responsibilities. According to Deery and Plowman (1991, 389) over seventy five years ago the industrial court recognised the need to reward skill and encourage workers to undergo training. To do this the court evolved the secondary wage or margin. Margins are minimum amounts above a base rate that a particular job classification receives for skill, experience or other factors such as responsibility. In determining the margin or secondary wage Sappey and Winter (1992) maintain that there are three basic criteria used.

The most significant is comparative wage justice; which the commission views as ensuring that workers doing the same job for different employers receive the same pay. This has been extended over the years so the workers doing jobs with similar skill levels and training should receive the same pay for that job. So a tradesman provides a benchmark for other occupational classifications within the award. In effect, jobs requiring less skill or training than trades receive less pay and jobs with more skill or training receive more pay. The basic trade classification used as a benchmark was the fitters and turners’ classification in the Metal Trades Award.

The other two criteria are capacity to pay and work value. The capacity to pay has been the dominant factor in determining margins. However, in determining capacity to pay it is the capacity of the industry as a whole, rather than an individual enterprise. The concept of work value is operationalised by assessing the nature of the training, skill and responsibility involved in the job. In using work value to establish or vary an award unions must establish that there has been a real or substantial increase in the value of the work done. In doing this there is flexibility built into the system of wage determination and allowances can be made for changes in training. In effect, the Commission can
arbitrate on the increase in work value or the increase in skill of an employee. Interestingly no employers have sought to have awards varied because of a decrease in workers skills. Although there are instances where employers claim they have used a technology such as CAD to deliberately deskill workers. For example Western Personnel Services Pty Limited were in a dispute with the AFMEPKIU when the union claimed that the CAD technology did not deskill the workers (Decision Summary Dec2676/95 M Print M7820). While the company argued that it had designed the system so that it required a low level of skill similar to clerical activities, the union argued successfully that the skill level was not diminished. The Industrial Relations Commission (IRC) after several sittings and site visits found in the union’s favour.

Changing Industrial Relations

Awards are the keystones of current industrial relations in Australia. However, they are under attack. As Sappey and Winter (1992, 2) point out the existing system is believed by many, particularly employers groups such as the Business Council of Australia (BCA), to be anachronistic. They argue that the changes taking place in economic, technological and industrial relations factors can not be addressed satisfactorily by the existing system because of its inflexible awards, work practices, union structures and industrial relations practitioners. As a result of the AWIRS study there has been an increasing emphasis on reforming industrial relations and establishing agreements at the enterprise rather than industry level. It is believed that the work place is the crucial unit of industrial relations because it is the work place that needs to be flexible enough to respond to changes in product and labour markets. The Industrial Relations Act (1994) which came into effect in March 1994 had the potential to significantly change sections of the industrial relations system. The Industrial Relations Commission has become a
regulator rather than a conciliator. The Act greatly increases the power of the Federal Government when compared to the States. Most importantly, the award system is still enshrined in this legislation. Awards are viewed as a safety net, which sets minimum wages and conditions. Under the new legislation awards will be reviewed and upgraded on a regular basis, the Commission will set minimum levels of wages, equal pay entitlements, termination of employment provisions and parental leave regulations for the 20% of employees not covered by awards. This in effect strengthens the influence of awards on the structure of labour markets because it ensure all workers can be covered by awards.

The 1994 Act had an important new provision. This was the establishment of an Industrial Court. Although there have been industrial courts before, this one is unique because it can exercise power over dismissals. Most importantly, its power extends to cover non-unionised middle managers and extends to the enforcement of minimum employment and anti-discrimination standards. Unlike previous commissions this one also has a division which will oversee and regulate enterprise based bargaining so that for the first time over award entitlements, can and will be, enforced by the commission. However, the Commission has had varying success in enforcing awards, particularly through penal provisions\(^\text{107}\). Although at various points in time the Commission has imposed fines and jailed union leaders for breaches of agreements and failing to abide by decision of the Commission, these penal powers have been vigorously opposed by the trade union movement.

\(^{107}\) For examples of the use of penal provisions see Teicher and McKenzie (1992)
Both employers and employees, through common law, can also enforce awards. Businesses or employers who are able to demonstrate that they have suffered damages as a result of industrial action can seek compensation through industrial or economic torts. These common law actions, according to Teicher and McKenzie (1992), fall into three categories: interference with contractual relations, conspiracy to injure by inflicting loss or by illegal means and intimidation. These categories cover such a wide range of issues that virtually any industrial dispute potentially will lead to liability for damages being incurred by workers or union officials.

In 1996-97 the Federal Government passed legislation that reformed workplace relations. The aim of these reforms was to free up the labour market, that, in the view of a conservative Federal government, was dominated by trade unions. According to the Metal Trades Industry Association (MTIA 1997) the main objective of the Act is to give primary responsibility for industrial relations and agreement-making to employers and employees at the enterprise and workplace levels. At the same time the role of the award system will be limited to providing a safety net of minimum wages and conditions. The government also claims that the Act will ensure freedom of association, the avoidance of discrimination and assist employees to balance their work and family responsibilities. While awards will still exist, they will be restricted to cover twenty allowable matters. In the place of awards employees and employers will be

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108 It could be argued that the aim of the changes to the Industrial Relations system was to enable employers to dominate what had become a system that enabled workers a greater say in work organisation.
encouraged to negotiate Australian Workplace Agreements or Certified Agreements\textsuperscript{109}. While the Federal government is seeking to alter and weaken the award system, the context that has been established over the last one hundred years has changed in minor ways.

The principles that govern the interaction amongst workers and between workers and employers have not been altered substantially by changes to industrial relations legislation. Workers still accept, and expect, that workers with more skill will be paid more than workers with fewer skills. Similarly, workers expect management to consult them and negotiate changes to working conditions and the introduction of new technologies. Australian workers, particularly in manufacturing, still expect employers to act in a fair way ensuring all workers have equal opportunities and access to jobs.

\textbf{An analysis of awards and enterprise agreements.}

The award system protects employers and employees, but most importantly it acts as a safety net. This safety net sets the basic conditions for employees in both unionised and non-unionised work places. Employers take a simplistic view in most cases that the award is a basic benefit. It is easier for businesses, particularly small and medium sized organisations to adhere to an award than it is for them to negotiate employment contracts. In the 1995 AWIRS survey findings Morehead \textit{et al.} (1997) maintain that the proportion of workplaces covered by awards decreases as the size of the workplace increases and the proportion of workplaces covered by collective agreements increases as size increases. Although the 1994 Industrial Relations Act encouraged workplaces

\textsuperscript{109} This type of action will allow the more powerful employers to exercise more control over all aspects of jobs and work.
to enter into collective enterprise based agreements by 1995\textsuperscript{110} thirty three per cent of workplaces were still covered by awards, thirteen per cent were making over award payments and forty four per cent were covered by enterprise agreements, with only nine per cent of workplaces being covered by individual arrangements. In the 1995 AWIRS\textsuperscript{111} survey the use of over-awards was still important but it was in decline because of the incidence of enterprise agreements.

AWIRS 95 found that 46 per cent of workplaces paid over-awards to at least some employees and it was more prevalent in the private sector; 60 per cent of workplaces compared to the public sector 11 per cent of workplaces.

The award system ensures that workers can enforce minimum conditions without having to negotiate a detailed individual employment contract. Although there is an argument that awards are inflexible, studies such as Callus \textit{et. al} (1991) indicate that the majority of business operate within awards and are prepared to vary award conditions to attract workers or to reward workers. Even when management has the opportunity to ignore the award they appear to prefer to use it as a benchmark. The award system acts as a control mechanism over excessive differences in wages and conditions. Awards allow for relatively minor adjustments, but it would be seen as unfair if, for example, trades people working the same hours in the same business were paid vastly different rates. Awards also influence technical workers, not necessarily covered by an award.

\textsuperscript{110} See Morehead \textit{et al} (1997)
\textsuperscript{111} ibid
Those workers would not be prepared to work at less than award conditions if they believed they were required to exercise more skill than workers covered by the award. The award system enables workers to predict minimum conditions\textsuperscript{112} when moving from one firm to the next or when being promoted within an organisation. Internal labour markets in Australia are strongly influenced by the award system. While there is the potential for many segments within large organisations, the conditions and characteristics of each segment will tend not to vary. This lack of variation is due mainly to the award system. Unlike the USA and other countries where employment contracts remain in force for a limited period such as three years, then have to be renegotiated. In Australia awards remain in force until varied by parties to the agreement.

Awards and enterprise agreements provide a description of some of the characteristics of jobs within an internal labour market. Classification structures provide the framework for segmentation within operations covered by particular awards and agreements. Since the early 1990s there has been a significant increase in the number of firms registering enterprise agreements. These agreements are \textit{de facto} awards covering one business enterprise. Not all awards and agreements describe segmented internal labour markets in the same way, but there are similarities across awards and agreements. An analysis of several awards, particularly the classification structures, shows that at least two segments\textsuperscript{113} are enshrined in most awards. Table 4.1 summarises examples of awards and agreements and it can be seen that there are distinct segments.

\textsuperscript{112} Unlike contracts and individual workplace agreements awards must be made available to workers so that they can see what wages and conditions all workers covered by the award are entitled to. However it does not force employers to disclose who is receiving over-award payments.

\textsuperscript{113} Flatau and Lewis (1993) have used cluster analysis to demonstrate that internal labour markets are segmented.
within each of these awards. Each segment consists of a set of jobs with up to nine
categories or levels and each segment has a range of wages. In each case the base rate of
wages is set by trades persons and is defined as one hundred per cent, workers who are
less skilled than trades persons earn less than one hundred per cent, and workers with
more skills than tradespersons earn more than one hundred per cent. In some awards
there is a distinction made between supervisors and non-supervisors, supervisors are
paid not at a set percentage but at a percentage say one hundred and ten per cent of the
wages of the highest level of employees they supervise. This indicates that from a
management perspective not all technical or professional workers are expected to carry
out supervision and control on behalf of management while in practice technical and
professional workers may have some supervisory function, but are not paid for it. In
some organisations there can be blurring at the boundaries so that on occasions a trades
person could be carrying out the tasks of an engineering associate and being paid for
them, but may not have the formal credential required for that classification. The
boundaries may be hard or soft depending upon the award. Clearly for a worker to be
classified as an engineer/scientist it is essential that they have the appropriate
qualifications, so the degree qualifications act as a hard barrier to entry. On the other
hand a CAD operators’ job could be in the Aerospace Technicians Level I- IV and as
there are no formal qualifications for CAD operators there are no hard barriers to enter
that segment once a worker has the necessary skills and knowledge to operate the CAD
system.
<table>
<thead>
<tr>
<th>Segments</th>
<th>Aerospace Technologies</th>
<th>Metal Industry</th>
<th>State Transport SA</th>
<th>Vehicle Industry BTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional</td>
<td>Engineer/scientist Level I-III 4 Categories in each level 119%-220%</td>
<td>Professional Engineers and Scientists Level C1 160+%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td>Aerospace Technicians Levels I–V 103%-165%</td>
<td>Engineering Associates Level C2-C4 135%-160%</td>
<td>Advanced Engineering Trades person Level C10-C12 120%-130%</td>
<td>BTR Technician Level 1-4 105%-135%</td>
</tr>
<tr>
<td>Supervisory</td>
<td>Supervisor I-II 9 categories 126%-159%</td>
<td>Trainer Supervisor Coordinator Levels 1-5 107%-122%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clerical</td>
<td>Clerical Officer Level I-III 9 categories 85%-159%</td>
<td></td>
<td></td>
<td>BTR Clerk Grade 1-5 85%-99%</td>
</tr>
<tr>
<td>Trade</td>
<td>Trades persons Base – Advanced 5 levels 100%-135%</td>
<td>Engineering Trades persons and Technicians Level C5-C10 100%-130%</td>
<td>Engineering Trades person Levels C5-C9 100%-115%</td>
<td>BTR Trades persons Levels 1-5 100%-130%</td>
</tr>
<tr>
<td>Operations</td>
<td>Aerospace worker I-III and Assistant Technician I-II 88%-100%</td>
<td>Engineering Production Employees Level C10-C14 78%-92.4%</td>
<td>Engineering support Person Level C1A-C5A 78%-100%</td>
<td>BTR Operative Level 1-5 78%-100%</td>
</tr>
</tbody>
</table>

Table 4.1 Job Classifications in Awards and Enterprise Agreements

Within job classification structures, other segments may exist, this will depend on the size of the firm and the number of employees. In a large firm with hundreds of production workers it could be expected that workers in different, jobs such as labourers and machinists, would constitute their own cluster or segment as Flatau and Lewis (1993) suggest in their study. Also workers such as cleaners form a distinct cluster within a separate segment.
In reviewing examples of awards and agreements it is evident that while they may describe how internal labour markets can be segmented on the basis of the classification structure, they do not provide a single simplistic model of internal labour markets in Australia.\textsuperscript{114} The picture can be even more unclear in enterprises covered by more than one award. What is clear is that internal labour markets are segmented and in the manufacturing sector this segmentation appears to reflect Osterman's classification along craft or occupational lines. However the picture is more complex than that put forward by Osterman. The tradesperson in Australia, as the custodians of the craft tradition, has been able to secure for themselves a position within internal labour markets that is superior to operations employees. As a result of gaining a trades persons rights certificate, or a trade certificate, they can gain access to further training that can articulate to post-trade or advanced certificates and then to associate diplomas, diplomas and degrees. Once they have access to this training it is possible for them to move to another segment which uses credentials as a barrier to entry. Access to training is the key that enables workers to acquire the skills and knowledge necessary to gain promotion within a particular internal labour market. Within the award system the level of skill is defined and the amount of training is specified.

\textbf{Awards, Enterprise Agreements and CADCAM}

Awards describe custom within different operations. As such they tend to be reactive rather than proactive. However, once a condition is prescribed in an award it is very difficult to alter it. In the case of technologies such as CADCAM, once a particular

\textsuperscript{114} In Flatau and Lewis (1993,292) they identified three main segments and five single occupational clusters.
segment has staked a claim to the technology by having a right to operate or maintain it written into their award, it is almost impossible for another group to hi-jack the technology. As awards evolve, unions representing workers bound by the award try to negotiate not only the best possible wages and conditions for their members, but also try to establish a powerful position by increasing access to training and resources. For example in the Rubber, Plastic, and Cablemaking Industry Award (1994), the parties to the award are committed to: developing a more highly skilled and flexible workforce providing employees with career opportunities through appropriate training to acquire additional skills and removing barriers to using the skills acquired through training. Although employers have committed to providing on-the-job training, unions have argued and insisted that training needs to be conducted through externally accredited training providers. This ensures that workers can gain skills and knowledge that is recognised and is portable across the industry sector.

Awards and enterprise agreements describe the basic characteristics of internal labour markets in Australia. Job classification structures broadly define segments within an internal labour market and may contain descriptions of work and barriers to entry to particular jobs. However, awards and enterprise agreements are the formal record of what has been agreed to by workers, their representatives and employers and do not contain all jobs and practices within an enterprise. As awards are based in part on custom they can determine how segments may alter, but in the main they are descriptions of work, jobs and terms and conditions of employment. Job classification structures vary widely from enterprise to enterprise but they provide a general picture of labour market segment and these segments can be classified into five basic categories: professional, technical, trade, operations and clerical. While some job classification
structures provide a detailed description of work that can be carried out by employees in different categories they do not contain a description of all work and jobs. Workers are able to move within the job classification structure by acquiring credentials demonstrating the required skills and applying for jobs when they become available. In many awards it is clearly stated who can use AMT such as CADCAM and some awards even state who can not use CADCAM. In most awards it is experienced and skilled trades persons who are able to operate CADCAM and the jobs associated with CADCAM are usually located in the technical segment of internal labour markets.

**Conclusion**

It has become accepted by workers and employers that the work associated with CADCAM is technical in nature. The tasks carried out by technical workers and the wages and conditions of technical workers are described in detail in awards. Employers do not hand down awards and workers, or their representatives are actively involved in negotiating all aspects of awards. So it has been through a process of formal and informal negotiation that workers and their employers have determined who will operate CADCAM and what skills are necessary to operated a CADCAM. Awards are the result of both negotiation and conflict. When employers and workers are unable to negotiate a resolution to conflict, the IRC has in the past been able to step in and resolve disputes. However the disputes have not been along class lines and workers in Australia do not perceive disputes between workers and management to be part of class conflict, rather they are seen as tools within an industrial relations system that can be used to involve an independent umpire, the IRC. While awards contain formal descriptions of the nature of CADCAM users jobs these descriptions may vary considerable within firms. So it needs to be established if CADCAM users perceive their work to be similar
to work as described in awards and agreements and if they also perceive it to have similar characteristics to work as described in job classification structures. It is also important to determine if CADCAM users view their work as skilled and which characteristics of their work they regard as important. But before examining the work of CADCAM users it is important to understand what CADCAM is and how it can be arranged, and operated. It may be the case that management has adopted CADCAM systems that allow them to control the work of users and eventually gain total control over the process of design and production. Chapter six describes CADCAM and looks at how it has evolved over the last forty years. Chapter seven and eight will examine the CADCAM systems in use in Australia and attempt to identify if they have been used to deskill workers and control the labour process.
CHAPTER FIVE

Linking Theories and Technology

Introduction

From an examination of the labour market, labour process and class analysis literature it is apparent that they have all provided a useful explanation of how the work of technical workers is difficult to locate within a one dimensional model. The radical labour market researchers developed a complex model of segmented labour markets that located technical jobs in the upper tier of internal labour markets. In an effort to explain all internal labour markets, they assigned to jobs in different segments very general characteristics. These general descriptions and explanations failed to take into account differences in national contexts and differences between industries. The labour market literature ignored the actions of individual workers and the mechanism available to them in acquiring a job in a particular segment. The literature also fails to explain why and how particular jobs are located in each segment apart from the jobs sharing similar characteristics.

While labour market segmentation theory provides a better description of Australian labour markets than neoclassical theories, it still does not provide an explanation of how each segments arises, nor what workers and employers can do to alter segments. Labour market theory needs to take into account the changing nature of the marketplace and labour market models need to be flexible if they are to take into account national
and regional differences. The positions of employees in internal labour markets are constantly being adjusted as jobs disappear and new jobs emerge.

This process can be both evolutionary and revolutionary. The evolutionary process sees the day-to-day tasks of workers changing gradually as workers learn new tasks and discard old ones. In the revolutionary process jobs are replaced by new tools and techniques and workers are made redundant. While workplace change is inevitable, the changes that are taking place occur within a framework that has developed over time. Any changes that occur in Australian labour markets must accommodate the Australian framework and workplace culture. Within the Australian workplace culture change must be negotiated and it must result in an explicit written agreement between workers and employers.

Technology has been used by management to change the jobs of workers in the manufacturing sector in Australia. Workers have responded to these changes in a range of ways. Skilled tradesmen, for example, have been able to use their knowledge of the production process and their trades skills to gain access to advanced manufacturing technologies. But to acquire more control of these technologies technical workers have had to acquire additional knowledge and skills. To acquire those skills workers must be able to access the necessary training. Training is a crucial factor in determining who does which job. Training or lack of it can act as a barrier to accessing segments of the internal labour market. The nature of training and who pays for it plays a significant role in the structure of labour markets. The specificity of skills and technologies also influence training. It is easier for workers to access and pay for training in generic skills and turnkey technologies than in specific skills and custom-built technology. So that
custom, skill, technology, and training interact to influence workers access to jobs and their movements between segments of a labour market.

The labour process literature has focused on Braverman’s work and much of it has discussed the deskilling of technical workers and the alienation of technical workers from the process of production. In drawing attention to the possibility of deskilling, labour process literature has provided a useful material on the potential impact of AMT on the jobs of workers in high technology industries. The usefulness of the labour process literature lies in its analysis of work at a micro-level. Unlike labour market literature; labour process literature has attempted to analyse work and the roles of workers at the enterprise level and has concentrated on manufacturing and the process of production. It has not taken into account the actions of workers individually, and at times in groups, in attempting to maximise their own pay and conditions. The labour process literature briefly deals with the choices available to employers and employees in selecting and configuring a technology to enhance workers’ skills. Most labour process theorists appear ignore that some employers actively seek to increase the skills of the workers. They also ignore the role of collectives and worker owned businesses from their analysis. In generalising their findings to all production processes in developed economies, labour process researchers have ignored national and industrial differences. As most of the literature has dealt with the European or North American experience it has not addressed the unique conditions in Australia and their effects on the labour process.

Capital is continually attempting to alter power relationships between themselves and workers so that they can establish greater control over all aspects of the labour process.
Capital is seeking to control not just the process of production, but all stages from conceptualisation through design and development to the final sale of goods to consumers. At the same time workers are attempting to maintain their power over their part of the process. Capitalists have organised production in ways that minimises the relationship of workers to the production process. On the factory floor they have successfully introduced technologies, and organisational structures that favour management in the struggle for control. Many labour process theorist claim that through computer-based technologies capital will be able to control the design and development process by deskilling technical workers. However, deskilling is not inherent in a particular technology and there are many technological trajectories. The impact a particular technology has on workers' skills is difficult to determine but it appears to be cyclical in nature. Workers initially appear to gain skills, but as the technology becomes more complex they lose skills as their work becomes more specialised. However some technical workers may be able to keep up with technological change by continually upgrading their skills.

There has been a tendency to over-emphasise the success of capital in deskilling and controlling workers. Part of this problem stems from people's perception of skill. As there is no tool or technique that can objectively measure a workers skill level, how skills are measured ends up depending upon a subjective perception of what is or is not skilful. In Europe and North America there may have been a concerted effort by management in large enterprises with thousands of workers to ensure that they control the labour process, but it does not appear that this has occurred to the same extent in Australia. While in Europe the industrial disputes and conflict of the 1960s and 1970s have been explained by the emergence of a new working class; there may be a simpler
explanation. A more aggressive technical workforce flexing its industrial muscle and positioning itself at the expense of other workers, could be the crucial factor.

Technology can be used by management and workers to achieve different outcomes. Technology can be used to deskill and displaces workers, it can increase the flexibility of a plant and the skills need to operate in a changing environment, it can be a barrier to communication or it can enhance communication, the final outcome is the result of several factors. To understand the place of technology in the labour process we need to consider the wider context and include intervening variables such as socio-economic, cultural, and industrial relations factors. Most importantly to understand how workers can use labour market structures to protect their jobs and the status of their jobs we need to link labour process and labour market segmentation theory.

The class analysis literature has highlighted the difficulties associated with trying to classify and define technical workers. It has pointed out the contradictory position of technical workers. Sociologists in attempting to come to terms with the contradictory position of technical workers have explored the complex dynamics of class structures and postulated the emergence of a new working class or a new middle class. Much of this work has been criticised for its economic and technological determinism. The emerging picture portrays the working class as a highly stratified group with technical workers dispersed over several strata. The class literature focuses on the struggle between labour and capital for control of the production process. By focusing on the conflict between capital and labour, class analysis paradoxically overlooks the struggle between workers for better jobs and better wages and conditions. It also ignores those workers not involved in a class struggle. In seeking to explain the class position of all
workers in all capitalist societies the literature has paid scant attention to national, cultural or institutional differences. It has also failed to deal in any great depth with the intervention of governments and the impact of industrial relations legislation in moderating the struggle between capital and labour. Wright’s fragmented class map has much in common with Piore’s segmented labour market. The main difference is the fragmented class map is used to describe the position of workers, whereas the labour market segmentation theory describes the location of jobs.

In their work Keefe and Potosky (1997) found no evidence of a new class or class system. Rather they suggest that workers are becoming increasingly stratified through the technical division of labour. This stratification produces a technical hierarchy with professional workers at the top and technical workers at the bottom, near trades and production workers. Workers are able to use training as vehicle to move up the hierarchy or they can use formal qualifications as currency to purchase a job with better status in the hierarchy. It becomes evident that technical workers are acting in their own interest rather than in the interest of management or other workers. Technical workers in Australia have used CADCAM to secure their position in the labour market.

In the past the position of workers’ jobs were defined in awards and agreements. The process of setting awards and workplace agreements encouraged workers to negotiate as a whole and increased worker solidarity. However, we are seeing changes to industrial relations in Australia that will have far-reaching consequences for workers. For example the Industrial Relations Commission is now a regulator rather than a negotiator. Currently the framework and philosophies behind awards are still retained by many employers and employees but this may change. These changes will not only be as a
result of changes to legislation, but due in part, to changes in the nature of the Australian society that once claimed to value mateship, egalitarianism equity and fairness. Changes in the workplace reflect changes in the values and beliefs of society as whole.

**An Emerging Model**

What emerges from examining these three interacting bodies of literature is the need for a model or construct. Such a model needs to explain the location of jobs within a labour market, how workers are allocated jobs, how workers compete for jobs, what actions are available to workers to maintain the skill level of their jobs within an increasingly fragmented labour process and the changing relationship between employers and employees. If some of the pitfalls of generalisation are to be avoided, such a model will need to take into account the national and industrial context and explain the position of a particular group of workers carrying out a specific job. Given the importance placed on the role of technology in most of the literature reviewed, the specific job needs to involve a computer based technology that could be used to deskill workers or further fragment the labour process. In the light of the theoretical models presented so far the thesis turns to a detailed examination of the market position of technical workers, the technological characteristics of CADCAM and its place in the production process and the relationship of technical workers to the rest of the workforce.

Throughout the literature reviewed so far a linking theme has been the possibility of employers using advanced manufacturing technologies such as CADCAM to exert more control over the process of production. Each body of literature has put forward different arguments to explain why employers need or want to exert more control over the
production process. If employers can use CADCAM to alter the work of skilled designers then eventually these technical workers will be displaced or will become machine minders. This analysis is based on the assumption that automation both deskilled and displaced production workers, and that was in the best interest of capital, so it is in the best interest of employers to do the same thing to technical workers. While there is some empirical evidence of deskilling and displacement of production workers there is little empirical evidence that this has occurred to technical workers. Much of the literature examining the way that AMT such as CADCAM can be used has failed to provide a detailed description of the technologies and how they can be configured. There is also a need to provide empirical data on how workers perceive their jobs and the characteristics of jobs using CADCAM. In examining this within the Australian context it is necessary to consider the differences between firms in Australia and firms in the Europe and North America using CADCAM. This is needed as Australia has an unique employment relations arrangements and large monopolistic firms in the USA and Europe are very different from medium and large size Australian firms.

From Theory To Empirical research
The next section of this thesis will describe the technological characteristics of CADCAM and explain how the production process has been changed since the development and introduction of CADCAM. After examining the technology the next chapter will present empirical evidence that will either support the views of theorists examined in the first three chapters or identify some of the limits of the theories proposed.
The subsequent chapter will analyse the results of interviews that were conducted to explore the theories and the inadequacies of the literature to explain the position of technical workers and the influence of CADCAM on technical workers' jobs. The concluding chapter will use CADCAM as example of a contemporary technology and explain how it fits the existing map of the production process.
CHAPTER SIX

CADCAM Technology

Introduction

To understand the issues raised in chapters two to four it is necessary to examine the
technologies that technical workers are using. This chapter will describe the
technologies and how they are organised and explain how the jobs of technical workers
have been altered since the implementation of these technologies. Further, to
understand how the technologies have themselves changed, this chapter will examine
the evolution of the technology, paying particular attention to recent developments.

CADCAM is representative of a rapidly expanding group of advanced manufacturing
technologies. The rapid expansion of these technologies is due in part to the recent
advances in computers and computer systems. While the term CADCAM has been
around for more than twenty years, Hill (1995) maintains that it is only in the last few
years that the systems have come close to providing a near seamless electronic link
between design and manufacturing. To understand CADCAM and how it has been
developed it is useful to define CADCAM and related technologies as well as
examining the range of CADCAM applications. This in turn leads to a description of
current CADCAM systems and system configurations as well as a typical hardware and
software. Finally the historical development of CADCAM and how it has been
introduced and applied provides useful insights into the technology itself.

According to Kochan (1986, 198) the term CADCAM has been in use since the early
1970s. The NSW Science and Technology Council (1989, 12) provides a simple
statement of what is commonly accepted as the meaning of computer aided design CAD and computer aided manufacturing CAM.

CAD - Computer Aided Design: The use of computers in the design and engineering process. Sometimes expanded to Computer Aided Drafting Design CADD and Engineering CAE.

CAM - Computer Aided Manufacturing: The use of computer technology in the management, control, and operation of manufacturing facilities, through either direct or indirect computer interface with physical and human resources.

CADCAM is simply a general name or umbrella term for the many ways the computer can be used as a tool to help design, make and sell all kinds of products more specifically CADCAM implies the automation of this process. Kochan (1986,198).115

It is necessary that a very general definition of CADCAM is used because it has to cover a wide variety of applications. The definition is further confused by the differing use of terms in various industries.

CADCAM is a marriage of many engineering and manufacturing functions116. At its simplest level it is any computerised communication between design, engineering and manufacturing disciplines, while at the other extreme it can include almost any phase of

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115 Kochan (1986) suggest that CIM,FMS and MRP are often confused with CADCAM
116 See Bowman (1984, 1)
the business and manufacturing cycle. CADCAM does not necessarily involve all the phases of design, production and manufacture but it should involve an overlap in the manufacturing equipment and drafting of production component. Bowman (1984,12) provides a simple model of CADCAM with the only required link being a common database.

**CADCAM**

<table>
<thead>
<tr>
<th>CAD</th>
<th>CAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometric Modeling</td>
<td>Numerical Control</td>
</tr>
<tr>
<td>Analysis</td>
<td>Robotics</td>
</tr>
<tr>
<td>Testing</td>
<td>Process Planning</td>
</tr>
<tr>
<td>Drafting</td>
<td>Factory</td>
</tr>
<tr>
<td>Management</td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td></td>
</tr>
</tbody>
</table>

These two systems are linked by a common database.

**Figure 6.1 The Linkage Between CAD and CAM**

The term CADCAM is applied to a wide range of computer based systems. These include CAD systems that do not include any computer aided manufacturing packages. However, the main CADCAM application package consists of a CAD package which is able to assist in the programming of (numerically controlled) NC equipment. To gain an understanding of the work done using CAD and CADCAM systems it is necessary to have an idea of jobs and work done before the introduction of these technologies. Then we can then examine CADCAM technological configurations. There are, according to Badham (1989, 10), five main components to be described. These are the basic
we can then examine CADCAM technological configurations. There are, according to Badham (1989, 10), five main components to be described. These are the basic hardware, the basic software, the system of configuration, the system development and customisation and the human/machine interface.

**Design and Manufacturing Before CADCAM**

To gain an understanding of how CADCAM has enabled employers and workers to alter jobs and work in manufacturing firms it is necessary to describe the jobs and work that have changed. The basic process of product development involves design and engineering tasks, the conception stage of new product development. In the initial stages senior designers (in large firms such as automotive, aerospace or arms manufacturers this would involve a group of engineers) would examine the customers' needs specifications and then develop concept plans. The concept plans are usually rough sketches and drawings that will be refined through many iterations. The concept plans are then passed onto the draughting staff, usually draughtsmen, who working on a drawing board with pencils, pens and paper, refine and draw detailed plans to scale. Drawing was, and still is, considered a highly skilled art form; each draughtsman using his own style to produce technical drawings. Often new products were in fact changes or additions and modifications to similar existing products. In such cases draughtsmen would copy and modify existing drawings from scratch, a time consuming process. The draughting and design was usually carried out in the offices away from the factory floor although minor modifications could be made to drawings on the factory floor. Engineers from the factory floor or manufacturing managers were able to suggest
changes to design at meetings of engineers. After the part or product was designed a prototype was built and tested. Finally when the product was finished in design the manufacturing manager and engineers would design a production process and schedule.

On the factory floor tradesmen were given drawings of sub-components and they would use hand tools, drills, presses, saws and lathes to manufacture the components. The knowledge required to use the tools and machines was the proprietary knowledge of individual tradesmen and machine operators. The operators would usually operate one machine or tool and after completing their assigned task would pass the part onto the next machine operator for the next stage of production. This process would be repeated until the various sub-components were ready and assembled into the final product.

Prior to the introduction of CAD into the design processes there had been many technologies and systems introduced onto the factory floor. It is argued \(^{117}\) that the main aim of these systems and technologies was to reduce the variation between different machine operators. With mass production it was necessary to ensure that a product varies as little as possible. With the increase in demand for skilled machine operators it was important that management ensure that all machine operators produced the same product to exacting specifications. This management requirement led to the development of numerical control systems. These systems reduced the need for skilled operators with a proprietary knowledge of how a particular machine could be optimised.

\(^{117}\) Much of the quality management literature argues that variation is costly and must be reduced in all stages of manufacturing.
to machine a product. Punch hole cards or tape was used to control the machines and as long as the machine was well maintained it would produce multiple copies of products to exactly the same specifications every time. With the introduction of computers into manufacturing, the tapes and cards could be produced by computers rather than manually.

Typical CADCAM Systems

**Hardware**

In both CAD and CADCAM the key hardware components are the central processing unit CPU, computer memory and input/output devices. These components can vary from the type of CPU, the degree of resolution of the graphics terminal, the type of input device (for example mouse), keyboard or digitising tablet and type of output, (for example electrostatic plotter, ink jet printers or NC tape).

There is a need for a large amount of memory and computing power for the storage and transformation of graphic images. Until recently this required a mainframe computer. Some packages that have a wide range of applications, including three-dimensional (3D), mechanical and sculptured surface applications and complex engineering analysis still require mainframes. However, minicomputers can now run 3D solids and surfaces, while micro-computers and personal computers are able to do 2D drafting work. Over the last ten years more memory and processing power has been designed into micro and super micro work stations so that there are fewer packages that require a mainframe. As can be seen from table 6.1, there are three basic systems which all vary to some degree in their capabilities, networking integration and flexibility.
### Table 6.1 Characteristics of Basic Systems

<table>
<thead>
<tr>
<th>Costs</th>
<th>Personal Computer Based System</th>
<th>Stand Alone Workstations</th>
<th>Central Computer Based Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low cost</td>
<td>Medium cost</td>
<td>High cost</td>
</tr>
<tr>
<td><strong>Capabilities</strong></td>
<td>Mainly 2-dimensional drafting, but also an emerging 3-dimensional capability. Essentially a drafting workstation but also an emerging range of design and analysis capabilities. Relatively limited range of drawing construction features.</td>
<td>Full 3-dimensional capability. Surface shading and solids modeling usually available. Substantial range of design and analysis features available. High-speed processing.</td>
<td>Full 3-dimensional capability. Surface shading and solids modeling usually available. Substantial range of design and analysis available.</td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>Limited data sharing capability with other workstations.</td>
<td>Generally have full data sharing capability with other workstations. System can be expanded readily.</td>
<td>Data sharing capability with other workstations. All workstations share common data base. System expansion can be expensive once computer capacity is filled.</td>
</tr>
<tr>
<td><strong>Integration</strong></td>
<td>Relative simple integration only.</td>
<td>Substantial integration possibilities with other technologies.</td>
<td>Substantial integration possibilities with other technologies.</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Multi-purpose hardware capable of operating other software e.g. word processing, spreadsheets, etc.</td>
<td>Special purpose hardware specifically engineered for graphics applications</td>
<td>Systems usually dedicated to graphics applications, but can run other software.</td>
</tr>
<tr>
<td><strong>Trends</strong></td>
<td>Gaining substantial acceptance and penetration within industry. Capabilities are constantly improving.</td>
<td>Gaining substantial acceptance for high performance applications. Capabilities are constantly improving</td>
<td>Were initially the only way to get sufficient processing capacity. Now less attractive as an option.</td>
</tr>
</tbody>
</table>


**Input/Output**

Input is simply the method of getting information into the CPU. There is a need to obtain information from a variety of sources such as:
The operators original ideas

Ideas previously defined such as formulae or drawings

Physical information about objects such as tools, parts and models

Electronic data from other computer based systems including NC and CNC tools and robots (Bowman 1984, 37).

To allow for these inputs a variety of devices have been developed. The most widely used device is the alphanumeric keyboard. Although similar to a typewriter the keyboards have additional keys which enable a greater range of communication commands. These are often used in conjunction with programmable function boxes and programmable function dials. These two input devices provide two-way communication between the user and host program. The first unique CAD input device was the digitising tablet. This is a flat board with commands in the form of displayed icons or symbols. Devices of this type detect the position of a fixed or hand held cursor or stylus on a digitising surface. The tablet contains a grid that corresponds to the resolution on the screen. Another popular input device is the 'mouse', this uses a pull down menu system and icons to input commands.

International Business Machines (IBM) CATIA® systems use their own specific device for the dynamic rotation of images on the screen. Other input devices such as joysticks, tracking balls or touch screens are now less popular. Also light pens and touch terminals are in limited use. One area that is undergoing rapid development is digitising scanners. These allow data on drawings to be digitised automatically and transmitted to the CPU. Voice data entry is one of the most desirable input functions currently under
development. Such systems would allow a greater range of skilled and unskilled workers to interface with a CADCAM system. It would also allow workers to concentrate on their task rather than the keyboard or screen. Voice entry data is currently available but its use is limited. It is being used however in quality control where inspectors are able to input data directly through a voice intelligent terminal.

Figure 6.2 Basic CAD Hardware

As can be seen in figure 7.2 the CAD system consists of a CPU, input/output devices and a screen or high resolution CRT. The screen has to produce high resolution images in real time, to do this the graphics process is built into the terminal rather than the main CPU. This allows faster creation and manipulation of images as well as complex
images such as solid or shaded models. Where terminals are able to carry out these functions they are known as a 'graphics engine'.

**Output**

The final stage in a CADCAM system is its output, that can be either digital information direct to a machine tool, punched paper tape for a NC machine, or a drawing produced by a plotter. The main output device is a plotter. Types of plotters include flatbed, electrostatic plotters and laser printers. Each type of plotter has their advantages and disadvantages but each produces a copy that is as close to the CRT image as possible. Although plotters dominate the output environment there has been an increase in raster-based technology such as lasers printers inkjet printers and thermal-dye transfer devices.

CAM hardware consists of tools and machines such as drills, lathes, welders, saws and other cutting devices that are controlled and operated by computers or chips. CAM also includes robots and mills. The computer controlled machines and tools are substantially the same as the human operated versions, the major differences are that they can repeat the same operation repeatedly without any human intervention and there is a PC or control device containing a microchip monitoring the machine. Mills are complex CAM technology consisting of a range of tools. A mill may contain a cutting device, several drills and other devices such as routers. Once programmed a mill will carry out several operations on a component without any human intervention. A machine operator who can cancel the operation if there is any unexpected difficulty usually monitors the mill. Robots vary in type and operation, but are usually used for highly repetitive tasks such as welding or drilling. Robots are often used in environments were
there are significant occupational health and safety concerns, such as noisy environments or areas of potential repetitive strain injuries. For example, in the aerospace industry when it is necessary to drill holes in carbon fibre composites the process can cause strain injuries to workers drilling holes for fasteners. The material requires three holes to be drilled and a single section may have five hundred fasteners. Rather than use human operators a robotic drilling rig costing over a million Australian dollars, can be programmed to drill holes in the material. Workers do not usually monitor robots' work although there is normally an inspection process to verify the accuracy and quality of the work carried out by robots. Workers usually carry out these quality checks.

**Software**

While the hardware is the visible part of CADCAM system it is the software which operates and drives the system. There are two main types of software; application software and operating system software. The application software is the more familiar software used in games, spreadsheets and word processors. Operating system software on the other hand, is the housekeeping system which performs procedures such as accessing, creating and executing programs and communicating with input and output devices. Although there are several operating systems, each hardware vendor usually has their own system. Unix has emerged as the standard for most workstations\(^{118}\).

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\(^{118}\) Unix was the first operating system written in a high level language called "C". As with any operating system Unix controls the running of the computer it is installed on and allows the user to avoid low-level programming. Another major benefit is that Unix enables the user to use a range of hardware rather than just one proprietary brand.
In the micro or PC based systems Windows NT is the dominant operating system since the majority of firms use IBM compatible workstations.

While the operating system manages the hardware it is the application software that gives CAD systems their unique manipulative ability. However as can be seen in table 6.2 not all software has the same capabilities.

<table>
<thead>
<tr>
<th>Method of Object Representation</th>
<th>2-dimensional Software</th>
<th>3-dimensional Software</th>
<th>Surface Shading Software</th>
<th>Solid Modeling Software</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>By line edges only</td>
<td>By line edges only</td>
<td>By line edges and</td>
<td>By combinations of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>accompanying surfaces</td>
<td>basic solid elements</td>
</tr>
<tr>
<td>Number of Dimensions</td>
<td>2-dimensions</td>
<td>3-dimensions</td>
<td>3-dimensions</td>
<td>3-dimensions</td>
</tr>
<tr>
<td>Software Capabilities</td>
<td>• Limited capacity to</td>
<td>• Enhanced capacity to</td>
<td>• Considerable capacity</td>
<td>• Few limitations to</td>
</tr>
<tr>
<td></td>
<td>use drawings for</td>
<td>use drawings for</td>
<td>use drawings for</td>
<td>the types of</td>
</tr>
<tr>
<td></td>
<td>engineering</td>
<td>engineering</td>
<td>engineering analysis</td>
<td>engineering analysis</td>
</tr>
<tr>
<td></td>
<td>analysis and</td>
<td>analysis and</td>
<td>and integrated</td>
<td>that can be performed.</td>
</tr>
<tr>
<td></td>
<td>integrated</td>
<td>integrated</td>
<td>manufacture, especially</td>
<td>• Capable of</td>
</tr>
<tr>
<td></td>
<td>manufacture.</td>
<td>manufacture.</td>
<td>for objects with</td>
<td>developing realistic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>complex surfaces.</td>
<td>object visualisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>for design assessment,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>advertising, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Aptech Australia, *Advanced Manufacturing Technologies*, Amtech, Victoria, 1 p.2-7

Table 6.2 Capability of Application Software

The core of any CADCAM system is geometric modeling. It is the geometric software that displays information and carries out any modification of a component. As well as displaying and modifying components, the geometric software can perform
transformations\textsuperscript{119}. All software varies in its range, depth and interface capabilities. As technical workers such as designers, drafting staff, and engineers become more familiar with systems they may require new application programs with additional features. Vendors of CADCAM systems claim that their systems can carry out all the functions necessary to design, analyse and manufacture a product. Yet as Lambourne (1995) points out, design packages are rarely linked to functional manufacturing programs. Also software vendors are keen to demonstrate the strengths of their systems but are understandably reticent to mention any weaknesses or shortcomings. However according to Mills (1996) the gap between what users need and what vendors deliver is gradually narrowing. Bill McClure of Intergraph (Deitz 1996) maintains that from 1985 to 1990 CADCAM developers focused on functionality adding more and more functions to their programs. So that by the early 1990s CADCAM systems had thousands of commands and were too complex for most users to take advantage of all the possible functions and commands.

According to Krouse (1996) some of the newest software has what he terms “built-in intelligence” that alleviates some of the problems associated with too many functions and commands. He claims that smart CAD systems by removing the more routine chores, enable CAD users to be more creative. Essentially as users spend less time thinking about how to operate the system they can spend more time thinking about their designs. Krouse (1996) maintains that intelligent CAD can be classified into four categories. The first intelligent CAD systems were parametric designing packages that

\textsuperscript{119} There are three basic transformations; translation, scaling and rotation.
were dimension-driven. That is geometry is represented by parameters linked together by numerical values or mathematical equations. These packages can easily modify existing designs as the user need only change key dimensions and the system automatically does the rest. This system is useful when several design variations need to be evaluated. The second category of smart CAD is variational geometry. This is similar to parametric design as the system is dimension-driven and the geometry can be automatically adjusted when key values are changed. However, this system uses equations to represent the geometry and design constraints. By altering a key variable in an equation the system can easily generate a new solution. This system is restricted to two-dimensional modeling because of the complexity of computation involved in solving a large number of equations. The third category of intelligent CAD is feature-based modeling. These systems use predefined geometry sets called “features” that are commonly used elements such as slots and holes. The system is able to recognise these features and automatically constructs to the dimensions specified by the system’s user. Importantly the system is able to recognise the significance of features such as holes. The last category includes knowledge-based, rule-base and expert systems. These systems can be used to capture designers’ expertise. The software contains a knowledge base that an expert would use do design a component or product. The knowledge base consists of information such as rules of thumb, good guessing criteria and routine formulae. The user feeds in dimensions and constraints and the systems uses the embedded knowledge to produce designs. While these systems are in use they are not widespread.
CAM Programming

Once a component or product has been designed it is necessary to plan and design its production. The basic element of CAM software is the production of information for NC machines. In many cases manual programming is still used in preparing tapes for NC machines. During this process the programmer, working from engineering drawings plans each step of the machine operation and defines the tool path required to produce a particular part of shape. This system requires the programmer to have an intimate understanding of specific machines and their numerical control systems. Krouse (1996, 15) maintains that when NC programming is performed manually it is time-consuming and prone to errors, even when the programmer is experienced. A slightly more sophisticated system of computer-assisted NC uses a computer to perform the calculations for defining the tool path and generating instructions to produce the part. The programmer is still required to work from engineering drawings and use the computer to calculate tool path offsets. Although new programs can generate a considerable amount of NC instructions based on geometric data from CAD drawings.

In more advanced systems the programmer can use interactive graphics and work directly from the geometric model stored in a database. This enables a programmer to accomplish in a few hours calculations that would require several days using computer assisted NC programming. The interactive graphics allow CAM systems to simulate machine operation on a CRT display. This can enable the operator to watch an animation of the tool path. A post processor can then provide machine-ready NC tapes.

120 The output instructions are usually in an industry standard language such as Automatically Programmed Tool (APT).
Not all CAM programs are for machine tools, some programs determine the operation of robots. There are a variety of programs for process design and control as well as programs for welders, flame cutting and press room operations\textsuperscript{121}. CAM is being used in the programming of robots. The robots are used in mills to select and position tools and workpieces for NC machines to perform tasks such as cutting, welding, drilling and assembly. Some CAM programs, according to Krouse (1996), are being developed that will do away with the need to manually teach robots the required motions and instead offline programming will provide instructions directly from a computer. Process planning and scheduling is also being incorporated into CADCAM packages. These functions determine the production flow and schedule. Software such as production planning and scheduling has the potential to remove all discretion from workers on the factory floor as the software not only determines the order of operation but dictates the exact time that will be spent on each operation.

\textbf{Systems Architecture}

The system architecture is the physical layout of a CADCAM system as a whole. As Badham (1989, 27) points out, the hardware and software components of a system may influence the physical layout of a system but they do not determine the system configuration. There are many types of configurations and it is the user according to Badham (1989) who should determine which configuration best suits an organisation's needs. This view is supported by Bessant and Levy (1992) but they point that as yet

\textsuperscript{121} Computervision has a program for sheet metal operations that automatically calculates all bending and stretching allowances and then generates the NC tapes for the equipment to fabricate the part.
there is no clear template that matches technological configurations with new organisational forms. In deciding on the optimal system, the user will have to take into account differing tasks required of the system. These include, frequency of use, cost of workstations and cost of communication. The tasks carried out by a system in the design phase include data communication, storage and retrieval as well as drafting, modeling and analysis. In the manufacturing phase a range of tasks including data communication and the control and monitoring of NC machines and robots may be required. Data communication can be simply the display of drawings and information or it may be the transfer and reporting of data for the operation and inspection of NC machines and devices. NC machine and robot supervision may involve the system monitoring the operation of machines, the transfer of complete operating programs and the receiving of production data from the machines.

![Mainframe Configuration Diagram](image.png)

**Figure 6.3 Mainframe Configuration**
Many systems currently in use have been upgraded but still maintain this configuration. When upgraded many of the terminals are replaced by workstations that greatly increase the speed of operation of individual terminals. The mainframe then can be used as a database or library of parts and programs and can be programmed to control access. In many instances the mainframe is shared by many users and systems such as accounts, payroll, inventory control and employee records this allows the cost of a mainframe to be shared over several functions.

Figure 6.4 Network Configuration

A more flexible approach is the distributed system. This configuration is based on a local-area network (LAN) which is a series of lines with interfacing units and other hardware that link processor's terminals and other peripherals.
This type of configuration is depicted in figure four. This system does not have a lag in response time since each workstation has its own local processor.

In most organisations there is usually some combination of these two systems. The architecture is then described as hierarchical. The combination of systems is determined by the need for processing power, communication speed and cost. The distance and the amount of data that is transferred by each unit influence these. However, LANs and distributed systems are becoming the main systems used as they offer speed and versatility, but they can be configured to ensure system integrity. Many microprocessors on the market today have the processing power of mainframe or CPU's manufactured twenty years ago. The trend is towards hierarchical architecture that permits modularisation. Modularisation allows a greater flexibility and modules can be upgraded to newer technology at minimal cost. For this to work standards must exist and these are being implemented\(^\text{122}\). This standardisation and networking allows greater flexibility so that new workstations and peripherals can be easily added to a network. Machover (1996) maintains that most users are moving away from closed systems, where the system supplier controlled and supplied all the elements of the system, to open architecture in which there are several sources and types of devices available, all performing similar functions and operating on a non-proprietary operating platform.

\(^{122}\) There is no industry wide standard and some of the standards are listed in appendix 5
CADCAM Standardisation

If computer hardware, software and computer controlled devices are to operate in an integrated system, then standards are essential. If standards are not used then it becomes necessary to manually transfer data between systems or to customise software that will transfer the data between two systems. As there has been a proliferation of CADCAM systems, so there has been several standards developed\textsuperscript{123}.

In selecting a CADCAM system the two main considerations are usually hardware and software. Many users purchase turnkey\textsuperscript{124} packages where a single vendor provides all the hardware, software and services. However, the alternative is to customise a system and buy unbundled software that can be installed on a variety of computer system configurations. There are obviously a wide range of features and configurations available to an organisation considering purchasing CADCAM. According to Martin, Martin, Mills and Beckert (1993) the features needed in a CADCAM system include:

- common Graphical User Interface (GUI) and Command so that all modules operate similarly and use similar commands and shared databases, these combined with a common GUI allows for a seamless interface. Other features include accurate geometry, if the geometry is not one hundred per cent accurate drawings that appear accurate on the screen must be modified when transferred to CAM. Advanced surfaces, methods for modeling complex surfaces, are essential and these allow for machining of contoured and complex surfaces and analysis tools, until recently tools such as Finite

\textsuperscript{123} These standards are known by a range of acronyms including GKS, CORE, IGES, PHIGS, VDI, VDM, and NAPLS. While standards compete they also perform similar functions. IGES appears to be the standard that will be most widely used.

\textsuperscript{124} A turnkey package is a system that when installed will operate without any customisations or modifications. However most turkey packages will permit modification by users.
Element Analysis (FEA) have come as separate packages or modules. However, as part of an integrated system they are invaluable for improving product quality and performance, decreasing design cycles and eliminating the need for prototypes.

Finally, accurate data exchange; for any system to operate effectively it must be able to export and import designs to and from other systems.\textsuperscript{125}

\textbf{A Typical CADCAM Operation:}

Manufacturing firms are varied in their operation. So it is difficult to describe a typical or average firm using CADCAM. None the less a firm using CADCAM could be expected to manufacture products with a level of complexity that needs to use plans or detailed drawings. The firm would usually have a front office where managers and administrators are located with marketing, design and possibly engineering personnel. The design and draughting staff would be in an office by themselves and the office will contain their CAD workstations and personal computers and at least one drawing board. The drawing board is there for several possible reasons; existing hand drawings may need minor modifications, concept sketches or plans need to be hand drawn, and some designers and draughtspeople refuse to learn to use CAD. The most likely reason is a safety net just in case the CAD system fails. The CAD workstations and PCs will be linked either directly or through LAN to a plotter, printers and a file server containing a removable hard drive. The hard drive will contain all the files of drawings and a library of parts and needs to be stored in a fireproof safe. Many firms will have a secondary

\textsuperscript{125} Most systems suffer flawed and degraded geometric entities as the Initial Graphic Exchange Standard 5. (IGES 5.1) has not been fully implemented but is the most widely used standard.
system that enables them to save all master files to a secure location. Most firms recognise the value of CAD drawings and files and have systems in place to protect them. Before the introduction of CAD the design office would have been dominated by the presence of drawing boards and each draughtsman and designer would have been perched probably on a stool carefully drawing a detailed plan at their own board. Today the attention of the designer is on a computer screen and input devices. While the design and drawing offices will vary, mainly in size, depending upon the number of CAD operators and seats (the term used for a terminal that can be used to operate CAD) the factory floor will vary a great deal.

However a typical manufacturing firm would consist of a small to medium engineering workshop. It would have between twenty and fifty workers on the factory floor. In larger firms with over one hundred employees the firm would consist of a series of workshops or assembly plants with fifty to one hundred workers in each workshop. The mix of workers varies depending on the complexity and level of automation. However most work shops would employ trades people machinists and labourers. Production employees or machinists are regarded as machine operators or machine minders. When the machines are computer controlled then machinists are machine minders and are only authorised to oversee the operation of a machine and turn it off when something goes wrong. Machine operators, on the other hand, carry out several tasks. They are responsible for selecting and checking raw materials such as a metal rod. Then they place the material in the machine or tool and ensure the correct operation is carried out. They would then send it to the next operator or carry out the next operation themselves.
The labourers are responsible for assisting machinists and tradespeople and moving raw material and work in progress from one workstation to the next.

Tradespeople usually include welders, boilermaker, fitters and turners, and electricians. In most workshops they are responsible for maintenance or the operation of sophisticated machines requiring high level skills.

There is usually a clear divide between tradespeople and production employees. This is particularly the case when they belong to different trade unions. Trades people usually refuse to carry out tasks that they regard as beneath their skill level and the work of labourers or machinists. In larger firms there is a distinct hierarchy of workers with labourers on the bottom and electrical tradespeople at the top. While machinists and labourers operate or mind CAM equipment, tradespeople are involved in maintenance and programming of CAM.

CAD can be used in conjunction with a variety of computer aided manufacturing processes and tools. A typical factory floor will appear to the casual observer as disorganised. Whether the product is made of metal, plastic, wood or fibre or a combination of materials there will be many operations being carried out at the same time. Machinists may be operating a single machine or minding several tools depending on the products and processes. Not all machines will be running at once and some machines will shut down be being maintained or repaired. There will be a variety of tools and machines, some sophisticated tools will be operated and monitored by computers, other less sophisticated will appear similar to everyday drills, saws and
lathes. The most complex computer operated machine tools are mills. The mills are multi-functional tools able to cut, drill, stamp and turn a metal component. In some factories there are highly complex production lines mass producing products such as cars, electronic products or printed circuit boards. In other factories customised products, such as elevators or electrical switches, will be assembled by hand and maybe one or two parts of the production process, such as turning cutting or stamping, are carried out by computer controlled tools. The one thing that will be common to all factories will be the presence of workers on the factory floor. In Australian factories the number of workers has decreased and many jobs have been replaced by automated machine tools and workers are now required to operate more than one machine. It is common practice for workers to supervise the operation of several machines at the same time. With increase in the introduction of CAM the knowledge and skills need to operate a tool or a machine is no longer the proprietary knowledge of skilled machine operators.

Perhaps the biggest change that has occurred with the increase use of CADCAM and changes to work organisation is the pace of work in the production area. With the introduction of multiskilling and work teams, fewer workers produce more goods as they mind automated and computer controlled machines. In the design phase CADCAM users do not appear to be suffering the same fate. If a design has to be rushed through then the firm can employ contract CADCAM users to help out, or if they are not available they can always employ some one to use the drawing board. However, the number of drawings an operator can produce using CAD rather than a drawing board has increased dramatically. CAD operators are able to call up and
modify existing drawings far quicker than a draughtsperson using paper and pens. The availability of a library of drawings and parts means that a skilled operator can download several parts and combine them to produce a new drawing far quicker than his manual counterpart. At the same time designers are carrying out functions once the preserve of professional engineers\textsuperscript{126}. Perhaps beneath a calm surface the pace of work in the drawing office has increased.

**The development of CADCAM**

The development of CADCAM has been closely tied to the development of computers. However, it would be difficult to briefly trace the history of computers. Rather than look at all aspects of computing, CADCAM and particularly CAD are linked to the development of computer graphics workstations. The development of graphic workstations can be traced\textsuperscript{127} from the early 1950s when Michigan Institute of Technology (MIT) produced a display on a cathode ray tube (CRT). In the mid 1950s the SAGE air defence system used command and control CRT consoles which allowed the operators to identify targets with a light pen. Most of the hardware used in CAD today was developed before 1965, for example graphic displays were available in 1951, plotters were in use in 1953, light pens existed in 1958 and data tablets have been available since 1964. The idea of interactive computer graphics according to Amirouche (1993) was put forward by Ivan Sutherland in his doctoral thesis in 1963.

\textsuperscript{126} Depending on the package a CAD user can carry out complex testing and analysis with the appropriate software and knowledge.

\textsuperscript{127} See Chasen (1996)
Building on his thesis, Sutherland developed many of the fundamental ideas and techniques that are still being used today\textsuperscript{128}.

In 1965 Thurber Moffett at Lockheed-Burbank developed CADAM \textsuperscript{129}. This system, greatly modified, is still in existence today but at the time it was the leading, comprehensive drafting system. The system required high powered computing capabilities but facilitated large numbers of CRT terminals on the one host computer. The system operated on an IBM system that was kept a proprietary secret\textsuperscript{130} until the late 1970s. The real advances of the sixties were based on time-sharing that allowed central-processing facilities to be shared by satellite users and by increasing the number of terminals development cost could be shared and productivity was also increased. So, the system configuration was driven by cost sharing and was determined by the need to minimise the cost of central processing facilities and maximise the use of computing power. In configuring the systems in this way systems designers were building into the systems centralised control. This centralised control may have been a deliberate strategy by management to maintain control over output but there is little evidence in the technical literature to support this.

A major break through occurred in 1966 when Lockheed-Georgia and General Motors (GM) installed the first fully operational time-shared CADCAM system. The high cost

\textsuperscript{128} By 1965 computer graphics research was being conducted by GM, MIT, Bell laboratories, Lockheed Aircraft and MacDonnell Douglas.

\textsuperscript{129} See Chasen (1996)

\textsuperscript{130} The need for secrecy was justified on the grounds of national security as the system was used for defence industry and aerospace projects.
of computing facilities meant that larger companies were the only one that could afford to invest in CADCAM. The most cost effective way of configuring the system was to have a central mainframe and a network of satellite terminals. The first turnkey software systems were developed by McDonnell-Douglas and included CADD Unigraphics and FASTDRAW. In 1968 and 1969 other companies such as Applicon, Autotrol, Computervision and Intergraph released turnkey systems that were based on a time-shared host and multiple work stations. The cost, in 1969, approximately $US50,000 made the systems extremely expensive, but did not stop the growth and development of systems as they were being used in the aerospace and military industries.\textsuperscript{131}

The tremendous advances made in the fifties and sixties laid the foundation for the next twenty five years. The main developments consisted of refinements and improvements to existing technologies, in particular bigger and better CRT or screens. These combined with the emergence of raster graphic technology\textsuperscript{132} allowed the development of colour screens, selective erasure, and reduced costs\textsuperscript{133}. The development of personal computers saw a demand for low cost systems that could operate on PCs, or stand alone workstations. While many software suppliers could cut down their systems to operate on high-end workstations it was not until the mid-eighties that PC -based software such as AutoCAD was widely available. The lack of enthusiasm among senior managers is identified by Chasen (1996) as a consequence of poor planning and a poor integration of

\textsuperscript{131} These industries were working on lucrative government contracts and could afford to buy or develop new technologies.

\textsuperscript{132} According to Mavhover (1996) raster-refresh and colour is becoming the de facto standard in CADCAM

\textsuperscript{133} Although as Chasen (1996) points out initial raster systems were limited in screen resolution, picture quality, and software versatility all of these have improved in the last fifteen years.
CADCAM systems in businesses$^{134}$. This lack of interest by managers may be attributed to their inadequate knowledge of computing and their fear of the unknown. This would lead to technologists and engineers championing CADCAM systems and designing them to meet their requirements rather than designing "user friendly" technologies that suited other workers and the organisation.

In the 1980s and 1990s developments went in many directions. The key innovations identified by Chasen (1996) were the radical improvements in chip design, which resulted in ongoing increases in both speed and capacity, increases in the size of hard disks and a resultant increase in storage capacity and new and improved software applications$^{135}$. At the same time there have been improvements in networking systems that enable a variety of different PCs and workstations to operate on the same network. Networks make it possible for multiple users to share input and output devices and to access common databases and parts libraries. These result in cost savings, as firms only needed to store data on one central database rather than on several individual machines, this saved on disk spaces and needless copying and duplication. It also saved on input and output devices, as user can share scanners, printers and plotters which are all expensive and are rarely used on a continual basis by a single user. The changes taking place in software development have seen a movement to user-friendly software, such as Windows 95 and Windows NT, that allow individuals without advanced computer

$^{134}$ With the lack of enthusiasm of CEO's for CADCAM it is difficult to sustain an argument that management was deliberately introducing CADCAM to monitor and control workers. If CEOs were not enthusiastic in adopting CADCAM it is highly unlikely that they saw it as a tool that could be used to deskill technical workers and ensure management's control over the process of production.

$^{135}$ These applications now include features such as parametric analysis, feature-based design, object-oriented software, and improved picture quality.
programming skills to operate complex computer packages. These developments combined with advances in communications, electronic data transfer, and messaging have made CADCAM easier to use, more transferable, and cheaper. It can be argued that improvements that make CADCAM systems easier to use will enable skilled operators to be displaced by unskilled operators. But it can also be argued that in making CADCAM more accessible it can now be operated by trades people and production workers rather than engineers and a technical elite.

Companies funded by the US Department of Defense drove the majority of developments in CADCAM in the 1950s and 60s, and most of the breakthroughs occurred in the aerospace industry in companies such as Lockheed and McDonnel-Douglas. As these companies were contracting to the US government they focused on designing systems that were centralised and allowed security to be maintained by locating all information in a secure database. But not all developments were dependent on military contracts. There were according, to Chasen (1996), centres of activity outside the US and these included Rolls Royce, Pressed Steel, University of Edinburgh, Cambridge University, Olivetti and Italian Electrics. But it was not until the late 1960s that a widespread interest in CADCAM developed in Europe.\textsuperscript{136}

The CAM technology that was first developed was computer numerical control. In the late 1950s two of the first CAM programs, APT and PRONTO, were developed. These did away with the need for a programmer to directly communicate with the machine.

\textsuperscript{136} The widespread interest was the result of conferences at the Technical University in Trondheim and Brunel University London.
tools using cards with hole punched codes. In the early 1960s General Motors were the first to develop a system using Design Augmented by Computers (DAC) that enabled non-programmers, such as designers and engineers, to communicate graphically with a computer. However, DAC almost disappeared with the release of the IBM 360 mainframe. A major breakthrough occurred in 1973 when GM began using Vehicle Structural Analysis Program (VSAP). The other major developments in CAM relate mainly to robots. George Devol developed the first industrial robot in the 1950s. It was not until 1958 that Consolidated Control Corporation developed them on a large scale, under license. Most recent developments in CAM have been refining software and hardware to work in a more efficient way.

However, with the growth in CADCAM, more complex systems are being developed. The trend is for CAD systems to merge with office systems forming a complex hierarchical architecture. With the improved communication available through networks, personal computers and microprocessors can be linked to provide an integrated system. This increase in interactivity between CADCAM systems and other systems means there is a growing need to better manage the flow of data and has lead to the development of product data management systems (PDM). These PDM, according to Chasen (1996), have expanded at enormous rates, some estimate as high as 35 per cent per year. This expansion has been so great that a specialised PDM conference was held in Amsterdam in November 1994. PDM is not widely used in Australia and even in those firms with PDM its use is not well developed. PDM systems are expensive and
require a great deal of work to get them up and running effectively, this is in part due to incompatibilities between different software systems. There has been a growth in specialised software in areas such as computer aided production planning (CAPP) and in database such as RDMS (Relational Database Management Systems). There is a movement towards Flexible Manufacturing Systems (FMS) with an increase in Distributed Numerical Control (DNC) linked to machine monitoring and materials handling systems.

Recent Developments

While most of the improvements in the last ten years have been software enhancements there have been major improvements in hardware. The cost of hardware particularly workstations and PCs has dropped considerably. At the same time the processing capabilities of PCs and workstations have improved dramatically and they are able to carry out more and more complex functions at much faster speeds than their predecessors. Hanratty (1993) claims that the gains to be made by switching from a mainframe/supermini plus terminals to a workstation or PC based system can be significant, ranging from a minimum of 4:1 to as high as 50:1 increase in performance and throughput. Many CADCAM users have opted for PCs, particularly with the launch in 1993 of Intel’s Pentium P5 chip\(^{137}\). Another innovation in PCs that is the only real serious competitor to the Pentium chip are the PCs that use computer chip design called reduced instruction-set computing (Risc). This is a

\(^{137}\) Pentium PCs released in 1993 were selling for $US5000 half the price of the 486 machines launched in 1989. Also in 1993 the 486 machines were selling for less than $US1000.
technology that was previously only used in workstations. To compete with Pentium companies such as Motorola, IBM, Apple, NEC and Digital have all been involved in developing and launching Risc-based PCs. Other hardware devices including digital video cameras, sophisticated mouses, pucks, balls, pens and digitizers that look like a glove are available on the market\textsuperscript{138}. There is an increasing emphasis on ease of use rather than on the systems development. This may be a result of systems developers realising that unless workers can easily use the system they will be unable, or unwilling, to use it to its full capability.

For workstation and PC user 1993 saw the introduction of Microsoft’s Windows New Technology (Windows NT)\textsuperscript{139}. Windows NT is a 32 bit multi-tasking system that offers excellent networking features. With the release of Windows 95 buyers now have the choice of two user friendly, open systems at reasonable costs. Both systems run true multi-tasking, time sharing mode, so that when you open your spreadsheet to do a calculation your finite element analysis program will continue to calculate in the background, while you work on your spreadsheet. Because the Windows environment allows the linking of different applications, such as CAD and FEA, engineers can gain immediate feedback on their work\textsuperscript{140}. This leads to improvements in quality and accuracy, reduced administration overheads and improved engineering productivity.

\textsuperscript{138} These devices simplify CADCAM input and provide user with access to multiple software functions capable of increasing user productivity. See Mills, Beckert and Kempfer (1993)
\textsuperscript{139} See Mills Beckert and Kempfer (1993). This was the first time in years that a new operating system was launched that promised real changes in the operation of CADCAM systems.
\textsuperscript{140} See Dietz (1996)
One of the few drawbacks of the Windows systems is that Object Linking and Embedding (OLE) does not operate with 3D data.

The reduction in price of CADCAM platforms and software combined with customer pressuring their suppliers to use CADCAM in design and manufacturing has seen it spread to more and more small to medium enterprises (SME). These SMEs, according to Owens (1994), are purchasing user friendly systems. At present the user-friendliest systems are those operating in a Windows environment on a PC or workstation. Also as Brian Summers of CNC Software Inc. claims, new entrants from SMEs are finding that these PC based systems are acting like high end systems at a fraction of the cost.

With the expansion of CADCAM systems throughout the manufacturing sectors many firms are experiencing difficulties recruiting CADCAM users. Many organisations are unwilling or unable to bear the cost of training CADCAM users. While some CADCAM users have initial training in their pre-employment training this is not the case for all CADCAM users. Workers such as experienced tradespeople who completed their training before the early 1990s, would not have CADCAM training. From the results of interviews discussed in detail in chapter eight it appears that many CADCAM users pay for their own training to gain entry to CADCAM jobs or are learn on the job. The difficulty as Winter (1995) points out is that skills become obsolete a lot faster today than 20 years ago. When a draftsperson learned their skills or trade those skills lasted a lifetime now computing skills can be obsolete in 18 months. However, not all computing skills become obsolete and it is easier for a computer literate worker
to learn a new or improved software package than it is for a worker with no experience with computers.

The Future of CADCAM

The future of CADCAM is difficult to predict but undoubtedly it will become more widespread as it becomes cheaper, faster and even more user-friendly. Machover (1996) believes that computing performance in PCs and workstations will continue to improve and prices will continue to drop, which will result in CADCAM being used in more industries and smaller firms. To provide access to a range of peripherals such as high capacity disks, high speed printers and plotters, and superminicomputers there will be an increase in the use of high performance communication networks that allow data sharing. As industries become more and more global and designing and manufacturing no longer need to occur in the same country or at the same site, teleconferencing and the Internet will become an everyday part of doing business with CADCAM.

With the increases in processing speed made possible by technologies such as massive parallel processing and distributed problem-solving, Machover (1996), believes there will be an increase in the need and demand for database management. Database management, systems networking and systems integration will continue the trend for CADCAM functions to link more closely with an organisation's business functions, such as marketing, accounting and customer service. The development of the CRT was the beginning of CADCAM and it is predicted that it will be replaced by flat-panel devices such as plasma, liquid crystal display, or electroluminescence. But it is unlikely that such technologies will replace CRT within the next decade. Users are demanding
large-screen high resolution colour displays and there will be improvements in these technologies and reductions in costs.

The distinction between workstations and personal computers is increasingly blurred as PCs become more powerful and perform as well as some workstations. Both workstations and PCs will have special purpose processors to improve graphic displays and manipulation. There will be an ongoing improvement in user friendly interfaces as more people need or want to use CADCAM. While the mouse, keyboard and graphic tablet will still be the dominant input devices they will have to improve or be replaced as the demand for 3D to 6D devices emerge. With the current backlog of existing drawings in paper copy only creating problems and wasting time, scanners will become increasingly important as a means of entering existing drawings for editing and electronic distribution. To deal with the backlog scanners will need to improve and with a growing database of drawings and designs there will be a greater need for product data management (PDM) systems. The major software trends identified by Machover (1996) include increases in the use of expert systems, databases, solid modeling and parametric and automatic design capabilities. Many of these changes will make it possible for more people to use CADCAM as the skills and knowledge need to operate the systems change. It may be the case that developments in hardware and software will change the nature of the jobs of existing users; whether these changes will enhance the jobs of users or disenfranchise current users remains to be seen.

The changes to work that have occurred during the development and implementation of CADCAM are determined by the technology alone. This chapter has described the
different ways in which the technology has been configured and it is clear that there is no one dominant technological configuration, although distribute systems using networks are common. Decisions about which technology will be used and how it will be implemented depend upon factors such as management philosophy, the production process, market conditions, personnel and employment policies, job design and organisational structures. If management’s philosophy is tied to centralised control then they will most likely opt for a system that enables them to control and monitor the work of CADCAM users, regardless of whether this optimises the performance of workers or not. In the case of the production process, highly automated production systems will allow CADCAM users to control the design and manufacture of products while manual production systems will not. Market conditions will, in part, determine if there is a high demand for CADCAM skills. If they are in short supply technical workers will be able to negotiate favourable terms and conditions of employment. Who can operate CADCAM systems, where users will be recruited from and how they are trained will be influenced by both market forces and personnel and employment policies. If CADCAM users’ jobs are designed to be creative and need people with good computer and communication skills then the technology needs to be configured to allow for creativity and communication and do so without expert systems or artificial intelligence. Organisational structures will influence the prestige of CADCAM jobs and the status of technical workers using CADCAM.

Conclusion

In a review of the social and organisational consequences of CAD Majchrzak (1987) found no evidence that designers and draughtmen had been displaced by CAD technology. Although there is anecdotal evidence that draughtsmen unable or unwilling
to use computer technologies are being marginalised. Few manufacturing firms have completely replaced drawing boards with computers so that there is still a place, albeit an insecure one, for draughtsmen with drawing board skills. In her review Majchrzak found that CAD necessitates an increase in skills. While CAD users need more skills such as problem solving, communications skills, and human relations skills, they will also have to increase their knowledge of manufacturing and engineering, their creativity and ability to conceptualise. So CAD and CADCAM represent a challenge for workers! The challenge, is who has (or can acquire) the skills needed to operate the systems: Will it be professional engineers or trades and technical workers who end up controlling the use of CADCAM systems? This question can only be answered through empirical studies. Once it has been determined who has access to CADCAM system, the question of career paths is important. Is CADCAM part of a career path in engineering or can it be a separate career path for technical workers?

All of the systems configurations described in this chapter, with appropriate software, can be used to monitor the work of CADCAM users. While it appears that little monitoring of workers' performance is being carried out this needs further investigation. Is it the case that simply measuring time on a work station or time spent modifying and editing a drawing, is more appropriate than on time delivery of drawings, creativity of designs and customer satisfactions? If it is the case then management will automatically monitor CADCAM users.

Unlike automation and the production line, the development of computer based technologies is not simply determined by the needs of employers. The development of
computer based technologies such as CADCAM is influenced by users, employers and the companies who manufacture the software and hardware. Users are demanding different functions and components to meet the needs of their individual jobs. Employers, as the purchasers, of the technology are demanding lower prices and faster operating systems. The system manufacturers are attempting to guess what future users’ need and determine who or what they will be. They are adding more and more features and attempting to make the systems as accessible as possible to increase the market for their products.

The developments in CADCAM have altered the skills required to design and draw a component or product. CADCAM users are now required to manipulate computer application software and operate input and output devices attached to a variety of computers. In firms where the interface between CAD and CAM is seamless CADCAM users control the process of production from conception through design to manufacture. Few firms, however, have the technology that will allow CADCAM users to control and operate all phases of production. The increasing complexity of tasks that a CADCAM user can complete, given the technology, is balanced by the increase in userfriendliness of operating systems. Windows based software reduces the need for people with computing and particularly programming skills. There is still a need for CADCAM users to understand the design process and the production process. The need to understand the production process ties CADCAM users to workers in the factory. With any increase in CAM based technology the link between CADCAM users and production workers becomes weaker. While recent developments have seen an increase in the use of LAN to link all CADCAM users to a central fileserver this does
not appear to have increased the amount of centralised monitoring of work. This issue will be investigated further in the following chapters which contain an analysis of interviews conducted at various sites. CADCAM systems still need skilled workers to operate them. What is apparent from examining how CADCAM has been implemented and recent trends in CADCAM, is the diversity of technologies and technological configurations. Although CAD and types of CAM have been used for almost forty years no technology dominates the manufacturing and design environments. This is partly because of the varied nature of manufacturing operations and partly because of the diversity of computer based technologies. What is apparent is that CADCAM has enabled employers, and to a lesser extent employees, to alter jobs, re-organise work practices and change the skill mix needed to design and draw products and processes. These changes will have had an impact on the characteristics of jobs, the characteristics of work and workers and may alter the class-consciousness of workers using CADCAM. The impact of these changes will be analysed in chapter seven, using data collected in a survey of firms using CADCAM.
CHAPTER SEVEN

Research Findings

Introduction

As has been shown in chapter four, an analysis of awards reveals that in manufacturing industries internal labour markets in Australia are segmented. While recent changes to Federal Workplace Relations and other legislation have significantly simplified awards they still contain a detailed description of job classifications and skill-based career paths. Although recent changes to legislation encourage the use of Australian Workplace Agreements and Certified Agreements, these have included minimum conditions that are determined by relevant awards. Increasingly, industries are introducing advanced manufacturing technologies such as CADCAM. The knowledge and skill workers need to use these technologies has changed. At the same time the characteristics of jobs have altered. Prior to CAD being used in design and drafting, technical workers carried out these tasks on paper using a drawing board and pens. This did not require knowledge of computing or the skills required to manipulate a software program. Now designers and draughtspeople need to operate computer terminals and manipulate complex software packages. So the work of people has changed, job characteristics are changing, and the relationships between workers have altered.

This chapter will describe; the labour market characteristics of CADCAM jobs, the type of hardware and software in use, the characteristics of firms using CADCAM and the training and recruitment policies of firms using CADCAM. This information will be
analysed to determine if hardware or software is being configured in a way that would enable employers to easily monitor workers and exercise control over the pace of work. The analysis will also ascertain if workers perceive that their jobs in the labour process have been routinised and unskilled. While an initial review of awards indicates that CADCAM users’ jobs are located in a primary segment, the characteristics of these jobs will be compared with the characteristics of jobs described by labour market researchers.¹⁴¹

It is possible that employers, when introducing CADCAM, have set out to alter the work of skilled designers. Perhaps these technical workers will be displaced or will become machine minders. Just as automation was used to deskill and displace production workers when it was in the best interest of employers, so it may be in the best interest of employers to do the same thing to technical workers. While there is empirical evidence of deskilling and displacement of production workers there is little empirical evidence that this has occurred to technical workers. To support or reject the deskilling thesis there is a need to provide comprehensive empirical data. This data also needs to reveal how workers perceive their work and jobs.

The data will be analysed to determine the class position and consciousness of technical workers using CADCAM. An understanding of how recent changes in the organisation of work can alter the jobs and the relationships between workers in the manufacturing sector, can be gained by determining which workers are being allocated to CADCAM

jobs. There are several claims\textsuperscript{142} about how advanced manufacturing technologies such as CADCAM can be used to alter the work of technical workers like designers and draughtspeople. However, in Australia there has been no substantive study that has identified the characteristics of these jobs or analysed how these jobs have been allocated and changed\textsuperscript{143}.

**Methodology**

**Research Design**

The purpose of this chapter is to identify the characteristics of jobs of CADCAM users and to establish which workers are being allocated these jobs, within the theoretical frameworks discussed in the first three chapters. Analysis of this data will establish the characteristics of typical CADCAM jobs and what skills and knowledge are required to be allocated a job using CADCAM. This is a longitudinal field\textsuperscript{144} study that involves collecting classification data, employees' perceptions and details of the technology in use. Data collection began with a series of site visits and interviews that were conducted to understand the context of CAD and CADCAM in companies. Survey data was collected in 1992 by questionnaires and follow up interviews were conducted in 1997 to clarify issues raised in the survey and to determine if any changes had taken place. Surveys of CADCAM users and managers have been widely used to collect data on

\begin{footnotesize}
\textsuperscript{142} See Cooley (1981)
\textsuperscript{143} Badhan (1989) reported on developments in CADCAM in Australia but did not give details of labour market characteristics or the impact of CADCAM on work
\textsuperscript{144} See Babbie (1989) for details on research methodology.
\end{footnotesize}
social and organisational aspects of computer based technologies such as CAD\textsuperscript{145}. The unit of analysis used to examine job characteristics is the individual employee, although some demographic and classification data was collected at the company level concerning the characteristics of the firm. Technical specifications of the CADCAM systems were also collected.

**Data collection**

The most suitable instrument to collect quantitative data from a wide geographic area such as Australia is a questionnaire. It is also the lowest cost option. Questionnaires allow respondent time to think about their answer to questions and are often perceived by the respondents to be more anonymous than other survey methods. Questionnaires are useful when attempting to describe the characteristics of a population and allow for considerable flexibility in analysis. Furthermore, they ensure that the same definitions are applied as questions are all addressed in the same way to each respondent\textsuperscript{146}. Questionnaires have some inherent drawbacks, some of these can be overcome by using multi-methods. For this reason interviews were conducted after the survey to clarify issues raised in response to the questionnaire. Furthermore, the interviews were conducted five years after the survey so that an indication of changes in the technology could be determined, and changes to jobs and work organisation could be ascertained. Interviews were conducted in six companies in NSW. The companies are all manufacturers and able to use and benefit from both CAD and CAM. The firms were selected on the basis of a range of sizes and products and to allow for a range of

\textsuperscript{145}See Majchrzak (1987). Also Osterman (1984) used a questionnaire to collect data on labour market characteristics.

\textsuperscript{146}This ensures consistency of data.
CADCAM systems. Interviews were conducted with CADCAM users and managers to examine users and managers perceptions in more detail than was done in the survey.

Population and Sample

The population frame for the survey sample consisted of CAD/CAM/CADrafting Installations in Australia and New Zealand as compiled by ACADS (1987) (The Association for Computer Aided Design Limited). ACADS compiles a list of installation based on data supplied by vendors, user groups and members. The ACADS list was recognised as the most comprehensive listing of CADCAM users at the time of the survey. Firms were selected from the 1987 list to reduce the possible impact of a newly introduced technology. The study was eliciting responses from users who had been using CADCAM for some time and their responses were not biased by the difficulties often experienced when using a newly introduced technology. Firms surveyed had been using CADCAM for at least five years. A total of one hundred and four organisations were contacted and surveyed. Of these, forty five replied, a return rate of forty three per cent, which for a mail questionnaire is higher than the average return rate. Three questionnaires were discarded: two had no questions answered, one from a university and one from a manufacturer who was no longer using CADCAM. The third survey was discarded as there were too many blank responses.

Questionnaire Design

In designing the questionnaire five firms in Sydney were visited to collect contextual data. Copies of details of site visits and interview summaries are included in appendix one. After the visits two questionnaires were designed. One was to be completed by
CADCAM users and the other by human resource management staff from each firm. In pre-testing these questionnaires major problems were experienced in attempting to have both questionnaires returned. To overcome these problems the questionnaires were modified and one questionnaire was sent to each firm to be completed by CADCAM users. A copy of the questionnaire is included in appendix two. In designing the questionnaire respondents were asked questions about the characteristics of their jobs, their work and aspects of their work which would give an indication of their class position and class-consciousness. The role of gender and ethnic background has been analysed in detail by Doeringer and Piore (1971) Piore and Sable (1978) Osterman (1984) and it is generally agreed that gender and ethnic background are used to exclude workers from labour markets. As the focus of this study is on technology no data was collected on gender or ethnicity.

Survey Results

Organisational Characteristics

In classifying the firms, respondents were asked to provide details of the number of employees, the number of years of operation, the type of production technology in use, and the products manufactured. The size of firms using CADCAM is of interest because if a primary reason for using CADCAM is to monitor workers then it should be the case that it is utilised more by large firms than small and medium sized firms. Large firms should be able to use to monitor workers CADCAM rather than employing supervisors and managers. It may also be the case that large firms are the only ones that can afford the cost of using the technology. The age of the firms using CADCAM can also be a factor when examining the types of firms using the technology. Is it young
entrepreneurial firms that adopt technologies such as CADCAM or is it well-established firms who have determined that they can benefit from a stable internal labour market? Is it firms that have been around for more than twenty five years that have had the time to establish training, career paths, and customs that allow them to effectively manage and utilise CADCAM? Some of the literature indicated that CADCAM provided a competitive advantage to firms using small batch production rather than mass production or process production technology such as petro-chemical industries. So it needs to be determined if CADCAM is used in a range of production processes or is it more suitable for mass production where automation on the factory floor is widespread.

As can be seen from figure 7.1, only 20 per cent of firms in the sample using CADCAM technology had fewer than one hundred employees and a large number of firms had between 100 and 200 employees. But what is important is firms of all sizes are using CADCAM technology. The use of CADCAM technology in Australia in 1992, when the survey was conducted would have been more prevalent among medium to large firms for two main reasons. Firstly CADCAM still required expensive workstations and secondly the use of PCs capable of running CAD software was not widespread in small jobbing shops and manufacturers. Few small firms would see the value in investing in expensive technology when the alternative is a relatively inexpensive drawing board. It was not until 1993\textsuperscript{147} that the price of PCs, with sufficient memory and operating speed and capacity to run CAD, dropped substantially forcing workstation suppliers to drop their prices. Small to medium enterprises are extremely price sensitive when buying new technologies that are not considered to be part of the factory floor.

\textsuperscript{147} See chapter six for details of the innovations that reduced the price of computers.
Figure 7.1: Employee Numbers

Further analysis will determine if the size of an organisation as defined by the number of employees has any bearing on the characteristics of CADCAM users jobs and the way their work is organised and if this is related to the system configuration.

Firms were asked to indicate how long they had been established. It may be the case that the more mature businesses, that is the ones that have been in business longer, are more likely to introduce technologies such as CADCAM. However, it may be the case that younger more dynamic firms have adopted CADCAM technology more so than the more established manufacturers. As table 7.1 indicates, almost 33 per cent of firms using CADCAM had been in business for between 1 and 25 years. So that 60 per cent using CADCAM had been in business for more than 25 years. It would appear that well-established firms could afford to take the risks associated with relatively new technologies such as CADCAM.
It is also well established firms that have the infrastructure and personnel needed to introduce, maintain and train personnel to use CADCAM.

<table>
<thead>
<tr>
<th>Number of Years</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-25</td>
<td>12</td>
</tr>
<tr>
<td>26-50</td>
<td>15</td>
</tr>
<tr>
<td>51-75</td>
<td>5</td>
</tr>
<tr>
<td>76-100</td>
<td>2</td>
</tr>
<tr>
<td>101-125</td>
<td>3</td>
</tr>
<tr>
<td>no value given</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 7.1 Number of Years Operating

Firms were also classified by type of production and 45 per cent of respondents, as can be seen in table 7.2, indicated that their production was mainly discrete or unit production. As indicated in the literature, CADCAM technology reduces lead times and is effective in small run or unit production, it is to be expected that it would be more common in firms focusing on unit production. However, as the survey results indicate, the technology is used in mass and process production facilities. The technology does not appear to be industry specific, and in Australia at least, it is not more prevalent in a particular industry segment. This would mean that if firms were using turnkey systems workers would be able to move throughout the whole manufacturing sector, rather than be restricted in their mobility, as a result of acquiring highly specific skills.

<table>
<thead>
<tr>
<th>Production Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT</td>
<td>19</td>
</tr>
<tr>
<td>MASS</td>
<td>12</td>
</tr>
<tr>
<td>PROCESS</td>
<td>9</td>
</tr>
<tr>
<td>OTHER</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 7.2 Production Type
Technological Characteristics

The configuration and nature of the technology in use provides an indication of what Doeringer and Piore termed the "technology specificity" and how it impinges on organisational culture. It has been argued elsewhere\textsuperscript{148} that centralised technologies, such as mainframes, enable higher levels of supervision and control while "stand-alone" PC's and workstations indicate that there is little remote or automatic monitoring of workers' performance. Mainframes, networks and workstations are expensive and the fact that they are not widely used reinforces the idea that a major barrier to using CADCAM is cost, particularly for small and medium firms. As can be seen from table 6.3, in 1992 sixty per cent of respondents did not use a centralised system such as a mainframe or network. The use of networks such as LANs was restricted in the early 1990s because operating systems such as OS2 and Ethernet were not widely used. These operating systems allow systems' designers and administrators to run a variety of PCs, workstations and peripherals on one network, but the PCs do not need to use the same operating system such as DOS or Windows NT.

\textsuperscript{148} For details of how computers can be configured to increase control see Kaplinsky (1987)
## Table 7.3 Hardware System

<table>
<thead>
<tr>
<th>System Configuration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central computer only</td>
<td>9</td>
</tr>
<tr>
<td>Networks</td>
<td>3</td>
</tr>
<tr>
<td>Work stations</td>
<td>8</td>
</tr>
<tr>
<td>PC only</td>
<td>11</td>
</tr>
<tr>
<td>PC and workstations</td>
<td>3</td>
</tr>
<tr>
<td>PC and central computer</td>
<td>5</td>
</tr>
<tr>
<td>PC and w/stations central computer</td>
<td>4</td>
</tr>
</tbody>
</table>

This suggests that most firms are not using CADCAM as a mechanism to centrally control the pace and flow of work done by CADCAM users. However, it may be the case that only larger firms are prepared, or can afford, to install mainframes and networks and this may change over time, as local area networks become comparatively cheaper to install and run. This is investigated further in the interviews.

As indicated in Table 7.4, most of the firms responding used more than one software package and the majority of firms are using “off-the-shelf turnkey” packages, rather than firm specific packages. There were only seven firms using custom designed software. The use of “user specific” software does not necessarily mean firms were deliberately using technology requiring firm specific skills. It could be the case that firms developed their own software to link a CAD system to a machine, such as a plasma cutter, because no turnkey package was available. It could also be the case that firms developed their own software because the specificity of their processes made it more cost effective to write a custom-built program.
The dominance of turnkey software packages would indicate that firms are using non-specific technology and they require a range of software to meet their needs. It would also indicate that in the majority of cases it is cheaper to buy software than to develop it. In the exploratory site visits conducted before the survey it was evident that some firms used a range of software because their customers used differing packages. Factors other than intra-firm production and organisational issues clearly influence the technology used by a firm. Why they use a variety of software rather than one specific package will be investigated further in the interviews. This table also shows that the generic Autocad software at the cheaper end of the market was the most frequently used.

<table>
<thead>
<tr>
<th>Software System</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autocad/Cam/Desk</td>
<td>21</td>
</tr>
<tr>
<td>CADCAM</td>
<td>4</td>
</tr>
<tr>
<td>CATIA</td>
<td>6</td>
</tr>
<tr>
<td>Unigraphics/McDonnell Douglas</td>
<td>9</td>
</tr>
<tr>
<td>CADDs 4.0</td>
<td>3</td>
</tr>
<tr>
<td>Applicon Bravo</td>
<td>3</td>
</tr>
<tr>
<td>User Specific</td>
<td>7</td>
</tr>
<tr>
<td>Others (16 different packages)</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>71</strong></td>
</tr>
</tbody>
</table>

*Table 7.4 Software Systems*

Firms decide to use a particular software package for a variety of reasons. Often firms are required by the customers to use a particular package; for example, if you supply
Boeing then you must use CATTIA because all their designs and drawing are done in CATTIA. Similarly, if you want to supply McDonnell Douglas then you must use Unigraphics. Despite attempts to develop standards, such as IGES, to ensure data can be transferred between packages, some businesses are not prepared to accept the risk that data exchange standards will ensure the integrity of data. In high risk business such as the aerospace sector, large customers with million dollar orders, can insist that a supply company employ a specific software package. So it is not a question of which software management favors or can afford, rather it is a question of do we want to supply Boeing or McDonnell Douglas. In one firm visited the manager maintained that the main reason for buying a CAD system was to keep the designers and draughtsmen happy, so they would not move to a firm where they could use CAD and develop CAD skills. In some circumstances the software requirements dictate whether a company will buy a workstation, PC or mainframe, as software packages such as CATTIA will not run on a PC. The decision to use a user specific package rather than a turnkey system may be influenced by the technology in use rather than a decision about work organisation. In one firm visited, a small engineering firm, they maintained that they had custom designed software to run their plasma cutter from their CAD system because they had been unable to find software that would do the job.

The number of CAD and CADCAM users appears to be related to the size of the firm. But not all firms used their CAD and CADCAM systems for the same purpose or to the same extent. It may be the case as suggested by Kaplinsky (1984,53) that while there is enormous variation in the productivity of CAD systems there is an increased productivity that enables large firms to displace up to 60 per cent of their draughtspeople. The reason for this variation, according to Bessant and Levy (1992), is
that effective implementation depends upon appropriate organisational changes and that
the changes must be coherent and across the whole organisation. The cross-tabulations
in Tables six and seven give an indication of the extent to which firms are fully utilising
the capability of their software. Interestingly, while some firms are under-utilising their
software by failing to use functions embedded in the software, it was revealed in the
interviews that in other firms users were writing their own macros to extend the utility
of the software. The majority of firms, almost 60 per cent, had less than ten staff using
CADCAM. For these firms it may be difficult to argue that CADCAM users by
themselves make up a distinct segment or tier but they may be part of a segment or tier
incorporating technical workers involved in areas such as planning and design.
Although, in some firms where large numbers of CADCAM users are employed (see
Table 7.5) they may constitute a unique segment or tier.

<table>
<thead>
<tr>
<th>Users</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>14</td>
</tr>
<tr>
<td>6-10</td>
<td>11</td>
</tr>
<tr>
<td>11-15</td>
<td>5</td>
</tr>
<tr>
<td>16-20</td>
<td>6</td>
</tr>
<tr>
<td>21-25</td>
<td>2</td>
</tr>
<tr>
<td>26+</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 7.5 Number of CADCAM Users

Some firms made limited use of their systems, as can be seen from Table 7.6, almost 50
per cent of users restricted their system use to relatively simple CAD functions. For
example 92 users in 10 firms had a CADCAM capable system that was only used for
CAD and 16 users in 6 firms had CADCAM capable systems restricted to CAM
Table 7.6 CADCAM Capability of Firms

The number in parentheses indicates the number of firms using CAD, CAM or CADCAM while the other numbers indicate the number of individuals using a particular system. The majority of respondents, almost eighty per cent of users indicated that they were only using their systems for drafting and design and as can be seen from Table 7.7, less than ten per cent of users were using their system in a multi-use capacity\textsuperscript{149}. These results may indicate that companies bought software that had functions they planned to use in the future and did not have staffed adequately trained to use its full potential. So that while firms are prepared to invest in software, they are not always prepared to invest in training workers and therefore get the most out of their software. Given the number of users, number of terminals, and type of software in use, few firms appear to be using systems that require firm or job specific skills. The table also indicates that CADCAM users are skilled in a range of areas. The data indicates that some users are using CADCAM for design, drafting, engineering analysis and to program CAM tools and machines. So if CADCAM users need to be skilled in design, drafting, and engineering applications it is difficult to sustain an argument that CADCAM users are deskilled.

\textsuperscript{149} Underutilisation of technologies is common particularly in firms where management is unwilling to bear the cost of extensive training.
<table>
<thead>
<tr>
<th></th>
<th>Number of Terminals</th>
<th>Number of Terminals</th>
<th>Number of Terminals</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CAD/CAM</td>
<td>CAD &amp; CAM</td>
<td>CAD</td>
<td></td>
</tr>
<tr>
<td>Drafting</td>
<td>46 (10)</td>
<td>31 (6)</td>
<td>193 (21)</td>
<td>270 (37)</td>
</tr>
<tr>
<td>Design</td>
<td>29 (7)</td>
<td>26 (4)</td>
<td>150 (12)</td>
<td>215 (23)</td>
</tr>
<tr>
<td>Engineering</td>
<td>12 (7)</td>
<td>15 (6)</td>
<td>21 (8)</td>
<td>48 (21)</td>
</tr>
<tr>
<td>Multi-use</td>
<td>26 (2)</td>
<td>20 (1)</td>
<td>46 (3)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>8 (4)</td>
<td>24 (4)</td>
<td>1 (1)</td>
<td>33 (9)</td>
</tr>
</tbody>
</table>

Table 7.7 CADCAM Use by Terminal

It may be the case that in comparison to draughtspeople CADCAM users have had an increase in their skills and that if the skilling process is cyclical, as suggested, that they will experience a degradation of their skills in the near future. The issue of skill degradation is examined in the interviews.

**Job Characteristics**

CADCAM users were employed both as permanent and contract staff. In the exploratory site visits (and subsequent interviews) it was apparent that contract staff tended to be involved in mainly drafting and design and were employed on the basis of their expertise in a particular software package, such as CATIA. Staff were employed both full and part time, and depending on their term of employment, were paid wages or fixed hourly contract rates. From the data supplied by respondents, most firms, just over fifty per cent, had restricted points of entry into jobs, and opportunities for appointments from outside the firm were restricted in fifty per cent of firms. So no clear pattern of entry and access appears from the sample of firms surveyed. Access can be restricted for a variety of reasons not associated with the technology. For example because of the small size of the Australian marketplace there may be only one firm that
manufactures aircraft components using composite materials such as carbon fibre. Then this firm may have a policy of only recruiting CADCAM users with experience in composite materials. It creates a recruitment position that virtually restricts them to internal recruitment. While some CADCAM users' jobs in large firms may be located in a primary segment of an internal labour market, not all CADCAM users have the same job characteristics.

Similarly, with the career paths indicated in Table 7.8, over fifty per cent of firms had internal career paths.

<table>
<thead>
<tr>
<th>Career Paths</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainly within firm</td>
<td>22</td>
</tr>
<tr>
<td>Industry-wide</td>
<td>17</td>
</tr>
<tr>
<td>Both</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.8 Career Path

The results do not clearly indicate if firms were designing jobs in a way that made them firm specific. It appears that about half of the firms have restricted entry points within firm career paths. So that a CADCAM user would be expected to start at the bottom of a job classification scale and with training and experience progress up a job ladder. Firms with career structures such as these would have formal internal labour markets and would be likely to bear some of the costs of training employees. Given the variation in access, recruitment and career paths it is not surprising that promotion structures appear to be poorly defined in some firms, variable in others and only in a minority clear and well defined.
This lack of a clear structure for careers across the manufacturing sector is supported by respondents' perceptions of job descriptions; less than twenty per cent of job descriptions had a clearly defined job description. As can be seen from Table 7.9 almost eighty per cent of job descriptions had some or extensive overlap. This overlap in job descriptions is to be expected given the contradictory position of technical workers using CADCAM. Part of the tasks that make up their jobs would overlap with engineers. For example, both technical workers and engineers may be required to exercise discretion in altering plans and designs under their control. Similarly there could be an overlap with tradespeople who are authorised to alter the operation of a NC, CNC or DNC tool by reprogramming the machine.

<table>
<thead>
<tr>
<th>Job Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly defined</td>
<td>7</td>
</tr>
<tr>
<td>Considerable overlap</td>
<td>15</td>
</tr>
<tr>
<td>Some overlap</td>
<td>19</td>
</tr>
<tr>
<td>No response</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.9 Job Description

The evidence collected here differs significantly from work rules. Work rules were clearly defined in sixty per cent of firms; but variable in forty per cent of cases. It appears from these responses that some firms may have firm specific jobs that have clearly defined job descriptions, and work rules. Entry to these jobs are restricted, but may be the first step in a career path within part of the firm. The survey provides contradictory data on the organisation of CADCAM users work in that most firms have
clearly defined work rules\textsuperscript{150} yet most respondents valued their autonomy. Bessant and Levy (1992) noted similar findings on the need for autonomy. They argue that managers wanted workers who could solve problems quickly and viewed flexibility and autonomy as key characteristics of technical workers. A more detailed examination of individual respondents indicates that no firms exhibited all the characteristics of firms with job specificity as described by Doeringer and Piore.

Workers’ perceptions of their skills level, creativity and training are linked. Jobs that require no training are unlikely to be highly skilled and jobs that only require formal structured training are unlikely to allow for creativity. Skill specificity is also strongly linked to training. Specific skills are usually developed through on-the-job training and are demonstrated by supervisors or co-workers. As was discussed earlier, technocratic elites are seen to have skills and knowledge that can only be gained through formal accredited education and training. The status of a technocratic elite is established and maintained by their formal qualifications. So it is important to determine the nature of training and how it is delivered. As can be seen from Figure 7.2 all respondents rated the job of CADCAM users as skilled or highly skilled, although three respondents maintained that the work was repetitive, and eleven claimed that the work required a level of creativity.

\textsuperscript{150} It may be the case that the work rules of CADCAM users are standard operating procedures (SOP) which are written rules used to control process and system in Factories. Also many firms with ISO 9000 accreditation have quality manuals that are required to have clear descriptions of tasks carried out by workers. If a company is accredited to ISO 9002 they need to have work descriptions for design and development as well as manufacturing.
The repetitive nature of a job does not necessarily reduce skill requirements, but it does mean that the skill is often repeated and eventually becomes second nature to a worker.

Absenteeism, punctuality and staff turnover are all indicators of staff low morale and how workers perceive the reduced status and the prestige of their jobs. Workers with low morale and job satisfaction are likely to be late for work, take all their leave entitlements and leave the firm as soon as they can find work elsewhere. Porter (1990, 593) maintains that turnover is a function of the investments firms make in their employees. He claims that firms with low labour turnover invest in employees and tend to be innovative and accepting of change. So that if CADCAM users view their jobs as prestigious and believe the company is innovative and prepared to invest in them acquiring skills, we can predict low labour turnover. In all the firms in the sample worker punctuality was excellent, the vast majority of respondents maintained absenteeism was low or in a few cases moderate. Staff turnover was rated as low or
moderate in every firm. These results indicate that CACAM users were satisfied with their work and they believed their employers acted in a fair and equitable way.

**Training and recruitment**

The skill level of the job is reflected in the number of hours spent in initial training. As indicated in Figure 7.3 over seventy per cent of firms spend more than twenty hours in initial training and fifteen per cent spent more than ten days or eighty hours in the initial training of staff. This indicates that staff are untrained in CADCAM at recruitment level and the firms are prepared to bear the cost of this training. It may be the case that initial training is to ensure users can operate the software that may differ from the software they have used in the past. In discussions and interviews with CADCAM users it is readily apparent that the initial training, in most cases, is simply a familiarisation with basic operating systems and commands. As with the operation of most tools and machines, to acquire high levels of skills it is necessary to use the system for an extensive period of time. Users indicated that “learning by doing” and working with other users was how they became skilled.
All firms provided some training for CADCAM users and twenty five per cent of firms combined formal and informal training. However, thirty per cent of firms used only informal training to teach workers the necessary skills. This indicates that new staff are only given familiarisation training when joining a company and the amount of training depends on several factors, including the skill and knowledge of the new recruit, and the amount of time and money the firm is prepared to invest in training.
Who provides the training is an indication of how firm specific the skills are and who is able to control the transfer of skills from one worker to another. It also provides an indication of who controls the knowledge and skills needed to operate the system in a firm. Most software from suppliers comes with training in its use. However with highly specific products and processes software suppliers are unlikely to be able to provide training in CADCAM unless they have extensive knowledge of design and production processes. As can be seen from Figure 7.5, firms tend to rely on more than one source to deliver training, which would to some extent reduce the level of control workers have over generic skill transference. The amount of training conducted by other workers and supervisors indicates that a considerably amount of specific skills transference occurs in the workplace. It may also indicate that technical workers are controlling the transfer of skills so that they can protect their proprietary knowledge of how the system operates with a factory environment. They may, or may not, be doing this in a conscious effort to maintain control over the work processes.

Figure 7.4: CADCAM Training Type
Figure 7.5: Training Providers

Most firms rely on other workers to assist in skills training. In relying on workers to transfer their knowledge and skills to other workers, management is establishing a work environment that depends on worker interaction. Whether by design or otherwise, it is important that workers have contact with other CADCAM users if they are to help them learn to use the system. This indicates that skills do have some level of specificity. Over eighty-five per cent of respondents perceived their skills to be transferable from firm to firm and in thirty-five per cent of firms it was common practice to recruit from other firms. Also in seventy per cent of firms it was usual for staff to transfer from other areas within the firm. Given the transferability of workers, both within the firm and from one firm to another, it appears that there is only a low to medium level of skill specificity. However, if there is a shortage of skilled CADCAM users then firms may have to recruit from where ever then can find workers with the requisite aptitudes.
The backgrounds of workers' work and training are important indicators of whether the technology is being used to deskill or enhance skills. They also indicate which workers can access CADCAM user's jobs and if professionals or technical workers have captured the work. If the work can be carried out by unskilled workers with no post-school or vocational training then, in comparison to draughting and design work done on a drawing board, it has been deskilled. It could also be the case that because of the complexity of functions built in to software programs more and more computing skills are required to operate the CADCAM systems. If it was the case that computing skills were becoming increasingly important then users would be recruited from computing backgrounds. As well as recruiting from inside and outside the firm, CADCAM users were recruited from a variety of backgrounds. Figure 7.6 indicates the distribution of workers' backgrounds, Piore (1978) suggests that workers in the primary sector have completed some pre-employment training or firm specific training. This is supported by the data from respondents as 85 per cent of respondents had more than a secondary school qualification as their minimal entry requirement. It also indicates that the skills needed to use the systems require knowledge of manufacturing and engineering functions.

It is interesting to note that only one firm recruited from computing disciplines. This is an indication that the increase in software that operates in a user-friendly way has ensured that, at this stage, computing specialists do not control the systems.

While users with an engineering background tend to be the dominant group few of them where university qualified. During site visits and interviews it was evident that most CADCAM users had gained their initial engineering qualifications, such as certificates
and diplomas, through Technical and Further Education colleges (TAFE). Some had gone on to complete University degrees but most were TAFE trained engineers.

Figure 7.6: Recruitment Background

Prior to getting jobs as CADCAM users eighty-five per cent of workers have some vocational training, mainly in engineering, trades or design. Most firms surveyed recruited employees with some level of pre-employment training. Although firms recruited from a variety of areas and most firms recruited from more than one area, engineering was the dominant area with forty per cent of recruits.
It appears that workers with trade and TAFE backgrounds have been able to use their qualifications and knowledge of the production system to gain jobs as CADCAM users. In some cases workers with secondary school qualifications and from the factory floor have also been able to access jobs as CADCAM users. It is evident that factors other than the technology determine who can use CADCAM. It is also apparent from this sample that the technology is being used in inclusive, rather than exclusive ways.

Work and Workers Characteristics

Respondents were also asked to rate various aspects of their work on a five point scale from essential via important, neutral and unimportant to irrelevant. Work characteristics provide an indication of the nature of work and the ability of workers to exercise control over their day to day tasks with the production process. If workers can exercise control then they can maintain and enhance their skills. To determine if workers had any level
of control they were asked about aspects of their employment which would indicate if they worked in an autonomous manner. Autonomous workers should be able to make decisions, solve problem, use their initiative and work without supervision. Workers with a great deal of autonomy exercise greater control over their work than workers with little or no autonomy. On the basis of their responses it is possible to identify the characteristic with the highest priority. The characteristics with the highest priorities are rated in Figure 7.8 are: on the job training, working unsupervised, and the ability to use their initiative, solve problems\textsuperscript{151} and make decisions while working as part of a team. These were all rated as essential or important by a majority of respondents. These characteristics indicate that CADCAM users need to be able to work autonomously\textsuperscript{152} or as part of a team or semi-autonomous work group. The lack of supervision is indicative of the absence of elaborate work rules and the need to work as part of a team indicates the development of an internalised code of behaviour.

\textsuperscript{151} Curtain (1992) maintains that by using a mix of internal and external labour market strategies firms can improve workplace culture, provide opportunities for workers to acquire skills and enable workers to respond positively to new technology and take more responsibility for problem solving.

\textsuperscript{152} See Boreham (1991) he used a similar scale to measure the autonomy of workers.
It may be the case, however, that workers believe they are working without supervision but management is monitoring and controlling their work using the CADCAM system as a surveillance mechanism. This will be examined in more detail in the interviews when systems administrators and managers will be asked if the monitor CADCAM users' work using the system and without the workers' knowledge.

Users were asked questions concerning career paths, promotion, salary and other workers to gain some indication of their class-consciousness and position. They were asked about salary to find out if monetary rewards and financial position were important aspects of their work. The views of workers on career paths and the basis for promotion provides and indication of the importance they place on seniority and their ability to achieve management status. Workers who are concerned with high salaries, promotion, career paths enabling them to become managers and place a positive value on seniority
are more likely to be aligned with management than workers. A slightly lower priority was given to CADCAM training, merit based promotion, working with other CADCAM users, job security, low staff turnover and working with a variety of people.

![Graph showing job rating: medium priority](image)

**Figure 7.9: Job Rating: Medium Priority**

Finally the characteristics with the lowest priority were the ability to alter the system, above average salary, the personality of other workers, a clearly defined career path, promotion based on seniority and lastly the ability to work under close supervision.
It is apparent from this sample that CADCAM users, if they are conscious of their class position, are more closely aligned to the working class than to a middle class. Salary and money power, seniority, career paths are rated in the five lowest categories of importance. They believe that it is more important to recognise merit than simply promote someone on the basis of length of service. They appear to be more concerned about how well someone works rather than the personality of their co-workers.

While an initial analysis of the survey results presents a detailed picture of which characteristics CADCAM users perceive to be important, it does not align clearly with descriptions in awards. The description of job characteristics, although similar to Piore’s segmentation typology do not fully correspond. As this sample includes a range of firms that differ in size, production processes and age it is reasonable to assume that there will be differences between the internal labour market of the firms. The different industrial relations system in Australia, Europe and North America will result in different job and
work characteristics. It is also the case that the class-consciousness of Australian workers differs from that of European workers but would be similar to North American workers. Australia, the USA and Canada as we know them today have developed more egalitarian societies in their short histories since settlement by Europeans\textsuperscript{153} than European countries.

However, given the similarities between the technologies in use in Australia and other developed economies it may be the case that technologies have been configured and used in similar ways in Australia. As noted earlier in this chapter CADCAM software and hardware can be configured in at least two ways. If a company buys a turnkey software, then the software is unlikely to be as company specific as a customised software package specifically designed for a firm. A customised software package can either be specifically written for a firm, or it may make use of a turnkey package such as AutoCAD and adapt it to suit the company's needs. The most common hardware used is personal computers, workstations and mainframe computers with interconnecting terminals or seats. There can be various hardware combinations and workstations and PCs can be linked to each other or a mainframe by a local area network (LAN). It has been proposed that in linking seats through a LAN, or via a central computer, management would be able to exercise greater control and monitoring than with stand-alone workstations. There is no indication that firms responding to the survey had selected a particular configuration to assist monitoring and control over the flow of work. The skills required to operate CADCAM, although different from the skills

\textsuperscript{153} While indigenous peoples have influenced development, Western influences have been dominant
needed to design a product using a drawing board, are still regarded by workers as important. The responses indicate that CADCAM users are highly skilled and autonomous workers. The level and amount of training and the importance that users place on training are a clear indication of the skill level of CADCAM jobs. From the data in this study it is difficult to argue that the workers using CADCAM in the firms surveyed would perceive their jobs to have been degraded or deskilled. However, as mentioned above, it may be the case that users are being monitored and are unaware of it. This issue will be resolved by the interviews where both users and systems administrators will be asked about the monitoring capability of the system.

An analysis of where workers are recruited from indicates that the majority of CADCAM users come from a trades background. Some CADCAM user came from a production operations background and it needs to be clarified if they were using the equipment to the same capacity as trades people or if they were “machine minders”. Few CADCAM users have a professional engineering background or were recruited with university qualifications. It appears that rather than professionals wresting total control of the design and manufacture of products from workers by using CADCAM, that professionals are avoiding CADCAM. Given the background that most workers are recruited from it is difficult to see them aligning themselves with management. If CADCAM users were in conflict with their employers they would most likely align with workers from the trades and operations areas. While they may at times have supervisory roles it appears that CADCAM users, as technical workers, would see themselves as a part of the working class.
Recruitment is an important aspect of class-consciousness as workers are often tied to their social roots. A worker with many of the apparent characteristics of the middle class will continue to see themselves as working class because their family was working class and their first job was a working class job. So workers recruited from trade and manual factory jobs are likely to align themselves with the working class. An analysis of entry level qualifications (see Figure 7.6) indicates that few CADCAM users are recruited from the factory floor. However, most CADCAM user are recruited from a trade or technical background (see Figures 7.6 and 7.7) rather than a professional, university or computing background. An indicator of management’s perceptions of workers class position is the level and type of supervision used. Traditionally, management has held the view that the working class needed close supervision, detailed job descriptions and clearly defined work rules. From the responses received being able to work unsupervised was the second most important priority for workers (see Figure 7.8) and working under close supervision, was rated as the lowest priority (see Figure 7.10). Also only 20 per cent of jobs had clearly defined job descriptions (see Table 7.9) and 60 per cent of respondents believed their jobs had clearly defined work rules. These results are indicative of the contradictory class position of technical workers. In terms of their qualifications and background they are neither professional middle class nor are they clearly working class.

Traditionally, working class career paths have been based on seniority rather than merit. Promotion based on seniority has as its basis the longest serving employee (who is regarded as “the first amongst equals”) being rewarded for his length of service. So in firms where workers retain this aspect of class-consciousness, seniority and guaranteed promotions paths would be seen by workers as important. In the firms surveyed
seniority was seen as second last in order of importance (see Figure 7.10) and
guaranteed career paths were ranked third last in importance. Not even merit based
promotion was seen as of critical importance, it being ranked eighth in importance (see
Figure 7.9). Across all firms there was no dominant system of promotion or career
advancement. From the respondents point of view promotion was based on a
combination of merit and seniority, and career paths and promotion systems varied
within and across all firms surveyed.

Conclusion

The picture that emerges of technical workers using CADCAM is a complex and multi-
faceted one. CADCAM users are clearly in a contradictory class position. In moving
off the factory floor and leaving their trades, they have entered the realm of white collar
work. However, their origins, and in many cases their allegiances, are closer to the
working class than that of employers or the standard and professional middle class.
They have not forsaken their class because they neither own, nor control, the tools and
process of production. They are able to exert some control over the flow and pace of
their work in the design phase of production. But Management still has the final say in
how work will be done. At times they may assisted management in its effort to exert
greater control over work on the factory floor. In producing the computer generated
tapes and instructions to operate CAM tools they helped to reduce the demand for
skilled machinists. But some of these skilled machine operators have used their
knowledge of the production process to access jobs as CADCAM users.
Within the labour process CADCAM users have been able to maintain a high level of autonomy. Their level of autonomy can be gauged by their ability to work unsupervised, use their initiative, make decisions and solve problems (see Figure Nine). At the current stage in the organisation of work, they believe, and their employers recognises, that they are highly skilled and valued workers. Their work organisation is based on collaborative teamwork. This helps to explain why they are satisfied with their work and they exhibit such low staff turnover, absenteeism and maintain excellent punctuality. CADCAM users within the labour process are central to the design of products and processes. While the secure jobs of CADCAM users is due in part to their knowledge and skills, it is also the result of a negotiation process. As a result of negotiations process technical workers have retained their role in the design phase of manufacturing. Technical workers and their representatives in the union movement have used their knowledge and power to secure for CADCAM workers good pay and conditions. As part of the negotiation process they have “traded off” some of their solidarity with other workers. This can be shown by their willingness to carryout tasks that enables management to displace workers, for example, when they agree to produce the programs and tapes used to operate CNC tools. While the results in this chapter have clarified some issues there are other requiring clarification. These are the subject of the next chapter.
CHAPTER EIGHT

Case studies

Introduction

The information emerging from the analysis of survey data reinforces the contradictory nature of technical workers and their ambivalent class position. It appears from the data that the majority of CADCAM users are technical workers, who have secure well paid jobs with good working conditions. Yet some are employed as contractors rather than permanent employees. This may indicate that although they are valued, they are not all critical to the design and manufacture process. From the survey data no clear picture emerges of who controls access to skills and knowledge; this needs to be clarified. As indicated in chapter six there have been significant changes to the technology in the period from 1992 to 1997. The interviews were conducted to determine which changes have been introduced into Australian firms and why changes have been adopted. It may be the case that Australian manufacturers are using technologies that are centralised and have purchased software that allows management to control the pace of work and electronically monitor the work of CADCAM users. As noted in chapter three the software and hardware in use is the result of a negotiations between many actors. The technology employed is the output of politics and power.\textsuperscript{154} To understand the balance of power between management and workers we need to clarify not only who monitors and controls the process, but who has the power to capture and transmit

\textsuperscript{154} See Soressen (1996).
knowledge of the process. The survey data revealed that there was a variety of training methods. The acquisition of knowledge and training partly determine who has the power to control access to a technology. So the interviews explore training and skills acquisition. These are both important aspects of the labour process and labour market structures.

The Interviews

The goal of the interviews was to shed more light on the job characteristics of CADCAM users, and in particular to note any changes that may have occurred and to provide a more detailed picture of how work is organised, monitored and controlled. Also it is apparent from the survey data that the majority of CADCAM users were technical workers from a trade, engineering or operations background. The interviews determined if this was still the case and why these workers are CADCAM users. The survey also identified that CADCAM workers believed it was important to work in teams and that working in teams was more important than working with other CADCAM users, but the survey findings did not explain why this was so. The interviews examined how work is organised and the nature of teams involving CADCAM users. The labour process literature\textsuperscript{155} indicated that CADCAM technology had the potential to alter the jobs of technical workers. Potentially employers are able to use CADCAM to monitor and control the jobs of workers. It was argued that in much the same way as the production line and automation determined the pace of work on the

\textsuperscript{155} See the deskilling debate in Chapter 2
shopfloor, CADCAM could be used to control the workflow of technical workers. To determine if CADCAM was being used in some way by management to exercise direct or a more subtle control, CADCAM user were asked how their work was monitored and controlled. Managers were asked how they monitored work and measured CADCAM users performance. Users and managers were also asked about features such as libraries, access levels and the ability of users to alter or customise the system, as this can provide an indication of a more subtle form of control. Workers were also asked how their job had changed to determine if management, to alter jobs, was using the technology, or if workers were modifying their own jobs.

Analysis of survey data indicated that there was no substantial difference between the job characteristics of workers using different CADCAM hardware and software configurations. Questions were also asked about the hardware and software configuration in the interviews. This was to determine if on more detailed questioning of individual workers a particular hardware or software was being used to ensure technology specificity. The flexibility and transparency of the system is an important indicator of how management is using the technology. Inflexible systems, where workers are unable to access a wide range of data and the drawings of other workers, are indicative of systems where management is attempting to control and restrict the tasks of employees. Interviewees were also asked about the role of their professional associations and trade unions in influencing who used CADCAM and the conditions of workers using AMT. CADCAM users were asked if they saw a future in CADCAM and was it important to their careers. Managers were finally asked if CADCAM was a technology that was critical to the future of the firm to determine the place of CADCAM in a manufacturing environment.
Methodology

The interviews\textsuperscript{156} were structured \textsuperscript{157} and conducted face to face. Both managers responsible for supervising CADCAM users and CADCAM users were interviewed. This was done to ascertain if there were differences between the perceptions of managers and employees and to find out if managers were using the system to monitor work and users were not aware of this.

The Firms

The firms involved in the interviews were:

Firm A is an aerospace manufacturer specialising in manufacturing component parts for commercial aircraft from composite materials. The company was wholly owned by a UK based multinational but operates as an independent business unit. Most products are designed and built to one or two customers’ specifications and products take about two years to design and deliver. Most contracts to supply are for a period of more than ten years and there is not a large product range. In this complex high technology firm with over one thousand employees, three CADCAM users were interviewed, including one who had moved from a managerial role into a CADCAM role to gain experience in using CAD.

Firm B manufactured valves, the firm specialised in flow valves for industrial applications such as power generators, the petro-chemical industry and water reticulation schemes. While the firm has a range of standard products most jobs are

\textsuperscript{156}The questions used in the interviews can be found in appendix 4
\textsuperscript{157}See appendix 4 for details of interview questions.
customised to fit a particular application. The company is the Asia-Pacific headquarters for a multinational organisation that has recently relocated its Singapore operations to Australia. The firm located on the South Coast of NSW has approximately one hundred employees but uses a large number of local subcontractors to source castings and sub assemblies. In this firm three CADCAM users were interviewed, all were full time staff one was employed under award conditions, while the other two were full time staff employed under individual contracts.

Firm C is a cable manufacturer based in southwest Sydney. This is a multi-site organisation with head offices in the Sydney CBD and manufacturing plants around NSW and Victoria. The southwest Sydney site consists of five factories producing cable for the power industry. The firm employs between two hundred and fifty and three hundred employees. Most staff and production workers are permanent full time employees, all maintenance staff are subcontractors and CADCAM users are contract staff. The firm was a wholly owned subsidiary of a UK based multinational. The company produces a wide range of cables to meet Australian and export markets needs. Most product is long run low variation with few changes to customer specifications. In this firm the engineering design manager and two CADCAM users were interviewed.

Firm D is an electrical switch manufacturer located in western Sydney. The firm manufactures high voltage switches for the Australian and Asian power industry. Apart from one specialised circuit breaker all products are customised and designed to meet customer specifications; most products are single unit production with a run of ten units considered a large production run. The firm employs twenty six staff and was run by four partners who established the business in the mid 1980s. The CADCAM manager
and main designer is one of the managing partners and he, with one other CADCAM user, does all the CADCAM work. The company is currently investigating a strategic alliance with an Asian partner because there is a strong demand for their highly specialised products in the emerging Asian power market.

Firm E is an electrical power generator facility designer and manufacturer based in southern Sydney. The firm is a wholly owned subsidiary of a multinational company. The firm designs and manufactures electrical generating and distribution equipment for Australian and export markets. Most of the products are for large-scale installation projects lasting several years. The company has over three hundred and fifty employees and ten CADCAM users. The firm employs contract CADCAM users on a needs basis for periods ranging from three to twelve months. The CADCAM system administrator was interviewed and he is also a CADCAM user and manages the CADCAM team.

Firm F is an elevator manufacturer in south west Sydney. The company designs, builds and assembles elevators, mainly for large commercial buildings and apartment blocks throughout Australia. The firm is a wholly owned subsidiary of an overseas based multi-national. The company has undergone restructuring and rationalisation over the last five years and all its operations apart from one in Melbourne are now in Sydney. The Melbourne site is primarily a Research and Development operation and is linked to the Sydney site through a dedicated ISDN line. The company employs more than two hundred people, eight of which are permanent staff who are CADCAM users. There are also contract CADCAM users who work on design and assembly. The interviews were conducted with the senior CADCAM user and the systems engineer in charge of administering the CADCAM system.
<table>
<thead>
<tr>
<th>Firm</th>
<th>Size</th>
<th>Products</th>
<th>Ownership</th>
<th>Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1000</td>
<td>Aerospace components</td>
<td>Subsidiary UK Multinational</td>
<td>UNIX Mainframe with a network of workstations using CATIA, Auto CAD and Unigraphics</td>
</tr>
<tr>
<td>B</td>
<td>100+</td>
<td>Industrial Flow Valves</td>
<td>Asia-Pacific HQ of Multinational</td>
<td>Workstations and PC’s Networked on a file server using AutoCAD 13</td>
</tr>
<tr>
<td>C</td>
<td>250+</td>
<td>Cable</td>
<td>Subsidiary of UK Multinational</td>
<td>5 Workstations networked operating CATIA</td>
</tr>
<tr>
<td>D</td>
<td>26</td>
<td>High voltage switches</td>
<td>Australian Company owned by 4 partners</td>
<td>2 Work stations networked operating Microstation</td>
</tr>
<tr>
<td>E</td>
<td>250+</td>
<td>Power plants and distribution systems</td>
<td>Subsidiary of European Multinational</td>
<td>12 Workstations networked operating Microstation and some AutoCAD</td>
</tr>
<tr>
<td>F</td>
<td>200+</td>
<td>Elevators</td>
<td>Subsidiary of US Multinational</td>
<td>11 Sun Ultra 170E workstations networked and operating Pro Engineer</td>
</tr>
</tbody>
</table>

Table 8.1 Characteristics of Firms

Systems Configuration

The hardware configurations were very similar in all the firms visited, even the small business firm D, which had two work stations, was networked and operated on a fileserver. This allowed both users to access common files and use plotters or printers as required. The only company still using a mainframe was firm A and the work stations there were also networked which allowed for common access and ease of file transfer and communication. The mainframe was linked into a LAN. Two firms, firm A and firm F, have introduced production database management system (PDMS).

This allows them to develop and build in protocols that help them better manage their IT systems, including the CADCAM system. These systems have the potential to increase the capability of managers and systems administrators to build in monitoring
and control mechanisms. PDMS are designed to collect data from remote sources such as workstations and PCs and using a framework track all facets of an IT operation. But there does not appear to be any demand for computer-based performance measurement tools that will automatically measure the work and output of CADCAM users.

The trend in manufacturing is towards local area networks with workstations linked to a file server. This configuration allows users to access common data while maintaining personal directories that can be encrypted so that the individual user is the only person that can access them. This does have some dangerous implications for firms, such as firm B where;

Like we had a guy here that was fired and he had a heap of files here that we never could get into. They were all password protected no one could get into them. We ended up throwing them away, we didn’t know the password.

Also a disgruntled employee could access and subtly change data and it would be difficult to detect. As an interviewee at firm B put it;

..if you get a disgruntled employee one day he gets fired and decides he’s going to mess around in there all hell would break loose. .....[He] could just go in and delete whole directories. There is a backup. I think it’s backed up every week. So you can, it can all be put back on, but you’ve got to know, I suppose you just load the whole lot back on again, but if somebody went in there and changed things all over the place subtly so that you didn’t pick it well that would be even worse I think.

The lack of inbuilt monitoring and control mechanisms allows workers to alter designs and drawings without any record being kept. A CADCAM user could alter drawings
that would have severe ramifications for the company, yet it would be almost impossible for management to detect these changes.

The ability of disaffected workers to sabotage or damage the system as a way of hurting management indicates that CADCAM users are trusted employees and management has not yet put in place intricate electronic control measures. It indicated that firms have not implemented CADCAM in such a way that workers are restricted from accessing data and fully utilising the system. It may, however, indicate that management is naive or does not fully understand how the system operates, or how it might be configured to allow management greater control. It is more likely that managers, particularly at the senior level, are not computer literate and so they are unaware of potential problems and do not see a need to implement electronic solutions. Although in one firm a manager commented that when they had to sack a CADCAM user they did it so swiftly that the CADCAM operator was not allowed to return to his workstation after he was informed that he was being fired. At the same time as senior managers were firing him, the systems administrator was removing his access privileges. This is yet another indication that management has not implemented remote control techniques.

The software in use varied and included AutoCAD, CATIA, Unigraphics, Pro Engineer and Microstation. All systems were turnkey, off the shelf systems and had been customised to suit individual operators. Two companies firm B and firm F had changed software at least once in an attempt to facilitate compatibility across the larger organisation mainly because of difficulties with transferring files from one package to
another. Three organisations; firms A, E and F used more than one software package and this was in part determined by their customers or the nature of the design job. It was regarded as a waste of resources to use a CATIA system for a drawing that could be easily done on AutoCAD. Interviewees were asked what they used CADCAM for and almost all used CADCAM as a drawing and design tool with little use being made of engineering, analysis or modeling capabilities. As the CADCAM manager at firm E commented “Basically it’s just an electronic drawing board at the moment. But we’ve got a built in databases and stuff like that.”

Although firms had purchased turnkey software CADCAM users were able to customise their workstations to suit their individual needs. For example firm E had their system set up so that when a CADCAM user changed workstations his or her customisation moved with them. According to the CADCAM manager; “We also set it up on the network so that no matter where we sit, our own toolbars, whatever we’ve personalised ourselves, will follow us around the network.” At firm B individuals have customised their own workstations so that;

Everyone works on their own workstation when you go and jump on someone else’s machine it’s always set up differently so you’ve got to know the minor differences and things. There’s a lot of things in there that are really difficult to set up and setting it up properly is a big job, you really need somebody who knows what they’re doing.

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158The number and variety of exchange standards available makes data transfer difficult for a list of standards in use see appendix 5.
Customisation was limited and it could not interfere with standard operating procedures that are text-based instructions for users normally contained in a manual. At Firm D the CADCAM users had exactly the same on screen configuration. Users were not allowed to alter or customise the set up without the agreement of the systems administrator but given the size of the company this was not difficult to achieve. There was no effort by management in any of the firms visited to use firm specific configurations to ensure users had to develop firm specific skills.

**Labour Process**

The software in use was not always the latest version and was often a basic package with no add-ons. Several users commented that firms tended to buy the bare minimum software package. Yet CADCAM users could have made use of add-ons or more complex modules. Surprisingly users were prepared to spend their own time learning how to accomplish complex tasks with the existing software and indicated that they shared their knowledge and experience freely with other workers. At firm F both the systems administrator and the senior CADCAM operator commented on the way CADCAM users learned and shared information.

> The training courses gives you the basic side of the thing, and then you’re forever coming up with something you don’t know how to do. You find that the draftsmen working together a bit, and then one will ask the other ‘how do you do this’

Although this informal learning occurs there has been no effort made to capture the process or record the knowledge and skills.
I think that is one of the good things that our draftsmen do. We've got a pretty relaxed sort of atmosphere and people are quite happy to lean over to the next guy to them without fear of having their head bitten off and saying 'hey I'm stuck on this' or 'Oh that's interesting how did you do that?' And there's a good deal of cross-pollination between people and I think that's a good thing. I don't think we capture enough of that knowledge that people build up into any sort of formal tips and tricks guidelines for future people. I think it probably is relearned, again and again as new people come on board which isn't too frequently.

As management and firms are failing to capture the learning that occurs, this ensures that at this stage within Australian firms, the knowledge and skills needed to operate the CADCAM systems is the property of individual workers. As the users own the knowledge and skills they are able to exert significant control over who can access or acquire the skill and knowledge. Ownership of knowledge provides CADCAM users with a powerful basis to negotiate with management and influence the current and future technological trajectory of the firm.

At firm D the CADCAM user there had joined a local Microstation users' group to help him learn how to use the software. He used it as a source of knowledge and expertise. It was through attending the users' group that he became aware of the need for a standard operating procedures manual and he used the group as a problem-solving tool. A slightly different approach was taken by two of the CADCAM users at firm B. One CADCAM user attended classes run by his brother who taught computing and CADCAM at TAFE and he used his brother's skills and knowledge as a learning resource.
My older brother teaches engineering at Wollongong TAFE and you know he teaches CADCAM as well, AutoCAD, and I pick his brains quite a bit because I really haven’t had a great computer background. I had to pick it up as I sort of went along. I did a bit of a course at TAFE, sort of thing just to pick up a few things and even sit in on a few, you know, lessons my brother gave.

Another CADCAM user at firm B used contacts on the Internet as a source of information and learning. He often posted a problem to other users on the Internet and maintained that it was unusual not to receive several suggestions within forty eight hours.

I didn’t have any program or I hadn’t written one at that stage so I just put it on the Internet and I’d say I probably got about fifteen different programs back in about two days you know, from all over the world. But you know, they were very keen to help.

From the responses of interviewees it appears that they had made a conscious decision to learn how to operate a CADCAM system and took pride in their ability to use the system effectively.

The draftsman at firm B saw the move from rigging to CADCAM as “A challenge. Something that I look at present as a challenge, you know, I just wanted to do it”. Some of the interviewees made remarks about fellow workers who could not or would not learn how to use CAD.

the chief engineer the guy running the department he wouldn’t know how to use AutoCAD at all he wouldn’t have the faintest and then, one of the guys over there who can kill me for saying this but he’s a professional draftsman but he’s only been on AutoCAD or any sort of CADCAM
system for about two years and he's bloody hopeless he's a good draftsman
but you put him in front of a computer and he falls to bits.

So although some draughtspeople have chosen to learn how to use CADCAM others
have been unable or unwilling to acquire the necessary skills and knowledge. There is a
range of formal and informal ways for technical workers to access and develop the skills
needed to operate CADCAM. It is important to note that they have selected strategies
to share knowledge that are similar to strategies used by craft workers in the past. They
have established networks of skilled users who either meet to share their knowledge or
share their knowledge through vehicles such as the Internet. The group meetings and
Internet networks at this stage may be open to all, but it may be the case that at some
time in the future technical workers will attempt to restrict or control entry to these user
networks. Importantly, the transfer of knowledge within a craft tradition is not a formal
transfer of skill and knowledge, but an informal transfer from a skilled craftsman to a
less skilled craftsman. This involves the sharing of artisanal knowledge by working
with other workers who are recognised as especially skilled in the craft.

In response to questions concerning monitoring and control mechanisms it appears from
responses that no formal computer-based structures were in place. As one respondent
who had a managerial role put it, "I mean we monitor in terms of monitoring
completion dates of tooling and that. Try and work out if things are late why they're
late or otherwise, but yeah that's about it." Although there is no formal monitoring
there are restrictions in place in terms of access. For example firms A and E have
passwords to restrict access to the system and there were differing levels of access.
Most users have a private directory or personal drive that only the individual worker
and the systems administrator could access. Also there were restrictions on who could
alter the name of a project so that a project file name could only be altered by a senior operator. The CADCAM manager at firm E explained the restrictions in this way:

For the drafting side I’ve just got it set up as a group called ‘NT Security’
I’ve got a group called ‘CADCAM users’ and ‘CADAdmin’. I’m a member of ‘CADCAM and CADAdmin’ so I have full access to everything and ‘CADCAM users’ have also got full access but.....There are a few privileges they haven’t got. Such as they can’t change ownership of files or that sort of thing.

At Firm C the manager maintained the system was transparent;

Yes, yes. The information that’s on the system is freely available to anybody else and, we haven’t gone as far as locking up all the access or the use of any of the information. Apart from when a drawing is finally approved and issued, but at any time prior to that anybody can walk into any drawing and could add to it.

Apart from relative minor restrictions much of the operating control measures were based on written standard operating procedures. A common view of interviewees was there was no need for controls as people simply got on with their jobs. The only reason given for standard operating procedures was to ensure that changes were made in a systematic way. But at firm F there was nothing to stop two or more operators working at the same time on a file. As the systems administrator put it;

Basically what normal users have to do is fetch whatever they’re going to work on out of the database and then make sure they submit it back afterwards. Some people find that intimidating, others take it in their stride. Had a bit of problem trying to persuade people to actually go through the process of submitting. There’s problems if someone fetches
their thing out, does all the work on it and then just leaves it sitting in the
directory and someone else comes along and fetches the thing out of the
database again and presto you've got two copies of it, but their different.
Fortunately that doesn't happen very often now.

There was a common response across all the organisations involved in interviews that
there was no need to monitor the work-flow electronically. When asked how work was
monitored and the performance of CADCAM users was measured typical responses
were:

- it just depends on the level of their skill. Like our apprentices we
  supervise fairly closely, but some of the contractors that we've had in quite
  regularly, we know them and trust them. They can work unsupervised and
  we know they'll have a fairly good output. You just supervise depending
  on the level of skill. (Firm D)

- we don't, we don't control it to that degree but the only criteria that we have is meeting
timetable for time schedule, that's part of our project, timetable. (Firm C)

  Again I suppose it's the nature of the organisation to a certain extent,
  people work together, get on with the job and that's the important thing
  rather than worrying about how it was done or who actually did it. Main
  thing that goes without saying is that it is up to the team leader who knows
  what the deadlines are for things and makes sure these people are sticking
to it. (Firm F)
When pressed if potentially the system could be used to electronically monitor work rates, the manager at firm D maintained; “Yeah, it’s there but its not used, the counting side. Generally we just keep an eye on them and see how they’re going.” Similarly at firm F the system administrator when pressed about electronic monitoring claimed; “No, I don’t have anything like that in place.”

It appears that because of the way CADCAM work is organised, electronic monitoring is not seen as important. This is because of the project and team-based nature of CADCAM work that requires CAD users to work to timelines. The team approach, where people work collaboratively and are able to monitor one another’s work by just looking over someone’s shoulder, ensures that the work gets done. It appears to be the case that management is using organisational structures such as teams to monitor and control work. Within the design and engineering project-based environment this is viewed as the most appropriate and cost effective way to control the process. It is more likely that managers are not fully aware of the potential of CADCAM to monitor and control and they have not implemented it.

Although it does not appear that CADCAM has been used to monitor or overtly control the flow of work, it has influenced the pace of work. Although managers see the increase in workload as improved efficiency. As the manager at Firm C put it;

it’s possible for us to be much more efficient than we were in the past as far as modifications are concerned. And once the information is in the system it can be used as many times as needed, which is a big productivity advantage for us.

The manager at Firm F supported this view as he put it “Most of the drawings we currently use are on CAD or going on CAD. Pull the plug …………all we’d have is just
paper and with the number of staff we’ve got now you wouldn’t be able to keep up with it.” At Firm E the manager maintained the pace of work was quicker; “it’s a very powerful tool. It’s getting quicker for one thing to draw and you know compared to manual drafting it’s getting quicker”

Although the senior CADCAM user at Firm F was not as convinced about time saving and efficiency; I don’t think CAD has been the enormous time saver as people might think. In a lot of ways to use a system especially like Pro Engineer requires a lot of thought and a lot of attention to how you put the design together. The changes to the pace of work may not be uniform across all firms. However as the systems have the potential to increase the output of workers, managers will expect increase output from all users. With experienced users it may be the case that they can increase their output without increasing the pace of their work.

The debate concerning the introduction of technologies such as CADCAM often assumes that management is free to choose a technology and to configure it to meet their needs. But the selection of a technology is influenced by many factors. Often to keep a customer satisfied and stay in business a firm must use technologies that suit the customer. In one of the sites visited, a bus and coach manufacturer, they introduced CAD so that the designers and draughting staff would not leave the firm to get experience using CAD elsewhere. The CADCAM system in organisations such as firm C had been selected after careful consideration;

we had the opportunity to select a system from scratch and as I said we spent about twelve months doing that, visiting various sites around Sydney. I think we visited Qantas, we visited Hawker De Havilland, we
visited Comalco at Minto and we visited Glennons in Newcastle and the outcome was we opted to select CATIA.

Other firms such as firm A were forced to select systems that their major customers used. As the first interviewee at Firm A commented; "But Boeing only uses CATIA owns CATIA actually.......as long as you work with Boeing you’re going to have to work with that version the latest version". While at other companies CADCAM systems had evolved, for example Firm B had changed from Applicon Bravo to AutoCAD because the organisation was attempting to set a company wide standard ....see what we are actually doing now we had to, because we’re a world wide company we had people on all different systems trying to transfer information and it just never worked . But now everybody is supposed to be going onto AutoCAD so that we can transfer information. But before someone would do a full design package over in Italy or somewhere on one system and it would come out here and we redo all the drawings from scratch. It’s just insane. You can imagine how much waste of your resources there are just duplicating something that already exists....

Similarly company F had tried three different systems;

So, in a lot of ways we follow, we’re basically followers of the corporate edict, we originally started off with a Computer Vision CADCAM system, that’s what, 1982 and that was the corporate edict at the time,  But Computer Vision which we in Australia used but no other part of the company followed us so we were a lone island with this wonderful CADCAM system and we made it do quite a lot. Then they looked, seven
or eight years ago at Applicon Bravo systems. They failed to meet a lot of important goals in the transition phase and never really came to pass and then Pro Engineer came along and at about Release 8 of that we took it up which was about five years ago.

So worldwide they have established Pro Engineer as the company standard in an effort to reduce time and effort wasted in redrawing because of the lack of a standard graphic interchange. Clearly firms are selecting CADCAM systems for a variety of reasons. Once a firm has introduced a system, how it is configured and how work is organised will be partly determined by local management and the local workforce. National and regional differences in management philosophy and style combined with the negotiating power and ability of the workforce to influence management will play a role in how work is organised and technology is implemented.

The apparent *ad hoc* way in which Australian companies organise and set up CADCAM systems is clearly demonstrated by the lack of central libraries in some organisations. The draughtsmen at firm C did not have a parts library and used existing drawings as a resource. However at firm F they had started to develop some library structures.

We have got some things such as standard parts libraries that were developed here for simple things like metric fasteners and channels, different types of channels and beam sections and so forth then the [United] States [division] came up with another set of libraries for ISO standard fasteners...

While at firm D they have libraries that are viewed as a crucial resource and are maintained and kept up to date by the CADCAM users;
They use things called ‘cell libraries’ and its always under constant revision. We’ve got all these strange standard symbols for circuits, we’ve got another cell library as well for standard sort of parts and circuit breakers.

When asked who maintained the system they replied; “Generally it’s just everyone’s job. Every now and then we get somebody to go through it and clean it all up and that gets pretty messy sometimes.” The efficiency of the CADCAM systems are greatly enhanced by detailed libraries of parts and by a systematic procedure for storing and maintaining data. Management, as yet, has not recognised the value of such resources and the need to manage them. Although CADCAM users are aware of the benefit of an organised library of parts they have not spent time creating them. At firm B the same problem existed while individual CADCAM users maintained libraries on their own directories these were not shared. Although one draftsman had been highly innovative and had acquired data from suppliers and made use of existing electronic data held by the marketing division, other staff did not use the available data.

While individual users have learned to carry out complex tasks and analysis using CADCAM the majority of work being done was drawing with elements of design. Users claimed that the systems were less than satisfactory and extremely basic. Although there was a view that Windows 95 or Windows NT was easier to use and made moving from one package to another simpler. There was also a general view that learning one package made it easier to learn a new package. Management’s refusal to put resources such as parts libraries, additional features or allocate time and people to organise the CADCAM systems indicates their failure to understand the strategic importance of the technology. If they do not understand the technology’s strategic
importance then they are unlikely to grasp the potential use of the technology as a tool that can reshape the design, engineering and manufacturing processes.

CADCAM was viewed by users as a replacement tool for the traditional drawing board. In firms A, E and F however CADCAM had not completely replaced the drawing board. While CADCAM is more complex and required different skills to the drawing board as mentioned previously it is still being used as an electronic drawing board rather than a complex design and engineering tool. This view was supported by the survey data that indicated firms were more likely to use systems for CAD even when the system could be used for CADCAM. In firms where more complex software packages were available it was still predominantly the tool used by draftsmen rather than the tool of professional engineers. As the manager at firm E suggested; “Well that’s like a multifunction tool now. Before there might have been 3 or 4 different tools....... Yeah it’s a very powerful tool, used to draw you know rather than to do manual drafting...”

Although it was regarded as a tool it was still a tool that required workers to make judgements and exercise skill and users did not believe they were being recognised and rewarded for using their initiative. As one user at Firm B commented;

I think if, people were rewarded for their.... I suppose skills. User skills, to a certain degree, then they would probably take that a bit further and apply it a bit more than if it’s just used as an ordinary tool like a calculator or something

As a tool CADCAM can have little impact on the organisation of work by itself. At present CADCAM is a sophisticated tool that is used by technical workers from
production, trade and engineering backgrounds. It is seen as a complex substitute for
drawing boards, but just as drawing boards were not used extensively by professional
engineers and scientist, CADCAM is not widely used by professionals to any great
extent. Some of the graduate engineers who were interview and were using CADCAM
had come from a trade background and had gained a university degree after working as
a tradesperson.

Users were asked if they believed CADCAM had altered or effected their creativity and
their ability to use their initiative. These areas were rated as important in the survey but
as the labour process literature argues it may be the case that there is an initial increase
in skill and creativity but this declines as users become highly specialised. So as each of
the firms interviewed had been using CADCAM for more than five years they would
have been past the initial implementation stage. A typical response came from a user in
firm B;

"I think it's improved actually it's helping me a lot in being more creative. It's a lot easier to work with the CAD information than it is with drawings, for it sort of makes visualising ideas a lot easier than when you look at the drawing. I believe you tend to lose a lot of the time trying to understand the drawing. First because it's something static and just a picture of something that doesn't trigger ideas as it does when you have your model right in front of you. One thing I do is when I'm thinking with the CAD I'm always moving the component around. But that seems to give me or instigate some other aspects that I didn't see before and it tends to give more ideas."
Although the subcontractor at Firm A was not sure he still felt that he needed to use his initiative.

Where ever you're employed at some time you're only limited by what they want to teach you and you're not really allowed to expand and learn as a contractor. But you are because you've got to think for yourself first thing on different jobs and use your initiative. And you've got to try different ways of doing the job with AutoCAD not just a simple straight forward matrix.

Similar responses came from another CADCAM user at Firm B and the manager at Firm C when asked if users could make decisions and use their intuition; 

Probably do, because a lot of the thought or the method, how you're going to do something, design something, it's still a personal sort of choice in their mind. One person can do something one way and another person will do it totally different. Like for instance you can be asked to design something, a mounting kit for this item ....... and you give that job to one person who'll do it one way and another person can do it, sometimes quite considerably different. Peoples ideas, people have different ideas and methods of doing something. They find something a bit more comfortable or one way more comfortable than another. And so it is, you who is thinking, calling back on your experiences. (Firm B)

The systems manager at firm C also thought that users were expected to make decision but these were more based on background knowledge rather than intuition.

Yes, very much based on a background of skills and experience and there is input from a number of different sources. I suppose it's fair to say that we would come up with a proposal and then that's submitted to the
manufacturing areas, production areas, where it can be discussed with production people and have their input and then modify the layout according to that. So that at the end of the day, what we are going to do is fully agreed to by both engineering and manufacturing.’ (Firm C)

So clearly CADCAM users believe that they are still using their initiative and intuition. Also they felt that in some ways using CADCAM has increased their creativity. As this is the case it is difficult to support an argument that CADCAM is being used to deskill technical workers. Creativity is difficult to determine, for some, creativity is the design of a concept for a sleek sports car, for technical workers however, creativity can be using a tool such as CADCAM in an innovative way to solve a problem. There are some aspects of CADCAM users work that is repetitive, such as redrawing plans and designs but they are no more repetitive than the jobs of draughtsmen who have to redraw a design using a drawing board. It is apparent that some CADCAM users have been able to expand their jobs by using the software to solve problems in new and different ways, carrying out tasks that were previously the work of professional engineers. Other workers who can not develop the skills required to use CADCAM may be displaced from their jobs as draughtsmen and designers. While this may be a result of the technology becoming more widespread it is not a deliberate strategy on the part of management.

**Labour Markets**

There appears to be widespread use of subcontractors in the drawing and design areas and firms used contractors when there was a build up of work. This allows for greater flexibility in labour levels within firms and can be indicative of a secondary labour
market. In the main, short term subcontractors were employed to undertake relatively repetitive and simple tasks for experienced CADCAM users. As the systems administrator at Firm F put it;

Our contract draftsmen work on those contract modifications. They tend to do a lot of work because of lead-time problems and so forth. They tend to use a different CAD system a simple 2D package for lots of it. Often it's modifications to a bracket or a fitting or something like that. So they tend to do it on a 2D package for that contract just for the expediency of getting it out.

Sometimes they are employed on the basis of their knowledge and expertise of a specific software package such as CATIA or AutoCAD. At Firm C all the CAD operators were contract staff, according to the manager; "All people that work for this company are actually contract employees in the drafting area". However, he claimed that this could be a problem for both the workers and the firm;

One of the problems with a lot of contract drafting is that people will do a job or be involved in a project and then before the project is sometimes even started or certainly long before it's completed they then move onto another project or another site for another company. They never see the outcomes of the drawings or the designs that they've done. They never find out where things have, perhaps not been satisfactory or could be improved in the design process.

It was not unusual for a contract CAD user to work for long periods of time on several projects. As the manager at Firm E commented;
Like one contractor who's here, he's worked here before me. He hasn't been here full time. He's been in and out a few times. But I've been here about six years and he first started working here about seven years ago. He's been in and out a few times but we keep getting him back and there others we keep getting back.

Interestingly one of the contract CADCAM user at firm A maintained that he had deliberately chosen to work as a subcontractor. In fact, given the choice he preferred work for himself as he saw himself as “president of your own company.”

His decision to remain a contractor was based on his belief if he went back full time, "you’re going to be limited to the amount of knowledge you can use not what you want to use but because of the jobs they give you specifically to do”.

It appears that in design and drafting it is common practice to use short-term, contract labour. This is not the direct result of introducing CADCAM. Some firms indicated that it had long been common practice to employ additional draughting people when there was a build up of work and then to let them go when work dropped off. So that in these instances the employment of contract labour is a response to labour market supply and demand, rather than a deliberate strategy to destabilise the workforce. In most firms it is normal practice to have some long-term, permanent CADCAM users.

Although there appears to be an increase in the use of subcontractors, most workers interviewed believed that company specific knowledge was useful and a background in the industry was helpful in designing and drawing components. As the chief design engineer at firm C explained; “But it's fairly important that people understand sort of,
machine shop procedures and capabilities in order to be able to use the system to its full". The subcontractor at firm A when asked if a background as a fitter machinist and a TAFE Engineering Certificate was helpful in his current work replied;

Yeah it helps to relate to the tools [that are used] and that helps especially when you’re dealing on CAD and you’re trying to explain to people in the workshops what the problem is. The way of getting to the [cause of] problem. And most of the ways, unless you know how they got to that stage you can’t explain to them otherwise it’s just a piece of paper to you and to them. You know, well you know when they have actually achieved [something] and where they went wrong you really have to analyse the problem from the beginning to the top yourself. See where they went wrong where they could have gone wrong then try to rectify it you know.

So a trade or operations background although not essential, is useful. The aeronautical engineer at firm A maintained that; " ..it’s pretty important that you’ve had some experience on the floor to know the sorts of problems you get ". At firm F although the background and knowledge of workers varied there was still a need for skilled workers. As the systems administrator put it; “Some have come through from the factory and others have just come through with a drafting apprenticeship and been draftsmen with our company or with another company the whole time”. Although firms are using contract CADCAM users to allow for more flexibility this was the situation before the introduction of CADCAM. It is apparent that most firms still need a core of experienced workers with knowledge of the design and production processes. The core of experienced CADCAM users typically come from a draughting trade, and production or engineering background. In comparison to contract staff these core workers have
relative secure jobs. But many of the contractors had worked for one firm for extensive periods of time often several years. The contradictory position of technical workers is evident in the varied employment conditions.

Interviewees were asked how CADCAM work was organised and was it project based and were CADCAM users working alone or as part of a team. The majority response was that CADCAM users worked in project based teams. These teams typically consisted of one or more CADCAM users and other design and engineering staff. Given the importance that respondents to the survey placed on teamwork it is not surprising that this was reinforced in the interviews. The responses to the interviews also help to explain why working in teams rated higher than working with other CADCAM users. Teams often did not require more than one CADCAM user but consisted of other expert staff such as engineers who probably did not have any CADCAM experience, as the CADCAM manager at firm E put it;

For each project there is, you know, generally a project team of engineers that do the design work and then the drafting. We have a few key people that work on one particular project and then there's always a bit of integration like a rush job comes in, we might borrow a draftsman here or there and get that job done.

When asked if engineers used the CADCAM system the manager at firm F replied

Oh no, Just draftsmen that work on the CADCAM system at the moment. I think we're heading towards engineers drafting as well, but I think we may, actually it's more the draftsman heading towards engineering than

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engineer’s heading towards drafting. We’re just getting more, they’re [CADCAM users] increasing their role in design.

So an important aspect of teamwork is that technical workers can learn from professional engineers and have been able to acquire the skills necessary to carry out engineering tasks. This can be regarded as upskilling for those workers who incorporate these tasks in to their day to day work. It also supports the proposition that in taking on the tasks of professional engineers technical workers are moving away from the working class and becoming more closely aligned with a new middle class.

While work was organised around projects and most firms used teams there does not appear to be a systematic approach to job design and work organisation other than team based projects. There is not a typical CADCAM user’s job as they vary from firm to firm. Each CADCAM user is expected to do a range of tasks and the range is only limited by the firm’s expectations and the workers skill. As the designer at firm A saw it;

the tasks that I have to perform amongst them CAD is just one that I have. There are other things that I have to do. And basically what we’re doing in the tooling group we have this person who is working more with this project than others. They’re assigned to that project. So you’re sort of interacting a lot with the same people from the [Boeing] 777, we are basically dedicated to that project within that team. Although we belong to the tooling group and the other guys belong to the planning group.

So, as we saw in the survey data, the work rules and job descriptions continue to overlap with other workers. Although a technical worker is from the tool design area their work overlaps other areas and they work on many aspects of a project. If, as was
the case in firm A, only one team member had CADCAM skills then they would be expected to do all the CAD work for the team. As the designer at firm A put it;

Yeah we work as a team but because I’m the only one who is into CAD in my team I’m doing everything in my team... They come to me if they got problems. The guy that’s in charge doesn’t know about CAD and he’s asking me what do. you think the problem is. And so I look through the CAD and have a look if that is a problem for them or something else so we’ll work as a team to solve it.

Similarly at Firm C work was team based as the manager described it;

It’s very much a team based situation. We’re just entering into a typical project job at the moment where we have two people who are working side by side developing the overall concept of the project. And from there, various parts of that project are then handed on to other draftsmen to fill in all the details as required.

At Firm B the teams were not well structured and workers designing products would have loose associations with other employees.

Yeah it’s strange like that. We usually work by ourselves, one person, we haven’t had much of a team. If you have a team it’s usually like you might have a fitter and a storeman or something like that. You don’t have a couple of engineers working on any one thing. Unless it hits the fan and the deadline gets brought forward or something. But this is a strange place you normally work one person to a project and then it used to take years and years to do it. You don’t work 3 people and take a year to do it.
But in this environment technical workers were responsible for all aspects of a project from conception to completion. So they were responsible for component design, pricing bill of materials and working with manufacturing to iron out any defects. Finally they are involved in the design of marketing material and selling it. As one designer at firm B put it; “We work out what it’s going to sell for talk to the salesman, technical support, sales literature. The whole works. It takes you years and years and years to even to do a simple thing because of the amount of work involved.” CADCAM users are required to carry out an increasingly wide range of tasks. They are required to be multiskilled in both technical and non-technical areas. The increase in the knowledge that CADCAM users have, has the potential to put them in a powerful negotiating position. It does not appear that either CADCAM users or their managers as yet realise the negotiating power they now possess.

Class Analysis

CADCAM users see themselves as part of a group involved in the design and development of tools, products, plants and processes, and separate from workers on the factory floor who are involved in manufacturing and maintenance of plant and equipment. From observations during site visits there is a clear divide between CADCAM users and employees involved in work on the factory floor. The exact nature of groups of CADCAM users varies from site to site. The most common structures are teams of designers and draughtsmen working together on project based work. CADCAM users have established a position in the labour market that has excellent status and prestige but does not have the status of professional engineers. As most of them work in teams on projects the skills and knowledge needed to complete a project
are viewed by management as belonging to the team as whole rather than individual technical workers.

The background of CADCAM users was predominantly from either trade or production areas. Those CADCAM user with an engineering background mainly had TAFE level qualifications and had worked in operations then moved to design and drafting and had decided to learn to use CADCAM. A fairly typical pattern of entry from a trade background was for a tradesman, in say fitting and machining, to have done some drafting at TAFE and be offered or tried to gain more drawing work in a firm. Eventually their design and drawing skills are recognised and they are given a drafting job. The older CADCAM users (except two at firm A) had traditionally used a manual drawing board and gradually transferred to CADCAM systems. The chief design engineer at firm C maintained that

All the people that are on the system were draftsmen working on the drawing board and we bought the system and migrated from the drawing board to the CADCAM system and I think the majority of them would have come from a trade background originally.

There is no clearly defined career path for CADCAM users, there are few restrictions on entry and users come from a variety of backgrounds. When asked at firm B about the background of CADCAM users one person commented;

mostly engineering, one guy’s a draftsman but we don’t seem to have draftsmen like most places have draftsmen and then engineers and then the engineers do the design work and then the draftsmen do the drawing but here ... you’re the draftsman you’re the engineer you do the whole lot and we’ve only just recently got one draftsman.
The background of the draftsman who was interviewed later was from a rigging and operations job. The engineers using CADCAM were from varied backgrounds; "...I'd say we've got two degrees and TAFE certificates or associate diplomas...a couple of guys with qualifications who can't fit into any sort of basket".

The impression gained from interviewing CADCAM users about their background and how they ended up in jobs using CADCAM is that there is no clear cut career path that leads to CADCAM. As yet manufacturers have not established any defined entry criteria apart from being able to use a CADCAM system.

However, not all manual draughtsmen had made the transition to CADCAM. In firms A and B there were still staff using the traditional boards who were either unable or unwilling to use CADCAM. "I know there is only one person or one or two people who are still working with drawing boards but they are old-timers so they have a little corner working on something". Also at firm D, E and F some work still required board drawing skills when an existing design was altered rather than having it completely redone on CADCAM.

The incidence of TAFE qualified engineers, that is technical workers with a TAFE Certificate or Associate Diploma using CADCAM was high. This is most likely because these workers did not have the status of university qualified engineers but were able to use their skills and knowledge of CADCAM to gain more status. The apparent lack of interest in CADCAM shown by professional degree qualified engineers is interesting. In two firms Firm Band Firm C the university qualified CADCAM users had started out as tradespeople. As the manager at Firm C describe him;
Yes, one example that we have here is a young man who’s currently completing his, a Mechanical Engineering Degree at the University of Wollongong, but he, over time, acquired an Associate Diploma in Engineering, and then decided to extend that to a degree. He’s still working on the CAD system and seems to enjoy that part of his work and maybe he’ll stay with it, but in the capacity of a design engineer.

Only three of the CADCAM users interviewed had university qualifications.

In terms of career paths and promotions they did not believe that it was essential to have a working knowledge of CADCAM to progress in their careers. If a designer chose a managerial/technical career path there was little need for any knowledge of CADCAM. Even if there was a career path available in an engineering/technical strand knowledge of CADCAM was not seen as essential. Some CADCAM users saw CADCAM as being essential to the future of the organisation and in almost all of the companies where interviews were conducted there was an increasing use of CADCAM and a decrease in the use of traditional drawing boards.

There appears to be no involvement by unions, or professional bodies such as engineers associations, in negotiating conditions or remuneration for CADCAM skills. It did not appear from the interviewees’ responses that they were actively involved in either a trade union or a professional engineers association. So that in working with CADCAM most workers are moving out of an award based system. This can make negotiating salary difficult as a draughtsman at firm B saw it; "It’s a funny type of system here. They have negotiation [more] than anything else. They tell you what you’re getting. Not much negotiation “. But as they are aware of the terms and conditions of award
based employees they can negotiate for themselves conditions they believe to be superior to those of workers on the factory floor. Individual workers are able to negotiate a contract for using CADCAM. However there may not be significant room for negotiating if you want to keep your job. As one worker at Firm B put it;

Well, what happens every year, you know, your boss comes into your lane and tells you what you’re getting for the next year. Like it could be a three per cent increase or something like that. But there’s not, [much discussion] you don’t really sort of negotiate in making the decisions. You’re just told.

At firm B workers had to sign an agreement that they would not disclose or discuss their salaries and remuneration packages.

you sign a thing saying you won’t disclose your salary so you never know what people earn, the obvious things like when you see a company car and that sort of thing I mean that’s pretty obvious you can’t hide that.

The draftsman at firm B believed that he had negotiated a better position than he had on the factory floor and was better off than other office staff;

I’m probably better off than most, because I when I first came into the office and that didn’t go on staff, I made the choice and said, no, not at this stage, so I still get my flexidays, I still get overtime and all that sort of thing. Where the guys on staff don’t, they don’t get paid overtime, they don’t get flexiday[s]

Similarly the subcontractor at Firm A believed that compared to a tradesperson his pay and conditions were better. He believed that he was able to negotiate rather than be paid
a standard rate; "No there's no such thing as a rate as a contractor. You bargain for what you feel you're worth and what the company can afford".

Conclusion

From the survey and interview data it is apparent that CADCAM has been used to alter the labour process. However what emerges is not clear and distinct trends. It appears that CADCAM has not been used in Australian firms to deskill workers and this will be discussed further in chapter nine. CADCAM users in some firms have had to acquire computing and computational skills that in the past were not required of draughtsmen and designers. The structure of the design process in Australian Manufacturing firms has seen draughtspeople who are able and prepared to acquire CADCAM skills increase their role in the design process. At the same time those draughtspeople unable to use CADCAM have become marginalised. The tendency throughout the manufacturing sector has been to purchase off the shelf software and modified it to suit the firms needs. The current tendency in hardware is to workstations and PCs linked on a LAN. But the LAN is not being used to assist the monitoring or control of work.

The labour market position of CADCAM users is complex. While it appears the majority have secured good jobs, many have contract positions and move from firm to firm as the demand for their services fluctuates. Those CADCAM users in good jobs would appear to be located in a segment similar to the upper tier of a primary segment as described by Piore(1978) and they have some characteristics of the craft segment described by Osterman (1984). However the characteristics of jobs are changing, as is the nature of internal labour markets in Australia.
The class position of technical workers using CADCAM is no less contradictory now than it was in the 1970s and 1980s. From the data in interviews and the survey CADCAM users are moving further away from their working class origins and becoming closer aligned to the professional middle class. The move to subcontracting is an indication that CADCAM users are establishing their own middle class businesses to sell their skills, knowledge and services. At the same time the majority of CADCAM users have come from a production and trade background which is the natural location of the working class. As professional engineers encroach upon the work of CADCAM users it may be the case that technical workers realign with the trade union movement to secure their positions as CADCAM users.
CHAPTER NINE

Technical Workers and CADCAM

Introduction

The starting point for this thesis was the view that workers are able to defend their jobs from being deskillled by employers and not all employers seek to control labour and displace skilled workers. It is often in the best interest of employers to have a highly skilled workforce and advanced manufacturing technologies require employees with high skill levels to operate them. Also employers are prepared to recognise and reward workers to keep them in an organisation and they will do this by a variety of methods.

While accepting Braverman’s argument that employers had degraded the jobs of many workers not all work has been degraded. Furthermore not all employers organise their production process in a way that enables them to control as many aspects of work as possible. To view capital as a homogenous soulless juggernaut rolling over all workers to minimise costs and maximise profits is a simplistic view that fails to consider the varying philosophies of employers and the power and abilities of workers. Workers can negotiate changes to their jobs, or are able to influence the way work is organised through methods other than formal negotiations.

Review of Theoretical Framework

The labour process literature, particularly since Braverman’s work, has been dominated by arguments that management in order to exercise greater control over the process of production is deskillling workers, separating them from the production process and creating new divisions between groups of workers. A large body of evidence has been
accumulated to demonstrate that technologies such as automation and robotics have been used successfully by management to deskill production workers. So it is argued that other technologies such as advanced manufacturing technologies (AMT) will be used to deskill technical workers and eventually remove them from the production process. CADCAM is representative of AMT and has been identified as a potential tool to be used in the deskillling of technical workers.

This thesis examines the work of CADCAM users and has sought to determine if either management, or technical workers have been able to use CADCAM technology to alter the labour process. Since its introduction CADCAM has resulted in many changes to the way work is organised. CAD has changed the work of draughtsmen and designers and the drawing board has virtually disappeared. CAM has reduced the need for skilled machine operators as machines have become computer controlled. Potentially CADCAM can be used by skilled engineers to design a component and then manufacture it on an automated multifunctional mill without any input from technical workers, tradesmen, or production workers. This assumes that engineers have all the skills and resources needed to do the job and are prepared to do it. It also assumes workers would be unable, or unwilling, to oppose this process. It needs to be established who is using CADCAM and how it is being used.

Empirical evidence is needed to determine which workers are using CADCAM are they skilled technical workers, engineers, or unskilled machine minders. The background of workers using CADCAM needs to be ascertained, are they from a trade, production, or professional background? If employers are hiring CADCAM users from a variety of backgrounds it is difficult to argue that they are increasing the technical division of labour and increasing the subdivision of work so that task become more simplified and
routine. As well as determining who is using CADCAM it is important to collect data on the characteristics of CADCAM users' jobs. The technology may already be at the stage where it is replacing skilled workers, incorporating into an expert system all the knowledge and skills of designers and enabling management to control the design and development processes.

This thesis has focussed on technical workers in Australia and the impact of technology on the organisation of their work and in particular technical workers using CADCAM. In selecting technical workers they were used because of the claims that computer-based technologies such as CADCAM where being used by employers to deskill workers. CADCAM was used as a focus because it is the interface between design and production and it can be configured in a variety of ways either ways that centralise control, or ways that allow individual control. But the decision as to how CADCAM is configured and who will operate it is not the decision of management alone. Management has negotiated both formally and informally with workers to determine what system will be installed how it will be configured and who will have the right to use it as part of their job.

The theoretical framework for this thesis encompasses three bodies of literature. The labour market literature was reviewed to establish a framework that would take into account the changing nature of jobs in the marketplace and allow for individual differences at national, regional and enterprise level. Labour market theories postulate on what is happening to labour at a macro-level to explain fluctuations and anomalies in the supply and demand for labour. So the labour market literature provides explanations of why jobs are disappearing in terms of demand and why workers are being deskilled in terms of supply. To understand what is happening to jobs within enterprises and how
work is being reorganised in the production process the labour process literature was reviewed. Labour process literature has focussed on work and work organisation within manufacturing enterprises. Labour process research has examined in detail how employers have used technologies to control aspects of the production process and the effects, deliberate, or accidental, that these technologies have had, or workers skills and tasks. A recurring theme in both these bodies of literature is the fragmentation of workers as group that has resulted in conflict between groups of workers. The apparent division amongst workers led to the proposition that a new middle class was emerging. To determine if this was occurring the literature on class-consciousness and the job classification structures were analysed. This review examined the particular case in Australia, as Australia has a unique system of industrial relations and is portrayed as an egalitarian and relatively classless society.

**Australian Labour Markets**

The review of labour market literature reveals that the basis of many theories and models of labour markets are simplistic and fails to take into account market transactions within firms. However, labour market segmentation theory with some modifications to suit Australian conditions provides a structure that can be used to explain many of the exchanges and transactions in firms. As Doeringer and Piore pointed out in their work labour market segmentation is an evolving theory so it can be modified to suit Australian conditions. Labour market segmentation provides the most appropriate means to describe the systems of job classifications within Australian firms. Labour market segmentation theory proposes internal labour markets with a hierarchical framework consisting of a number of segments and tiers within the segments. Several authors such as Doeringer and Piore, Piore, and Ostermann developed typologies that they used to explain why particular jobs were located within certain segments.
They then used these job characteristics to explain how employers could exclude workers particularly disadvantaged groups from jobs in some segments. If segmentation theory can be used to explain why some workers were disadvantaged then it can be used to explain which workers were advantaged and why they were able to gain an advantage over their fellow workers. In attempting to generalise their theory to suit a wide range of industries they ignored, or did not attempt to explain regional and national differences and did not take into account small and medium size enterprises. In Australia small and medium enterprises employ more than sixty per cent of the workforce and Australian industry operates in a unique industrial relations system that has developed over the last ninety years.

As has been demonstrated labour markets in Australia are segmented and segmentation is the result of several interacting factors. There are three critical factors. The first is the role of technology in structuring labour markets. The key to this argument is that firm specific technologies can be used to tie workers to a particular technology and a particular firm. So that firm using CADCAM and ensuring that the software is firm specific and the hardware is configured in a firm specific way will be able to ensure workers using the system are not mobile. The data from the survey and the interviews indicates that no effort has been made to make the technology specific to firms. The second issue, which is based in radical labour market analysis, concentrates on class conflict and the efforts of employers to control the labour process. This argument suggests that employers develop a segmented labour market to separate workers in desirable jobs from workers in poor jobs this reduces the possibility of workers unifying and developing class consciousness and uniting in a class struggle for better pay and conditions for all workers. From the empirical data CADCAM users worked in teams and teams consisted of professionals, technical workers, trades people and in some
instances production workers. This does not support the argument that segmentation is used to reduce class-consciousness. Although in firm B workers had to sign a document saying they would not disclose their salary to other workers. This is further supported by the work of Flatau and Lewis (1993) who demonstrated that segments in Australia were not homogenous. The resulting heterogenous segments allow for worker mobility and place few restrictions on the development of class-consciousness and class struggle.

The third argument emphasises the role of workers and their unions in the process of labour market segmentation. As unions have been traditionally craft based so that all electricians belong to the Electrical Trades Union then these organisations will act to defend jobs for their members. In defending the jobs of their members unions try to control part of the labour market by establishing barriers to entry which leads to segmentation. In the past the actions of craft based unions played a major role in segmenting Australian labour markets. With the advent of enterprise based unions and enterprise agreements unions have to defend the status quo of all union members in an enterprise. With the new wave of industrial relations legislation the role of trade unions will diminish, but the role of individual workers in protecting the status and prestige of their jobs in segmented internal labour markets will need to increase. Even if workers are unable to maintain the current characteristics of segmented labour markets segmentation will be sustained by the ongoing role of social security safety net.

In examining internal labour markets in Australia aspect of the job competition model are relevant. Once a job has been established in a segment, or cluster, workers compete for jobs on the basis of their skills and qualifications. It may be the case that workers with acceptable background characteristics such as gender, ethnicity, age and physical attributes are the only ones able to gain entry into internal labour markets, but these issues were not within the scope of this thesis. In the job competition model job
opportunities depend upon the distribution of knowledge, the sociology of wage
determination and the allocation of training costs. Within Australian firms using
CADCAM the process of design and development and to a lesser extent the
manufacturing process consists of skilled jobs, but not all jobs require the same skills,
or the same level of skills. From the data collected it is apparent that knowledge of
design and production is distributed amongst the workers. For this reason it is difficult
for management to alter the system without the agreement and cooperation of workers.
To gain the cooperation of workers management must negotiate changes, or variations
to awards, or enterprise agreements. In most cases to gain workers agreements to
variations in certified agreements employers need to accept increases in wages. This is
a clear indication of the negotiating power of workers. An example of the negotiating
power of workers was seen in firms A and C when management wanted to introduced
self-regulating work teams in manufacturing unions were able to negotiate wage rises
for all employees involved in, or with the new teams. As was demonstrated in
analysing examples of awards and enterprise agreements the sociology of wage
determination is a major factor in internal labour markets in Australian firms.

The sociology of wage determination is based on the ideal that job preferences are
interdependent and that wage expectation is relative rather than absolute. So that
workers doing similar jobs should get the same pay and conditions and workers in better
jobs should get better pay and possibly conditions. This was the case in Firm B where
the rigger who was promoted to drafting expected to have better pay and conditions than
workers were getting on the factory floor, but did not expect to earn as much as a
university qualified engineer. There is a clear expectation underlying awards and
enterprise agreements that there should be equity and fairness in wage expectations.
Finally the allocation of training costs have an important role in determining the job
opportunities available. Workers who can bear the cost of training can open up job opportunities for themselves while workers who cannot, or are unable to, bear the cost of training have restricted job opportunities. The increase in job opportunities was evident in Firm B where the engineer who was interviewed had started his worklife as a tradesman and put himself through university part time. As a university qualified design engineer his promotion and job opportunities were better than less well-qualified workers. Similarly in firm D two of the production workers had completed CAD training course in their own time and at their own cost. They were able to use the CAD system when there was a backlog of work to be done, or when the regular designer/draughtsman was on leave. This gave them experience in using CAD and open up the possibility of more work in the CADCAM area. So that once internal labour markets are established and jobs are allocated to particular segments, or clusters workers compete for jobs by acquiring skills and qualifications. An understanding of the formal nature of internal labour markets can be gained from awards and enterprise agreements.

A formal description of how parts of internal labour markets are structured in Australian firms can be found in awards and enterprise agreements. Awards and enterprise agreements are negotiated agreements by trade unions on behalf of workers and they are usually the result of formalising past custom and future practices. While Doeringer and Piore argued that custom was only a passive factor in segmenting labour markets in Australia when custom is formalised in agreements it becomes an active force. That is custom in awards can become an area of conflict if management seeks to change any without consultation, but it can also be an area of trade-off in negotiations. Workers are prepared to trade-off outdated customs during wage negotiations if they believe it is in
their best interest. It is more usual though for custom to be a passive impediment to change.

The current system of awards, enterprise agreements and workplace contracts have evolved out of an industrial relation system that is unique to Australia. An analysis of Job Classification Structures contained in awards and enterprise agreements reveals that at least formally internal labour markets consist of several segments. An examination of a sample of Job Classification Structures containing jobs of CADCAM users describes which workers can access CADCAM users jobs and what skills and qualifications they need to access these jobs. The examination also reveals that these jobs are relatively well paid, have good working conditions associated with them and are regarded as highly skilled. The good pay and conditions are reflected in the low staff turnover. The low turnover is also an indication of other intangible factors such as working with the right people and fairness and equity in work rules. While an examination of documents such as awards establishes the formal structures further empirical work needs to be carried out to determine if the formal description is an accurate description of what is happening within Australian firms using CADCAM.

The Federal government argues that to survive in a highly competitive global market place Australian businesses need a flexible deregulated labour market. So perhaps it is the case that more employers are seeking to degrade workers skills and replace them with computer based technologies. Perhaps the current wave of industrial reform in Australia will destroy the power of unions and do away with the last remnants of collective bargaining. Once awards and enterprise agreements are replaced by individual workplace contracts and unions are prohibited from representing groups, or individual workers then each workers is on their own. So will it be the case that
powerless workers negotiating with all-powerful employers will find that employers extract more and more surplus labour at lower costs. It appears that this is increasingly the case as we are told workers are working longer hours and unpaid overtime for no extra pay or rewards. Unemployment has dropped from a high of 12 per cent to 7 per cent and manufacturers are experiencing a shortage of skilled labour. This is the case in many developed economies where high value added manufacturing such as microelectronics, automotive industries and aerospace companies need a highly skilled work force. Trades people such as fitter and turners and mechanical engineers are in short supply. These skilled trades and technical workers are able to demand and get increased wages so perhaps employers are not as powerful as they appear.

The Labour Process

Much of the labour process and labour market segmentation literature examines the organisation of work in North America and Europe. Within the Australian context neither body of literature has focused on the role of workers and other actors such as unions and governments and how they can shape labour markets and the organisation of work. This thesis examines and challenges some of the arguments concerning technical workers and technology put forward by labour process researchers. The examination is carried out within the framework of labour market segmentation theory. This is based on the assumption that the labour process does not operate in isolation, rather it operates within the internal labour market. If the labour process is altered in significant ways then this will have an impact on the structure of the labour market. Similarly because of the interrelated nature of labour markets and the labour process if labour markets are altered significantly this will enable major changes in the labour process.
This thesis has established that much of the labour process literature has tended to overemphasise the desire, ability and the success of employers to deskill workers and control all aspects of the process of production. In particular the literature failed to fully take into account the knowledge and skills of technical workers and the power that workers have because of their technical expertise. The early debates on technical workers in the labour process were inconclusive as they focussed on the question of the class location of technical workers. Rather than address the issue of technical workers and their role in the labour process they became a debate about whether they were part of capital, or part of the proletariat. Labour process theorists have downplayed the role of workers in opposing management’s attempts to control the process of production and they assume that workers have nothing to gain from, nor do they wish to have, new divisions created between groups of workers. Similarly much of the labour process literature appears to deal superficially with the exchange process, where workers exchange their capacity to work in order to be allocated a job within the labour market at a negotiated rate of pay. The market mechanism means that workers with few, or no, skills are paid less than workers with scarce, or highly valued skills who are able to negotiate higher wages and better conditions of employment for themselves.

The labour process literature has painted an accurate if at times depressing view of monopoly capital and Braverman remains an influential figure in the labour process debate. The scale of production in most large enterprises means that workers, technical, trade or manual do not own the means of production. However, this is not a recent phenomenon. The advent of the factory system deprived artisans from owning the means of production. Individual craftsmen, tradesmen and artisans did not have sufficient resources to establish factories even if they wished to do so. The key impact of the factory system is not that it is an arrangement of machines, tools and technologies
but a system of organising work. Braverman recognised that factories had altered the way work was organised and he emphasised that the factory production system had altered social relations and enabled employers to impose their will. But Braverman maintains that workers opposed Taylorism as a means of sub-dividing labour and capital was not capable of transforming the whole labour process. There is no doubt that manufacturing enterprises in developed economies have altered social relations of production and enabled employers to impose their will on workers.

Work is a social activity and workers in large enterprises still need to interact and develop social relationships. In Australian factories, social relationships are now rarely based on families as they were in the past rather they are more broadly based on ethnic, or occupational groupings. On the factory floor with highly automated systems that force the pace of work there is little opportunity for production workers to interact. With the move to multi-skilling and teams in many firms the social interaction workers is changing. The social interaction is increasing, as workers need to communicate for teams to operate effectively. Technical workers working in project-based teams regard working with a variety of people as important. At present social relationships of technical workers are still important and management has not introduced technologies, or work practices that diminish theses relationships.

That employers impose their will on workers is not surprising because as Braverman emphasised capital must transform and control labour if it is to fully realise the potential of purchased labour. Labour process theorist argue that to exercise control over labour it is in employers best interest to increase the technical division of labour by sub-dividing tasks into simple routines that can be done by automated machines, or poorly paid unskilled labour. This view fails to recognise two things. First, it is not always
possible, or even desirable, to make all aspects of work into simple routine tasks. If all
design work was routinised and simplified it would remove the creativity from the
work. If designers did not have an understanding of product design and the process of
manufacturing they would be unable to come up with new and creative solutions to
design problems. It is not employers who come up with new products and concepts it is
designers and engineers. Second, to fully realise the potential of purchased labour
capital needs to extract value in terms of goods produced and ideas and concepts
generated. From the interviews it was evident that employers were able to extract value
from their employees by purchasing a basic CADCAM system and then expecting
workers to come up with creative ways of using it to solve problem. In almost all cases
CADCAM users were working in their own time on increasing their output from the
CADCAM system. Workers joined users groups, attended TAFE classes, sought
solutions through user groups on the Internet, or worked at home to prove to themselves
that they could master a problem. Employers rather than pay for expensive training,
organised work so that employees are able to learn from one another. Over the last
twenty five years since Braverman wrote his book the level of technical complexity of
manufacturing firms has increased. Factories are an array of high technology computer
controlled devices. In an environment of high technical complexity, Osterman (1995)
and Barley (1996) maintain there is a need for more skilled labour. Firms that design
and develop new products need technologies such as CADCAM and to operate these
technologies they need skilled technical workers.

Many labour process theorists have focused on deskilling and ignored other important
issues. Deskilling arguments failed to take into account workers resistance, strategies
for protecting jobs, the size and structure of firms. While it is widely accepted that craft
workers such as printers have used strategies such as social exclusion to protect their
craft it is assumed because printers were unsuccessful in saving their craft tradition social exclusion was a failed strategy. But social exclusion is used in segmented labour markets to keep disadvantaged groups from entering the internal labour market. Inside the internal labour market social exclusion can prevent groups of workers from gaining access to jobs in particular sectors. For example very few women operate CADCAM in factories. While women are gradually being accepted into trades and engineering roles there are still customary practices which exclude women from jobs. So social exclusion can be used to protect jobs for long periods of time. The size and structure of firms are also important when considering the labour process and the organisation of work.

Management in large firms with several thousand employees may believe that the only way to manage the labour process is by monitoring and controlling workers. In small firms with twenty to one hundred employees everyone may be part of a social work unit that sees no need to monitor and control because everyone knows what is happening. In a participative workplace where employees with one years service can gain shares in the company, workers may feel a sense of ownership so that they all work to their full potential and there is no need for controlling labour. The structure of a company can have a significant impact on work organisation. Firm A has an interesting multi-disciplinary team-based structure were the barriers between divisions are weak. When they are tendering for new work they put together a bid team from manufacturing, engineering design and marketing to work on the bid. If they win the tender then the team is modified to include more manufacturing and engineering personnel and the marking staff move to another team. Workers rotate through project teams and are encouraged to work on a range of activities. On the factory floor work is also team-based and workers are rotated through different jobs to reduce occupational health and safety issues such as repetitive strain injury which is common. Team structures and
practices such as rotating staff create a dynamic culture were workers are able to interact with a wide range of people at all levels in the organisation. With such a dynamic structure control and monitoring are hardly desirable let alone feasible. In firms with strategies that enable the deskilling of workers such as moving offshore to low wage countries, or moving interstate, to regions with little, or no union organisation is usually limited to high volume low cost goods such as clothing and footwear. In technologically complex manufacturing industries it is not cheap, or easy to move a factory that needs highly skilled workers and access to skilled maintenance and support systems. So it has been demonstrated in this thesis that capital is not all-powerful and there are real constraints on capital's ability to dominate. In developed economies such as Australia there have been shifts in power of workers and employers and work has been reorganised. In manufacturing there has been a realignment of skills rather than simply a process of deskilling.

The labour process is not a static process rather it is a dynamic process. The nature of management practice is changing to keep up with changes in product markets and alterations to the position of competitors. The way work is organised has evolved to keep pace with market changes and these changes mean that job have to be designed differently. Australian firms are not isolated from this changing environment and they have had to respond to these changes. In the last thirty years they have reduced their workforce, introduced new technologies and work practices. All these changes have altered the jobs of workers and the way managers operate. The outcomes of the changes are determined by four factors according to Child (1987). The factors are the strategic purpose of the technology, the employment and job design requirements, the integration and control and the role and structure of management. So if an employer has a deliberate strategy to use technology to deskill, or displace workers he must select a
technology that can be used for that purpose. Then he needs to ensure he can employ workers to operate and maintain the technology then design their jobs so he can establish control and integrate the technology into the labour process. Finally management must be structure in such a way that managers can have a control and supervisory function that will ensure they maintain control and workers are unable, or powerless, to wrest aspects of control from management. The way managers behave is partly determined by cultural, social and historical factors as well as their education and training. In the empirical data there is no indication that managers were introducing, or using CADCAM with a deliberate strategic intent to control and monitor workers, or to displace skilled workers with unskilled workers.

**Technical Workers**

The changing and dynamic nature of new technologies has seen the emergence of a growing workforce of technicians and technical workers who are able to operate and maintain advanced manufacturing technologies. Technical workers occupy a contradictory position within both labour markets and within class structures. Class analysis provides a deeper understanding of the complex hierarchies of authority and control that impinge on technical workers. The predominant European literature has done little to clarify the position of technical workers because of its contradictory views of class and the contradictory roles of technical workers. Technical workers do act on behalf of management in operating and programming machines that have been use to displace production workers. But in this thesis has demonstrated that technical workers are recruited from a non-professional background and technical workers operating CADCAM are recruited from the factory floor, trades and engineering backgrounds. In analysing the class-consciousness of CADCAM users they are more closely aligned to trade and production workers than professionals or management. As Wright (1977)
pointed out class relations in capitalist societies are determined by three control mechanisms, control over labour power, control of the physical means of production and control of resources and investments. Technical workers as employees do not exhibit control over these three mechanisms. Although they can exercise some control over their own labour power. Subcontractors are able to exercise more power and control than permanent employees.

Interviews made it apparent that many CADCAM users were still members of trade unions and few were members of professional associations. But as Wright (1977) noted there is never a clear cut division of labour and there is usually some overlap. The class-consciousness of Australian workers and managers is not as strong, or as evident, as the class-consciousness of European workers. In a predominantly egalitarian society with no hereditary ruling class and a "national character" that in the past was based on a "fair go" and equity militant class-consciousness plays a relatively minor role. But the nature of the Australian character is changing, the role of trade unions is changing and weakening as few young people join unions, or understand the relevance of the trade union movement in an affluent society.

In an industrial environment where workers are employed on individual contracts are forbidden to discuss the terms and conditions of their contracts, they can still negotiate fair and equitable conditions. While a large trade union with thousands of members can wield more power than five or six workers, it is still possible for a few workers to influence the organisation of their work. They can still develop customs and organisational structures that enable them to exercise control over many aspects of their job and as a group they can have an impact on the process of production.
Workers unlike machines and computers are not mindless drones. Employers need and will continue to need workers with knowledge, skills, discretion and creativity. When a manager buys a technology and installs it on the factory floor he, or she, is often creating more problems than they are solving. It is not management who solves the problems, learns how to operate the new technology, adapts it to the production process, maintains and repairs it when it breaks down and teaches other workers how to program it and operate it. It is workers in the design office, in maintenance, in engineering and on the factory floor who develop the skills and knowledge required to optimise the technology.

**CADCAM and Work**

While CADCAM technology has been developing and increasing its complexity there have been few changes to the work patterns, or jobs of CADCAM users. The main changes that have taken place in hardware are faster systems and improvements to networking including the capability to link to systems throughout the world through the Internet. There have also been improvements to input devices such as scanners and output devices such as printers and plotters. The major changes that have taken place are software improvements. The move to a windows based system such as Windows NT has improved the "user friendliness" of CADCAM. The computing skills needed to operate a CADCAM system are at a lower level as users do not need to know a large number of commands required for DOS based systems. Although the windows interface makes it easier for users to interact with the system, the systems have become more complex as software developers attempt to incorporate more and more functions into a system. However, it appears that in Australia at least, many users, or the companies buying CADCAM systems are more interested in basic systems with a user friendly interface than complex systems with a large number of add-on functions. This may in part be because of the cost of complex systems, although in relative terms the
cost of a system has decreased they are still expensive compared to traditional drawing boards. Although the number of businesses using CADCAM, or part of a CADCAM system is increasing there appears to be few high-end users.

It is apparent that technical workers and management have not dramatically reshaped work processes, or the relationships of technical workers within the internal labour market in response to changes in drawing and design technologies. Regardless of the way the technology both hardware and software is configured the characteristics of CADCAM users jobs are not significantly different. So that worker using turnkey, or customised software both have similar job characteristics. The skills required of CADCAM users are different to the skills required of technical workers prior to the introduction of CADCAM. There is some evidence that some technical workers have been unwilling, or unable, to develop the computer skills needed to operate CADCAM systems. However, the level and types of skills needed are still changing and the development of Windows based systems may increase the number of users, as the systems at least on the surface appear to be more accessible. Those workers who have not changed to CADCAM systems are still able to find work on traditional drawing boards as many firms still use or modify traditional drawings and plans.

Results and further research-
The empirical data indicates that highly skilled CADCAM users need knowledge of manufacturing and engineering functions. So technical workers from trade and production backgrounds with good computer literacy are ideally suited for jobs as CADCAM users. It is the case that blue-collar workers regard jobs as technical workers as prestigious and these jobs have a better status than jobs on the factory floor. CADCAM users jobs are located within an upper tier of a primary internal labour
market. As such they are relatively secure and regarded as well paid with good working conditions. It is apparent that in the firms responding to the survey the technology is being used in inclusive rather than exclusive ways. That is a worker with the necessary skills and knowledge is able to gaining jobs as CADCAM and entry is not restricted to one occupational grouping, or a technical elite. At least within this group of Australian manufacturing companies CADCAM users are highly skilled and autonomous workers. No obvious effort has been made to deskill workers using CADCAM. The level and amount of training and the importance that users place on training are a clear indication of the skill level of CADCAM jobs.

There is a range of opportunities for technical workers to access training and develop the skills needed to operate CADCAM. It is important to note that they have selected strategies to share knowledge that are similar to strategies used by craft workers in the past. So an important aspect of teamwork is that technical workers can learn from professional engineers and other more skilled CADCAM users and they have been able to acquire the skills necessary to carry out engineering tasks. This can be regarded as upskilling for those workers who incorporate these tasks in to their day to day work.

Rather than professionals wresting total control of the design and manufacture of products from workers by using CADCAM professionals are avoiding CADCAM. Given the background that most workers are recruited from it is difficult to see them aligning themselves with management. If CADCAM users were in conflict with their employers they would most likely align with workers from the trades and operations areas. While they may at times have supervisory roles it appears that CADCAM users, as technical workers would see themselves as a part of the working class. These results
are indicative of the contradictory class position of technical workers. In terms of their qualifications and background they are neither professional middle class nor are they clearly working class.

National and regional differences in management philosophy and style and the negotiating power and ability of the workforce to influence management plays a role in how work is organised and technology is implemented. It has long been common practice to employ additional draughting people when there is a build up of work and then to let them go when work declined. So this practice is continuing with the employment of contract CADCAM users. But the employment of contract labour is a response to labour market supply and demand rather than a deliberate strategy to destabilise the workforce. The variation in employment conditions is not a tactic to locate technical workers in a less secure segment of the labour market, but a flexibility strategy used to meet fluctuations in demand.

Technical workers have used awards and enterprise agreements by to ensure that jobs involving CADCAM are secure and well paid. They have attempted to restrict access to CADCAM work by having entry criteria based on advanced trade qualifications written into awards. But such is the flexibility of awards that production workers without trade qualifications, but with computing skills, have been able to gain jobs as CADCAM users. With the drive for industrial relations deregulation in Australia awards and enterprise agreements will have less of an influence on work organisation. While the imposition of negotiated formal rules in awards will diminish the significance of informal rules and practices will increase. For technical workers using CADCAM this will mean they will have to use informal custom and practice to influence the organisation of their work. It will probably mean they are able to negotiate improved
pay and conditions if they realise the powerful negotiating position they are in. They may also choose to strengthen their power and position by excluding workers such as production workers from CADCAM jobs.

Since the late 1990s there has been little discussion in the academic literature, particularly in Europe and the United Kingdom, concerning technical workers and new technologies. This in part due to researchers in the field moving on to other areas and partly due to the lack of dramatic impacts, that were predicted, of technologies such as CADCAM. These technologies have not impacted on the jobs of technical workers to the same extent that automation and robotics altered the work of workers on the factory floor and the role of trade unions in Europe has greatly diminished. Areas such as the Internet, e-commerce and e-business have replaced or displaced advanced manufacturing technologies from the academic discourse on work and work organization. The emergence of virtual organizations, and the rise of networked projects and businesses are seen as having greater potential impacts on work and jobs than technologies such as AMT. The focus of this thesis has been on an examination of CADCAM in engineering firms, because at the time the empirical data was collected these firms were the dominant users of CADCAM in Australia. An examination of CADCAM in different sectors such as electronics and information technology firms may reveal significantly different results. Firms such as these in Australia have different customs and structures compared to the more traditional engineering and metal industries.

Several issues have been raised in this case study of technical workers in Australian manufacturing firms that are worthy of further research. One area for future research would be an examination of the ability of technical workers to use social exclusion to protect their jobs. This thesis has not examined the exclusion of groups such as women,
disabled workers, or ethnic minorities, but research in these areas would be fruitful. Further research will need to be done on the impact of industrial relations regulation on the jobs of technical workers. Such research could provide early evidence on the impact of deregulation on the jobs of production workers as many technical workers have been on individual contracts for several years and there has been an increasing tendency to use employment contracts for CADCAM users. This thesis has focussed on technical workers within the Australian context. So comparative research would reveal if similar trends and conditions exist in other national setting such as Europe and North America. It would be worthwhile to examine the class-consciousness of technical workers in the United Kingdom and the United States and determine the influence of varying systems of industrial relations and the effects of "national character" on the technical work. A more detailed investigation and analysis of experiences of CADCAM users in other countries may reveal that there is not a specific Australian model emerging. Rather if an analysis was conducted based on variables such as firm size or level of globalisation it may emerge that structural rather than regional differences are important and this area deserves further investigation.

Conclusion

This thesis has argued that employers are not using advanced manufacturing technologies such as CADCAM to alter the power relationship between capital and labour and work of technical workers in Australian labour markets. This thesis began by examining the debate in the literature that tries to explain why employers need, or want, to exert control over the production process. If employers have used CADCAM to alter the work of skilled designers then technical workers will have been displaced, or have become machine minders. While there was some empirical evidence of deskilling and displacement of production workers there was little empirical evidence that this has
occurred to technical workers. Much of the existing research examined the way that CADCAM can be used, but failed to contain a detailed description of the technologies and how they can be configured. It is important not only to understand the process within which the technology is used, but also the possible ways the technology can be implemented and how it has evolved. There was also a need to provide empirical data on how workers perceived their jobs and the characteristics of jobs using CADCAM. It is technical workers using CADCAM who are best positioned to determine how their work and jobs have been affected by a technology. This thesis examined the jobs of technical workers within the Australian context, as it was necessary to consider the differences between firms in Australia and firms in the Europe and North America using CADCAM. This was done because Australian employment relations arrangements are unique and large monopolistic manufacturers in the USA and Europe are very different from medium and large Australian firms. The empirical data in this thesis supports the view that technical workers in Australia are workers from trades, operations, and non-professional engineering backgrounds. That technical workers have used their knowledge and skills to gain access to jobs as CADCAM users and they have used their negotiating power to locate these jobs in a secure upper tier of a primary segment of internal labour markets. Further technical workers have a contradictory class position, but at present they are more closely aligned to their traditional roots in the working class than to the middle class.
APPENDIX ONE

Preliminary CAD/CAM Visits

The visits are carried out for two reasons firstly to clarify some issues raised by respondents in questionnaires and secondly to provide more detailed information on the selection use and development of CAD/CAM in each organisation. The interviews also provided an opportunity to determine if the claims made by respondents in answering the questionnaire matched up with the researchers impressions. In the main the interviews were unstructured and no attempt was made to restrict the information provided by the interviewee.

Interview One: Firm 1. Smithfield

This organisation manufactures aluminium windows and at present only use CAD to design the aluminium extrusion for window frames. It was felt that labour was only a minor cost in the fabrication process so that it could not justify the purchase of a CAM system and associated CNC machinery.

There was only one person permanently involved in design. Although at present they were advertising for a draughtperson who was familiar with CAD to work in the design area. The designer convinced senior management to purchase a CAD system. He justified the purchase on the cost saving. At the time the firm was sub contracting design work and the yearly cost of subcontracting was greater than installing a P.C. based CAD system. The method used to select the system was based on a detailed
tender document the tender document was made available to suppliers who then priced systems that they felt could meet the companies specifications. Once the tenders had been submitted the most suitable suppliers were selected and required to demonstrate the capabilities of their systems. It was stressed that there is often a discrepancy between suppliers claims and the actual capabilities of their system. Although the head of design selected the system he had to justify his selection to senior management, engineering section and head office computer section. The justification used other than cost reductions were, reduction in time lag between design and manufacture, improved production and drawings. The designer felt the greatest benefit came from being able to check and alter details on the screen. The system increased the speed of drawing and modifications can be easily made. The system selected was an IBM P.C. with sensor pad using CADKEY software.

One of the problems which was encountered during the selection procedure was the lack of computer literacy on the part of senior management. There is also a lack of understanding of CAD systems among workers both in design and production. This results in problems when attempting to recruit computer literate designers and draughtpersons. The usual practice within organisations is to retrain personnel to use CAD. The head of design had a background in engineering. Although the organisation was undergoing expansion the only area that the design engineer could see an increase in computers was in the use of PLC controlled machinery. Overall as there was no apparent senior management push to CAD/CAM it would appear that this firm would not expand into this area under the current management.
Interview Two: Firm 2, Campbelltown

The interview was conducted with a computer integrated manufacturing engineer. He explained that elevators are very customised and each building has to have an elevator designed to fit its particular requirements. Although the organisation use a mainframe based CAD/CAM system for design drawing and production of tapes for NC machines, the system appear to have reached its full potential. The basis of the system is almost 14 years old as it was first introduced in 1976. While the system is working to its capacity this is only possible because of a series of software and hardware updates. As the system was initially installed in 1976 it was not possible to ascertain the major input in system selection. However, as the system was upgraded the criteria used to select new software and hardware included: solving system problems such as database of parts, improved drawing techniques and response time, speed of design and drawing, compatibility with NC machines and cost effectiveness of the system.

The design and draughting staff would like to see an entire new system replace and current system. In particular it would help if there was a relational database management system (RDBMS) that would tie design into purchasing and manufacturing. There would appear to be little use at present of any software which would enable complex engineering analysis such as stress analysis.

Training was done within house. The Campbelltown plant was attached to the companies main training centre. Although attempts were made to attract computer literate staff it was not necessary for design and drafting personnel to have experience with CAD/CAM. The training time for staff to become familiar with the system was about one week. The company valued skilled staff and there was a formal allowance paid to staff using CAD/CAM.
On the shop floor most of the work, 90% is done in sheet metal the NC machines consist of; two mills developed by the firm, a drilling machine, a Hitachi lathe, two Amada punches, a specialised engraving machine and a small welding robot on an assembly line. The main reason for introducing AMT's (Advanced Manufacturing Technologies) was to reduce labour cost and maximise the return on investments. Overall it was felt that there had not been any major changes in the tasks carried out by workers, but there had been some upskilling. Most workers had been with the organisation for a long time. Some workers left because of changes introduced. In the design office staff had left when they were unable, or afraid, to use computer based systems. Some draughting staff felt that the use of plotters had the effect of making everyone's drawings the same standard. There was no room for creative excellence.

**Interview Three: Firm 3. Milperra**

Firm 3 is part of a large organisation. It is a specialist machinery and component manufacturer which has a large commitment to manufacture machinery and parts for McDonald Douglas Aerospace division. Although the firm has only been using CAD for four years it has a strong commitment to its use and development. The system selected in a McDonald Douglas Mainframe used in conjunction with IBM based CADKEY. The system was selected after pressure from McDonald Douglas U.S.A. The system allows the direct transfer of design information to the CAM section on the shop floor. The firm makes extensive use of NC and CNC machinery. Data and programs are sent directly to machinery from the CAM section. On the factory floor supervisors can access, but are unable to alter programmes on the CNC Machines. The NC and CNC machines include drills, saws, lathes and several sophisticated mills. One of the major reasons the firm has for using CAD/CAM is to reduce costs and lead times. This is essential if they are to remain competitive in the international market place.
Although the value of the Australian dollar is an important factor the ability to produce a quality high precision product quickly is paramount.

The problems experienced by the organisation are varied. They include a lack of skilled staff which required in house training, and the lack of an established database of available parts and designs. It was felt that it would take at least five years to learn how to fully utilise the system. Overall the system was costly to maintain. The programming was done by design staff who had a background in engineering as there was a lack of staff with backgrounds in computers.

Initially the firm started with a Gerber CAM system and then after pressure from customers bought a CAD system. The system purchased included a software update option which allows the firm to update packages at minimal cost. The cost of software was high with some specialist packages costing over $25,000. At present the system used six basic software packages. However, the potential of these packages was not being fully utilised.

The Cam system was used by engineering staff who had trained on the shop floor. For this reason they felt that a knowledge of what really happens on the shop floor was essential. In recent times as the CAM users have less contact with shop floor and new machinery sales people there has developed a gap between what is available and what is being used. There was a suggestion that there was quite a high turnover of workers who used the CNC machines. On further questioning it was felt that this was partially due to repetitive and boring nature of the work. The only control function available to the machine operators was to push three buttons.
Overall Firm 3 is a good example of a specialised manufacturer using advanced manufacturing technologies to remain competitive. There were strong indications that there was a lack of skills in the senior management, that would enable a more successful approach to introducing AMT. Several other divisions and the head office had purchased CAD/CAM systems, but no effort had been made to ensure that the systems were compatible. It would appear the each division purchased a system that they were convinced suited them.

If systems were compatible the transfer of information would be faster and cheaper.

**Interview Four: Firm 4. Fairfield**

Firm 4 is a manufacturer of specialists components for cars including transmission and axles. The selection process involved users suggesting what they wanted the vendors demonstrated what was available. The draughting staff had little input into system selection as they were only asked for suggestions. The main decision was made by the managing production engineering in conjunction with other engineers and the MIS managers. The final decision was made by senior executives. The system selected used CAD packages designed in Japan. The main reasons used to justify CAD included, reductions in lead time, and increase response to customers demands. In particular CAD allows the firm to produce a prototype quicker than other methods. CAD has also increased the flexibility in design drawing and ensures a constant quality of repeated drawings. The firm felt that they had experienced few problems while implementing CAD. The draughting staff had little to do with CAD which was mainly used by engineering and design staff. The training of users was fast taking only two to four weeks as most staff were familiar with computers. At present the company were slightly behind in software since the software ahs to be tested at Fujitsu in Japan. If the
software has to be altered after it has been used in Australia this must be done in Japan. So that it has to go through several development steps before it can be used effectively by BTR. The system uses individual workstations linked to a central IBM mainframe. There have been no problems with the mainframe, but some difficulties have been experienced by users of the work stations.

The system consists of the IBM mainframe and dumb terminals as well as stand alone work stations and intelligent terminals. As well as this and firm use one version of AutoCAD to modify drawings as required. The main system consists of eight Falcon stations, 16 Uni-graphic stations and these use Micro CAD/CAM. The system is served by three plotters; pen plotter for high quality, work electro static plotter for speed and checking and a dot matrix printer. The dot matrix printer can print via a modem directly from the mainframe although transmission is slow and the actual drawing is fast.

The firm is mainly using CAD and has experienced few changes in the tasks carried out by a design and draughting staff. A part from using the work stations and keyboards most work is virtually the same. The firm is still developing their system and hopes to integrate 3D and 2D in the near future. Staff are at present being trained for 3D drawing. Eventually the engineers will be able to use solid modelling. There are no personnel involved in writing programmes for the system at present.

The main CAM machinery are NC lathe's which only do simple jobs, at present there is no need for CNC machines. The firm uses long runs to produce customised product. These are made on a simple assembly line in which does not require major changes to manufacture a new product. As the organisation is limited in the products they
currently manufacture there is little push to use other advanced manufacturing technologies.
APPENDIX TWO

A. CAD/CAM PROFILE

1. What are the main products made by your firm?

2. How many employees do you employ?

3. How long has your firm been established?

4. Which type of production technology does your firm use?
   □ Unit
   □ Mass
   □ Process
   □ Other, please specify

B. How would you describe the following conditions of CAD/CAM users, you may tick more than one.

Remuneration
   □ Salary (Fixed)/Wages
   □ Hourly rate/Casual rates

Employment
   □ Permanent
   □ Contract
   □ Full-time
   □ Part-time
C. Which of the following are relevant to CAD/CAM users?

Points of entry to the job

- Restricted
- Unrestricted

Promotion structure

- Clear and well define
- Poorly defined
- Variable

Promotion based on

- Merit
- Seniority
- A combination of both

Career paths

- Mainly within the firm
- Available throughout the industry

Opportunity for appointments from outside your organisation

- Restricted
- Unrestricted

Work rules

- Clearly defined
- Variable

Job descriptions

- Clearly defined with no overlap
- Considerable overlap
- Some overlap
Absenteeism

- High
- Moderate
- Low

Punctuality

- Excellent
- Fair
- Poor

Staff turnover

- High
- Moderate
- Low

D. How would you describe the job of CAD/CAM users?

- Highly skilled
- Skilled
- Unskilled
- Repetitive
- Creative
- Boring

E. From what area are most CAD/CAM users recruited?

- Computing
- Engineering
- Design
□ Trades

□ Factory floor other specify.

F. CAD/CAM Staff Training

What type of CAD/CAM system does your firm use?

□ PC based system

□ Stand alone work stations

□ Central computer (mainframe)

What software packages are you using?

□ Specifically designed for firm turnkey software

□ CADAM CATIA

How many terminals are used for

□ Draughting

□ Design

□ Engineering

□ Other

How many people work directly with the CAD/CAM?

□ CAD

□ CAM

□ CAD/CAM
What is the minimum educational level for entry into a CAD/CAM job?

- High School
- TAFE
- University
- Other

How many hours do staff spend in initial training?

- 1 - 20 hours
- 21 - 40 hours
- 41 - 60 hours
- 61 - 80 hours
- more than 80 hours

What type of training do CAD/CAM staff undertake?

- Formal training outside
- Formal training on-the-job
- Informal training on-the-job
- No training

Who conducts the training?

- Other workers
- trainers
- supervisors
- trainers (external)

How would you rate the following aspects of your job

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<th>Neutral</th>
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<td>Feature</td>
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<td>Job security</td>
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<td></td>
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<tr>
<td>Guaranteed career path</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>Above average salary</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>Working under close supervision</td>
<td>1 2 3 4 5</td>
<td></td>
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<td>Low staff turnover</td>
<td>1 2 3 4 5</td>
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<td>Merit based promotion</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Being able to make decisions</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Being able to wrk as part of a team</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>Specific training in CAD/CAM</td>
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<td>Seniority</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Being able to alter existing CAD/CAM systems</td>
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<tr>
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<td>Working with a wide range of people</td>
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<td>Being able to use your initiative</td>
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<tr>
<td>Being able to solve problems</td>
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How relevant are the skills used in this firm to skills used in other firms?

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How common is entry into this job from outside the firm?

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</table>
How common is it for staff to transfer to your position from other areas within the firm?

Very Common Neutral Uncommon Uncommon

1 2 3 4 5

G. What other aspects of your job are important?

H. If required, who could we contact for further information?
APPENDIX THREE

Conciliation and Arbitration Act 1904

In the matter of the

Metal Industry Award, 1984 - Part I (1)

[ODN C No. 2568 of 1984]

1 - TITLE
This award shall be referred to as the Metal Industry Award 1984 - Part I

2 - ARRANGEMENT

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Commitments to reform

Comparative schedule of old classifications and new broadbanded levels

Construction allowance: A.I. & S. Project, Port Kembla

Construction allowance: BHP Company Limited, Newcastle

Contract of employment

Crib time

Crib time - holidays and Sundays

Daylight saving

Date and period of operation

Definitions

Dismissal from employment

Dismissal disputes procedures

Distant work

Drinking water

Emergency provisions

Excess travelling and fares

Extra rates not cumulative

Fare allowance - air-conditioning industry

Females

First aid allowance

First aid attendant

First aid outfit

Foundry disability allowance

Hearing aids - damage to

Holidays

Holidays - absence on working day before or after
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Wage rates - adults
Wage rates - juniors
Wage rates - apprentices
Washing and sanitary conveniences
Watchman and/or gatekeeper (NSW only)
Year of service - definition
Interview Questions

Section A

What hardware is used in the CADCAM system?

How is the system configured?
Stand alone mainframe, LAN
Is the system transparent

What software packages are being used? (Are these off the shelf or custom designed packages?)

Why are these your preferred software?

What are the mainly used for:

- design
- drafting
- analysis
- modelling
- 3D prototyping?

Is the system flexible?
Section B

What is the background of CADCAM users?

☐ Design
☐ Drafting
☐ Engineering
☐ Operations

Are they mainly TAFE or University qualified?

How are cadcam users trained?

Is training an important aspect of your job?

How is the work of cadcam users monitored?

Do you have performance measures for either the individual, team, business unit or is it all project based?

Has the work done by cadcam users changed over the last 5-10 years?

How has the work changed?

Would you see conditions as improving or getting worse?

What are the best and worst aspects of your job?

How are CADCAM jobs regarded in the company are the seen as critical or really not all that important to getting the work done?

Do you think they will become more or less important in the future?
Section C

How are CADCAM jobs organised?

Is most of the work project based?

Are there any barriers to entering CADCAM jobs?

Do CADCAM users work as a team or is it mostly individual projects?

Are you encouraged or are you able to:

☐ Make decisions

☐ Work autonomously

☐ Use your initiative

☐ Work without supervision

☐ Improve your work skills

☐ Work intuitively

☐ Upgrade your skills

In terms of promotion and career paths do you see a future in jobs using CADCAM?

What would enhance or improve your opportunities for promotion?

In terms of a career path in design have you come up against any obstacles to your progress?

Is it possible for CADCAM users to influence the way the system operates and to suggest and implement improvements to the system?
Does your professional association or union get involved in discussions/negotiations about the influence of technological changes on jobs and career paths?

How do you think awards and changes from awards to enterprise agreements will or have had an influence on your work?
APPENDIX FIVE

APPENDIX 5.1

Mapping which includes cartography, surveying, land information, terrain and geological-modelling, mineral exploration and mining analysis.

Architecture which includes prefabricated homes, building, space planning, construction, facility management, bills of quantities as well as furniture, kitchen, interior, curtain, wall-cladding design.

Civil and structural engineering which includes hydraulics and roadworks.

Electrical which includes building services and air conditioning.

Electronic including printed circuit board design.

Piping mainly involving plant layout.

Mechanical which includes machinery, sheetmetal, industrial design, automotive components, tooling, shipbuilding, and steel design.

Numerical control which includes computer numerical control, computer aided manufacturing, computer integrated manufacturing and manufacturing in general.

Bureau Services which includes general and contract drafting.

Educational which includes academic educational and organisations offering tuition.

Others which includes a wide range of applications from garment design and manufacture to local government applications.
# CAD/CAM/CADRAFTING INSTALLATIONS IN AUSTRALIA AND NEW ZEALAND

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Appendix
APPENDIX 5.2

Wire-Frame Display

A display of a volume which shows all of its edges is called a wire-frame display. These models allow the computer to produce different views of a model quickly. One drawback of these 3D drawings are their transparency, in that the backside of a model is visible. Wire-frames are relatively easy to create and provide a convenient geometric model for many engineering applications.

Finite element Analysis and modelling

In finite element analysis a 3D model is divided into a network of simple elements. The network consists of a mesh or grid which gives the impression of a solid model. This type of mesh is produced by hundreds of thousands of equations which describe the structure. This is usually referred to as FEM or finite element model.

Surface Modelling

Surface modelling bridges the gap between wire-frames and solids. In applications where complex 3D geometric models of products are required for example in sheet metal or moulded plastics, surface modelling is used. Surfaces are useful when producing colour-shaded three-dimensional views of a product.
Solid Modelling

Solid modelling enables the visualisation and manipulation of a geometric model as an actual solid. Solid models are multicoloured, almost photographic quality pictures of what is being designed. There are two basic methods of solid modelling.

Primitives or Constructive Solid Geometry (CSG):
This technique involves using elementary shapes (primitives) such as block, cylinder, tube, cone, sphere and hexahedron to create solid models.

Boundary representation (B-rep):
Boundary representation begins with a two-dimensional surface then extrudes or revolves the boundary. The extrusions can be linear or compound then finishing touches are applied by a variety of operations.

Other methods of solid modelling include Hybrid, Sweeping and Non-uniform rational B-Splines.

GKS (Graphical Kernel System): a worldwide standard which in essence is a standard for graphics programming interface and a standard graphics subroutine package. Basically GKS is designed to allow portability of graphics systems between different installations.

CORE was developed by SIGGRAPH "ACM/SIGGRAPH CORE Graphics System Recommendations" and is in direct competition with GKS. However it is not as widely accepted although some groups prefer it.
IGES (Initial Graphics Exchange Specifications) is for the interchange of design and manufacturing data. IGES supports the transfer of engineering data about part geometry. It can transfer most geometric data but is unable to transfer data on solid models.

PHIGS (Programmers' Hierarchical Interface for Graphics) serves as a functional specification of the control and data interchange between application software and its graphics support system.

VDI (Virtual Device Interface) standardises the interface between the graphics utilities and device drivers. This allows a group of computers to run the same program.

VDM (Virtual Device Metafile) is a way to transport the definition of a picture over space and/or time.

NAPLPS (North American Presentation Level Protocol Syntax) is a code for defining storing and transmitting computer graphic information.


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