Integrated Business Environment : An implementation of CIM in a Small to Medium Enterprise.

Volume 1 of 2

by

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Abstract

This thesis documents the Computer Integrated Engineering philosophy and concepts adopted by Fortune Engineering Limited during a three year period commencing August 88.

Management at Fortune Engineering had identified one major bottleneck that would inhibit the growth of the company. This bottleneck was the engineering drawing office. Fortune's business involved a great number of special parts and products. As the business expanded so did the number of personnel required to design these special products. The company's profits were diminishing and action had to be taken to reverse this trend.

Senior management made the decision to embark on a Computer Integrated Engineering project. This was seen as the only way for the company to develop and grow in the 1990's which would enable them to compete in the European and Eastern markets. CIM was seen as an all embracing philosophy which would encompass all areas of the company's activities from customer sales to design, scheduling and, eventual manufacture.

It was foreseen that CIM would bring a number of direct and indirect benefits to the company:

Control of design and manufacturing data.
Reduced product design lead times.
Reduced development times of new products.
Certification to BS5750.
Increased utilisation of key production processes.
Increased customer service.

Fortune approached CIM in a unique way which has rarely been achieved in any other manufacturing company, of similar size. When the decision was made to adopt CIM it was agreed not to use computers in an ad-hoc manner to produce very efficient 'islands of automation' but to produce an Integrated Business Environment (IBE).

This Integrated Business Environment was not only achieved by new technologies such client/server processing, relational data bases and networks but by an all embracing integrated approach which also covers detailed methods and procedures.

Fortune's policy was one of continuous software development where all software would be written in-house by members of the Computer Systems Department. Fortune realised that the software may have reduced functionality and may be slower than proprietory software but the emphasis was placed more on total integration.

The author was directly responsible for the development and installation of all Manufacturing Shop Floor systems.

These systems include;

CNC Programming System
Direct Numerical Control System
Tool Management System
Production Scheduling System

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I would like to thank my wife Anne, for her help and support.

The author would also wish to acknowledge the help of Andreas Tsiotsis (University of Glasgow) and the inspiration given by Alan Fortune, (Fortune Engineering).

Trademarks

Spiracon is a registered trademark of Illinois Tool Works Company, Chicago, United States.

Rolaram is a registered trademark of Fortune Engineering Limited, Blantyre, Glasgow.

All other products mentioned herein are identified by the trademarks, service marks, or other product names as designated by the companies who market those products.

Abbreviations and Symbols

ASCII	- American Standard Code for Information Interchange
BOM	- Bill of Materials
BOT	- Bill of Tools
CAD	- Computer Aided Design
CAE	- Computer Aided Engineering
CAM	- Computer Aided Manufacture
CASE	- Computer Aided Software Engineering
CIBE	- Computer Integrated Business Environment
CIE	- Computer Integrated Engineering
CIM	- Computer Integrated Manufacture
CNC	- Computer Numerical Control
CPU	- Central Processing Unit
DNC	- Direct or Distributed Numerical Control
DO	- Drawing Office
ECN	- Engineering Change Notice
EDMC	- Engineering Data Management and Control
IBE	- Integrated Business Environment
IPSDT	- Institute of Production Systems and Design Technology
JIT	- Just in Time
OSI	- Open Systems Interconnection
PC	- Personal Computer
XON/XOFF	- Transmit on transmit off

Chapter 1.0

Information Resources

1.1 Introduction

Data and information flow is crucial to any company and the manufacturing industry is no exception. Inefficient use or, poor control, of these data can affect the flexibility to tender and hence the profitability of many companies. Manufacturing systems are traditionally paper based and include detailed policies and procedures. These systems involve the movement and processing of large amounts of information stored on paper. (figure 1)

With the advent and availability of relatively cheap computing power it is possible to replace many parts of this paper based system with an efficient computer based one. A computer based system would not only process data quicker but would also promote a parallel environment in which data and decisions would be made as soon as the data is available to support it. (figure 2)

A computer based system would also provide the opportunity to replace the traditional serial flow of information where paper based information is transferred sequentially from one department to the next by introducing simultaneous engineering activities and improve the company's competitive advantage through an:

increase in product quality.

reduction of product lead times.

decrease engineering support costs.

These objectives could be met by increasing engineering data flow and controlling customer orders efficiently from initial order, to finished product.

Many engineering companies have adopted new technology in a piecemeal way but few have followed an integrated approach. There are many computerised packages available that will cover most areas of an engineering business but few of these packages have been integrated with each other in a systematic and logical way. This is also true of packages purchased from a single vendor or software house. (figure 3)

Development of numerous computer based systems will improve departmental efficiency but will contribute very little to the efficiency of the company's system as a whole. An integrated approach can be adopted where all computer based systems generate and access the same data in a controlled way. This data maybe stored centrally on one single computer platform or distributed across a number of platforms using a local area network. This integrated system could notify other systems or applications whenever the data is available to support them.

A computer based system would have a number of clear advantages over systems relying on paper storage:

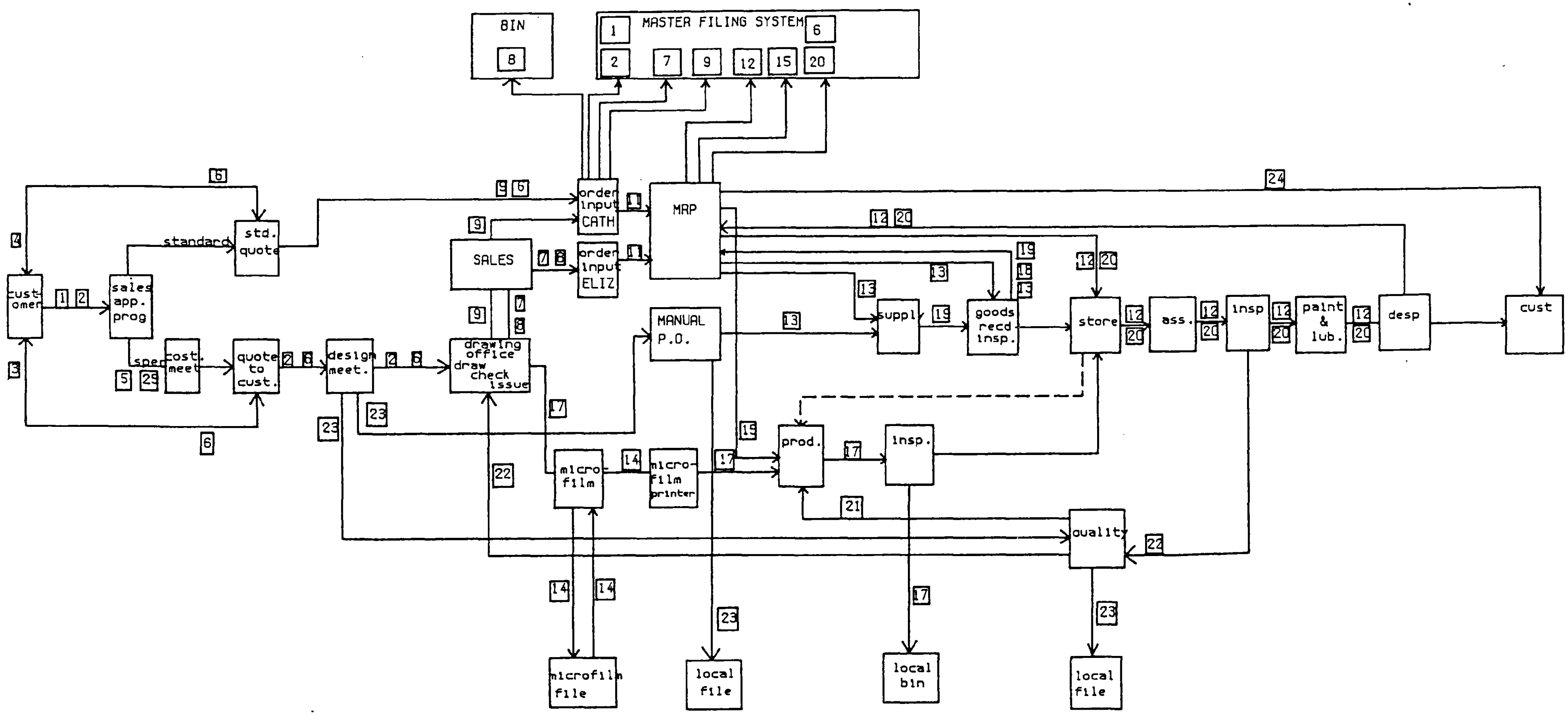
Data is generated and stored once only.

Activities downstream can commence immediately as the data become available.

There is no explicit restriction to the flow of generated data.

Customer orders can be controlled from order inception to finished product.

Administrative costs would be reduced.



1. CUSTOMER SPECIFICATION
2. CUSTOMER DRAWING
3. MANUALLY GENERATED QUOTE
4. AUTOMATIC QUOTE
5. COST SHEET
6. CUSTOMER ORDER
7. BILL OF MATERIALS
8. ADD A PART SHEET
9. EDIT SHEET (AUTO)
10. EDIT SHEET (MAN)
11. KEYBOARD INPUT TO MRP
12. WORKS ORDER (PINK)
13. PURCHASE ORDER (AUTO)
14. MICROFILM DRAWING
15. MANUFACTURING ORDER
16. PURCHASE ORDER (MAN)
17. PRODUCTION DRAWING
18. GOODS RECEIVED NOTE
19. DELIVERY NOTE
20. INSPECTION CHECK LIST
21. QUALITY DOCUMENT
22. ENGINEERING CHANGE
23. SPECIAL ORDER INSTRUCTION SHEET
24. INVOICE
25. CALCULATION SHEET

Figure 1 Paper Based Business System

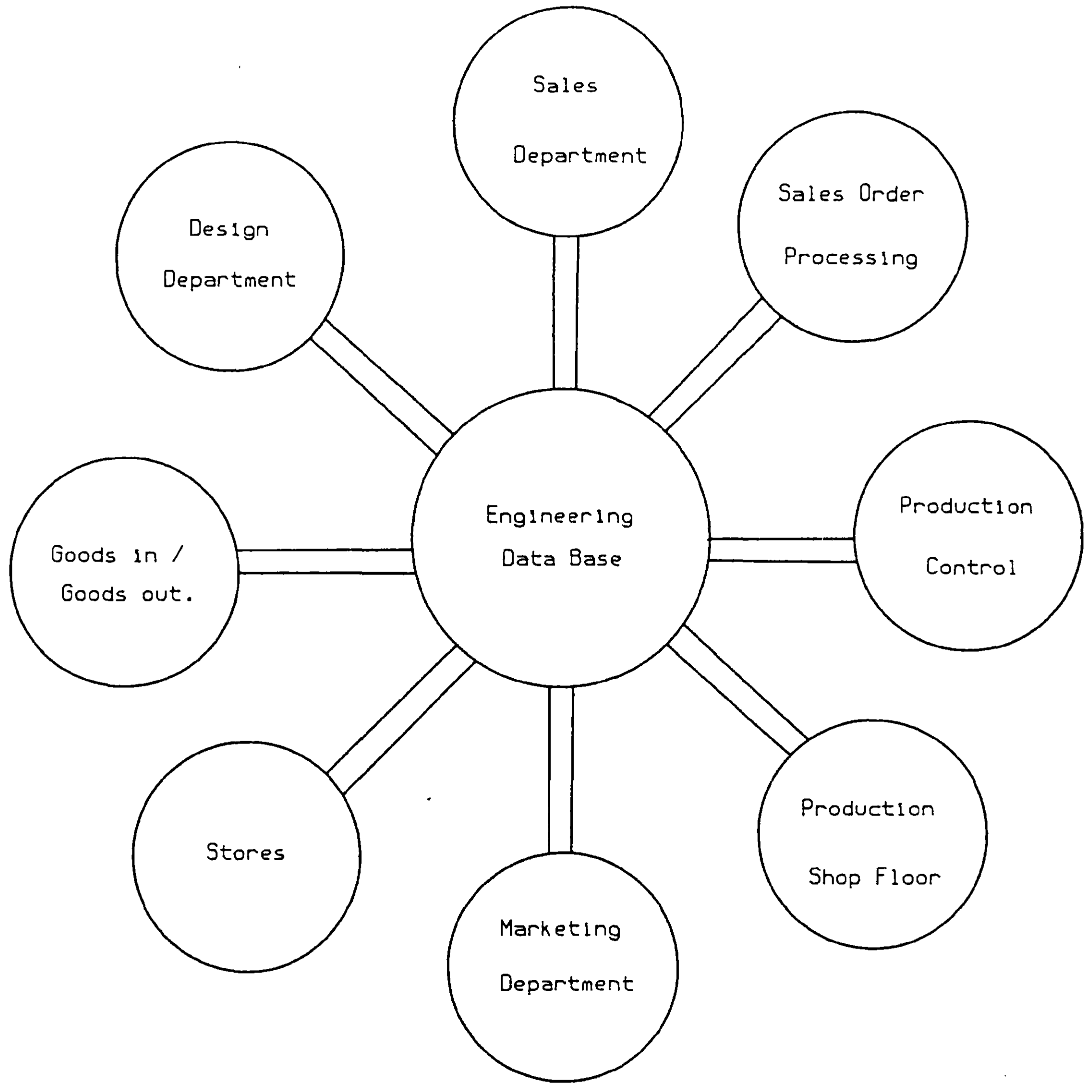


Figure 2 Parallel Processing Environment

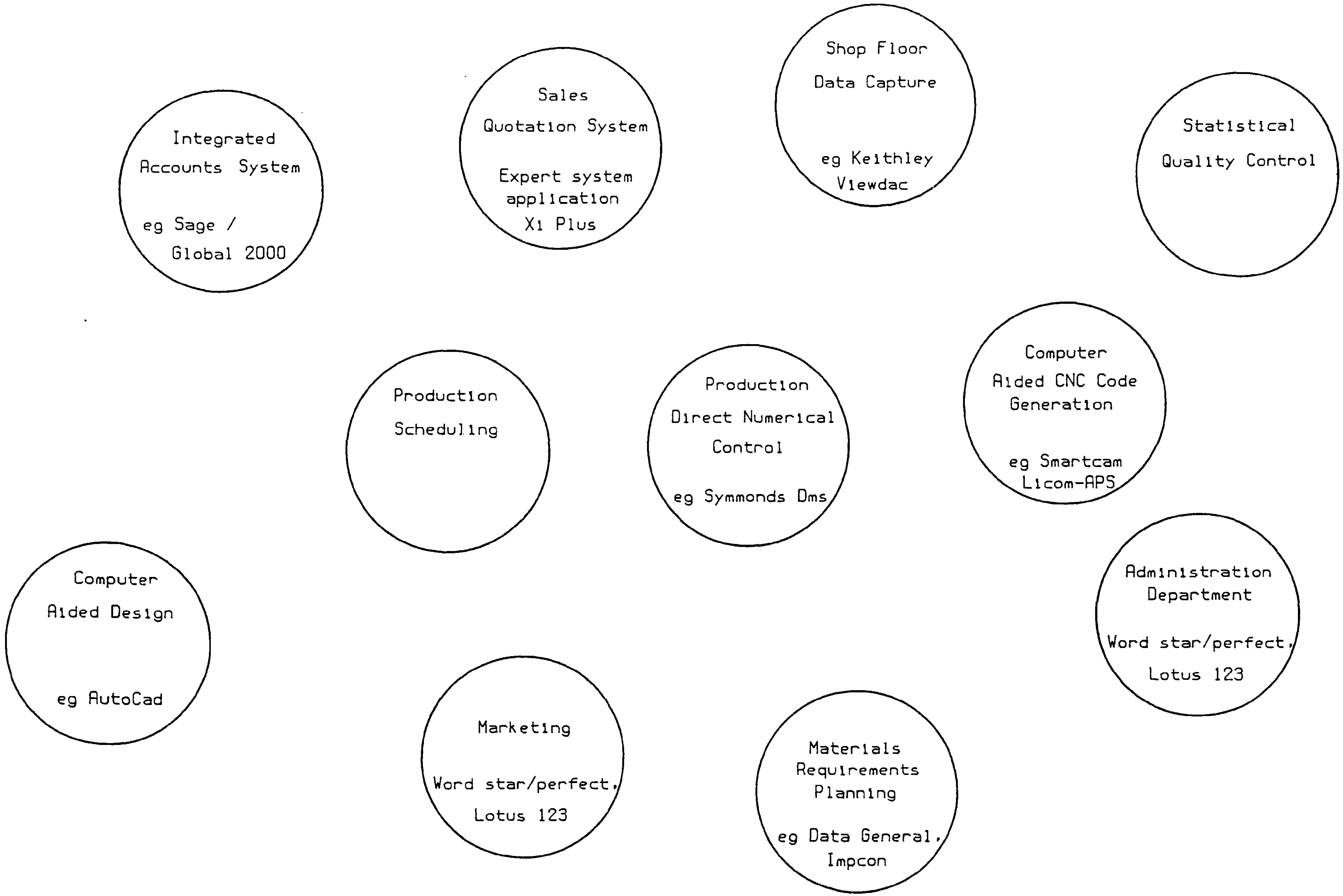


Figure 3 Islands of Computer Activity

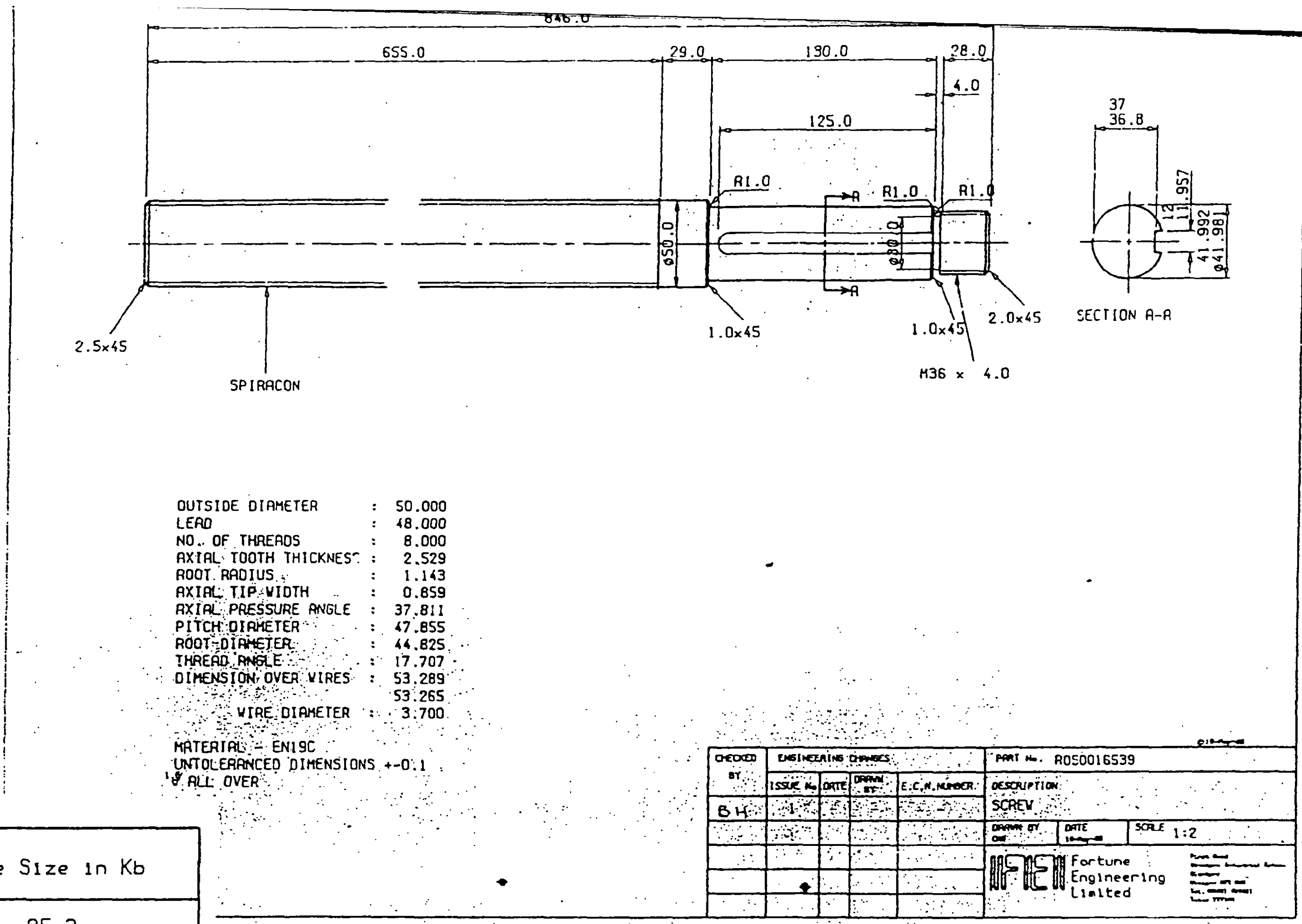
For example, there are numerous Computer Aided Design packages that will produce 2 and 3 Dimensional geometry; the geometry may then have to be converted from one system to another to run a Finite Element Analysis package or Modeller. Some suppliers such as Ferranti will supply a suite of Computer Integrated Manufacturing (CIM) software packages which are well integrated, however they frequently will not communicate easily with drawing or bill of materials management software. Subsequently a company may wish to create numerical control (NC) code from geometry details on CAD; the geometry again needs to be converted to another format for the CAM package. Converting geometry is time consuming due to the size and complexity of geometry files (see figure 4). If a standard export protocol, such as IGES or the de facto DXF or HPGL, are available then transfer will be easier but control becomes more difficult with multiple copies in different computer formats on different computer and manual systems. The solution is to limit and control the number of copies. These copies can then be managed by an appropriate computer based system. (figure 5)

A solution exists which is conceptually simple to implement. The philosophy is one of creating data once and once only in a format that all systems can understand and to distribute throughout all areas of company activity thus reducing traditional serial information flow. (figure 6)

This philosophy is not usually adopted due to:

Lack of vision of engineering companies.

The reluctance of software houses to agree and develop suitable software standards.



Computer Format	File Size in Kb
Infocad CAMX Format (IFC)	25.3
MPS	107.2
Compressed MPS	19.0
Calcomp (Cal)	29.7
Compressed Calcomp (Cal)	85.0

Figure 4 Engineering Drawing storage structures

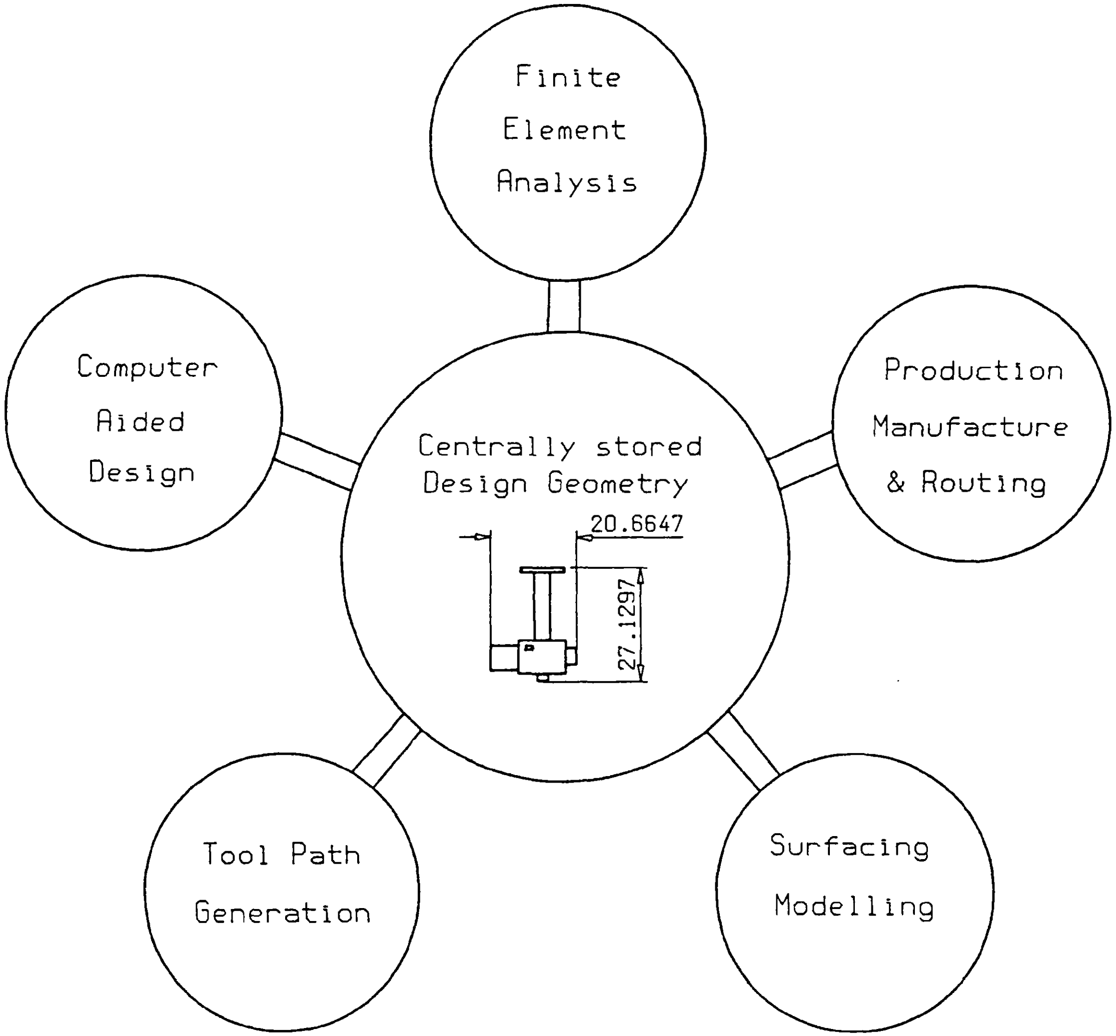


Figure 5 Design Definition Stored Centrally

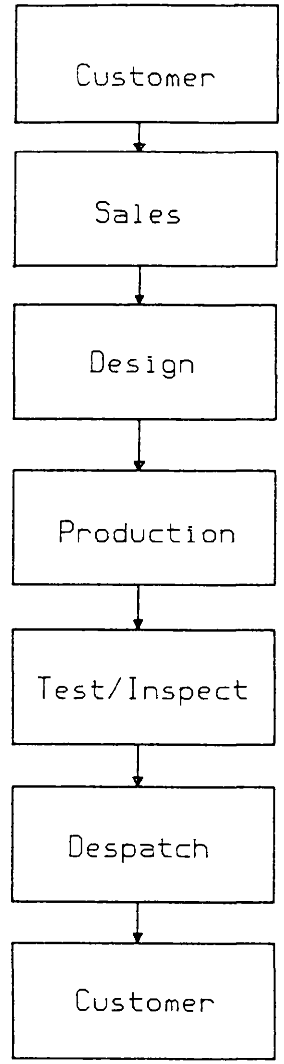


Figure 6 Traditional Data Flow

1.2 Controlled Change of Data

Many software packages employ a proprietory internal data base or file structure. These packages can control the change of information very well. Integrating these packages throughout all areas of the business system is more difficult, as difficulties arise when data is stored in numerous computer based systems across diverse computer platforms.

Changes of information are resource consuming and usually result in disturbances to the company procedures and loss of focus on the tasks performed by the employees.

Engineering companies are no different and under BS5750 [Ref 9], the change of engineering data has to be carefully controlled, monitored and provide efficient audit trails.

The main attribute of an integrated computer based system centres on the ability to adapt to change quickly and efficiently through all levels of the business.

eg BS5750 4.5.2 Document Changes and Modifications,

> 'A master list or equivalent document control procedure shall be established to identify the current revision of documents in order to preclude the use of non-applicable documents. '

When an engineering drawing is changed using an integrated computer system the re-issue of the drawing will be updated in the central master data area. This update will then be reflected in all other areas in the engineering system.

A practical example of this concept can be found in the Direct Numerical Control system applications, (see section 8.9).

True business integration and control are not necessarily the linking of various computer based systems.

The formulation of a data control strategy will ensure that the development of a true Integrated Business Environment can be achieved.

A totally integrated system should have access to business data wherever it may be stored. This data should be available for access and change by other applications.

A suitable change control mechanism should exist to manage critical data; a management system must be employed to safeguard the consistency of all data and manage user request contention.

A totally Integrated Business Environment involves the creation of common;

Data areas

Data management system

Software applications

Computer hardware

Computer communications

Figure 7 illustrates the seven layer OSI model for data communications, in addition to achieve total integration the data areas, data management system and software applications have to be standard throughout the business system.[Ref 11],[Ref 12].

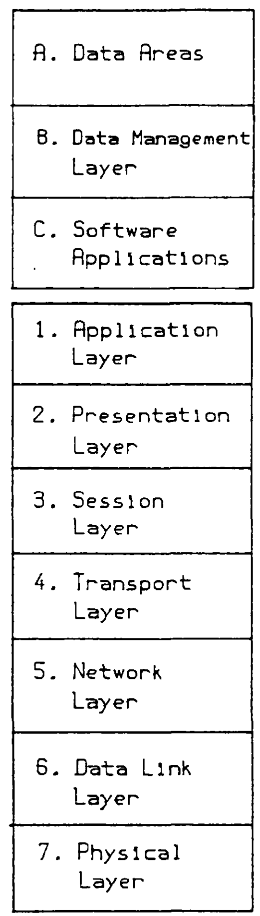


Figure 7 Seven Layer OSI Reference Model

1.3 Data Development Strategy

When developing an Integrated Business Environment a formal strategy should be adopted to ensure that:

(i) Data are created and stored once. If numerous copies are required then one copy should be recognised as the master and the other copies are limited as far as possible.

The limitation of data copies ensures data remains consistent across the whole information structure. For example, the issue and control of design data files cannot become inconsistent with the respective design file used in a CAM package if one neutral format is stored centrally.

Reducing the number of files also ensures that the Engineering Change Control mechanism is simplified.

(ii) All data are available to all applications and processes in the business system. This task is made easier if all data is stored under the control of the same data access mechanism.

Storing all engineering data under the control of the same data access system enables any application to reference any data from any area of the business structure to gain answers to complex 'what-if' scenarios.

For example, if manufacturing data existed to create various standard components and an enquiry arrived for a special product, the data areas could be interrogated by the sales order processing application. A number of questions could be answered;

How many of the standard components could be used and how many would have to be re-designed?

Does the manufacturing data exist to create the standard and special parts?

What is the cost of design and manufacturing activities to the company?

Does the production tooling exist to create these parts?

Do the raw materials exist and what are their lead times?

What is the loading on the shop floor at this time?

When the order is placed onto the system, what is the delivery time?

If high value items have to be ordered, can the company finance this order or are interim progress payments required?

An integrated business system must be able to address all these questions.

(iii) All applications or processes that use data can access them directly and does not enquire on any other local application or process data storage.

Locally stored data areas can become inconsistent and require their own backup and restoration facilities. If numerous local data areas exist, control becomes even more complex. As the business system expands these areas may be accessed by other applications for complex queries.

(iv) Data are stored in contiguous areas where the relations are determined by the enquiries on the stored data.

Business system users require reduced response times to complex queries. When designing a system it is important to take into consideration the way the users will access the data, how often they will access the data and what processing will be performed on that data. When data becomes redundant there should be a mechanism to archive the data or store in a new data location.

For example, an engineering bill of materials has a very complex structure and component part relationships. A bill of materials is usually created once and viewed many times throughout the life of the product. It would be beneficial in this instance to design a system which would create the bill of materials structure in such a way that retrieval is almost instantaneous.

(v) Only data that is required is actually stored.

For example, a Shop Floor Data Capture system could collect and process large amounts of manufacturing shop floor data, but if the management and shop floor control applications do not require this data then the processing resources have been wasted.

(vi) Heavily concurrent areas of information are divided into different data areas to avoid poor control and loss of performance.

Data areas that are used frequently by various applications can be split into unique data areas: this reduces the transaction processing on one data area.

For example, a Shop Floor Scheduling application with a planning and shop floor loading function could exist in one data area. In this case production planners and production shop floor would access the same data area, multiple users may cause collisions which would not be beneficial to a busy and dynamic shop floor environment. A decision may be made to split the planning and shop floor loading areas into two unique data areas.

(vii) The Management system employs sufficient security features to ensure that only authorised applications can create, edit or view sensitive data.

Security can be at various levels of a computer based system. The data management system should have a facility for logging user accounts, passwords and integrities.

For example, numerous accounts could view employee salaries but only one account and application could change employee salaries.

(viii) The system has suitable facilities for backup and data recovery.

The backup system should include all user and system data, accounts, passwords and integrities. The system should be quick, user friendly and cater for quick recovery if the data management system is inoperable.

(ix) The creation of software applications are authorised by the computer system department to ensure that they conform to the company standards and will exhibit the level of integration required.

In addition the creation and change of software applications should be controlled in the same way as the creation and change of engineering data.

It is also very important to log the version numbers of all software applications and log these same version numbers on all critical engineering data created by the application.

For example, a Parametric Design system which automatically generates detailed designs for customer applications has to be carefully controlled. [Ref 9]
The design data and the formula used may require to be logged to allow traceability in the future.

eg BS5750 4.4.1 General,

> 'The supplier shall establish and maintain procedures to control and verify the design of the product in order to ensure that the specified requirements are met. '

If a problem was discovered in a design program then it would be beneficial to identify which designs were generated using which versions of the design programs, and the input data used.

(x) Only recognised computer programming languages are used when creating new applications. These programming languages must be able to communicate with the data management system.

Standard programming languages ensure software integration in addition to data integration. Complex sub-routines can be used many times and used by many programmers. In addition any programmer in the company can change or debug another programmers computer code.

(xi) All software applications have the same user interface. This includes:

Screen layouts

User prompts

Error and warning messages

Keyboard and key function mapping

Menu structure

This common user interface reduces training requirements and ensures that all users are familiar with any computer based system adopted by the company.

(xii) All software applications have suitable user and reference manuals. If possible these manuals should also conform to a given standard.

1.4 Summary

This chapter has discussed the importance of data for every company, irrespective of the unique business areas. The creation, control and management of data resources is the nucleus of any business system.

At the outset of any Integrated Business Environment solution it is important to develop a working model, upon which developments can take place. This model will aid the development and integration of the business systems and ensure they develop in a structured and controlled fashion.

Chapter 2.0

CIM Models Adopted by Commerce

2.1 Introduction

Many manufacturing companies have adopted Computer Integrated Manufacturing and have purchased and installed numerous software packages to achieve their goal. Few have developed these systems as part of an overall CIM strategy and have only created more 'Islands of Automation'. Before the development of any CIM installation it is essential to define the model, (see figure 8). The model will aid the conceptual design of the system and outline how the various data and application layers are integrated.

Various companies and institutions have defined CIM models to aid project development. A brief analysis of these will aid in comparing the CIM model adopted at Fortune Engineering.

2.2 IPSDT CIM Model

The Institute for Production Systems and Design Technology define their model in Figure 9. Many database models look similar to this model. This model represents no fewer than four separate data bases or data areas. From these four areas all others have access by primary and secondary communications links.

The model shows the flow of data from one data area to another. The main problem with this model will appear when more than four data areas require to co-exist. The communications links will become more complex and it can be argued that due to the array of links the data will be more difficult to control.

For example, data from the Geometric modelling module to the Manufacturing module may not be consistent if an engineering change has been activated from the design module. Engineering control is a key element to any CIM model and is made easier through central control.

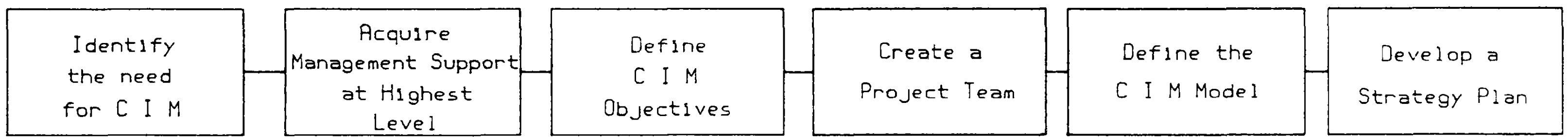


Figure 8 CIM Development Plan

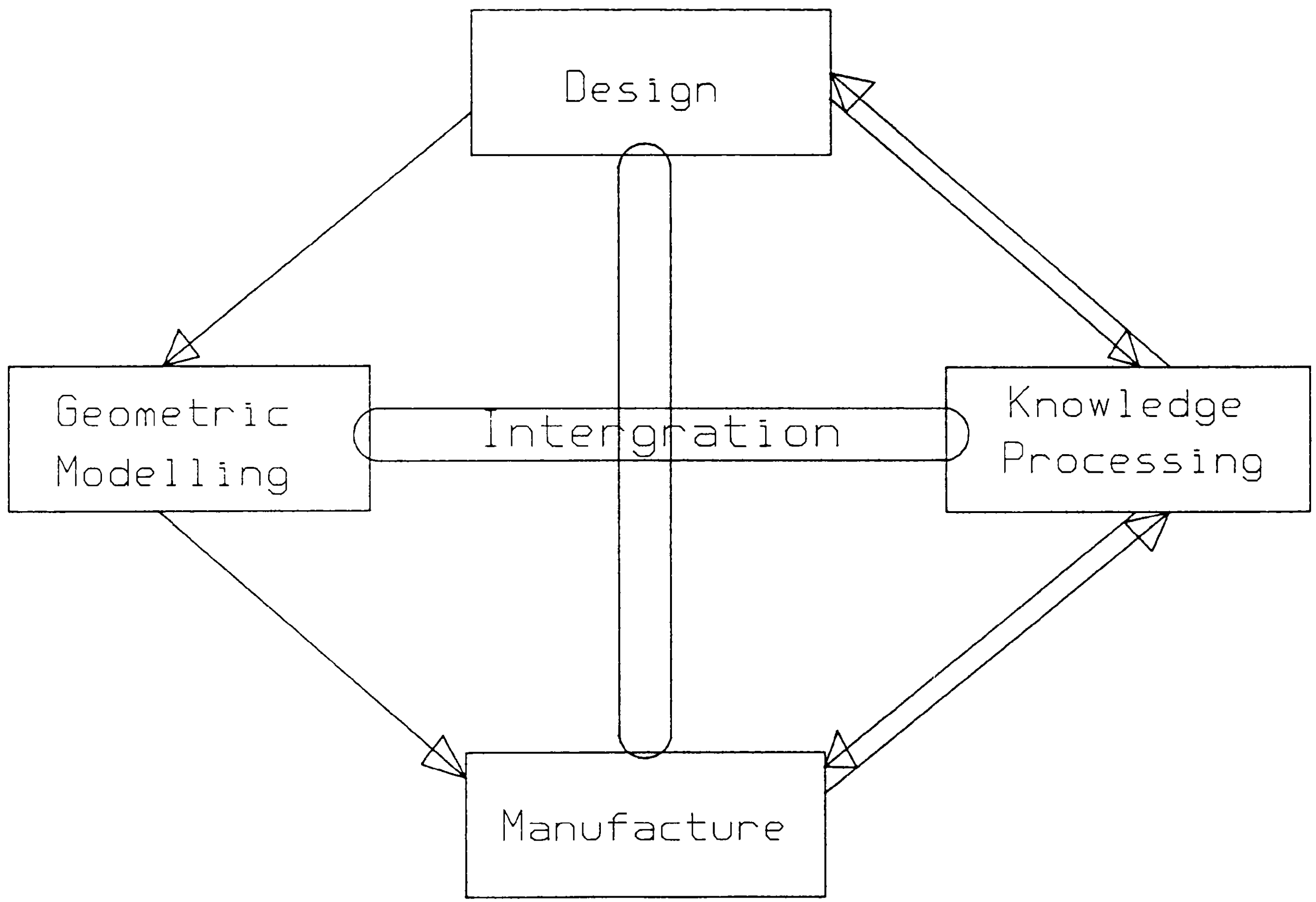


Figure 9 IPSDT CIM Model

2.3 Domino Amjet CIM Model

Domino Amjet Limited define a Company System Model similar to Figure 10. This data model has succeeded in creating data areas for important data requirements throughout the business system. This model has been developed to overcome the problems of traditional serial flow systems and develops parallel processing of data. There are some fundamental problems with this data model:

i) Some data only progress one way when in fact data flows both backwards and forwards. For example design data, such as component drawings to manufacturing,and manufacturing data such as tooling availability to design.

ii) The data areas are split into three parts when in fact some data is common to all three data areas. For example data on a production machine limitation may reside in the design data area but would also be beneficial for production to schedule the machines and for the manufacturing data applications to check that a machine is not used in error.

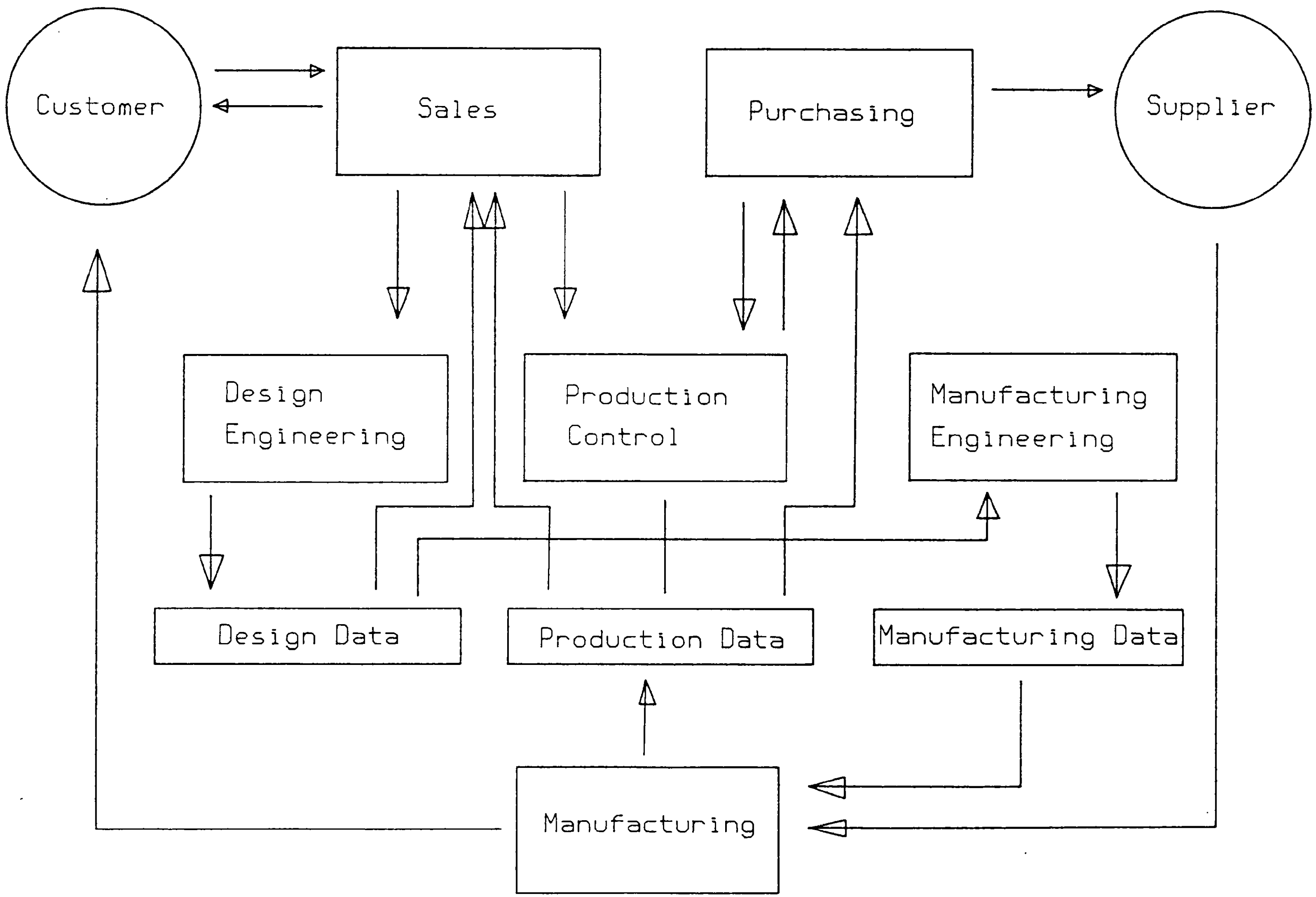


Figure 10 Domino Amjet Ltd System Model

2.4 Traditional CIM Model

Figure 11 shows a traditional CIM model. This model defines the flow of data from sales to customer in a vertical fashion. This has been defined as 'Vertical Integration'. Subsequently the model has been developed to include financial and supporting services in a horizontal way and has been defined as 'Horizontal Integration'.

Some companies have identified the need for vertical integration , from sales to design to production to manufacture. These companies have invested heavily in vertical integration products such as traditional CAD and CAM products. Each CAD or CAM product requires its own separate data area, these are sometimes difficult to integrate. Eventually the business system consists of two or three very efficient computer based systems with inefficient links between them. Links from CAD to CAM products could be in the form of exporting CAD drawings using standard gateways or redefining CAD geometry in CAM packages. The most inefficient case could be where the CAD drawing is read by the CNC part programmer and code is generated manually, (see figure 12).

Some companies have existing computer systems from an early computer era which dictate the procurement of new equipment and often suppress the development of a totally integrated business system.

For example Fortune Engineering have an inefficient Data General system which controls the Material Requirements Planning function. This system, although excellent in its day, has been left behind in modern hardware and software terms and is a liability to the development of a totally integrated business system. Data generated on one data base is printed and re-typed into the Data General System and then retyped back to the new system, (see figure 13).

Retaining two data areas in synchronisation is very difficult and requires a large amount of computer and personnel resources.

For example a component designed on a PC based CAD system will have little relationship to the same part with generated CNC Code in a CAM system. When the component is re-issued due to an engineering change the CNC Code file will have to be re-named or re-generated.

Two similar data areas will invariably become inconsistent and this can cause problems throughout the whole system. If attempts are made to bring data back into line then a decision has to be made to which data area is correct.

Very clear disciplines need to be adopted when implementing any system based on more than one data area.

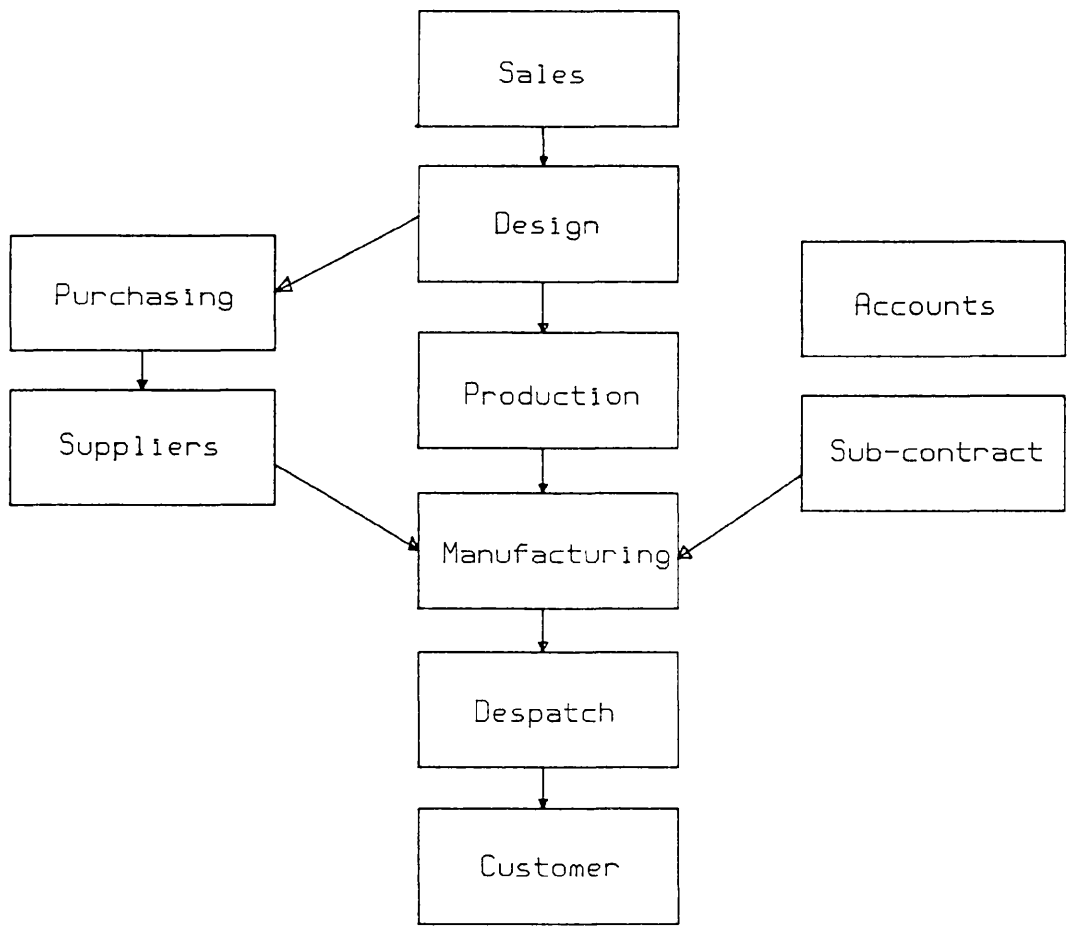


Figure 11 Traditional CIM Model

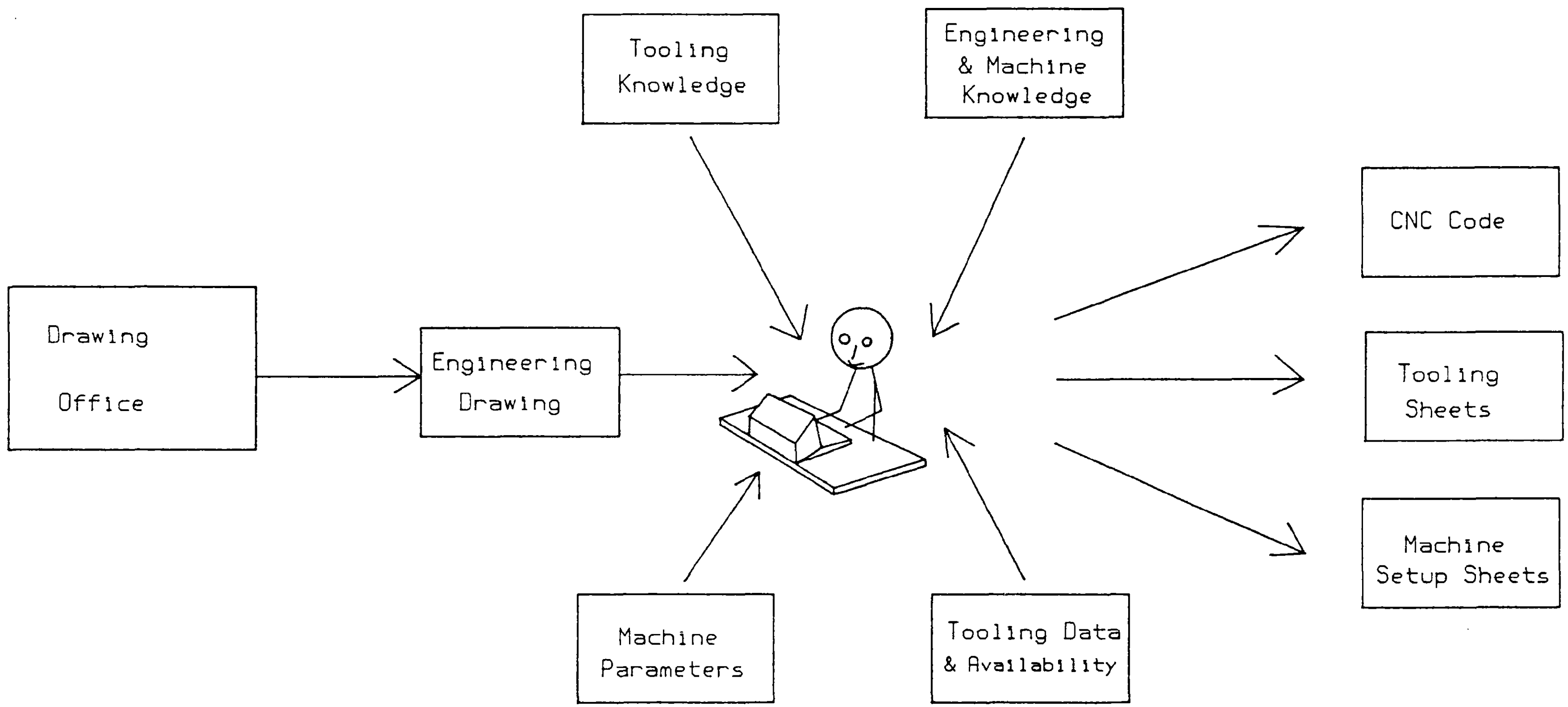


Figure 12 Manual Generation of CNC Code

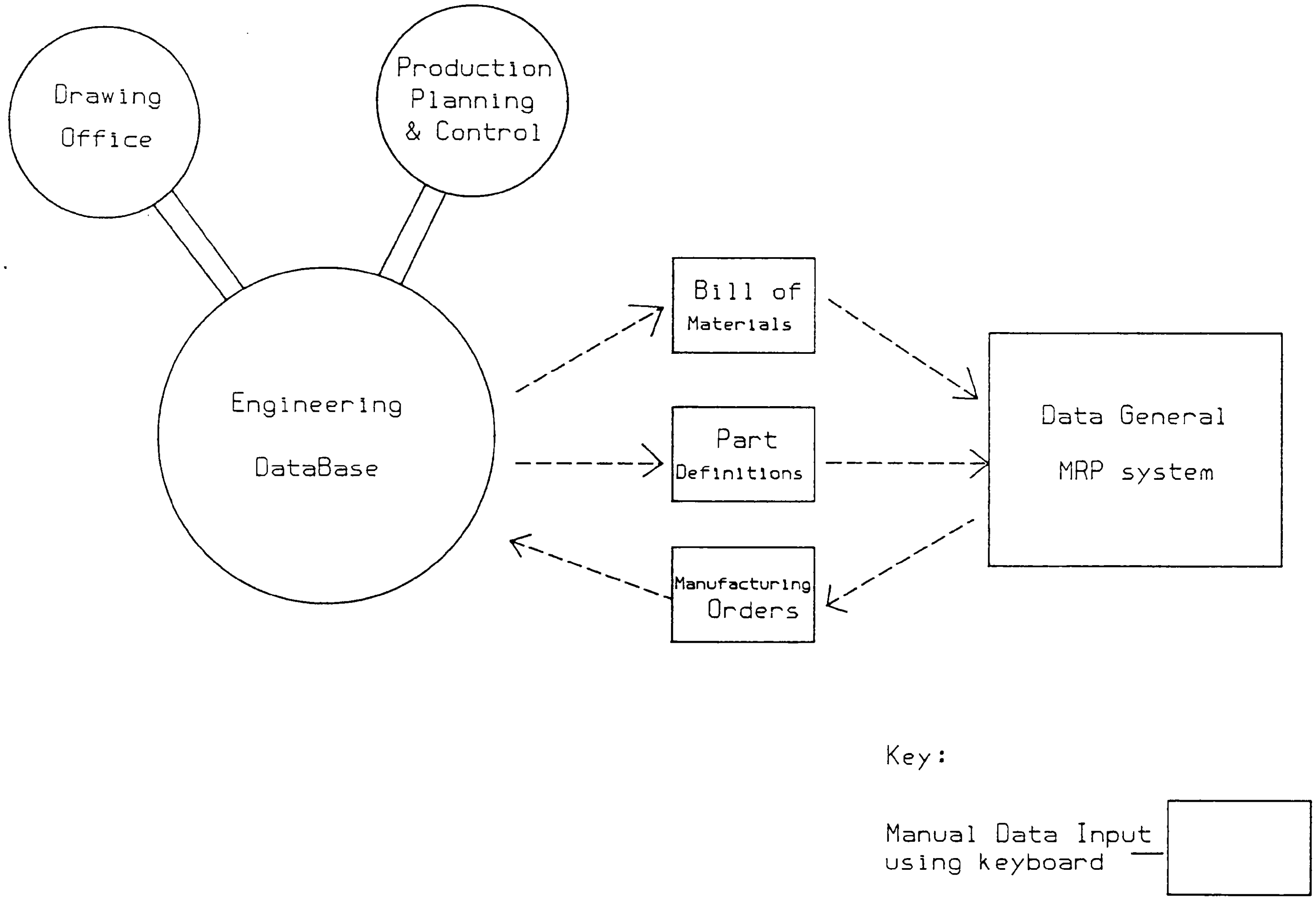


Figure 13 Integration of Old and New Computer Systems

2.5 CIM Information Systems Overview Model

This model, Figure 14, is similar in design to the IPSDT CIM model. The model defines four unique data networks which are all linked together to form the business environment.

There are no links in the model to integrate the business network to the process control network, this may suggest that process control data is not required by the business network. In many companies the management and business functions are not required to review the process control function in real time, but there will be a requirement to review process control reports during the course of days, weeks or months. Some link should exist directly between the two functions.

The model consists of four data areas, as mentioned in previous paragraphs the data is more difficult to control when data resides in different locations and in the case of the model, different networks.

2.6 Central Data Hub Model

The underlying goal of all computerised business systems is to integrate all departments and functions within an organisation so they can operate as a whole.

This model, Figure 15, was defined in such a way that all data areas are restricted to the central hub. This ensured that all data could be controlled easily without having to integrate or link with satellite data areas, in addition all the data stored centrally could then be controlled by one data management system.

All applications or systems exist on the circumference of the hub and all have ultimate access to all data within the central hub, within pre-defined security constraints.

Engineering change control is simplified with one copy of all data stored centrally.

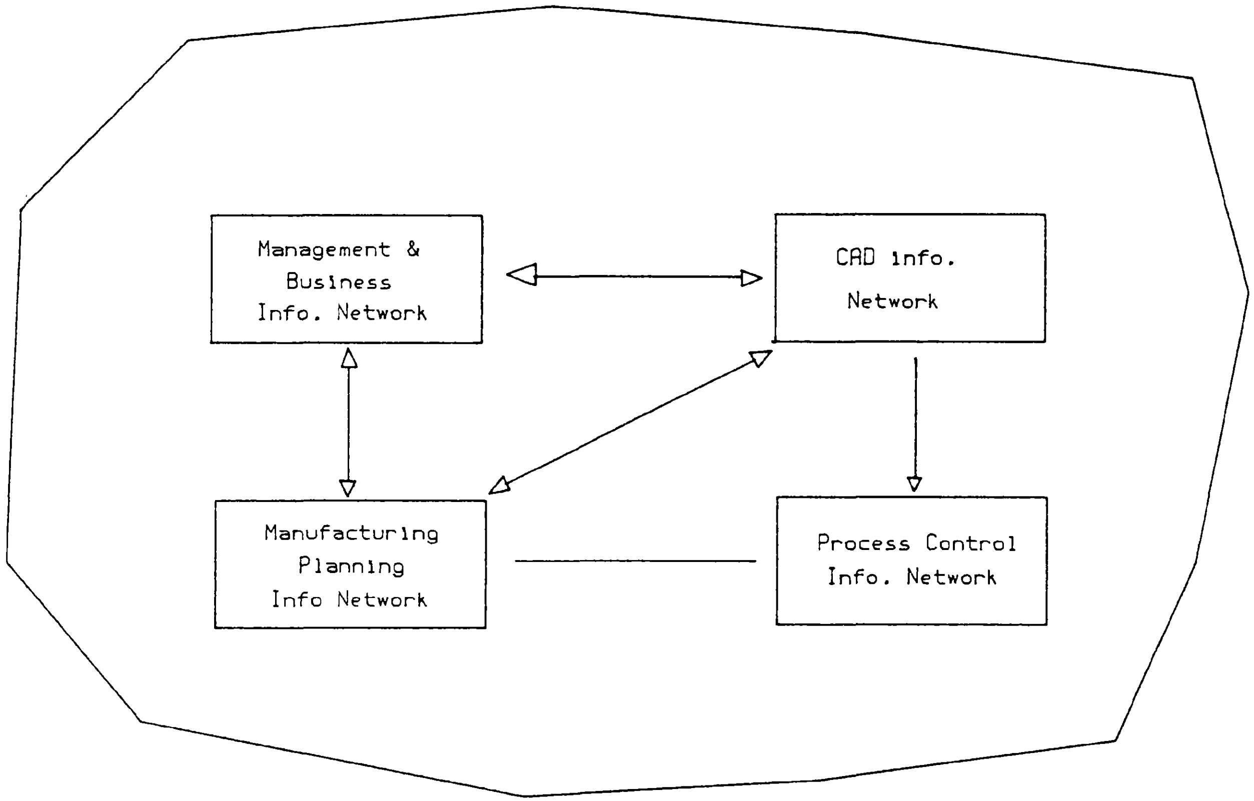


Figure 14 CIM Information Systems Overview Model

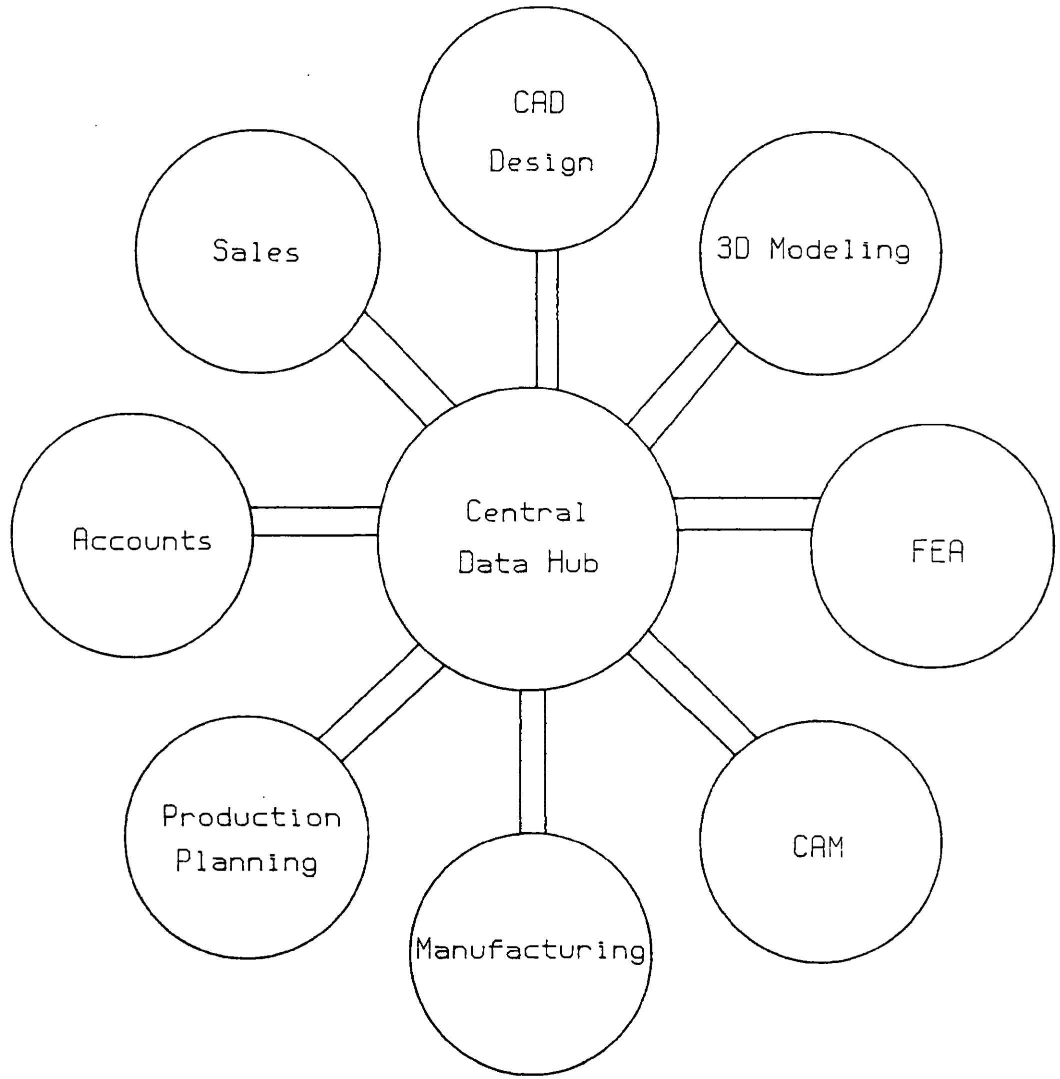


Figure 15 Central Data Hub CIM Model

2.7 Summary

The various CIM models have been reviewed and the advantages and disadvantages of each have been discussed.

Prior to adoption of a CIM model it is beneficial to identify the business requirements of the company which wishes to develop an Integrated Business Environment.

The following chapter will discuss the operations profile of a company who successfully adopted an Integrated Business Environment.

Chapter 3.0

Operations Profile of Fortune Engineering

3.1 Introduction

Fortune Engineering Ltd is located in Blantyre, some 5 miles South of Glasgow, Fortune was established in 1978 by Alan Fortune. The company specialises in the manufacture and supply of linear actuation products and systems. The company can design and supply complete solutions to actuation problems based on four catalogue products:

Screw Jacks

Electro-Mechanical Actuators

Spiracon TM precision Roller Screws

Rolaram TM Actuators

The products can be sold individually but are usually sold as part of a complete actuation system. Actuation systems include Fortune Screw Jacks and Actuators that are powered via proprietory AC or DC motors and driven by gearboxes, shafts and couplings and controlled by PLC or computer based control systems. (see figure 16).

Systems have included a four 100 tonne jack configuration to lift a railway bridge for British Rail, precise movement of a telescope lens for Thorn EMI and movement of discotheque lights for Stringfellows in London.

Fortune has prospered from the manufacture of jacks, actuators and precision roller screws with a large percentage of all components manufactured on-site. Fortunes products are marketed as catalogue items but specials can be designed to meet the customers exacting requirements.

Typical lead times for a standard unit are 3 to 4 weeks, and 5 to 6 weeks for a special item.

Fortune employs some 45 personnel producing 2000 units a year in over 300 applications. Their annual turnover was £2 million in 1989, £2.8 in 1990, £2.8 in 1991 and £2.4 in 1992.

In 1989 most of Fortune's business and client base was in the United Kingdom. Senior management realised that if the company was to prosper they should penetrate European and Eastern markets. In the United Kingdom the market for standard screw jacks is small and very competitive. It was identified that Fortune should also design and market new products to address the larger hydraulics market.

Fortune decided to address themselves to these new marketing opportunities in three ways.

(i) Invest heavily in advanced production machinery.

(ii) Design and manufacture a new product range to compete directly with hydraulics.

(iii) Develop the companies system structure to handle the increase in business.

It became clear that the core to these three areas of development was Computer Integrated Manufacturing. CIM was seen as the only way to develop and implement these areas and to payback the massive investment that would be involved. Senior management recognised and were aware of the advantages of CIM but identified that if Fortune Engineering was to gain a competitive edge and lead the world in actuation systems then a totally Integrated Business Environment had to be developed and installed to promote all areas of the business.

The installation of the Integrated Business Environment has given Fortune Engineering a competitive edge in the market place by reducing costs and decreasing product lead times. The system has also aided the company to its successful entry to the European and Eastern markets.

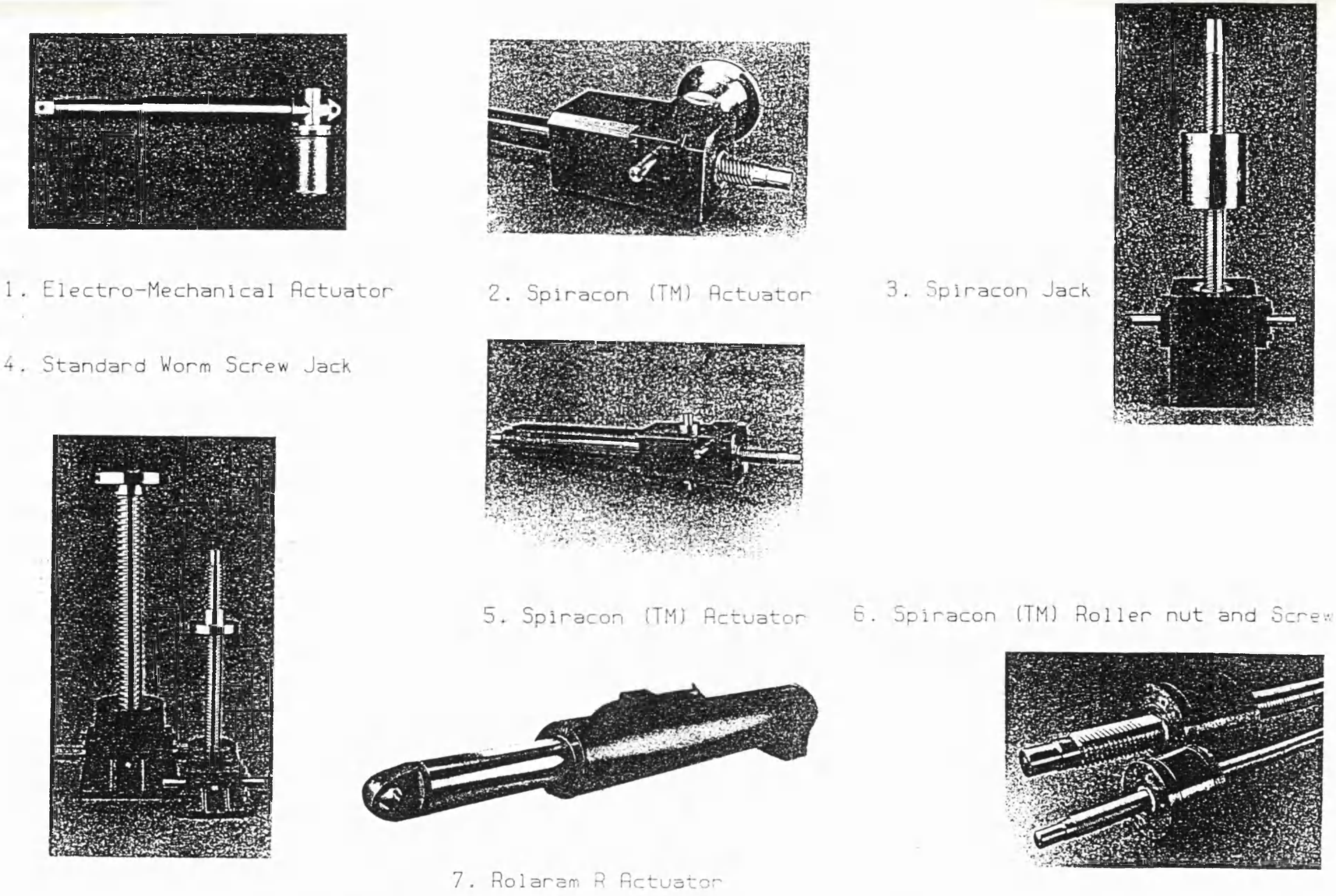


Figure 16 Family of Products Manufactured by Fortune

3.2 The Drawing Office

The volume of design work found in the Drawing Office increased dramatically as Fortune sold an increasing number of special products. Due to the sheer volume of work in the Drawing Office there was a bottleneck of approximately three to four weeks.

The design of a Spiracon screw and nut involves specialist calculations and a high level of design knowledge. The shear complexity of the product resulted in only one draughtsmen trained in the design of these units. It should be noted that the draughtsmen concerned only had a vague understanding of the product and could only design minor variations of an existing design. This resulted in poor overall understanding of the product and leaving the company open to design faults and inhibited Fortune from developing this product further.

A Spiracon design involved detailed design of some fifteen components which involved the creation of thirty detailed and assembly drawings. The logistics involved many hours of a draughtsmans time. Whether the design was a major change or a slight modification all related drawings would be searched in the micro-film library and then used as a basis to create new drawings.

Bill of Material creation took many hours and involved the searching of files for old designs and editing the Bill of Materials to suit the new design.

Fortunes Part number register was a manual system where new parts were logged into a book and a description attributed against it.

The creation of a new Spiracon unit would involve approximately thirty component parts. Due to the inefficiency of searching for existing component parts the designer would design and create new components that sometimes matched existing designs.

The design and creation of new parts was time consuming and the progression of these duplicate components, throughout the business system, created vast amounts of duplicated information. The task of designing a Spiracon product was time consuming and errors were sometimes made. These errors were not due to design miscalculations but were mainly the results of copying existing drawings and bills of materials incorrectly.

3.3 The Production Office

The Production Office consists of two unique areas:

Inventory control

Production planning

To manage the inventory there is a Data General hardware platform which runs a Materials Requirements Planning system from Weir Group Management Systems Limited. This Materials Requirements Planning system stores all component part information and all bills of material structures.

On a daily basis the system prints Manufacturing Orders and Purchase Orders in direct response to customer orders input via the sales order processing module.

The Manufacturing Orders are then passed to the production planning department who then plan the order throughout the production process. The Purchase Orders are posted to the suppliers.

The Data General system is very much a stand alone system with component parts and bills of materials from the design office required to be re-typed into the system. A computer operator would initially key in all the new parts and their descriptions. The operator would then continue to key in the bill of materials listing. At this stage some typing mistakes were made and part description inadvertently changed.

It was identified very early on that long lead time items such as special motors, if ordered too late, would delay the customers order. To accommodate this the design office, sales office and production office meet once a week to identify any long lead-time items that may be required.

The production controller would create a manual Gantt chart of MO's to be processed on each machine. The schedule would be written for each machine and due to the lack of setup and cycle time information only the MO run-time would be listed, no complete machine-committed time information was available, (see figure 17).

The Manufacturing Orders are then issued to the CNC Programmers who then create the CNC Code and write Setup and Tooling sheets. When the CNC Code had been written the Production department could further plan the Manufacturing Order throughout the production process, with the knowledge that the data was available to support it.

The Production department found it increasingly difficult to schedule the CNC machine Cells. Much of the data the production controllers required was not available early enough in the business process, they required detailed information about the production process, this information included;

Existence of production data eg CNC Code

Machine setup and strip times

Machine loadings

Material and Tooling shortages

The reduced planning functionality due to the restriction mentioned, resulted in ineffective management of critical production resources, (see figure 18).

Colchester 650 Turning Centre

Description	Quantity	Part number	Manufacturing Order No.	Comments
Clima Neu Lifting Screw	30	19618/002	21552	
1 Te Worm Shaft	150	6100/002	23750	
2.5 Te Worm Retaining Plate	200	5060/004	23775	
10Te Top Plate	30	103/001	23948	* Edit Program Unproven
Nut Housing	2	18229/001	23871	* Code Unproven Tool sheet blank
LBE Internal M/c'ing	1	18172/001	23858	* Requires Program and Tool sheet
LBE Internal M/c'ing	1	R098018682/001	23882	
Std.Opt Wheel Screwcut	12	5022/004	23694	

Figure 17 Manual Production Schedule

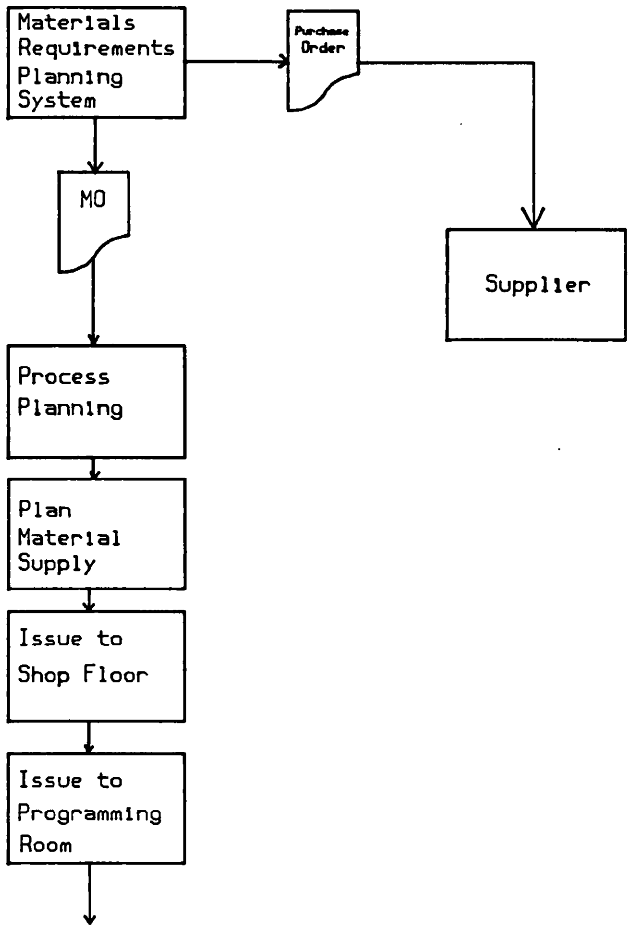


Figure 18 Production Planning & Control

3.4 The Manufacturing Shop Floor

When a Manufacturing Order was released to the shop floor, the material kitter would locate, cut and kit the material and then transfer the material to the machining area. The CNC machine programmers would then have the task of creating the CNC code. The programmer would first of all reference a directory of all components that had been programmed before, if the program existed the tooling sheet would be located in the local filing system and the CNC code found on audio tape. The audio tape would be transferred to a Laptop PC and then transferred to the machine controllers, (see figure 19).

The tooling sheet would then be referenced to identify all the tooling required to run the job. The tooling at this stage was stored in numerous cupboards around the factory, under the control of the CNC Programmers and key operators. There was no record of the tooling and respective location or if the tooling existed. If the tooling did not exist a purchase order was raised. This data control and tooling control process was time consuming and resulted in extended lead times.

The programmer was left with the responsibility of ordering tooling for the CNC machinery. It was found that because tooling storage was not structured and controlled there was an excess of some tooling and a shortage of other tooling.

When a CNC program had been written a note was made in the code directory and a copy of the drawing was placed in a local file. The drawing was used for the location of similar CNC code when creating a new CNC program. The major problem with filing drawings on the shop floor was that sometimes the operators and programmers reference old drawings and also the implications of adhering rigidly to BS5750 [Ref 9].

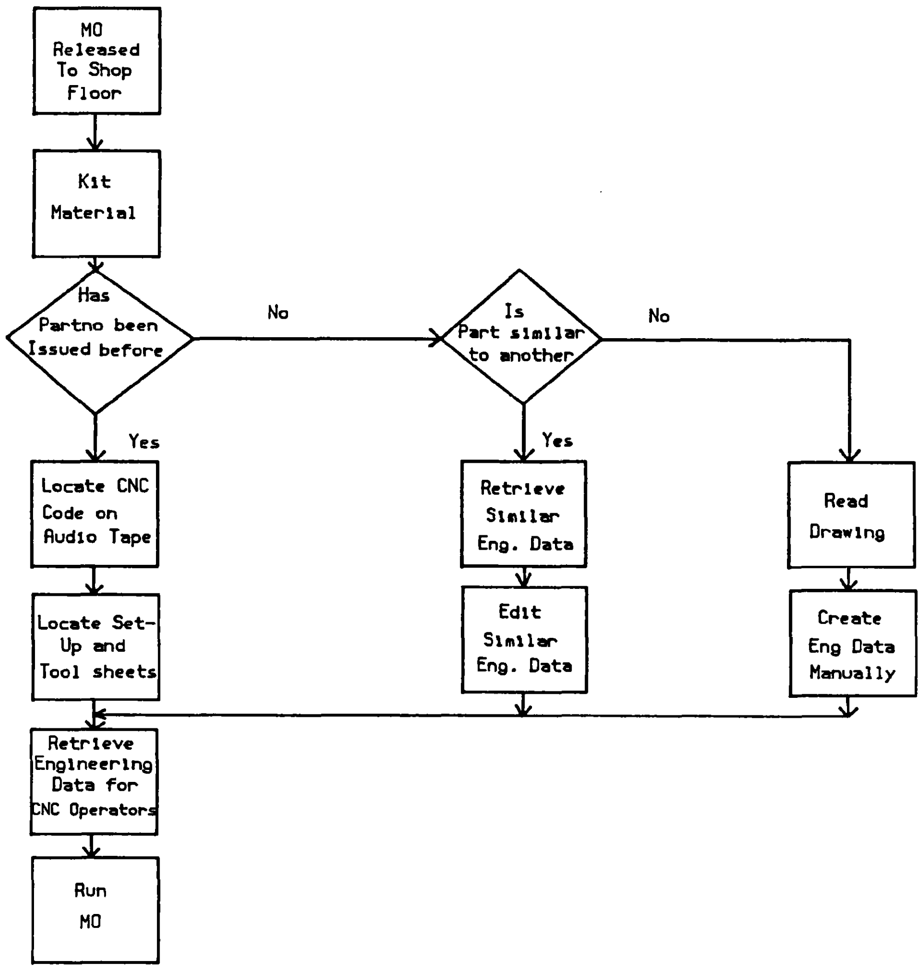


Figure 19 Shop Floor Engineering Data Creation

When the operator ran the job at the machine he would reference a tooling sheet, if it existed, this sheet detailed the tooling that was required. The tooling descriptions were written in such a manner that very few operators could clearly identify which tools was required. The programmer would be summoned to identify tooling and set the machine. Tooling sheets were all stored in ring binders locally to the CNC machines, there was no copies and sheets were sometimes lost. These tooling sheets were illegible and incomplete.

Archiving of CNC code also involved problems for the production shop floor;

> Some programs that were created were written on the Laptop PC and archived to audio tape.
>
> Others were written using the Fanuc Controller Editor.

When the job had been completed the operators sometimes failed to archive the CNC code to audio tape and the program would be lost.

The technology applied to transfer the Laptop PC's memory to audio tape was not very efficient. This resulted in the loss of valuable CNC code.

3.5 Summary

The Design / Production and Shop Floor system described, reflected a serial flow of information. Attempts were made to warn departments in advance of any problems that may arise but there was still an inherent problem with the system as a whole.

Similar to most engineering companies the last process or department is always seen to be the bottleneck resource even although some of the problems had been created earlier in the system.

Fortune Engineering required a system that would integrate with all areas of the business and exploit the continued investment in advanced production machinery.

Chapter 4.0

CIM Model Adopted

4.1 Introduction

The model adopted at Fortune Engineering for all computerised business systems was the Central Data Hub Model.

This model exhibited all the qualities of efficient management of engineering and business data. Engineering change would be made easier by the system and would aid the company to BS5750 certification.

The model also promoted the client / server model where the server would control the central data hub and the clients would be the satellite applications.

It was also recognised that centrally stored data could be controlled by one data management system.

4.2 Data Management Systems

There are many data management systems commercially available, for many hardware platforms. Data management systems consist of stand alone PC based systems such as FoxBase and DB2 to ORACLE, INGRES and INFORMIX for larger Unix and VMS multi-user based systems.

Many of the data management products mentioned, use relational techniques to produce fast and efficient data and information structures. It is not within the scope of this thesis to examine these products in detail but before selecting a data management product it is essential to define what the product will be used for.

For example it has been identified that due to the architecture of relational data bases they are very computationally expensive for financial services and process control business applications.[Ref 10]. The engineering environment, although complex, can make satisfactory use of this architecture and produce well integrated business systems.

4.3 Data Management System Adopted

The data management system adopted at Fortune Engineering was the Ingres Relational Data Base Management System. The selection of this product was due to a number of factors:

(i) The product would integrate with Fortunes existing CAD system.

(ii) The commitment of software companies to develop third party applications using the product, eg Ferranti, England Group & Source 1, [Ref 13].

(iii) The long history of the product and its excellent reputation.

(iv) Ingres are committed to the hardware installed at Fortune Engineering.

(v) The product was identified as one of the top four in the data management industry.

(vi) Hardware suppliers were committed to the product. eg Apollo, Hewlett Packard and Sun.

4.4 Development Policy

The Data Base Management system adopted was seen as the core to the complete Integrated Business Environment to be created at Fortune Engineering. The Data Base Management system, by definition, only manages data under the control of rules and logic developed using the application tools supplied.

Procurement and installation of the Data Base Management System was identified as one of the building blocks to the development of the Integrated Business Environment.

In order to obtain maximum benefit and develop the system in an integrated way it is important to formulate a development policy and plan.

The development policies adopted by Fortune Engineering are detailed in Chapter 1.3 of this document.

The development plan should be defined before any system development work has commenced. This plan dictates the procurement of manpower and financial resources throughout the system development. The plan should be defined in such a way that the system can be developed in a logical stepwise manner;

For example if a study of the existing system reveals that much of the information flows in from a customer, then it would be prudent to develop a system to process customer information first and then concentrate on other systems to use this data in a structured way throughout the business environment.

When formalising the plan there are a number of issues that will affect the order of development and time scales of the project:

i) System development may be delayed while awaiting new hardware to come on-line, or old equipment to be disposed of.

ii) Development may be suppressed with the request to integrate with old or un-supported software, previously installed within the company.

iii) The plan may have to address major bottlenecks in the companies system first, before other development work is started.

iv) Senior management may request that a system or department is developed first.

v) Government and local authority grants may be given for unique parts of the system and senior management may decide to approach these areas first.

vi) The marketing managers may propose that a system is adopted to promote the company and its products.

For example the installation of a Computer Integrated Manufacturing system can be publicised to prospective customers and demonstrate that the company is 'forward thinking' and at the 'forefront' of technology.

4.5 Development Concept

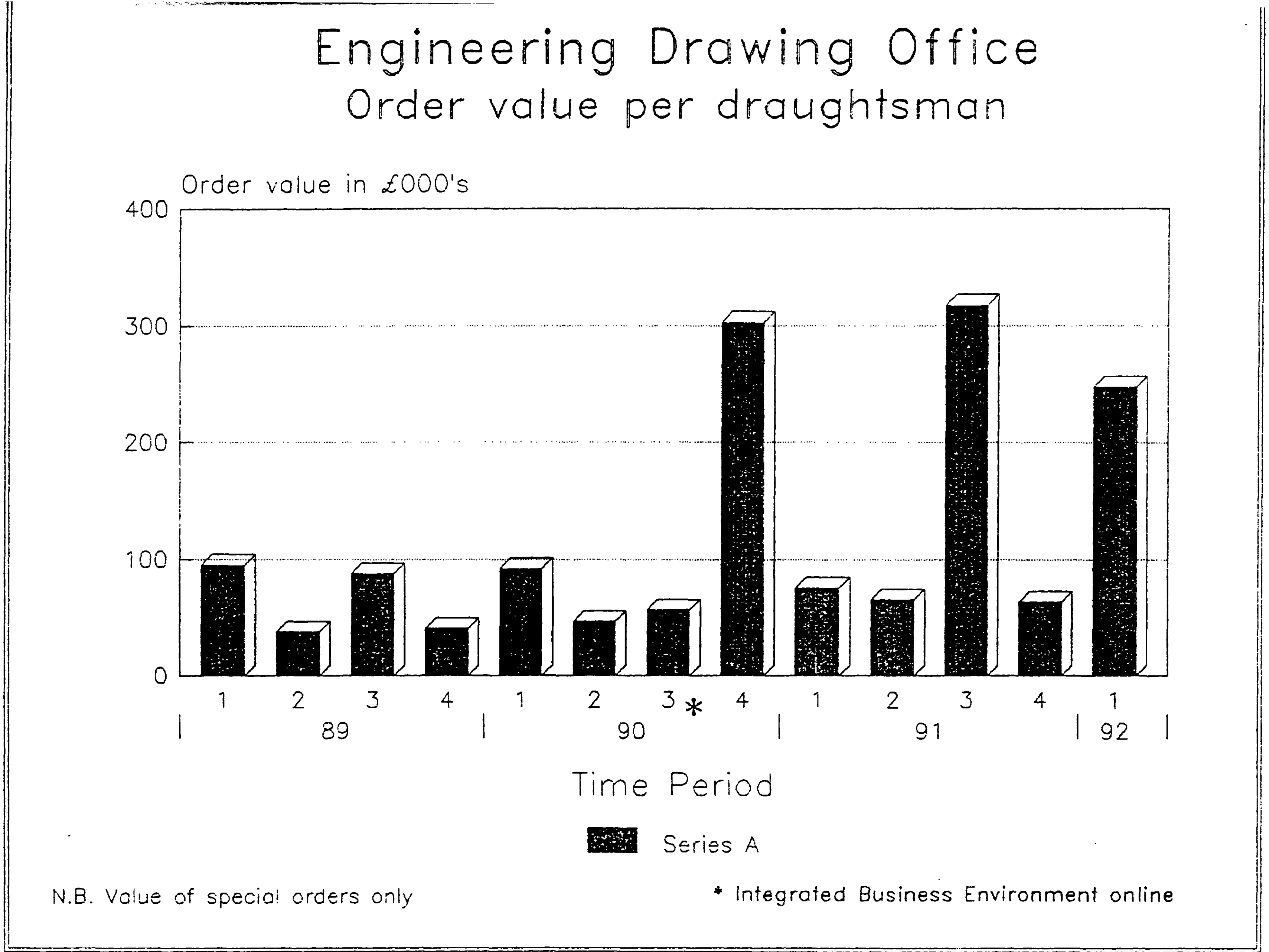
Prior to the definition of the development plan for Fortune Engineering's Integrated Business System a detailed system flow diagram was developed. This system flow diagram, (see Figure 1), details the generation and flow of information from all processes and departments in the company.

It was clearly identified that similar to most companies the customer order and specification is very important to the system and defines which products and components are required.

Although the customer order was used to trigger events throughout the system, the most critical process is that of Material Requirements Planning. This process controls all material requirements for the fulfilment of a customer order and is an essential part of the system.
The customer order controls the flow of information throughout the system and the Material Requirements Planning system is the main core of the business system.

An important part of any engineering system is the Engineering Change Control procedure or process, this may not be apparent in the system diagram but the control of engineering change is an important part of any engineering system.

The logical approach to the development of the business system was to commence with an engineering data creation and control module. This approach was further substantiated by the findings that the Engineering Drawing Office was a major bottleneck to the efficiency of the system and the success and growth of the company, (see Figure 20).



Engineering Drawing Office
Order value per draughtsman
Order value in £000's
400
300
200
100
0
1
2
3
4
1
2
3 *
4
1
2
3
4
1
89
90
91
92
Time Period
Series A
N.B. Value of special orders only
* Integrated Business Environment online

Figure 20

4.6 Development Methodology

The task of creating an Integrated Business Environment was developed using a number of discrete development modules or mini-systems. The responsibility for each module was given to a systems engineer who would design, write, test and install all software and hardware necessary for satisfactory completion.

During the development of these modules it was necessary for each system to stand-alone and have a positive contribution to the business system the day the system was made available. In addition, each system had to integrate with previous and future systems in accordance with the development policies, (see Chapter 1.6).

4.7 Development Modules

The responsibility of system development was given to two engineers. Detailed below are the system modules and the responsible engineer. The development phasing of the system modules can be found in Figure 21.

(i) Develop a computer based component part register to replace the paper based register.

Responsibility, Graham Silk.

(ii) Develop parametric programs to design and draw Spiracon Roller Nuts and screws.

Responsibility, Graham Silk.

(iii) Create a Drawing Office Management System to;
Create Bill of Materials.
Control generation and issue control of engineering drawings.
Manage engineering change.

Responsibility, Graham Silk.

(iv) Develop a parametric system to design and create detailed engineering drawings for a complete new product range.

Responsibility, Graham Silk.

(v) Develop computer based Tool Management system to control all component tooling and Bill of Tools structures.

Responsibility, Stuart Howard.

(vi) Develop computer based system to manage all shop floor CNC code, Setup and Tooling information.

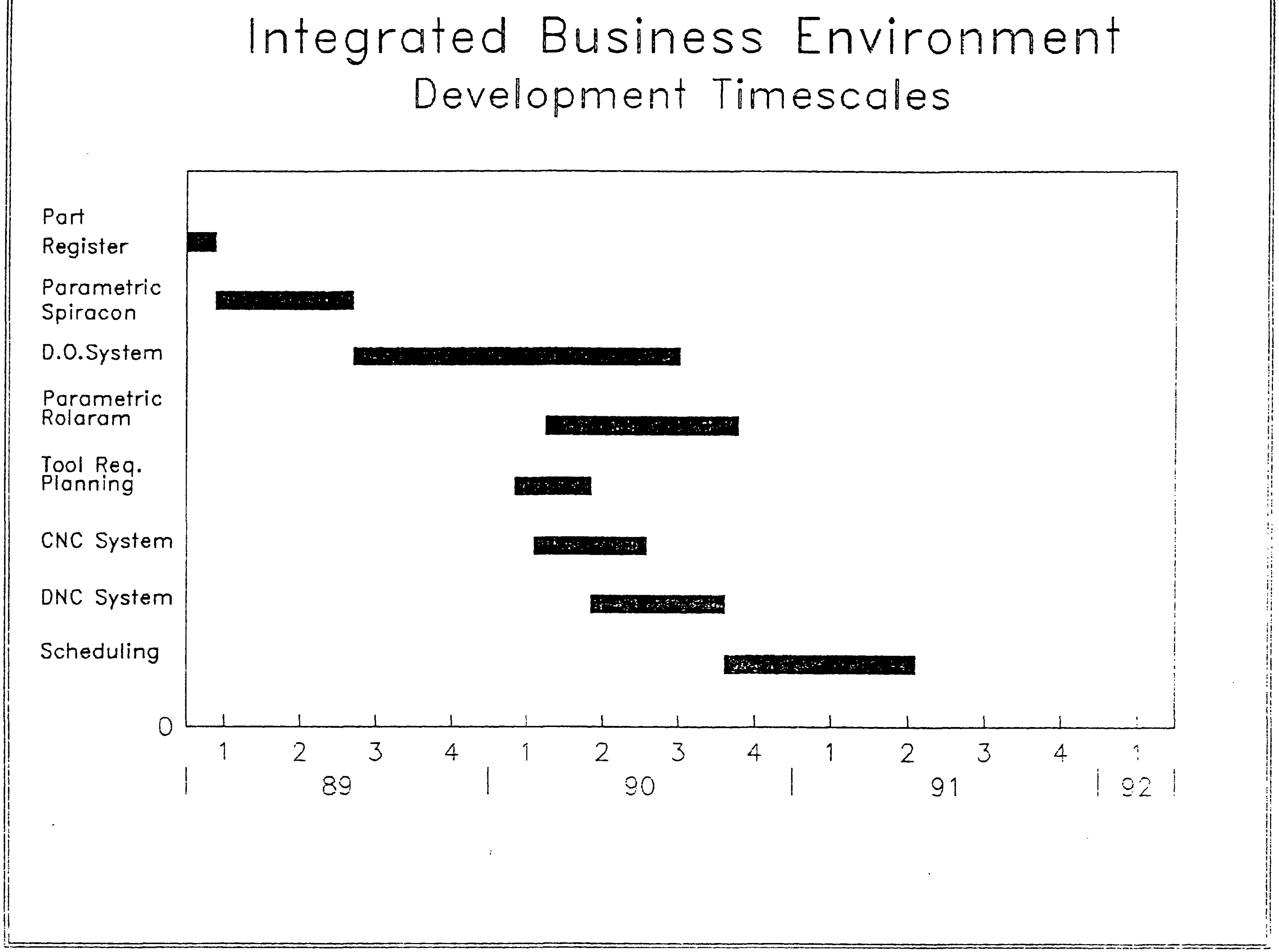
Responsibility, Stuart Howard.

(vii) Develop Direct Numerical Control functions to transfer CNC code from central data base directly to CNC machines.

Responsibility, Stuart Howard.

(viii) Develop production scheduling system by which all CNC production machines can be loaded and managed. Shop Floor Data Capture functions should permit CNC machine monitoring.

Responsibility, Stuart Howard.



Integrated Business Environment
Development Timescales
Part Register
Parametric Spiracon
D.O.System
Parametric Rolaram
Tool Req. Planning
CNC System
DNC System
Scheduling
0
1
2
3
4
1
2
3
4
1
2
3
4
1
89
90
91
92

Figure 21

4.8 Summary

The Central Data Hub CIM Model has been adopted and the Ingres Relational Data Base has been chosen as the standard Data Base Management system.

The system objectives, timescales and procedures were defined and documented and the workload distributed between the system developers.

The following chapter discusses each of the system modules and describes the integration of each with the central data base.

Chapter 5.0

System Module Descriptions

5.1 Introduction

This chapter describes the unique system modules which were developed to form Fortune's, Integrated Business Environment.

The modules are all stand-alone systems which have controlled access to the central engineering data base.

5.2 Computer Based Part Register

This system module was written in an attempt to formalise the creation and control of the large numbers of component parts created by Drawing Office staff. This module has since been superseded and a brief explanation should be suffice.

When a new component part was designed the system would assign the component the next sequential part number. The designer would then input a description of the part into the system. This description was controlled in such a manner that only standard descriptions, codes and abbreviations could be used. The adoption of standard descriptions permitted the facility to execute 'where used' queries on the data to find existing component parts. When an existing part was found the engineering drawing was used as a basis to create the new component, thus reducing valuable design resources.

This basic system was written and established within a very short time scale and succeeded in controlling the creation and re-issue of the companies increasing number of designed and proprietary parts.

Examples of designed component parts include;

S030 003117 30 Tonne Lifting Screw
S000 003120 Inverted Shell Cap 1/2 Tonne
S000 003123 Shell Housing 10 Tonne Ball Screw Jack
BS01 003124 Wormwheel Std Ratio 10 Tonne BS Jack
RS03 003155 Clevis 30 Tonne Roller Screw Jack

Examples of proprietary component parts include;

S999 003192 Burgess Micro Switch QVCF9P
S999 003202 M4 Nut
S999 003203 M4 Spring Washer
S999 003239 GEC D80 "C" Flange Motor 1HP 1400Rpm 380v
S999 003287 Cutler-Hammer Limit Switch ME500 PT 381

5.3 Spiracon Design System

The design of a Spiracon product was resource consuming and attributed to the bottleneck in the Engineering Drawing Office, (see Chapter 3.2).

The objective was to develop a system to design and create engineering drawings for the complete range of Spiracon products.

Parametric design techniques were employed to create a suite of design and drawing programs. Customised programs include;

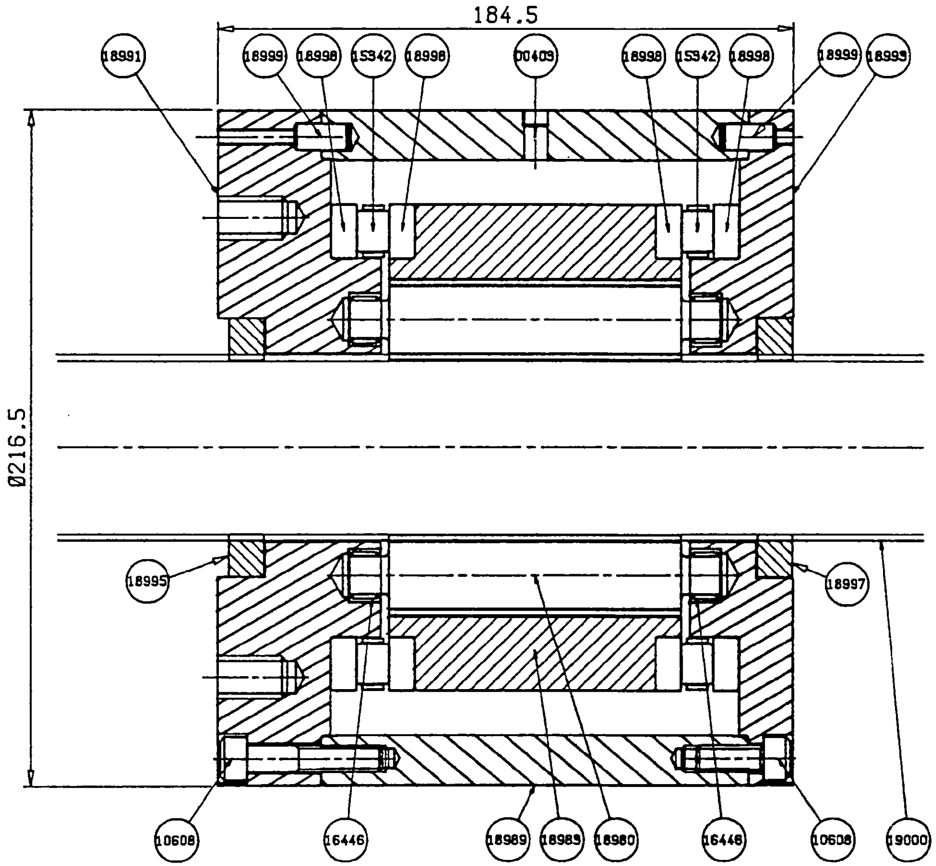
Design Spiracon Nuts

Design Spiracon Screws

Draw Spiracon Nuts (see Figure 22)

Draw Spiracon Screws (see Figure 23)

A complete description of these programs can be found in the appendix, (see Appendix A1.4).

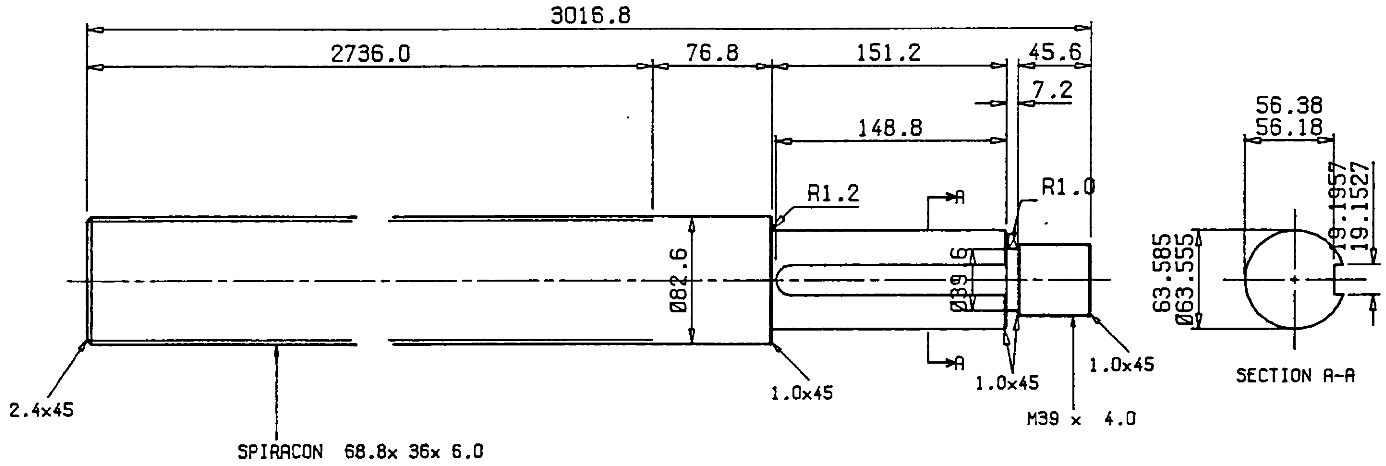


R068018979

1 - - - NUT ASSEMBLY

1:1

Figure 22 Spiracon Roller Nut



OUTSIDE DIAMETER : 68.800
LEAD : 36.000
NO. OF THREADS : 6.000
AXIAL TOOTH THICKNESS : 2.807
ROOT RADIUS : 0.926
AXIAL TIP WIDTH : 1.044

UNTOLERANCED DIMENSIONS +-0.1
1.6 ALL OVER
MATERIAL - BRIGHT BS970 708 M40

R068019000

1 - - - SCREW

1:2

Figure 23 Spiracon Screw

5.4 Drawing Office Management System

This system was developed to address further the bottleneck in the Engineering Drawing Office and to establish control of engineering data throughout the business environment. This system was also seen as one of the major cornerstones to the implementation of BS5750.

The system consisted of a number of discrete parts;

Component Part control

Product Structure control, (Bills of Materials)

Engineering Drawing Management, (CAD and paper drawings)

Engineering Change control

The parts were integrated in such a manner that changing or substituting a component part would result in a change to all Bills of Materials the component was referenced.

In addition, if a CAD drawing was changed the re-issue of the drawing would be reflected in the component part definition and hence the Bill of Materials product structure.

A complete description of this system can be found in the appendix, (see Appendix A1.2).

5.5 Rolaram Design System

After the successful development of the Spiracon design system it was proposed to develop the Spiracon product still further and incorporate the product into a new range of electro-mechanical actuators. This new range of products, known as Rolaram, were designed exclusively using parametric techniques.

The development of this system signifies a landmark in the application of parametric techniques. The system was used to;

Create initial design concepts

Design of the Rolaram product

Create assembly procedures

Develop promotional materials and catalogues

Create customer proposal drawings

Cost a proposed solution to a customers enquiry

Design standard range of actuators and options

Create bill of materials product structure

Design any special actuator product to customer requirements

A complete description of this system can be found in the appendix, (see Appendix A1.2).

5.6 CNC Programming System

The CNC programming System was developed to create CNC Part Programs, Machine Set-up and Tooling Sheets quickly and efficiently. This development would have a number of advantages;

Shop floor data is controlled and managed efficiently.

Data controlled using existing part component register.

One copy of data stored centrally.

Shop floor data created quickly using existing data.

Machine data can be made available across the network to all Machining Cells, (see Figure 24).

The introduction of this system has seen a dramatic improvement in the time taken to retrieve and archive CNC code, (see Figure 25). Additionally the system has addressed the problems of poor control and loss of valuable engineering data.

5.6.1 Menu Structure

The following system summary explain the basics of how each menu item aids the programmer from initial planning of the job to the creation of final CNC Program and Machining Sheets.

It should be noted that the system was written to aid the development of manual CNC programming techniques and not the more traditional CAM programming approach.

The structure also enables a programmer to define one or more tool assemblies, Bill of Tools, on a machining sheet and then to quickly view the part program and create CNC code. The programmer in this way can jump from machining sheet to CNC code very quickly, (see Appendix A4.1).

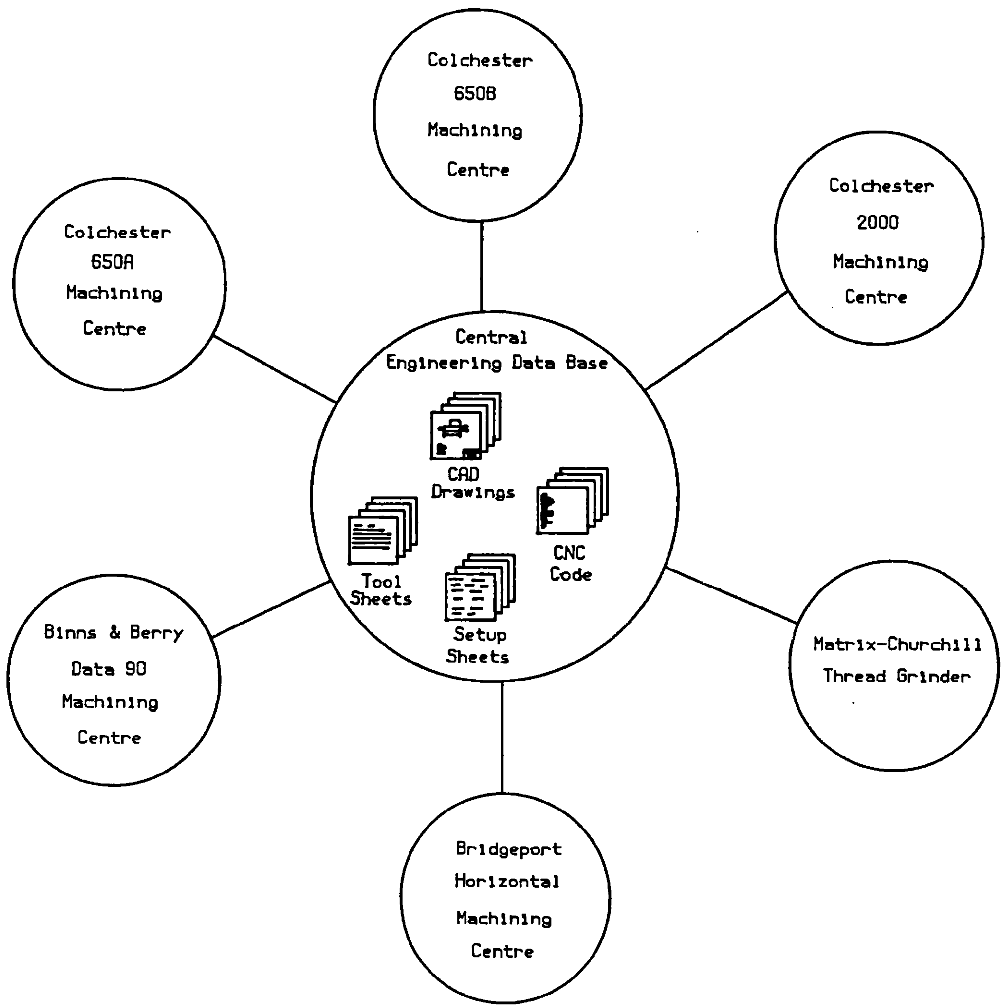


Figure 24 Supporting Data for DNC System

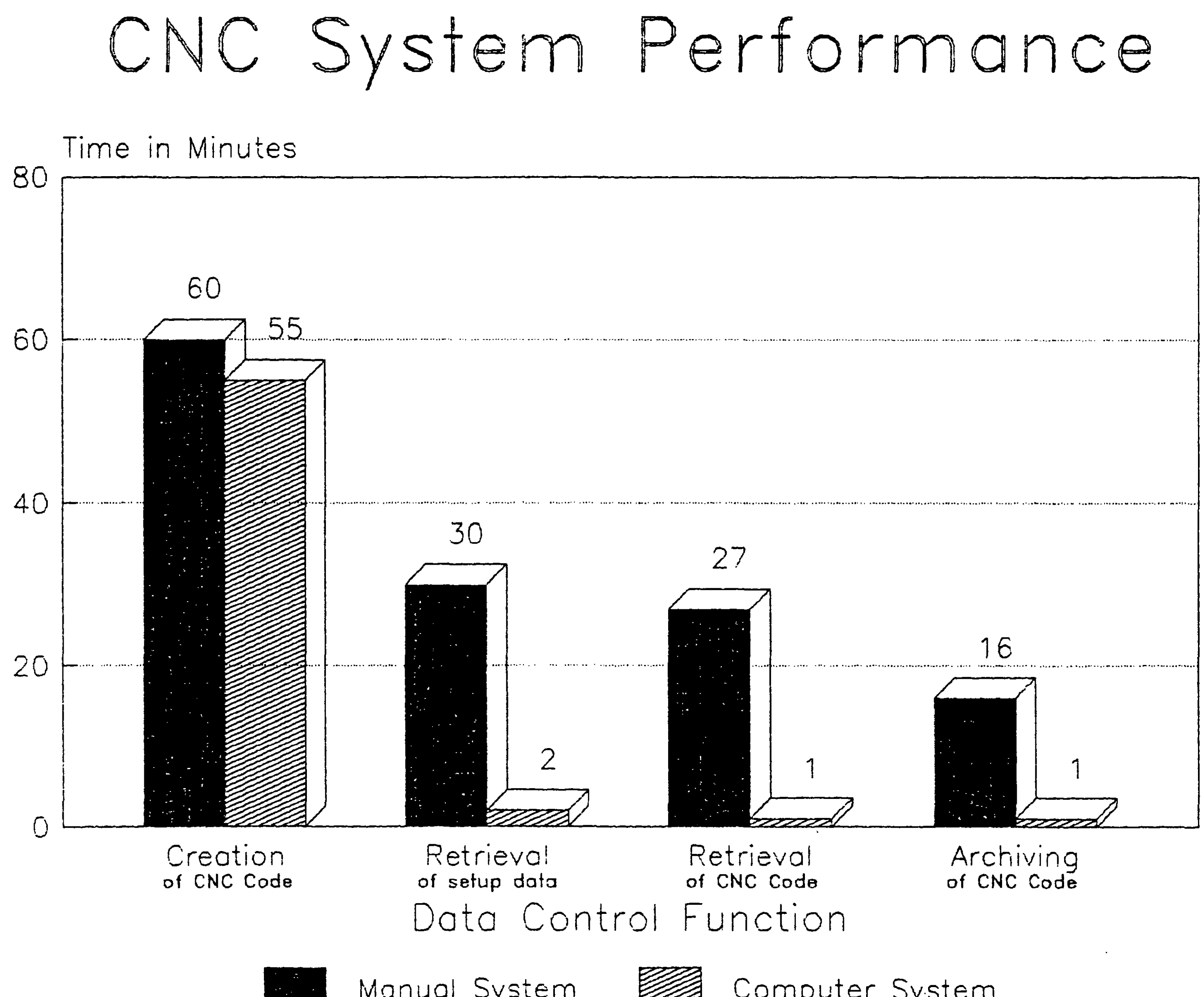


Figure 25 CNC System Performance

5.6.2 Shop Floor Register

A CNC programmer spends much of his time in planning and preparation prior to the creation of Machine Setup Sheets, Tooling Sheets and CNC code. This preparation time is reduced dramatically if the programmer can use an existing proven program as a basis to create the new program. Firstly the programmer can type a product or part description, all parts meeting the search criteria are retrieved. In addition to the parts the central data base identifies if machining data and CNC Code are available and if the data is in a proven state.

The programmer is also informed if a CAD drawing is available for view only at the PC. Once the component part number is identified the programmer can then retrieve this code from the data base and create the new CNC Code, (see Appendix A4.2).

5.6.3 Machine Setup and Tooling Sheets

The Machine Setup and Tooling Sheet is combined onto one form to enable the data to be created quickly. The programmer inputs the sheet definition which includes the part number the issue number, the machine number and the program number. After the definition is detailed then the Tooling definitions can be added. The Tool Assembly number (TA's) are defined in the Tooling Library and the programmer can view the Tool Library and then insert the TA onto the sheet, (see Figure 26).

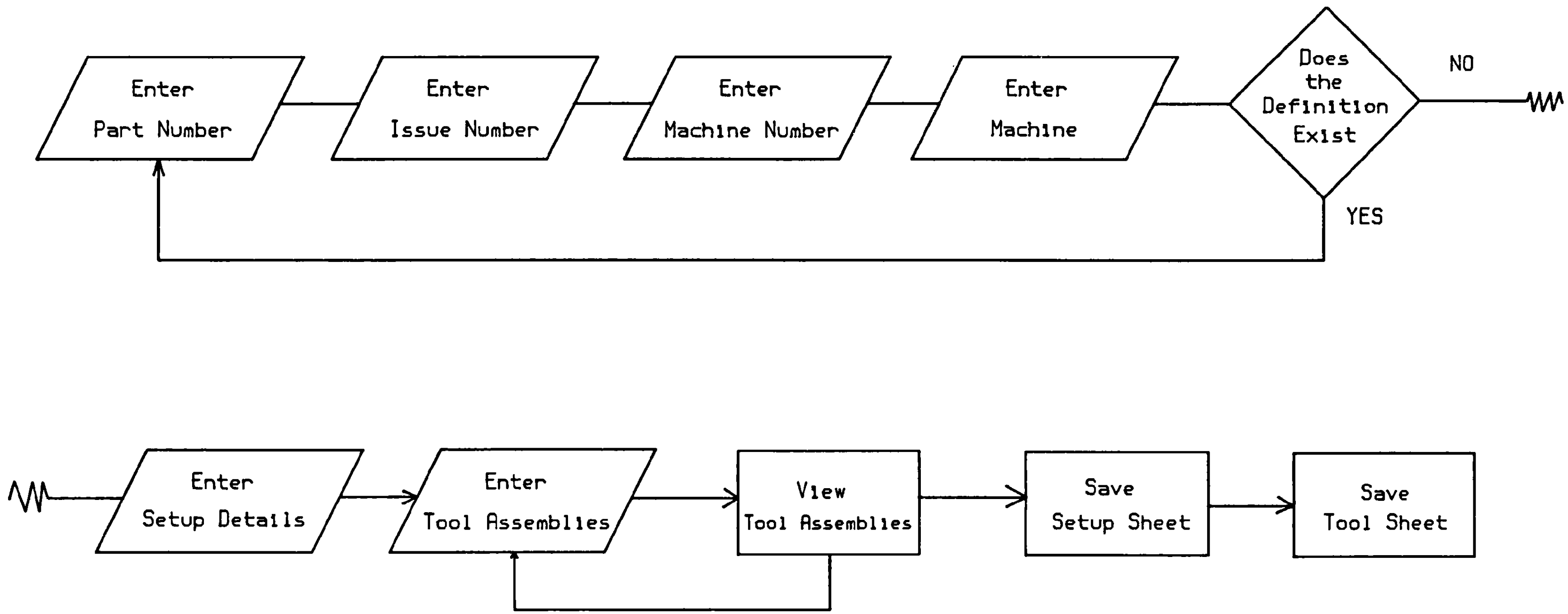


Figure 26 Creation of CNC Machine Setup and Tooling Sheets

5.6.4 Tool Assemblies

Tool Assemblies are defined by the programmers only. Tool Assembly defines a collection of unique tools into a unique structure, or Bill of Tools, (see Figure 27). The programmers can View a Tool Assembly, Detail a Tool Assembly or Create a Tool Assembly while creating a Tooling sheet. When a detail of a Tool Assembly is requested then the screen will display the seven tools, their class, description and part number that define the tool assembly.

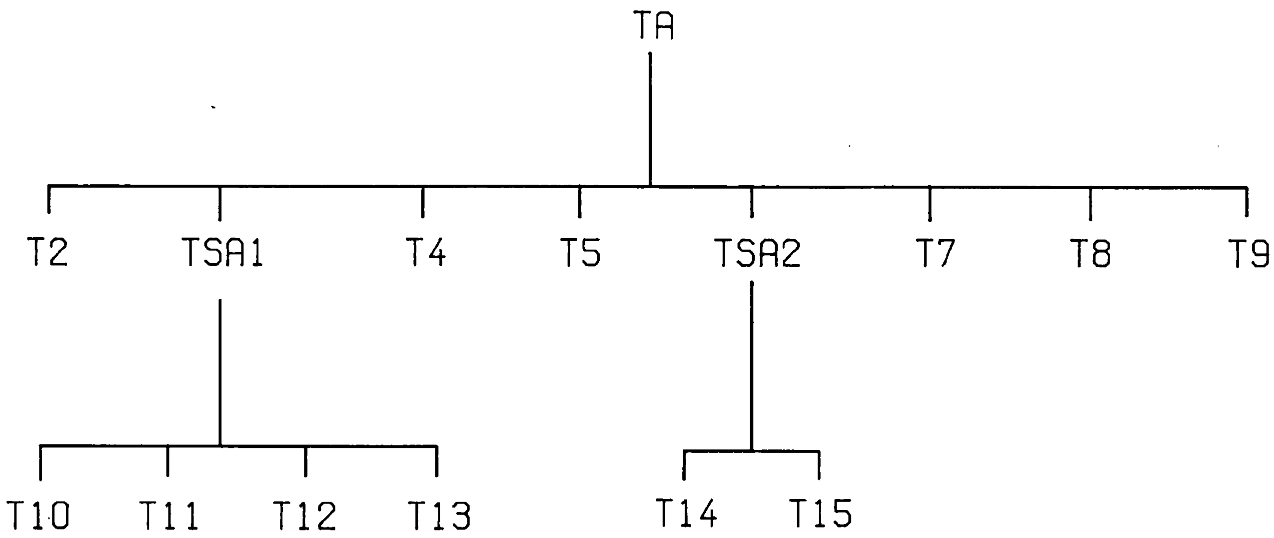
The programmer may wish to locate Tool Assembly numbers from the Tool library while constructing the Tooling Sheet. Keying in one of the three search fields all related tooling can be retrieved.

The programmer can then request a corresponding Tool Assembly where this tool has been used until the correct Bill of Tools is located. Choosing the 'Return TA' option the Tool Assembly retrieved during the search will be placed automatically on the Tooling sheet for the programmer.

If the programmer has searched the data base and a Tool Assembly does not exist with the correct tooling then the programmer can decide to Add a new Tool Assembly to the data base. Initially the programmer may decide to use an existing Tool Assembly as a basis to edit and create the new one. When a suitable assembly is located this can then be edited.

Using the search fields the programmer can key in a description and part number and retrieve the correct Tool Number for the assembly.

When all Tool Numbers are defined the new Tool Assembly can be saved to the data base for use on any future Tooling Sheets.



TA	- Tool Assembly	T9	- Tool (Insert)
TSA1	- Tool Sub Assembly 1	T10	- Tool (Shim)
TSA2	- Tool Sub Assembly 2	T11	- Tool (Shimpin)
T2	- Tool (Power Pot)	T12	- Tool (Screw)
T4	- Tool (Collet Extension)	T13	- Tool (Allan Key)
T5	- Tool (Collet)	T14	- Tool (Shim)
T7	- Tool (Collet Extension)	T15	- Tool (Screw)
T8	- Tool (Chipbreaker)		

Figure 27 Bill of Tools Structure

5.6.5 CNC Program Creation

The concept of creating CNC code is similar to that of Tooling sheets. The programmer has the option to create code from a blank form or can retrieve existing code as a basis to create the new code, (see Appendix A4.6).

To create code from an existing program firstly the code is retrieved by typing the search criteria. When the code is retrieved the essential fields are cleared to enable the programmer to key in the new Part number, Issue number, Program number and Machine. The code can then be edited and added to the data base. While creating, editing or viewing CNC code there will be an option to edit or view the corresponding Tooling sheet.

5.6.6 CNC Code Returns

The DNC System manages the access to machine data and CNC Code from the data base to the local PC. In addition the CNC Code Returns module manages the return of CNC Code from the individual CNC Cells back to the data base, (see Appendix A4.7).

For example code is copied from the data base to the local PC and then to the CNC controllers. When the data resides in the controllers the operators can alter the programs slightly to reflect feeds and speeds changes, maybe due to poor surface finish or sizes outwith tolerance limits. If a major change is required then the operator can change the code and transfer the code back to the returned area of the data base. The programmers can view the returned code and can compare the code to the original and then make a decision whether to replace the Data Base code with the returned code or delete the returned code.

5.7 Direct Numerical Control System

The Direct Numerical Control (DNC) System was developed to manage and control the access and flow of CNC Part Programs, Machine Set-up, Tooling Sheets and Engineering Drawings from the engineering data base directly to the shop floor CNC machines, (see Figure 28). A number of benefits where realised from this system:

Engineering data could be accessed from any PC on the shop floor.

Reduced setup times resulted from correct availability of crucial information.

The system promoted unskilled operation of all CNC machinery.

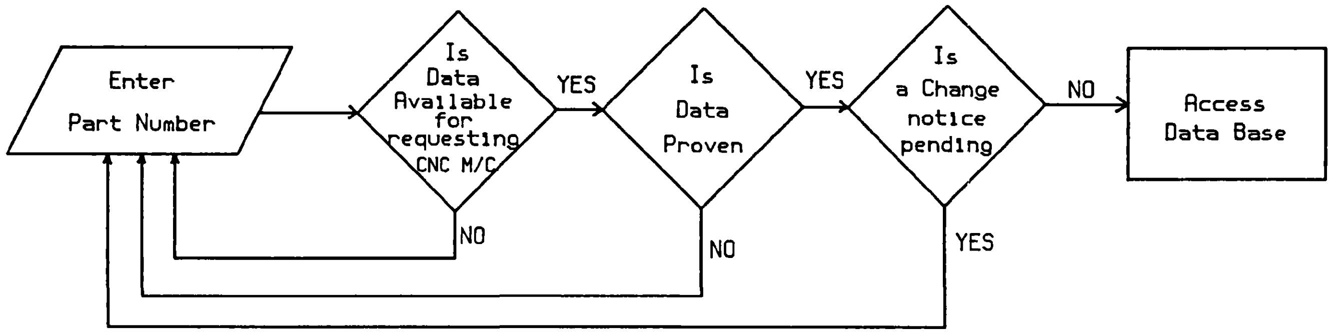


Figure 28 DNC System, Data Base Access

5.7.1 Menu Structure

The main menu displays all the functions available to the CNC machine operator. The operator has the option to view engineering data or transfer code to and from the machine controller, (see Appendix A4.8).

5.7.2 View CNC Part Program

This function displays the CNC Code for the operator. A typical component may require many programs and sub programs to complete. The Data Base is structured in such a way that all code necessary to complete the component is retrieved into one single ASCII file. The operator has no facility to edit the CNC Code at this stage, thus retaining the integrity of the CNC code, (see Appendix A4.9).

5.7.3 View Set-Up Sheet

All Set up sheets required to complete the component part are retrieved from the data base.
The Set up sheet informs the operator how to set the machine and displays details of any additional fixtures, tooling or gauges that may be required.
One of the most important facilities is the notes field where the programmer can display notes for the CNC operator, (see Appendix A4.10).

5.7.4 View Tooling Sheet

The Tooling sheet is retrieved from the Data Base and is displayed for the user. All tooling required to manufacture the component is detailed by the Tool Assembly number. This is the same number the programmer defined and used in the CNC Programming application.

The Tool Assembly number informs the CNC Operator which tool assembly to load from the pre-kitted kit of tooling.

The Tooling Sheet also defines the Turret Position in the CNC Machine and any physical or software offset registers used in the CNC machine, (see Appendix A4.11).

5.7.5 View Engineering Drawing

This function displays the engineering design drawing for the component part in 'view-only' format. The operator can view any part of the drawing and associated text, but cannot make changes. Prior to the display of drawings in 'view-only' format drawings were available on paper and stapled to the Manufacturing Order. This paper drawing caused control problems with parts manufactured to wrong issues or drawings not available. With the implementation of BS 5750 it was necessary to load all drawings into the data base and control the issue of drawings to the shop floor.

5.7.6 CNC Programs to Machine Controller

Part programs are stored in ASCII format on the PC, this function sets serial communication parameters such as Baud Rates, Stop Bits and Parity and then uses XON/XOFF protocol to transfer the CNC Code from the PC to the machine controller. When the part program has been sent to the controller it is then transferred to the controller again, this time for checking. If there is a discrepancy in any of the part programs then the files are deleted and the transfer begins again.

5.7.7 CNC Programs from Machine Controller

Part programs used to manufacture component parts can be altered slightly to reflect varying feeds and speeds. If the operator makes any more changes to the program or the programmer is running a test program then the part program may be edited. This function enables the edited part program to be transferred back to the PC and subsequently back to the data base. Again the program is sent twice for comparison and if transfer was successful the program is saved to the 'Returned Area' of the data base.

In addition to the program transfer, the Data Base records the time the program was sent back and the CNC machine which executed the transfer. This information is then used by the programmer for program identification, (see Chapter 5.6.6).

5.8 Tool Management System

The Tool Management system manages and controls all production tooling, gauges and fixtures required for the CNC Machine Cells. All tooling is stored in a central tooling room and is identified by a unique tool (T) number. This number leads to rapid identification of tooling requirements. All tool storage, inventory control, tracking and production kitting is executed by the engineering data base. In this way the availability of all production tooling can be monitored and scheduled using the Production Scheduling System, (see Appendix A4.12).

Advantages include;

Real time inventory control of all production tooling.

Scheduling of Manufacturing Orders to availability of tooling.

Just in time preparation of Tool Kits to the CNC machining centres.

5.8.1 Bill of Tools Structure

To support the system it is necessary to define a Bill of Tools structure. This structure is similar to the Bill of Materials structure and records Tool Assemblies (TA's), Tool Sub Assemblies (TSA's) and Tools (T's). The Tool Assembly is created and defined by the Programmer, The Tool Sub Assemblies and Tools are created and defined by the Tool Store person, (see Figure 27).

5.8.2 Menu Structure

This application is used by the Tool Store person to manage the tooling information in the engineering data base.

A number of management functions are available, (see Appendix A4.12).

5.8.3 Add Component Tooling

This function enables the user to add a new tool to the data base. If a Tool is purchased as an assembled tool but the parts can be ordered under different Part numbers then the assembled tool must be dis-assembled into the individual tools and each part given a unique Tool number. The next tool number is assigned automatically from the data base application, (see Appendix A4.13).

5.8.4 Edit Component Tooling

This function allows the user to edit the definition of an existing tool on the data base. The Tool number to be edited should be input in the correct field and the search option chosen. The data base will then return the definition of this Tool number. The user has the facility to search for any tool on the data base that is not a Tool Assembly. The user also has the facility to edit any field in the tool definition except for the Tool Number. This number will stay un-changed in the data base, to retain the integrity of the data, (see Appendix A4.14).

5.8.5 View Component Tooling

This function allows the user to view the definition of an existing tool stored in the Data Base. The function also displays a table of related tooling, (see Appendix A4.15).

5.8.6 Purchase Order Requisitions

This function allows the user to produce a Purchase Order Requisition and print the form for processing by the Purchase Department. The Purchase department can then order the component tool from the detailed description printed on the requisition, (see Appendix A4.16).

5.8.7 Kit Tooling

This menu item aids the Tool Kitter in pre-kitting production Tooling Gauges, Jaws and Fixtures for CNC machinery. The application retrieves the pre-defined Tooling Sheet from the data base. The Kitter then kits each Tool Assembly in turn retrieving the Bill of Tools, (see Appendix A4.17).

The Bill of Tools, details the Tool Class, Description and Location information to locate Tooling efficiently in the Tooling Room. The Tool Kitter has no facility to change any data that is displayed, thus retaining data integrity, (see Appendix A4.18).

When all tooling required for the Manufacturing Order has been located and assembled; the tooling is then placed in a Tool Kitting Trolley. This trolley is then placed in a special trolley park adjacent to the CNC machining cell, ready for the CNC operator to collect.

The advanced tool kitting facility in the Tool Management system aids the reduction of CNC machine setup times and further the efficiency of the production shop floor.

5.9 Production Scheduling System

This system is one of the most important systems in the Engineering Data Base, where the other modules discussed earlier are supporting systems this Scheduling System is one of the major Planning and control functions within the Integrated Business Environment.

The system, a module in itself, takes advantage of the previous systems by the management of Manufacturing Orders, Component Part structure, Engineering Drawings, Machine data and Tooling availability.

The Scheduling System creates the executive links that are the true characteristics of an Integrated Business Environment. These links include;

> Scheduling of production machinery with a knowledge of machine capacity, data availability, status and order requirements.
>
> Identification of critical supporting services within the production environment, eg CNC Part program, machine setup data, Engineering drawing and Tooling data availability.
>
> Forecast of likely bottlenecks within the production environment.
>
> Engineering change from the engineering drawing office which has an immediate effect on production, schedules.

5.9.1 System Control Hierarchy

There is an internal system control hierarchy which ensures that data is not accidentally changed or corrupted by an operator who is not authorised or trained.

5.9.2 Menu Structure

The menu structure permits the Production Controllers to log Manufacturing Orders to the system and load the appropriate load centre. In addition there are a number of utilities to aid the controller in the loading and scheduling task and to view captured shop floor data from previous Manufacturing Orders, (see Appendix A4.19).

5.9.3 Logging Manufacturing Orders to System

All MO's generated by the Material Requirements Planning system and are immediately logged onto the Scheduling System, (see Figure 13). The Production Controller will also input additional information to the MO definition to aid Planning and Scheduling.

Similar part numbers and issue numbers will be flagged by the system for collation. This collation process will mark a Master MO and all the MO's that are collated with it. This collation process will eliminate large quantities of similar parts obstructing the Planning and Machine Schedules but will still retain the breakdown or detail to enable unique MO's to be kitted and processed.

The MO number is the number generated by the MRP system. If the MO is a manual number then the Production Controller keys 'return' which will retrieve the next manual MO number from the Systems Internal Register.

The Controller will then type a PART NUMBER eg 53. The system will retrieve the component part number prefix and description. The Controller will then key in the ISSUE NUMBER. The application will then check the component part register, (Drawing Office Management System), and display a warning if a previous issue is requested for manufacture.

The BATCH size is now entered. This is the Batch size as read from the MO. If the batch is for a customer this should be input, this will inform the system that if the batch size is not completed then action should be taken to make up the short fall.

DUE DATE is keyed in, week number first and then year number, eg 30 91 - week 30 1991. The CUSTOMER name, Project Reference number and Sales Order number should then be input as defined by the paper register in the Sales Office.

The Controller should then identify if MATERIAL is available or not. If material is not available the Purchase Order number should be input.

The ROUTING within the CNC Cell should then be input. If a component part requires to be processed by more than one CNC machine then the Production Controller should identify all machines, (see Appendix A4.20).

5.9.4 Master Manufacturing Orders

When the Controller is ready to Log the MO onto the system the component part number and issue number will be searched in the System Catalogues to identify if an MO for that part already exists. If an MO already exists in the system the Controller will be asked if he wishes to collate the MO with the existing one. If the Controller responds 'Yes' then the batch size on the Master MO will be updated and the logged MO added to the Masters detail listing. If the Controller responds 'No' the new Mo will be logged in the Planning Schedule with the other MO's.

5.9.5 Logging Off Manufacturing Orders

The Production Controller is responsible for logging MO's onto the system. When the MO is processed at the CNC machine the operator will be asked if he has completed the MO. If the MO is completed the MO will be deleted from the Machine Schedule and logged in the completed MO's system catalogue. If the MO is not completed the MO will remain on the Machine Schedule.

The Operator will be prompted to ensure the data is correct and the quantity completed will be compared to the original batch size to ensure the operator has indeed completed the MO.

There may be times when the operator inputs that an MO is not completed when it has been completed. The MO will still be resident in the Machine Schedule. In this case the Production Controller will have to 'Force' the MO off the Machine Schedule. The Controller will firstly Unschedule the MO from the Machine Schedule and then delete the MO from the Planning Schedule. If the operator inputs that an MO is completed when there is still work to be done then the MO will be transferred to the Completed Mo's system catalogue. The Controller in this case would have to 'Force' the MO back to the Machine Schedule or Planning Schedule or Re-log the MO back onto the system. The Production Controller will firstly view the Completed MO's and then mark the MO that has to be placed back on the Planning Schedule.

5.9.6 Editing Facilities

When an MO is logged into the system there will be limited facilities for editing, this ensures the integrity of the data within the system. Only the Due date, customer, Project Reference number, Sales Order number and comments fields can be changed.

If any other field require changing this will interfere with the Manufacturing Order definition in the system. If another field requires changing such as the Part Number then this major change will require the MO to be deleted and logged again.

5.9.7 Deleting a Manufacturing Order

When an MO has been logged and is on the Planning Schedule there may be times when the MO is cancelled or logged incorrectly. In this case the MO can be deleted from the system.

If the MO has multiple routings within the system the Controller will be informed and prompted if he wishes to delete all routings. If the MO has multiple routings and one or more of the operations resides on the Machine Schedule then the Controller will not be allowed to delete all routings. To delete the scheduled operation then the MO would have to be unscheduled and then deleted.

5.9.8 Viewing the Planning Schedule

The Controller will be prompted to view the Schedule by Machine or view all. To retain data integrity and to eliminate unauthorised use all personnel will view the same schedule but some functions will only be available to authorised users. This will eliminate the Material Kitter scheduling or deleting MO's in the system, (see Appendix A4.21).

Detailed below are the functions available to each user:-

Production Controller	- all functions.
Material Kitter	- Redisplay and Detail.
Tool Kitter	- Redisplay and Detail.
CNC Programmer	- Redisplay and Detail.
CNC Operator	- View Schedule only.

In the Planning Schedule resides all the MO's that have been logged onto the system but have not been scheduled. In addition the application has retrieved and compiled more data to aid the Production Controller through his planning task:

i) The MO's that have multiple operations are split in the system so that for each operation there is an MO with a unique operation number.

ii) MO's marked with a "*" in the 'M' (Master) field identifies that the MO is a Master MO and further details can be found by keying 'detail'.

iii) Tool Sheet and CNC Code availability is displayed from the CNC Programming System.

iv) Physical Tooling availability is displayed from the Tool Management System.

v) The standard setup and run times are retrieved and displayed as machine time or the time the machine will be committed to the MO.

vi) If the MO can be scheduled the system marks the MO with a "*" in the 'S' (Schedule) field which informs the Production Controller he can schedule the MO at any time in the future.

vii) If the part number has an ECN pending then the system will mark the MO with a "!" in the 'S' (Schedule) field and further 'detail' will explain why the MO is 'on-hold', it should be noted that the Production Controller will not be restricted to schedule an MO with an ECN pending but the system will prompt the Controller if he wishes to continue. This data is retrieved from the Engineering Drawing Office System.

5.9.9 Viewing the Machine Schedule

The Machine schedule is the active schedule. When a MO has been launched to the Machine Schedule, by the Production Controller, the resources are committed and the material and tooling required should be physically kitted. When the material and tooling is kitted then MO can be processed at the CNC machine, (see Appendix A4.23).

All users will be able to view the Machine Schedule but only the Production Controller will have access to the full compliment of functions, as detailed below.

Production Controller	- all functions.
Material Kitter	- Redisplay and Detail.
Tool Kitter	- Redisplay and Detail.
CNC Programmer	- Redisplay and Detail.
CNC Operator	- View Detail only.

5.9.10 Current Machine Loading

This function displays, in a graphical form, the machine loading at each CNC machine. The loading is displayed in working hours and provides the Production Controller with a clear report on how the CNC resources are loaded. If the Production Controller decides that one machine is loaded more than another then there are facilities to move MO's to different CNC resources, and thus spread the load.

This particular function can be automated fairly easily and provide automatic rescheduling of MO's on heavily loaded CNC resources to lightly loaded CNC resources. The addition of this 'automatic' facility would reduce the requirement to monitor the loading on a regular basis and reschedule MO's manually, (see Appendix A4.24).

5.9.11 Enquiry on Manufacturing Orders

This function will permit the Production Controller to identify the status of any MO on the system.

For example. A customer may wish to know delivery on a particular order, the Production Controller can key in the MO number and trace the progress of the MO. MO's can be searched by MO number, the Part number, Customer name or Project Reference number, (see Appendix A4.25).

5.9.12 Viewing the Manufacturing Order Archive

This screen can be used to list all MO's that have been completed or deleted during a selected time scale, eg during the last week or month.

When the Shop Floor Data Capture System is in full operation the CNC Machine setup, run time and strip down times will also be displayed. These captured times will inform the Production Controller how economically the CNC resources are used.

A further enhancement recognised for the system will be the feedback of captured times back to the standard times allotted to each CNC operation. This feedback loop will further aid the Production Controllers with their scheduling tasks. In addition the captured times will be a valuable input to the standard times used in the Financial Control department and the standard times used in the Sales Costing system, (see Appendix A4.26).

5.10 Summary

This chapter has described the development strategy adopted at Fortune Engineering and a formal description of each of the system modules that have been developed by the Engineering Systems Department.

When implementing an Integrated Business Environment, similar to Fortune's, the development policies and methodologies are just as important as the technologies used.

These modules should never be considered in isolation but as part of the Integrated Business Environment developed at Fortune Engineering.

The following chapter will describe the integration of the unique system modules by illustrating how a customer order is processed through the business system.

Chapter 6.0

Project 142, System Example

6.1 Introduction

Previous chapters have discussed the unique system elements and modules which form the Integrated Business Environment. This chapter will discuss in detail the progress of a customer order from initial enquiry to completed product.

6.2 Integrated Business Environment Appraisal

The Integrated Business Environment consists of numerous discrete modules. To further the readers understanding of the system a customer project has been documented from initial enquiry to final product. Some system modules have already been described in detail and these will be referenced, as appropriate.

The development and installation of the Integrated Business Environment has realised a number of benefits to the development and profitability of the company. During the project the major system building blocks have been installed and have been in productive use for several months.
The high level of computer integration enjoyed by the business has eliminated many departmental and procedural boundaries;

i) The engineering drawing office is increasingly involved in the creation of customer enquiry and proposal drawings for the sales department.

ii) The manufacturing shop floor, as a direct result of the system, are increasingly involved in production planning and control of the CNC Machining Cell, where previously the personnel were involved in direct manufacture.

iii) Drawing office personnel have increased responsibility for the creation and control of engineering drawings which almost eliminates the role of copying drawings for the shop floor, a task previously completed by an administrative assistant.

To demonstrate the differences in the Integrated Business Environment and the previous paper driven system, a customer order was monitored. The performance was logged at a number of key system areas:

i) Initial Sales;
Enquiry, Product Selection & Quotation

ii) Engineering Design;
Component Part Definition, Bill of Materials & Engineering Draughting.

iii) Production Planning;
Component Process and Project Planning.

iv) Sales Order Processing;
Material Requirements Planning.

vi) Manufacturing;
Manufacturing Data Creation, Scheduling & Production.

6.3 Sales Office

The Sales Office is always the first point of contact between the prospective customer and the company. In order to give efficient and accurate quotations to all enquiries there was a need to automate this critical part of the business system.

This office receives approximately 10 - 15 product enquiries every single day. Some enquiries are for standard products, some for special configurations, and others for a mix of standard and special products.

A great deal of product and engineering knowledge is required when dealing with customer enquiries, and in order to increase enquiry throughput while still retaining the high level of service a Sales Costing system was developed, (see Appendix A1.1).

The system addressed three main areas;

i) Efficient customer enquiries.
ii) Computer based design calculations.
iii) Product data base.

(see Figure 29)

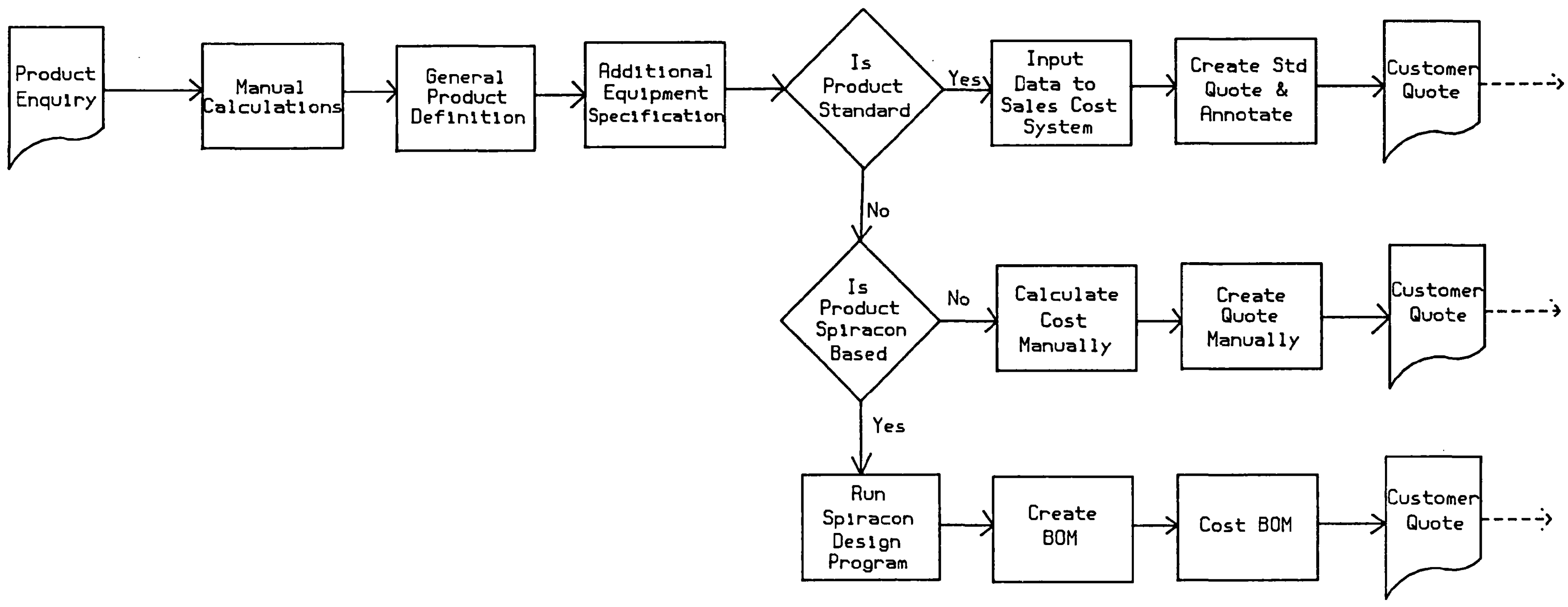


Figure 29 Sales Department Flow Diagram

The project involved the manufacture and supply of standard, special and proprietory parts for inclusion in a strapping machine for a local steelworks.

6.3.1 Product Enquiry

An initial enquiry was received from the customer on 5th August 1991. The enquiry consisted of one A4 sheet describing and detailing the proposed system, E1073/8/91, (see Figure 30). The customer had reviewed the standard catalogue range and had suggested using two 10 tonne screw jacks.

6.3.2 Product Calculations and Selection

The technical sales person then proceeded to complete two calculation sheets, on Day 1. These manual calculations confirmed that the two 10 tonne jacks requested would not withstand the life cycle of the system. The technical sales person decided to use 30 tonne jack gearboxes and a Spiracon Roller Nut and Screw.

6.3.3 Product Definition

To ensure that the Spiracon unit defined could be designed and manufactured efficiently the project enquiry criteria was input into the Parametric Design System. This system defined all loads and stresses in the Spiracon nut and created a design for all the component parts required, (see Figure 31). The design file was then used to create a Nut Assembly drawing from which the technical sales person could ensure the product dimensions were correct and that the correct nut and screw had been chosen.

The customer's system also required to be driven by a 5.5 kw brake motor. The technical sales person reviewed various supplier catalogues to locate a suitable motor.

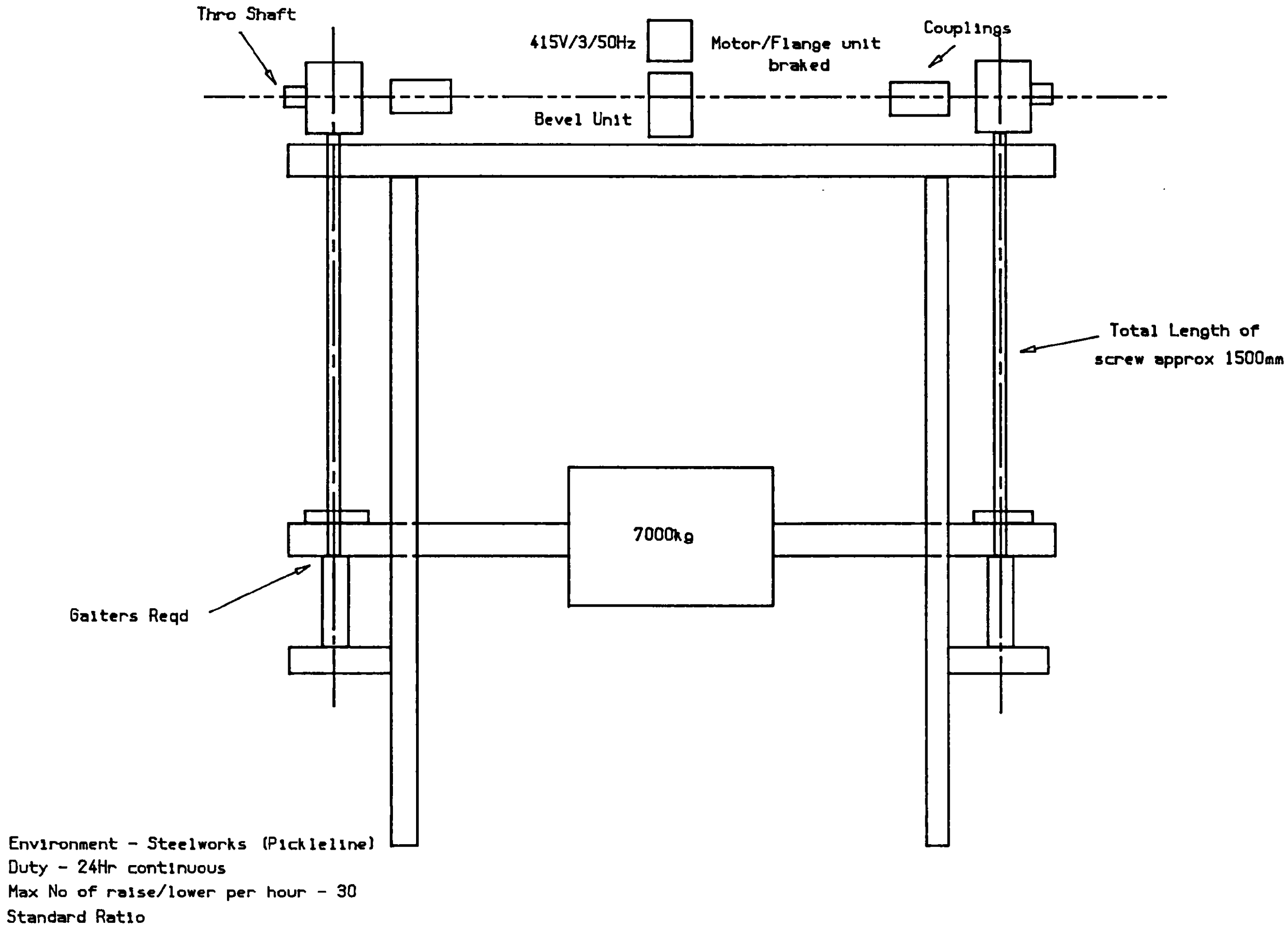


Figure 30 Project 142. Initial Enquiry Drawing

Spiracon Design Calculations ==== e1073 ====

Type 2

35000.0000	Dynamic Load
35000.0000	Static Load
0.0000	Sideload
0.0000	Moment about nut Centre
99047.0000	Screw/Roller contact stress
2644.0000	Shear Stress
---------------- SCREW --------------------	
62.5000	Outer Diameter
36.0000	Lead
6	Number of threads
6.0000	Pitch
. ....	....
-------------- ROLLER ----------------------	
30.0000	Outer Diameter
17.0000	Pintle Diameter
96.0000	Length
15.0000	Pintle Length
......	....
-------------- Load Bearing Element ---------	
170.0000	Outer Diameter
130.0000	Shoulder Diameter
113.4594	Inner Diameter
9.0000	Shoulder Length
......	....
----------- Thrust Bearing -----------------	
170.0000	Washer Outer Diameter
130.0000	Washer Inner Diameter
165.0000	Cage Outer Diameter
135.0000	Cage Inner Diameter
......	....
------ Bush or Needle Bearing --------------	
23.0000	Outer Diameter
12.0000	Length
17.0000	Inner Diameter
0.8000	General Radius

Figure 31 Spiracon Nut Design File

6.3.4 Product Costing

The products now defined, the sales person then requested a Sales Costing Sheet from the Production Director. The paper based cost sheet documents the component products which define the system with their respective purchase and cost prices. The Production Director then includes a suitable profit margin and notes the complete cost at the bottom of the sheet. The Cost Sheet for the enquiry was completed on Day 2 and then given to the technical sales person.

6.3.5 Customer Quotation

The Sales Quotation System was then used to create a quotation for the customer. The product defined was a mixture of a standard and special product and thus the Sales Quotation system could not be used to select the products but could only be used to document the costs and create a Project Reference Number. The quotation was created at the end of Day 2 and transmitted to the customer.

The quotation was then accepted by the customer and the official order, EED 5931, was received by the Sales Office, Day 8. The order was then given the next sequential project reference number, P142.

The Sales Costing system and the Parametric Design system has produced a number of benefits to the Sales Office;

i) The technical sales person could confirm within one working day that the system he proposed was correct and suitable for the application.

ii) Load and stress calculation were completed and documented within minutes of the enquiry entering the Parametric Design System.

iii) Designed and dimensioned product and component drawings were created, again within minutes. The dimensioned product drawings could have been sent to the prospective customer, if required.

iv) The Sales Quotation System is an efficient tool for the production of well presented quotations for the customer.

6.4 Drawing Office

The project then entered the Drawing Office, on Day 8, where detailed design data had to be created and collated before the customer could sign off the drawings. (see Figure 32).

The Engineering Drawing Office experienced similar problems as the Sales Office;

The throughput of customer orders was slow.
Simple designs and standard modifications consumed many man hours.

A lot of time was spent managing and administrating design information and less time creating new designs.

A Drawing Office Data Management system was developed to address these crucial system bottlenecks, (see Chapter 5.8 & Appendix A1.2).

6.4.1 Bill of Materials Creation

Initially a Bill of Materials and detailed drawings were created for the Spiracon Nut and Screw using the Parametric Design System, (see Appendix A1.4), Day 8.

The Bill of Materials for the screw jack was then created using the Drawing Office Data Management System, an existing Bill Of Materials for a similar screw jack was used to which the Bill Of Materials for the Spiracon Nut was added, then the special components required were keyed in manually to complete the Bill Of Materials. This task took approximately 1 hour.

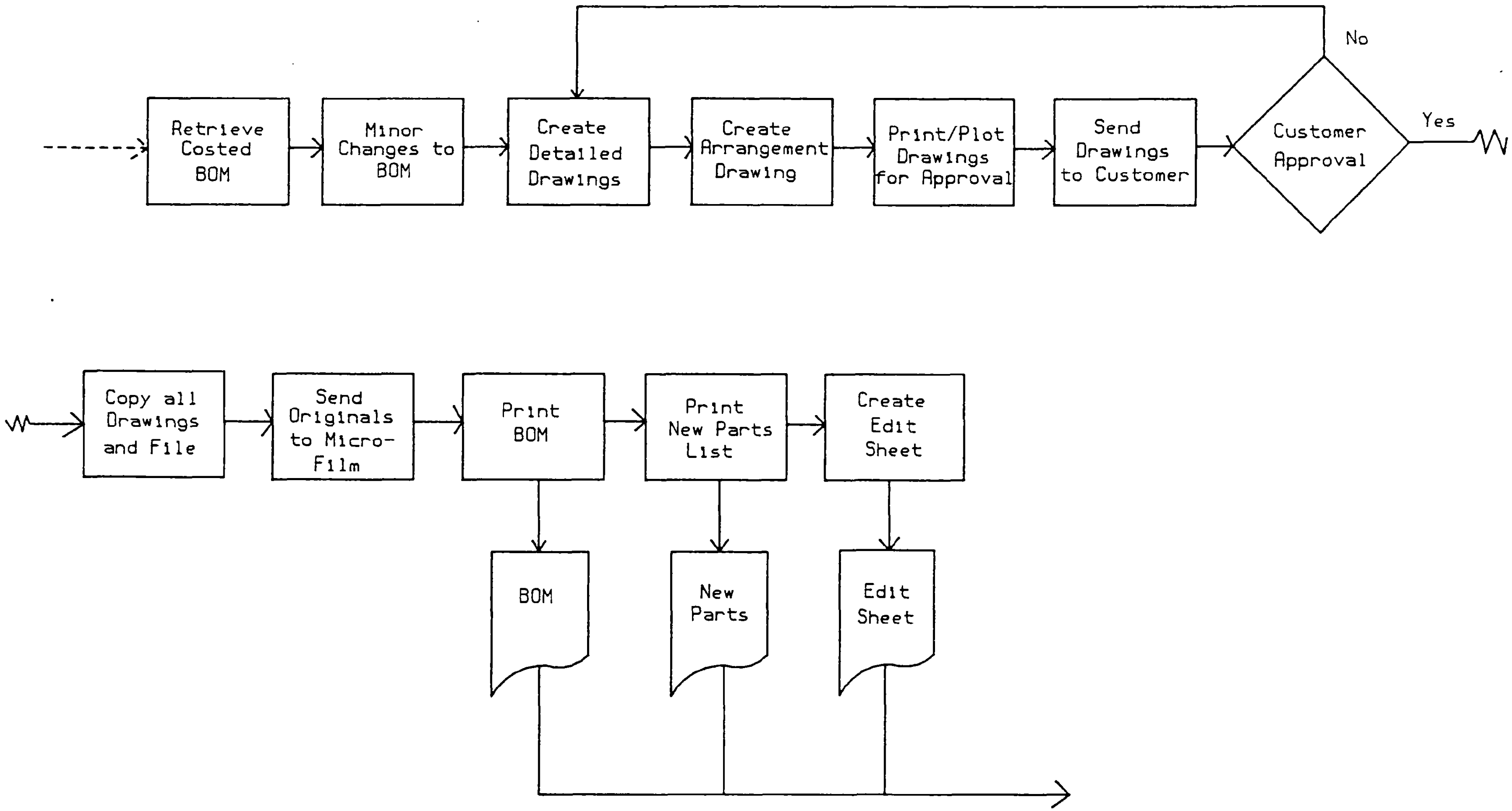


Figure 32 Drawing Office Flow Diagram

6.4.2 Detailed Drawing Creation

After the Bill of Materials was completed the detailed drawings required for customer approval were completed first.

The drawings are listed below;

Gear Box and flange drawing, Prefix S999 Part number 022472
Product arrangement drawing, Prefix R062 Part number 022494
Drive shaft drawing, Prefix R062 Part number 022495
Flexible Coupling drawing, Prefix S999 Part number 015749
Flexible Coupling drawing, Prefix S999 Part number 022001

The Gear box and flange drawing was created on Day 12, using manual draughting techniques. Although CAD was available there was no policy decision taken to use CAD as an ad-hoc draughting tool, only total parametric designs were generated on CAD. After the drawing was created the next available part number was used from the Drawing Office Data Management System and written onto the drawing.

Drawing, 022494, consists of a standard screw jack and a special Spiracon Roller nut and screw. This drawing had to be created by hand using manual draughting techniques. This drawing was created on Day 12.

The Drive shaft drawing was created, again using manual techniques, and the next available part number was written on the drawing. This drawing was completed on Day 13.

The remaining 2 coupling drawings are for proprietory parts, denoted by S999 prefix. The original sales quotation defined a general coupling description, the drawing office therefore had to define the detail design, eg keyways and finish bores. The detail drawings had been created before and original drawings were created in November 1988 and August 1991 respectively. The Drawing Office staff thus only had to locate the original microfilm in the filing cabinets and print the drawing for the customer.

All the drawings were completed and compiled by Day 14, ready to be faxed to the customer for official approval and for signing.

6.4.3 Customer Approval

Fortune Engineering have a strict policy of not continuing a project until all relevant drawings are signed by the customer.

The customer signed off the drawings and returned on Day 14.

6.4.4 Component Drawings

The Bill of Materials for the Special screw jack consists of seventy unique parts. Thirty parts were designed and plotted using the CAD Parametric Design System, Thirty-six parts already existed in the Drawing Office Management System and were used again to eliminate design workload. Four parts were special component parts and required drawings.

The four special parts were created, after the customer had approved the arrangement drawings and were created using manual draughting techniques. The Drawing Office completed these four drawings, printed the Bill of Materials and a New- Parts list on Day 16.

A copy of the new drawings were filed in the drawing file and the originals were sent for microfilming. The Bill of Materials and New-Parts lists were transferred back to the Sales Office, Day 17.

6.4.5 Edit Sheet Creation

When the Sales Office received the completed Bill of Materials, an Edit Sheet was created. This paper based sheet is used by an assistant in the Production Office. The sheet explains to the assistant which item on the Customer's Purchase Order relates to the Bill of Material items.

The Edit Sheet, Bill of Materials and the New-Parts lists are then given to the Production Office for further processing, Day 18.

The development of the Drawing Office Data Management system offered a number of clear benefits over the previous paper based system.

i) The system selects existing parts to eliminate expensive redesign work, thus simple designs can be completed very quickly.

ii) The use of the Parametric Design system for designing and plotting new parts has resulted the reduction of workload in the drawing office, while increasing the number of new contracts.

iii) The system controls the creation, checking and issue of all components and drawings satisfactory to BS5750, and reducing the administrative task that burdened the Drawing Office staff.

6.5 Production Office

The Production Office have a computer based Material Requirements Planning System called Impcon, (see Appendix A1.3). This system is not integrated with the rest of the Integrated Business Environment and because of this has a number of inherent problems;

Data stored in each of the systems cannot be accessed by the other.

The two systems are consistently out of step with each other and data is repeatedly keyed into the systems to retain concurrency.

Development of the Integrated Business Environment is suppressed by the ageing and incompatible Materials Requirements Planning system.

Paper based information is the only link between the two incompatible systems.

The development and integration of the Materials Planning system is not planned until 1993.

6.5.1 Process Planning

Prior to the input of the new parts and the Bill of Materials the Production Controller makes the decision to buy parts from suppliers, subcontract work or to manufacture in-house. After the Production Controller has made this decision the Bill of Materials is checked to ensure that the multi-level Bill of Materials reflects this. If the Bill of Materials is not correct the Production Controller requests that the Bill of Materials is changed. The Bill of Materials for Project 142 required very few modifications. This was mainly due to the minimal number of new parts.

6.5.2 Data Input

The Production Controller then transfers the New-Parts list and BOM to an administrative assistant, also in the production office. The assistant types all the parts on the New-Parts and Bill of Material into the system using one of the five terminals.

When the system has registered the new parts the Bill of Materials structure is then keyed into the system. The system checks the existing parts to ensure they are at the correct issue and registers the new parts on the New-Parts list against the new Bill of Materials.

The task of checking the BOM and input to the MRP system was completed on Day 19, (see Figure 33).

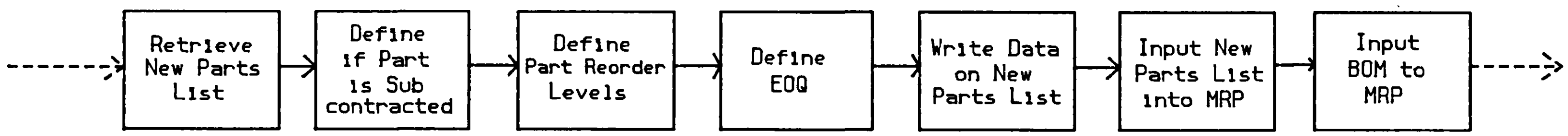


Figure 33 Production Planning Flow Diagram

6.6 Sales Order Processing

The Sales Order Processing module is an integral component of the Materials Requirements Planning system, (see Appendix A1.3). As discussed earlier the system is not integrated with the Integrated Business System but for completeness the order processing of Project 142 is described, (see Figure 34).

When the BOM is input into the MRP system another administrative assistant processes the customers order.

The assistant inputs the order and delivery details and the system identifies the Bill of Materials required to satisfy the order.

The system then creates an Order Acknowledgement. The acknowledgment was printed Day 20.

After the customer order has been input to the system the order waits in the system and no further processing is completed until the Bill of Materials is exploded to produce a Manufacturing and Purchase Orders recommendation report. The recommendations report for Project 142 was completed on Day 20.

The Production Planner then decides which Manufacturing Orders or Purchase Orders should be processed and which should wait. This is a manual task, the timing is determined by the Production Planner and his knowledge and experience of the products and the unique project.
The recommendations report, with the amendments, is then given to an assistant who proceeds to input the decisions back into the Material Requirements Planning System. When this task is complete the Manufacturing and Purchase Orders are printed. The MO's and PO's were printed on Day 21.

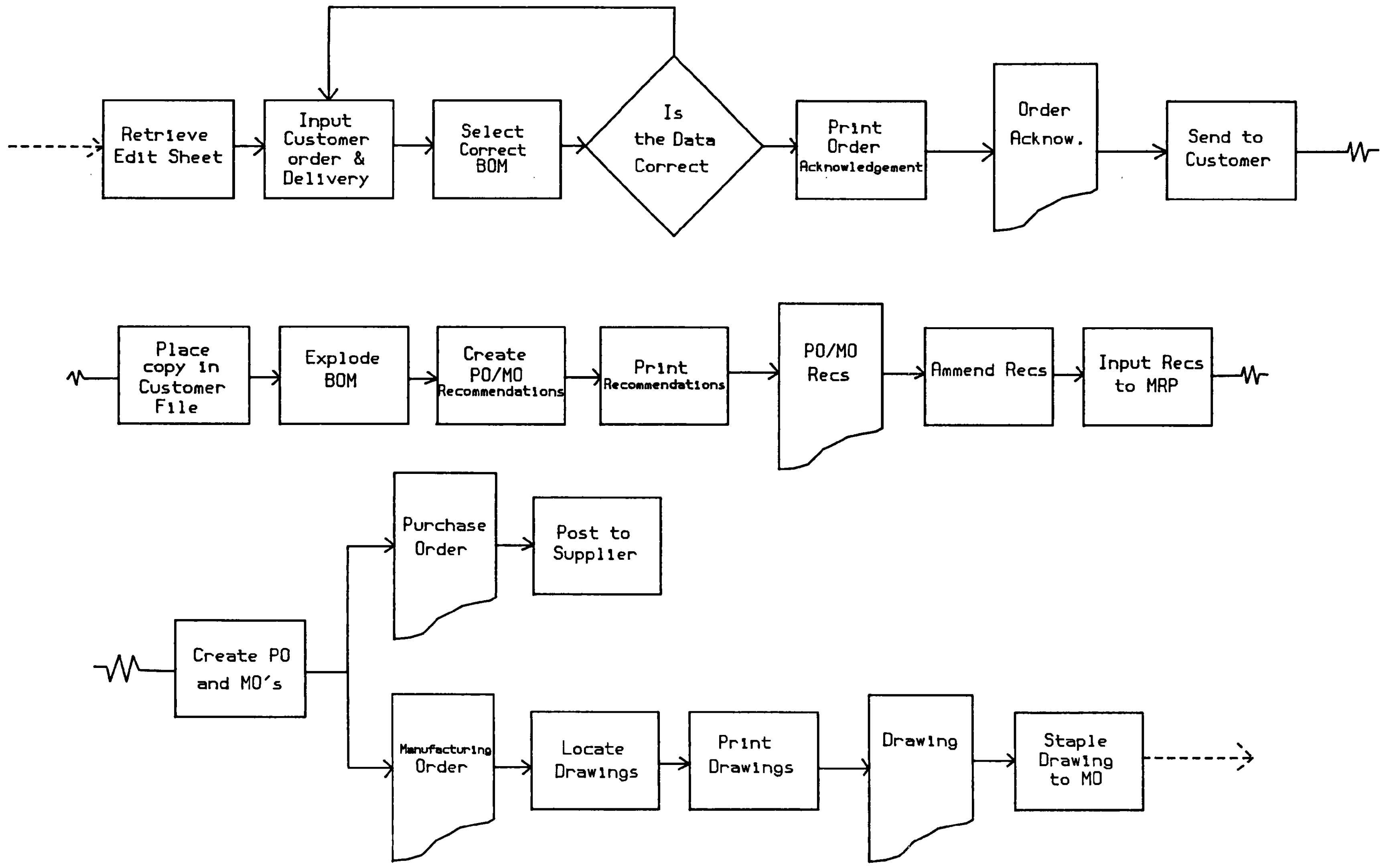


Figure 34 Sales Order Processing Flow Diagram

The assistant then reads each Manufacturing Order to identify the part number to be manufactured, the paper based drawing is then retrieved from the drawing files. After the drawing is found a copy is printed and stapled to each of the Manufacturing Orders.

The Purchase Orders are collated together, with all orders for the same supplier stapled together, the orders are then placed in envelopes and posted to the suppliers.

The Production Planner receives all Manufacturing Orders, along with the drawings. The Production Planner then consults the Senior CNC Programmers on the shop floor to define whether the part is made in the CNC machining Cell or one of the manual turning or milling machines.

6.7 Manufacturing

The last five years has seen a dramatic capital investment in Computer Numerical Controlled Machinery. The Integrated Business Environment was further developed to exploit the benefits that the CNC machinery had over conventional machinery and release the clear advantage that the company had over it's competitors;

CNC data had to be properly managed to reduce machine setup times and increase CNC performance.

Product lead times had to be reduced by efficient scheduling of the CNC machines.

Shop Floor data had to be collected to further target inefficient areas of the production process.

6.7.1 Standard Components

The project involved the manufacture of standard and special components, as discussed earlier. The standard components are usually in stock and therefore no Manufacturing Orders were generated for these items.

6.7.2 Special Components

There were sixteen special or non-stock items. Nine of these items were planned for the CNC Machining Cell, the remaining components were manufactured using manual machining methods or sub-contracted.

6.7.3 Scheduling System

The nine MO's for the CNC machine Cell were then logged into the CNC Cell Scheduling System at 10:30 am on Day 22.

The Scheduling system, (see Chapters 5.9), successfully managed the movement of resources critical to the CNC Machining Cell performance

eg Raw materials arrived at the CNC machines just in time for manufacture

Tool kits were assembled and kitted ready for use.

CNC code and setup sheets were created well in advance, (see Chapters 5.6).

Manufacturing information was transferred across computer networks directly to the CNC Machining Cell, (see Chapters 5.7).

6.7.4 Shop Floor Data Capture

The detailed history of the nine MO's are logged into the system via the Shop Data Capture module, in summary;

Manufacturing information was created between Day 23 and Day 42.

Average time to create manufacturing data in the system after the MO was logged was 1 day.

Manufacturing Orders processed at the CNC Cell between the period of Day 25 and Day 42.
Average time to process Manufacturing Order after data was ready, 5 days.

As the component parts were manufactured at the CNC Cell the components were moved to the store room to await assembly.

6.7.5 Assembly

Upon receipt of sub-contracted and supplied parts the jacks were assembled in the assembly areas. The jacks were assembled on Day 46. The gearbox and motor were modified and assembled on Day 47.

6.7.6 Inspection

After assembly, the jacks and all associated equipment, ie couplings,drive shafts, gear box and motor were moved to the inspection area where all parts underwent final test and inspection, Day 48.

6.7.7 Despatch

On Day 52 the consignment was despatched.

The development of the Integrated Business Environment to the manufacturing shop floor has resulted in maximising the resources of the existing Computer Numerical Controlled machinery.

i) The Scheduling System manages the processing and the data creation for all MOs in the system, in order to create information in a 'just in time basis'.

ii) The Scheduling System very quickly flags the Production Controllers if any data, tooling or materials is unavailable or out of stock.

iii) The majority of the component parts manufactured in the CNC machining Cell were produced hours before final assembly, illustrating the ability of the Scheduling System to manage the manufacture of components, just in time.

iv) The assembly, inspection and dispatch of orders is very efficient. These tasks represent a small proportion of the total lead time.

Manufacturing system flow chart, (see Figure 35).
It should be noted that it is not within the scope of this thesis to discuss the financial invoicing and accounting procedures involved in this project.

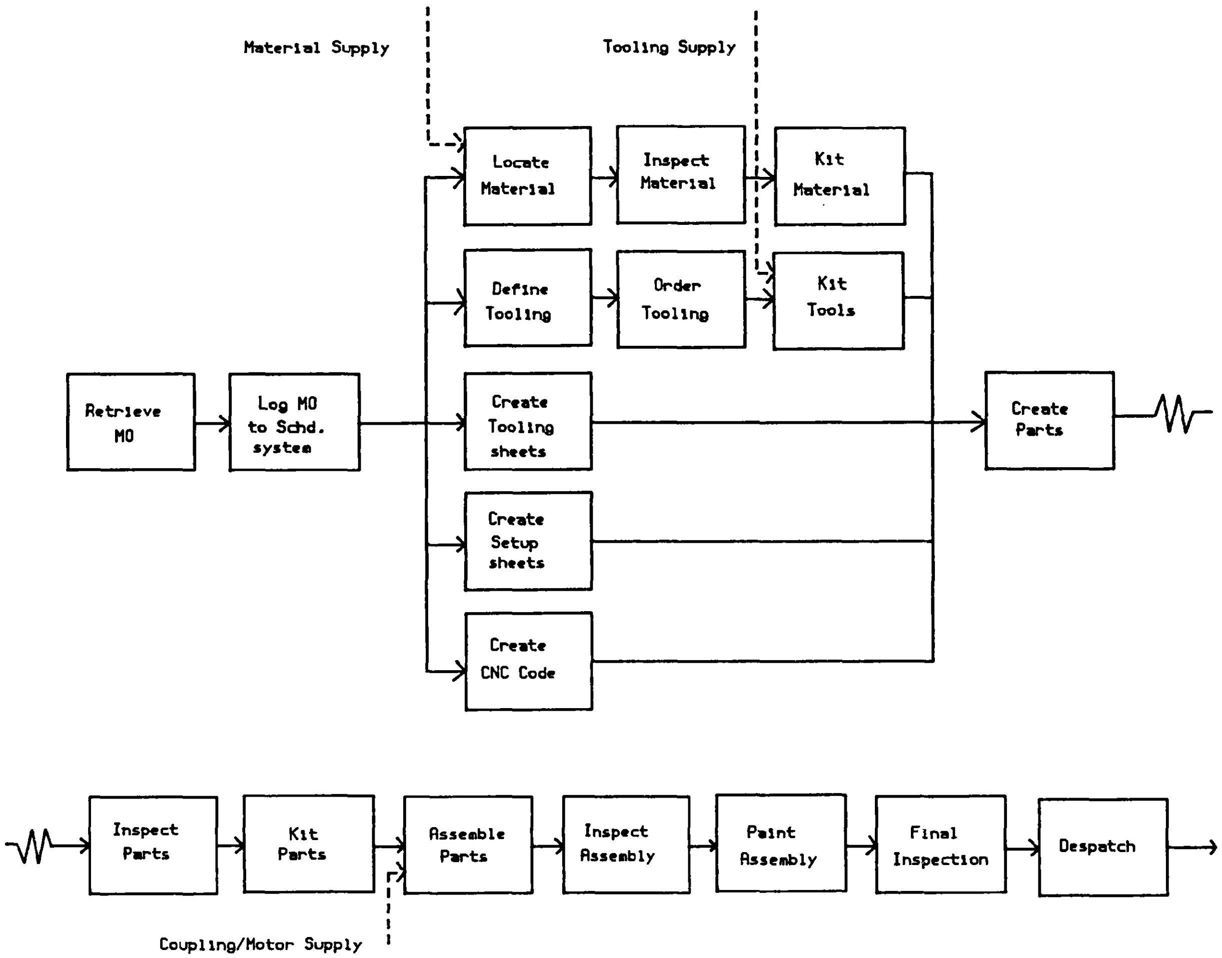


Figure 35 Manufacturing Flow Diagram

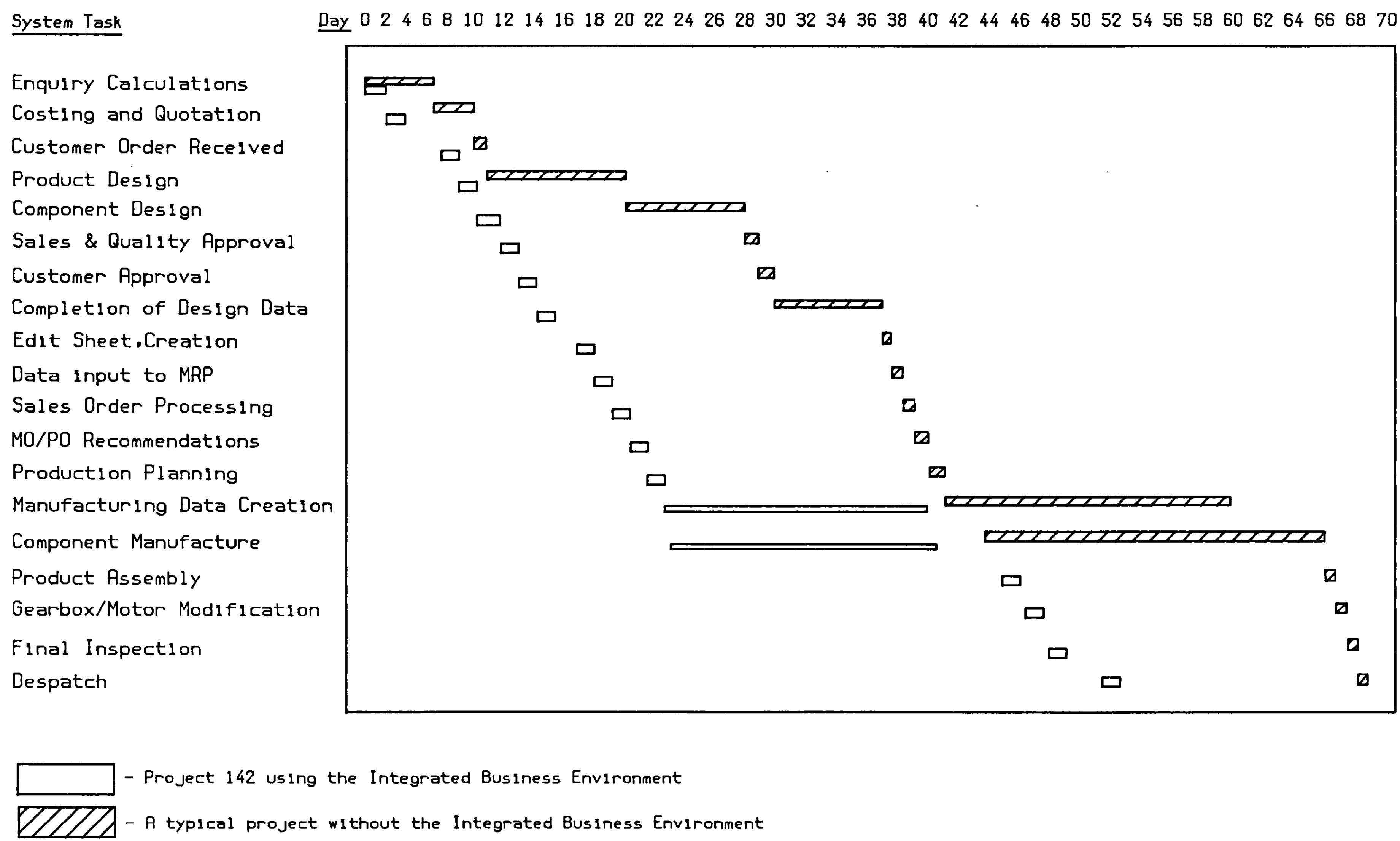


Figure 36 Project 142, Lead Times using the IBE

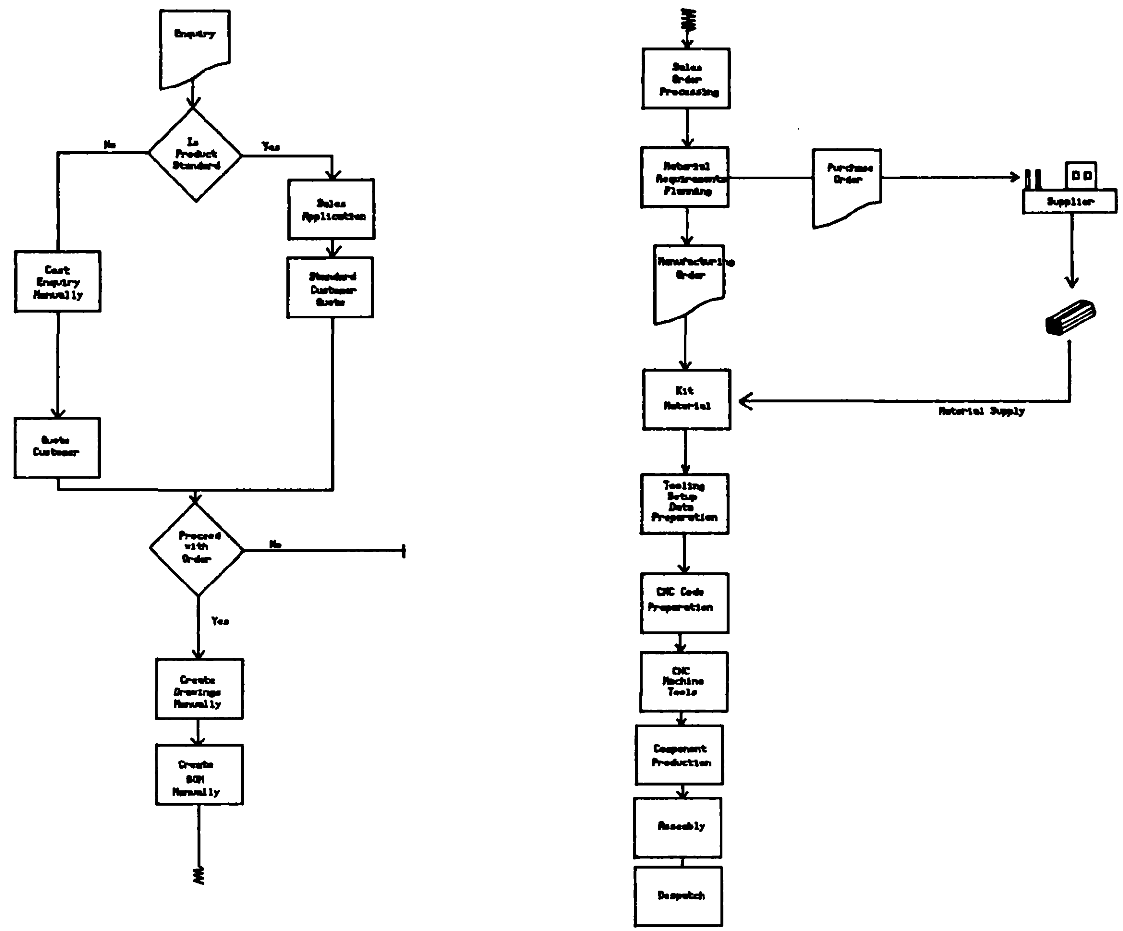


Figure 37 System Flow Diagram before IBE developed

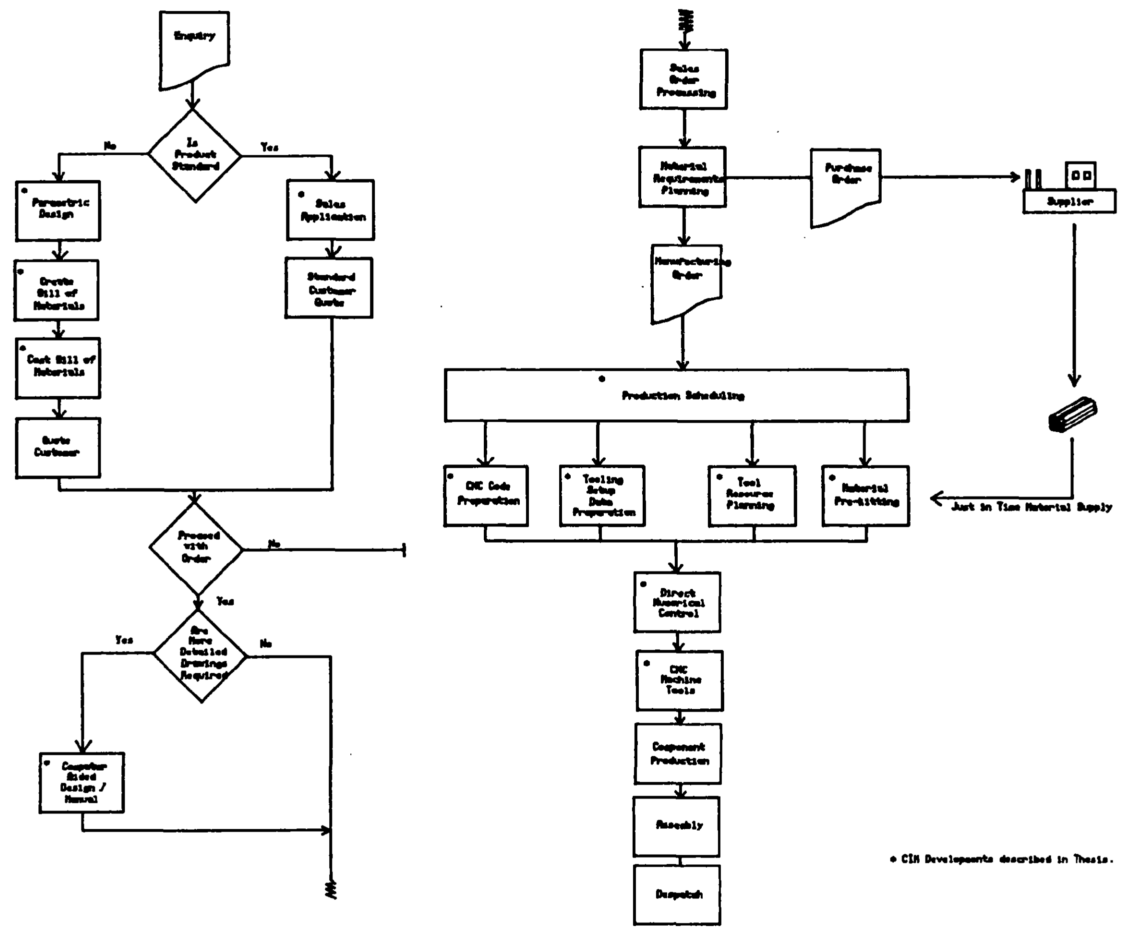


Figure 38 System Flow Diagram after IBE developed

6.8 Summary

The development of this computer based environment has brought a number of benefits to the company;

i) Product enquiries can be designed and costed quickly and efficiently with the knowledge that the component parts can be manufactured economically and the cost quoted is correct.

ii) The design and Bill of Materials information is created during the enquiry stage, stored in the data management system and reused if the enquiry results in an order. The re-use of these data reduces the lead time of the product to the customer.

iii) The Sales Costing system has enabled the technical sales staff to deal with more product enquiries in a reduced time period. This fast response portrays a professional image to the customer.

iv) The Integrated Business Environment promotes parallel data creation. The data created at the design process can be distributed and used throughout the company.

v) Material supply to the factory is aided by the Production Scheduling system which identifies the materials required to satisfy the production requirements.

vi) The CNC machining cell can be controlled and monitored in real time. A local PC transfers status codes to the central data hub. Shop floor data capture statistics are derived from these status codes to produce production reports.

Chapter 7.0

Conclusions

7.1 Introduction

The Integrated Business Environment adopted at Fortune Engineering is a philosophy that has been developed and honed to produce a totally integrated, computer-based manufacturing site where processes and business functions are managed and controlled through a central relational data base.

7.2 Direct Benefits of IBE

The Sales and Design department benefits considerably from the development of the Parametric Design system. Custom Designs may be created and sent to the customer, in direct response to a product enquiry. When the enquiry becomes a firm order all component drawings are complete, the bill of materials is available in the Design system and the CNC Code is created for the Thread Grinding machine. This instant creation of design and manufacturing information ensures that the product and parts can be manufactured on-site in greatly reduced lead times.

The Parametric Design system was also used to create a new product range of mechanical actuators. These products were designed entirely on the parametric design system. After the system was tested and proven, a standard set of products were designed and included in the sales literature.

The complete design of this new product from initial concept to finished system, and sales and marketing literature took approximately 18 man-months. This task and time scale would not have been possible in a small engineering company without the development of advanced parametric design techniques.

Simultaneous with the design and launch of the new product range was the development and integration of the production shop floor systems with the relational data base core. These systems succeeded in:

Dramatically reducing CNC Machine Setup Times thus increasing productivity;

Reducing component part lead times, ensuring speedy response to customer orders, especially special or custom products.

Controlling the purchase and kitting or raw materials, to develop a 'just in time' approach to material procurement.

Managing the purchase, storage and kitting or production tooling to ensure that all tooling is in the right place at the right time.

Managing the creation and flow of production data directly to the shop floor to increase machine productivity.

Scheduling the sequence of Manufacturing Orders to the CNC Machine centres and forecasting future work loading on the CNC machine centres.

Retrieval of shop data capture statistics for work in progress tracking and management reporting.

7.3 Business System Foundation

A great deal of the initial development time and effort was given to establishment and formation of suitable company policies, standards and the future vision of the business system. After these policies were established the main relational data base management system core was installed. This established the foundations for future system development.

7.4 Dynamic Business Environment

The system was written and developed in such a manner that it promoted a dynamic environment where decisions could be made the instant the data were there to support it. There is no queuing of requests or processes and the system can react promptly to the ever changing engineering environment.

Factories are very dynamic environments and operational conditions change rapidly. The system was developed in a way to emulate the environment and ensure that the data was correct and up to date.

'What-if' scenarios can be executed to identify the result of a decision before it is finally initiated.

7.5 Data Availability and Responsibility

All data in the business system are available to all processes and personnel who require them, taking into consideration any security restrictions. The data is displayed in a format that is legible to the end user and displays only the data required to complete the decision process and further the customer order through the system. The creator of the data is responsible for ensuring that the data are not corrupted or misused by someone else in the system. It should be noted that in addition to the personnel responsible for the backup and maintenance of the core system, every user is responsible for their unique system module.

7.6 Engineering Change Control

The dynamic Business Environment also promotes efficient and controlled change of engineering data. Change control is restricted to a select number of business functions. Prior to the change the users can identify the consequences of the change and can stop a shop floor process from continuing until the change is complete or a decision is made to continue.

7.7 Rapid System Development

A relational data base core has been developed, based on the Ingres System, which promotes the rapid advancement and introduction of further computer based systems. A typical system which involves analysis, development, testing and installation can be completed in three months. This rapid development program is furthered by the commitment of the Managing Director to the Integrated Business Environment and the rapid acceptance of new computer based system by Fortune personnel.

7.8 Supplier Relationships

Established relationships with hardware and software suppliers has increased the development of systems and the integration to the core relational data base management system. These relationships have permitted the developers to keep abreast of advancements in other areas of industry in order to develop standard software and hardware.

7.9 Open Systems and Industry Standards

The development and overall success of the Integrated Business Environment was made possible by the application and development of Open systems, industry and de-facto standard software and hardware. The hardware and software listed below is used as a basic tool kit to develop the Integrated Business Environment.

Hardware workstations - Apollo.

Personal computers - Compaq (IBM compatible).

Operating Systems - Unix, MS-Dos.

Network Hardware - Ethernet 802.3, 3Comm 503 cards.

Serial Communications - RS232.

Network Software - TCP/IP.

Programming Software includes; SQL, C.

Computer Numerical Machine Controllers - Fanuc.

Computer Numerical Machine Interface - Serial & Parallel User Interface.

7.10 Systematic Training Program

A Full and structured training is given to all new recruits to the company. Additionally all staff who use the system on a daily basis have in-depth experience of their application and how it integrated with the remaining business environment. Every four months all the personnel in the company are involved in a training programme to inform them of current progress and future developments.

The inclusion of this structured training has ensured that all personnel are aware of the system developments and as a direct result are more interested to see the business system develop in their areas in order to reap the benefits for themselves. This attitude, by the employees, ensures that the business system will be adopted, used and developed by the people who use the system on a daily basis and not some distant Information Technology or Data Processing department.

7.11 Software Change System

All software is controlled with a formal software change procedure. The procedure records the changes made to all the software modules, the history of the module, who requested the change, for what reason and the programmer who made the change. A record is also made of the source code effected and when it was installed. This procedure ensures that software change is controlled in a similar way to engineering change, thus retaining the integrity of the system modules and the engineering data created from the modules.

7.12 Integrated Business Environment Integration

Manufacturing businesses have tried to solve sales, design and production problems and bottlenecks with the random and sometimes ad-hoc introduction of many modern manufacturing philosophies and systems, eg CAD,CAM,CIM,FMS,DNC,JIT etc. The Integrated Business Environment would still promote the installation and development of these system modules and philosophies but the introduction would only be in a structured fashion and as part of an overall structured philosophy.

The Integrated Business Environment philosophy dictates that program modules may only be installed and developed if the data areas and data access mechanisms are one hundred percent compatible with the core, relational data base management system, that supports the IBE.

IBE is a state-of-the-art approach to data management in a small manufacturing company. The last three and a half years has produced a number of substantial benefits to the company through its direct application.

Benefits include:

Spiracon quotation response times, reduced from 4 man days to 1 man day.

Spiracon design time reduced from 4 man weeks to 2 man days.

Manufacturing efficiency increased by 27%.

Inventory of standard components reduced by 26%.

Chapter 8.0

Future Developments

8.1 Introduction

Fortune Engineering have a policy of continuous software development. This policy covers the addition of functions and enhancements to existing systems, under the control of the Software Change Request procedure, and the development of new software modules.

There are a number of system modules and enhancements planned for the coming years.

It should be noted that since the completion of the work described in this thesis there have been substantial software developments. These developments are described in the following section.

8.2 Tool Management System; Tool Requirements Planning

The Tool Managers system which controls the ordering, storage and kitting of all production tooling has been enhanced to provide a Tool Requirements Planning function. This function monitors the supply of tooling to Fortune Engineering in a similar way to the Material Requirements Planning system which manages the supply of materials.

The system stores the quantity, re-order level and economic order quantity of all production tooling. When the quantity on hand is less than the re-order level then a purchase order requisitions are created automatically for the purchase department to order the correct tooling.

This enhancement was developed and installed in September 1991.

8.3 CNC Programming System; Parametric Jaw Code

Analysis of the CNC machine setup times has revealed that a large proportion of the setup time was consumed with the boring of soft jaws. The soft jaws were not controlled and were machined manually by the operator.

It was proposed that we purchase a set of standard jaws which will be used for a range of standard parts.

The manual machining of the jaws was replaced by a CNC program which machines the jaws exactly and ensures that jaws are not machined excessively. This jaw machining, under the control of the CNC program has dramatically reduced CNC machine setup times.

The CNC Programming system was modified to automatically create CNC Code for the different sizes of soft jaws that require to be machined. The CNC Code is created using a customised parametric program.

The CNC Programmer inputs the length, width, height, grip diameter and clearance diameter of the jaw and the CNC code is created automatically to bore the jaw.

This modification has now been in everyday use since November 1991.

8.4 CNC Programming System; Renishaw Inspection

The CNC Programmers found that the creation of CNC Code to control the Renishaw inspection probe is error prone and time consuming.

It was planned to add the facility to create CNC Code automatically in Fanuc Macro A and B programming languages.

This CNC Code is created by prompting the user for a number of sizes critical to the measuring task. When the questions are answered the correct code is generated and embedded in the programmers CNC code.

When the CNC machine has Renishaw tool setting equipment then the system will automatically create CNC Code to measure the Tooling.

This enhancement was completed, March 1992.

8.5 Drawing Office Management System; Part Definitions

At January 1992 Fortune Engineering had approximately 30 percent of their component parts on their Computer Aided Design system. It was proposed that this should be increased to over 70 percent.

There were a number of possibilities available to load existing manually created drawings onto the system. These were investigated and a decision was taken to design a Component Part Definition system.

The system describes the components as a series of features, ie plain bore, thread, keyway, fillet, chamfer etc. from the definition, the system then draws the part on the CAD system. The engineer then compared the generated drawing to the original manual drawing and if correct the drawing was saved against the component part number in the Engineering Data Base.

This system was written in January 1992 and since installation more than 75 percent of all Fortune's working parts have been successfully transferred to the CAD system.

8.6 Drawing Office Management System; Draw Screw Jack

Parametric systems were created for the Spiracon and Rolaram product ranges, as discussed in the thesis. It was identified that a great deal of time was lost drawing Screw Jacks on the Computer Aided Design system. It was therefore proposed that a Screw Jack drawing program should be developed to create Screw Jack drawings automatically.

This system has been completed and has been in use since March 1992.

8.7 Manufacturing Shop Floor; Renishaw Tool Setting

It is planned to develop a Tool Setting system on each of Fortune's six CNC machines. This system will measure each Production Tool and load the correct Tool Offset directly into the Fanuc Controller. This system will dramatically reduce the time to set a machine for component part production.

This system will be developed in parallel with the In-Process inspection system during 1992.

8.8 Manufacturing Shop Floor; In-Process Inspection

Fortune are striving towards BS5750 and wish to increase the traceability and inspection procedures of many of their component parts. It is proposed that every CNC machine will have a Renishaw inspection probe mounted inside the machine. This inspection probe will inspect the component parts as they are manufactured. The measured sizes will then be used to update the Fanuc controller tool offsets. Additionally the measured sizes will be output to a personal computer and then transferred to the central engineering data base for further analysis.

8.9 Material Requirements Planning System

The existing MRP system is not integrated with the central engineering data base. It is proposed that during 1993/1994 a system is developed on the central data base to control all material movements from supply to final assembly and despatch.

The MRP system may be purchased from a third party (software house) but it will require modification in order to ensure that it is entirely compatible with the existing engineering data base. The system will include many elements of a Manufacturing Resource Planning system and almost certainly be developed beyond the standard MRP II packages that are commercially available.

8.10 Hardware Upgrade

The rapid development of software and hardware systems is increasing the response time of the engineering data base. It is proposed to upgrade the existing Apollo workstation to a more modern and responsive Sun workstation.

This hardware upgrade will be completed in parallel with an Ingres Relational Data Base software upgrade and ensure that the increasing number of systems users will receive reduced response times and more user-friendly software packages and systems.

This upgrade should be completed by the first quarter of 1993.

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Integrated Business Environment : An implementation of CIM in a Small to Medium Enterprise.

Volume 2 of 2

by

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Thesis submitted for the degree of
Master of Science.

Department of Mechanical Engineering
University of Glasgow.

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Glasgow, Scotland

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Appendix A1

System Descriptions

A1.1 Sales Quotation System

The Sales Quotation system is currently a stand alone system.
This system was installed some three years ago and has developed progressively in parallel to the Engineering Data Base. The Sales system uses a relational data base called FoxBase but currently is not integrated.

When a customer enquiry is received the application program is executed. If the enquirer has a current account number then this is used to retrieve the details of the account. If the enquiry is from a new company then the details are entered and a new account number generated.

A1.1.1 Menu Structure

The application program aids the sales engineer through the generation of a standard quotation. If the enquiry is for a precision worm screw or ball screw jack then the application will prompt for basic product requirements and define the correct jack for the application, (see Figure A1) .

Precision screw jacks make up 47.3% of Fortune's business (see Figure A2).

If the enquiry is for any other product then the application program will require direct input of product requirements by the sales engineer. The following screen layouts shows an example of a typical enquiry progressing through the Sales system.

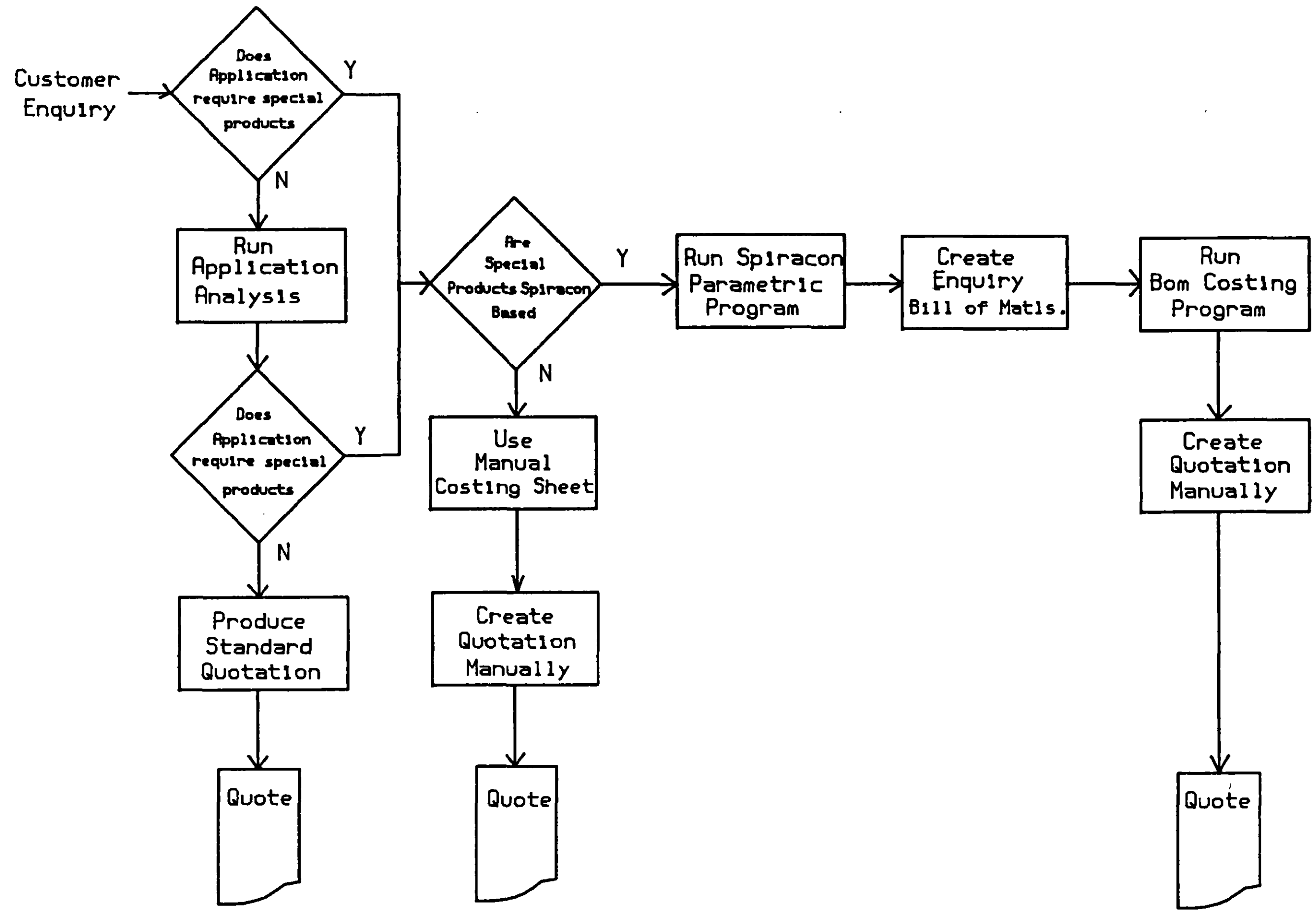

Figure A1 Sales Costing Flow Diagram

Standard Worm Screw Jacks	25.3%	47.3
Standard Ball Screw Jacks	0.9%	
Special Worm Screw Jacks	18.4%	
Special Ball Screw Jacks	2.7%	
Spiracon Based Products	37.1%	
Gearboxes/Couplings/Motors	15.6%	

N.B. 1990 Sales Figures

Figure A2 Fortune Product Mix

A1.1.2 Sales Application Main Menu

```
+------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91 APP PROGRAM : SALES |
+------------------------------------------------------------+

               ------------ MAIN MENU ------------

               1. Generate a new Quotation

               2. Review an Existing Quotation

               3. Lists, Letters  Address Labels

               4. File Management

               5. Tape Backup Procedure

               0. Exit

           Enter Selection  (0-5), then key (RETURN) ...
```

A1.1.3 View Customer Account

```
+------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91  APP PROGRAM : SALES |
+------------------------------------------------------------+
A/c No   Branch      Company name  Address        Telephone
+----+     +----+   +---------------------------+ +-----------+
|T072|     |0000|   |TELE-STAGE ASSOCIATES      | |0284 755512|
+----+     +----+   |UNIT 14                    | +-----------+
Sales      Price    |BUNTING ROAD               |
                    |MORETON HALL IND ESTATE    |   Facsimile
File  Area Code     |BURY ST EDMUNDS            | +-----------+
+---+ +--------+    |SUFFOLK                    | |0284 755516|
|TeS| |04 00   |    |PostCode:{IP32 7BX}        | +-----------+
+---+ +--------+    +---------------------------+

Contact
+------------------------------------------------------------+
| Rating  D | Field  S P MACHINES        |Name    MR P FROST |
| Hyd User Y| Notes  THEATRICAL EQUIP.   |Job Desc           |
| Origin of Contact  EXISTING                                |
| SENIORITY                                                  |
+------------------------------------------------------------+
```

A1.1.4 Process Enquiry

```
Enquiry    E1089/06/91        Account     T072    0000
+------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91  APP PROGRAM : SALES |
+------------------------------------------------------------+

Select Product
     1: Precision Screw Jacks           11: Electrical Motors
 *   2: Ball Screw Jacks                12: Accessories
 *   3: Miniature Screw Jacks           13: Spares
 *   4: Spiracon Roller Screws          14: Ball Screws
     5: Spiracon Roller Screw Actuators 15: Other Items
     6: Electro Mechanical Actuators     0: Cancel
     7: Lead Screws and Running Nuts
     8: Bevel Gear Boxes          ( * not yet implemented )
     9: Flexible Couplings
    10: Electrical contacts

        Enter Selection  (0-15), then key (RETURN) ...1
```

A1.1.5 Define Product

Enquiry E1089/06/91 Account T072 0000

```
+-----------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91  APP PROGRAM : SALES |
+-----------------------------------------------------------------+
```

Precision Ball Screw Jacks:-	
No of Jacks in actuator system	4
Total dynamic load outward	1000
Total dynamic load inward	1000
Is the dynamic load evenly distributed	Y
If not: heaviest load outward on Jack	0
If not: heaviest load inward on Jack	0
Total unladen weight of structure	3.5
Is the weight evenly distributed	Y
If not: heaviest unladen weight on a Jack	0
Total Static Load	5.0
Is the Static load evenly distributed	Y
Heaviest Static load, Jack extended	5.2
Heaviest Static load, Jack retracted	4.8

A1.1.6 Define Application

```
Enquiry    E1089/06/91        Account     T072    0000
+------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91  APP PROGRAM : SALES |
+------------------------------------------------------------+

Precision Ball Screw Jacks contd:-
Are the Jacks/ Actuators working horizontally .........    N
Is human cargo involved ................................    N
Is backlash elimination required ......................    N

Is the Load in Compression or Combined Comp / Tension .    Y
Are there off centre loads on the screw ...............    N
Do impact loads exist .................................    N
Is there an eccentric load ............................    N
Are there vibrations present ..........................    N
Is the system guided ..................................    Y
Can the Jacks be influenced by the structure Expanding     N
                                          Contracting .    N
                                          Deflection ..    Y
Which of the following environmental conditions Dusty .    Y
will the equipment be working in                Heat ..    N
                                                Ice ...    N
                                          Corrosive ...    N
                                       Radiation ......    N
                                 Direct Sunlight ......    N
                           Good Clean Conditions ......    N
```

A1.1.7 Define Application contd.

```
Enquiry    E1089/06/91         Account     T072    0000
+-----------------------------------------------------------+
|FORTUNE ENGINEERING LIMITED  12/6/91   APP PROGRAM : SALES |
+-----------------------------------------------------------+
  Precision Ball Screw Jacks contd:-
  What raise speed is required of the system (mm/min) ? .  0.1
  What lowering speed is required of the system (mm/min).  0.1
  What stopping distance is required (mm) ? ............. 10.0
  What ramp-up (acceleration) time is required (seconds). **.*
  Number of complete cycles performed per hour ..........    3
  Number of operating hours per working day .............    6
  Life expectancy required (years until maintenance) ....   10
  Do all jack components operate at the same temperature     Y
  What is the ambient temperature (degrees Celsius) ? ...   12
  What side thrust is on the screw / ram (kg) ? .........    0
  Motor Inertia (kg m ) Net Bevel Box Eff (%) >..........  100
  System Gear Ratio, Excluding the jack(s) ........... 1.00:1
```

A1.1.8 Application Calculations

```
Enquiry E1089/06/91  Account T072 0000
+------------------------------------------------------------+
| FORTUNE ENGINEERING LIMITED  12/6/91  APP PROGRAM : SALES |
+------------------------------------------------------------+

  Precision Ball Screw Jacks contd:-
  CALCULATIONS DETERMINING THE CHOICE OF JACK MODEL
--------------------------------------------------------------

  POWER CALCULATION:
  1-start, standard ratio, standard gears.
  Maximum raise / lower speed (mm/min) :                  0.10
  Input Worm speed (rpm) :                                0.16
  Input Torque (Nm) :                                     0.00
  Input Power (kilowatts) :                               0.00
  Power rating at this input speed :                      0.00
  Highest side load allowed (kg) :                        13.00
         Total System Power (kW) :                        0.00

-------------------------------------------------------------
  Duty (projected hours of operation)                     0
-------------------------------------------------------------

  Temperature raise over one stroke (C) :                 0
       ... added to ambient temperature                   0
-------------------------------------------------------------
```

After the application analysis is complete a standard Fortune product is selected from the internal system catalogue of standard products. The quotation along with a copy of the application analysis is then posted or faxed to the customer for approval,(see Figure A3). If a standard product can not be selected then the Sales Engineer will be required to cost a special product to satisfy the application.

The Sales Engineer may decide that a Spiracon Roller Screw or Rolaram Actuator would be more sufficient. In this case an enquiry design will be completed in the Drawing Office using a suitable Parametric Design Program. If the product is not standard and not Spiracon or Rolaram then the Sales Engineer has to manually cost a special Precision Jack using the costing sheet,(see Figure A4).

The Sales Engineer and the Production Director use their product and application knowledge and experience to cost the special job. After a cost has been defined a special quotation is then completed on the Sales Costing system. In this case the system is used as a word processing package to print a formal quotation.

FORTUNE
MECHANICAL ACTUATION SYSTEMS

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Facsimile: (0698) 829775

CENTRAL RECORD

Our Ref:

E1087/05/92 Your Ref 20/05/92

Date

FOR THE ATTENTION OF MR R BURNS
PURCHASING
BNFL
SELLAFIELD
SEASCALE
CUMBRIA

CA20 1PG

Q U O T A T I O N
================

DEAR MR BURNS,

We thank you for your enquiry dated 05/05/92, and now have pleasure in submitting our quotation as follows:

Item	Description	Qty	Unit Pr	Disc%	Value
1	LEADSCREW-LONG TO BNF DRAWING PR 50214D ST/ST BS970 GRADE 410 CONT S21 OUR QUOTATION IS ISSUED IN RESPONSE TO YOUR ENQUIRY REF BP1/621176/C. WE CONFIRM OUR ACCEPTANCE TO YOUR STANDARD CONDITIONS OF PURCHASE. WE CONFIRM THAT THE PRODUCTS ON	1	7396.00	.0	7396.00

continued/

Figure A3 Customer Quotation

FORTUNE
MECHANICAL ACTUATION SYSTEMS

PRODUCT COST SHEET

Customer	Date	Enquiry Ref.	Customer Drawing
Description			F E L Drawing

Product		Material Costs	Labour Hour Rate	Labour Hours Machining	Labour Hours Assembly	Total Unit Costs	Margin	Total Unit Selling Price
Basic Unit Assembly								
Options								
Special Features								
Proprietary Add - On Products								

Separately Quoted Charges if Applicable	Testing		Wooden Boxing Charges		Total Assy Cost	
			FOB CIF Charges		Total Assy Margin	
					Total Assy Sell Price	

Figure A4 Product Cost Sheet

A1.1.9 Parametric Enquiry Design

If the Sales Engineer decides that a Spiracon or Rolaram product is required then the customer enquiry file is given to a draughtsman in the drawing office. The draughtsman will then run a parametric program which prompts the operator for details of the application. (see Figure A5).

When the application analysis has been completed the program then designs a Spiracon unit to satisfy the analysis. The Spiracon unit is defined by a list of parameters which are transferred to a file. (see Figure A6).

A Bill of Materials is then created which defines all the components and quantities required to build the product. (see Figure A7). The Parametric Drawing program reads the parameters stored in the file to draw the Spiracon Assembly drawing and all the detailed drawings. (see Figure A8). If the Spiracon Unit is to be sold as a stand-alone unit, eg not in a Rolaram, then the Bom Costing System is then used to cost the Bill of Materials enquiry. The output of which can be seen in (Figure A9)

```
=========== Spiracon Design Calculations =============

Preferred Screw Sizes (From Bright EN19T) :
24.4  30.7  37.1  43.4  46.6  49.8
56.1  62.5  68.8  72.0  75.2
Screw Outside Diameter (mm)                 : 75.2
Screw Lead (mm)                             : 36
No. of Threads                              : 6
Roller Pressure Angle (deg)                 : 40
! Preferred Roller Diameter 25mm
Roller Outside Diameter (mm)                : 25
Spiracon Type (1 or 2)                      : 2
Thin tube for outer shell ? (Y/N)           : n
Is axial play important                     : n
Dynamic Load (N)                            : 83385
Static Load (N)                             : 83385
Side Load (N)                               : 0
Moment About Nut Centre                     : 0
..........
..........
..........

============= STRESS ==================================
 Screw/Roller Contact Stress ....... 166929. lbs/sq in
 LBE/Roller Contact Stress ......... 126416. lbs/sq in
 Shear Stress ......................   6951. lbs/sq in
 Number of Roller Ribs ............     14

============ BEARINGS =================================
 Thrust Bearing : INA 81126   170.0 x 130.0
 Needle Bearing : INA HK 1212   8.0 x  12.0

 Nut size Catalogue,Fixed or Minimum
 Choose C,F or M                              : m
 ! Nut Length increased from 166 to 170
 ! Nut Diameter increased from 200 to 203
```

Figure A5 Spiracon Nut Design Calculations

Spiracon Design Calculations ==== 21504 =====

Type 2

83385.0000	Dynamic Load
83385.0000	Static Load
0.0000	Sideload
0.0000	Moment about nut Centre
161269.0000	Screw/Roller contact stress
6488.0000	Shear Stress
----------------	SCREW --------------------
75.2000	Outer Diameter
36.0000	Lead
6	Number of threads
6.0000	Pitch
. ....	....
-------------	ROLLER ----------------------
25.0000	Outer Diameter
12.0000	Pintle Diameter
90.0000	Length
15.0000	Pintle Length
......	....
-------------	Load Bearing Element ---------
170.0000	Outer Diameter
130.0000	Shoulder Diameter
116.2452	Inner Diameter
9.0000	Shoulder Length
......	....
----------	Thrust Bearing -----------------
170.0000	Washer Outer Diameter
130.0000	Washer Inner Diameter
165.0000	Cage Outer Diameter
135.0000	Cage Inner Diameter
......	....
------	Bush or Needle Bearing --------------
18.0000	Outer Diameter
12.0000	Length
12.0000	Inner Diameter
0.8000	General Radius

Figure A6 Spiracon Nut Design File

Bill of Materials R075021504/000 Spiracon Nut Assembly

Level	Part Number	Description	Unit	Qty
*1	B010010098/001	Dowelpin 6 DIA x 18	Each	2.000
*1	R075021505/000	Roller	Each	6.000
**2	R075021506/000	Roller Heat Treat	Each	1.000
***3	R075021507/000	Roller Blank	Each	1.000
****4	S999014134/001	1.25" DIA BS970 EN36	Mtrs	0.140
*1	R075021508/000	Load Bearing Element	Each	1.000
**2	R075021509/000	L.B.E. Harden	Each	1.000
***3	R075021510/000	L.B.E. Int M/c	Each	1.000
****4	R075021511/000	L.B.E. Stress Relieve	Each	1.000
*****5	R075021512/000	L.B.E. Blank	Each	1.000
*****6	R075021513/000	180 Diax100 BS970 708	Each	1.000
*1	R075021514/000	Outer Shell	Each	1.000
**2	S999016791/000	219.1 Dia x163	Mtrs	0.144
*1	R075021515/000	Roller Locator 1	Each	1.000
**2	S999021516/000	200 Diax63 Mild Steel	Each	1.000
...	....	....	....	.....
...	....	....	....	.....
...	....	....	....	.....
*1	S999007112/001	Dowel 8 Dia x 20 Long	Each	4.000
*1	S999016032/001	1/8 Bsp Socket Plug	Each	1.000
*1	S999016670/001	INA HK Needle Bearing	Each	12.000

Figure A7 Spiracon Nut Bill of Materials

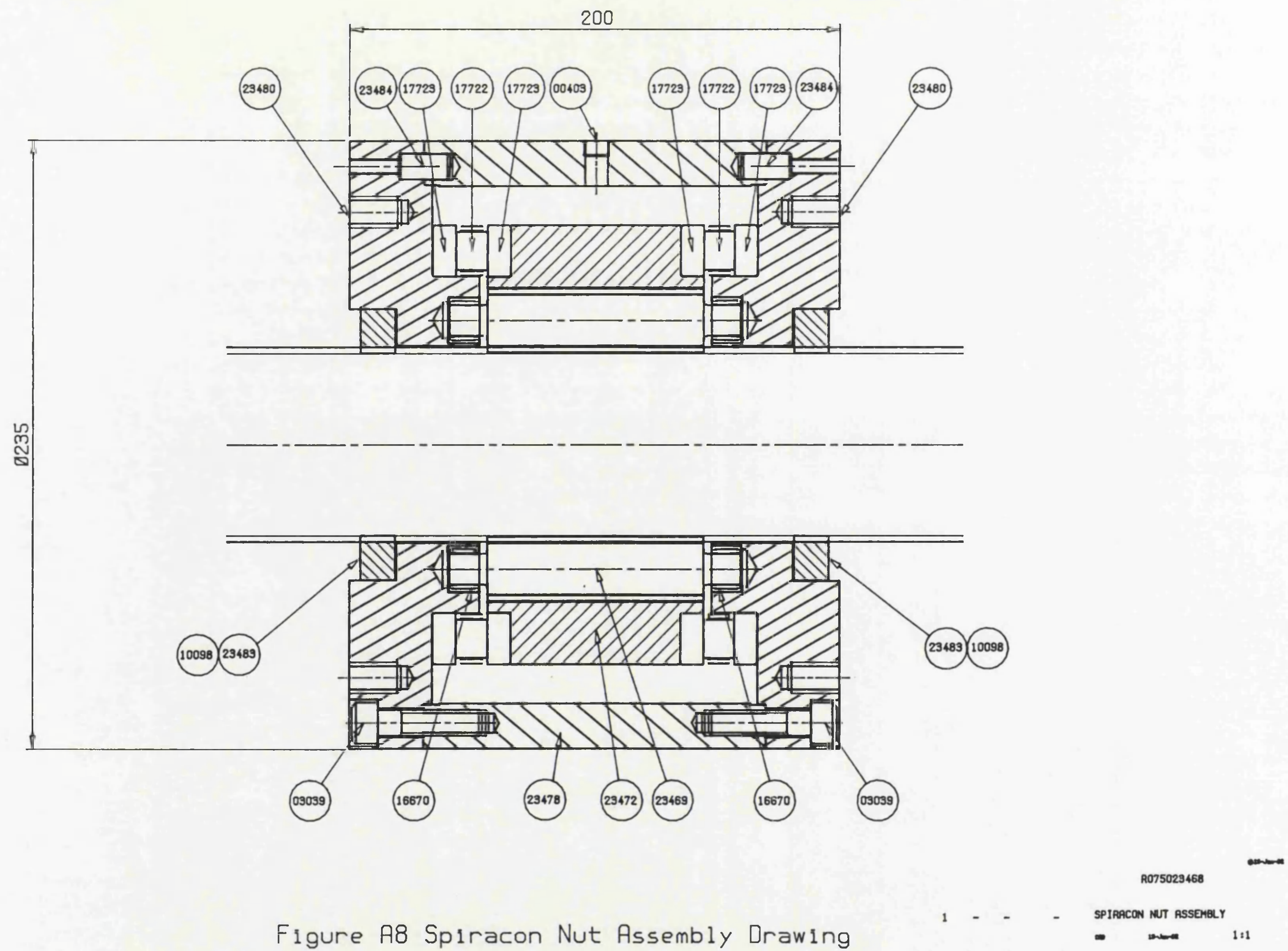

Figure A8 Spiracon Nut Assembly Drawing

Figure A9 Costed Bill of Materials

Costed BOM

Part Number : R075021504 Issue Number: 000 Total :540.78
Description : SPIRACON NUT ASSEMBLY

	Part	Description	Qty	P Cost	Set	B/S	Run	M Cost	Total
1	10098	DOWELPIN 6 DI	2.000	1.00	0	0	0	0.00	2.00
1	21505	ROLLER	6.000	0.00	0	100	30	10.12	104.84
2	21506	ROLLER HEAT T	1.000	1.00	0	0	0	0.00	0.00
3	21507	ROLLER BLANK	1.000	0.00	0	100	15	5.06	0.00
4	14134	1.25" DIA BS9	0.140	1.30	0	0	0	0.00	0.00
1	1508	LOAD BEARING	1.000	0.00	0	40	30	10.12	78.00
2	21509	L.B.E. HARDEN	1.000	10.00	0	0	0	0.00	0.00
3	21510	L.B.E. INT. M	1.000	0.00	0	40	30	10.12	0.00
4	21511	L.B.E. STRESS	1.000	5.00	0	0	0	0.00	0.00
5	21512	L.B.E. BLANK	1.000	0.00	0	40	45	15.17	0.00
6	21513	180DIAX100 BS	1.000	27.60	0	0	0	0.00	0.00
1	21514	OUTER SHELL	1.000	0.00	0	40	60	20.23	56.84
2	16791	219.1 DIA X 1	0.144	36.61	0	0	0	0.00	0.00
1	21515	ROLLER LOCATO	1.000	0.00	0	40	90	30.34	35.63
2	21516	210DIAX63 MIL	1.000	5.29	0	0	0	0.00	0.00

Save(1) Print(2)

If the Spiracon Unit is to be part of a Rolaram Actuator then the Design Actuator program is executed.

This program has a similar interface as the Design Spiracon program where the user keys in answers to specific application questions (see Figure A10).

When the application analysis has been completed the program then designs a Rolaram unit to satisfy the analysis. The Actuator is defined by a list of parameters which are transferred to a file. (see Figure A11).

A Bill of Materials is then created which defines all the components and quantities required to build the product, (see Figure A12).

From the parameters held in the file a drawing program can be executed to read the parameters and create the Actuator Assembly drawing and all the detailed drawings, (see Figures A13,A14 & A15).

When the Bill of materials is created the Bom Costing System can be utilised to cost all the components and assemblies which configure the Actuator, (see Figure A16).

Figure A10 Rolaram Actuator Design Calculations

```
=========== Actuator Design Calculations =============

20050.nut  20100.nut  20415.nut  20417.nut  20487.nut
20504.nut  20555.nut  20662.nut  20770.nut  20778.nut
20830.nut  20889.nut  trial.nut

File Name                                    :21504

Screw Outside Diameter (mm)                  : 75.2
Screw Lead (mm)                              : 36
Dynamic Load (N)                             : 83385
Static Load (N)                              : 83385
Compression/Tension/Both ? (C/T/B)           : c
Working Stroke (mm)                          : 1250
Over Travel (mm)                             : 50
Linear Speed (Max 43104 (mm/min)             : 10000

Output Power                                 : 19.09 Kw
Load Torque                                  : 649 Nm
Braking Torque                               : 453 Nm
Screw Speed                                  : 277.78 rpm

Gear Type (Worm/Bevel/WormBevel/BevelBevel:  w
Std/Opt/Special Ratio (S/O/X)                : x

====== 40.0 Tonne  5:1 H&G Selected ==================
Power Rating                                 : 22.78
Dynamic Capacity                             : 99721 N
Speed rating                                 : 1003 rpm
Life rating                                  : 2402 hrs
Facewidth rating                             : 29.29mm
Actual Rubbing Speed                         : 4.15m/s

! Dynamic Load exceeds capacity of standard bearing
L10 Life is 816 hrs
! Non-standard tube selected for outer case
Efficiency Worm driving                      : 94%
Efficiency Wheel driving                     : 94%
................
................
................

! Angular Stiffness is 614787. Nm/rad
! Critical load for elastic stability is 1551707 N
New Part Numbers and BOM (Y/N)               : y
Creating BOM ...
```

Figure A11 Rolaram Actuator Design File

```
===== Actuator Design File ======== 21521 ========
1250.0000   Stroke
2038.0000   Closed length
2037.0000   Minimum Closed Length
   0.0000   Linear Speed
  50.0000   Over Travel
  19.0900   Output Power (Kw)
 648.7600   Load Torque (Nm)
 277.7800   Screw Speed (rpm)
 ........   ...............
 ........   ...............
--------- Worm Wheel --------------------
      30    No of teeth
 197.7000   Outside Diameter
  57.2000   Inner Diameter
 140.0000   Shoulder Diameter
 171.2093   Root Diameter
 ........   ...........
 ........   ...........
--------- Worm Shaft --------------------
       6    No of starts
  43.4600   PCD
  35.1721   Root Diameter
  77.0000   Thread Length
  .......   ..........
  .......   ..........
-------- Bearings ----------------------
   51228    Thrust Ball Bearing
   51228    Thrust Ball Bearing
   31308    Wormshaft Bearing
  ......    ..........
  ......    ..........
```

Figure A12 Rolaram Actuator Bill of Materials

Part Number : A075021521 Issue Number : 000
Description : MODEL A075 ACTUATOR

Level	Part Number	Description	Unit	Qty	Y
*1	A075018556/001	LOCK NUT	EACH	1.000	
**2	S999012937/001	RM 4" DIA MS BAR	MTRS	0.051	
*1	A075021522/000	SCREW	EACH	1.000	
**2	A075021523/000	SCREW GRIND	EACH	1.000	
***3	A075021524/000	SCREW HEAT TREAT	EACH	1.000	
****4	S999018386/001	3" DIA BS970 708	MTRS	1.711	
*1	A075021525/000	GEARBOX	EACH	1.000	
**2	S999021526/000	CASTING FOR A0750	EACH	1.000	
*1	A075021527/000	WORM WHEEL 40T	EACH	1.000	
**2	A075021528/000	WORM WHEEL PILOT	EACH	1.000	
***3	S999021529/000	AB2 SPUN CASTING	EACH	1.000	
*1	A075021530/000	WORM SHAFT 40T	EACH	1.000	
**2	A075021531/000	WORM SHAFT HEAT	EACH	1.000	
***3	A075021532/000	WORM SHAFT INT.	EACH	1.000	

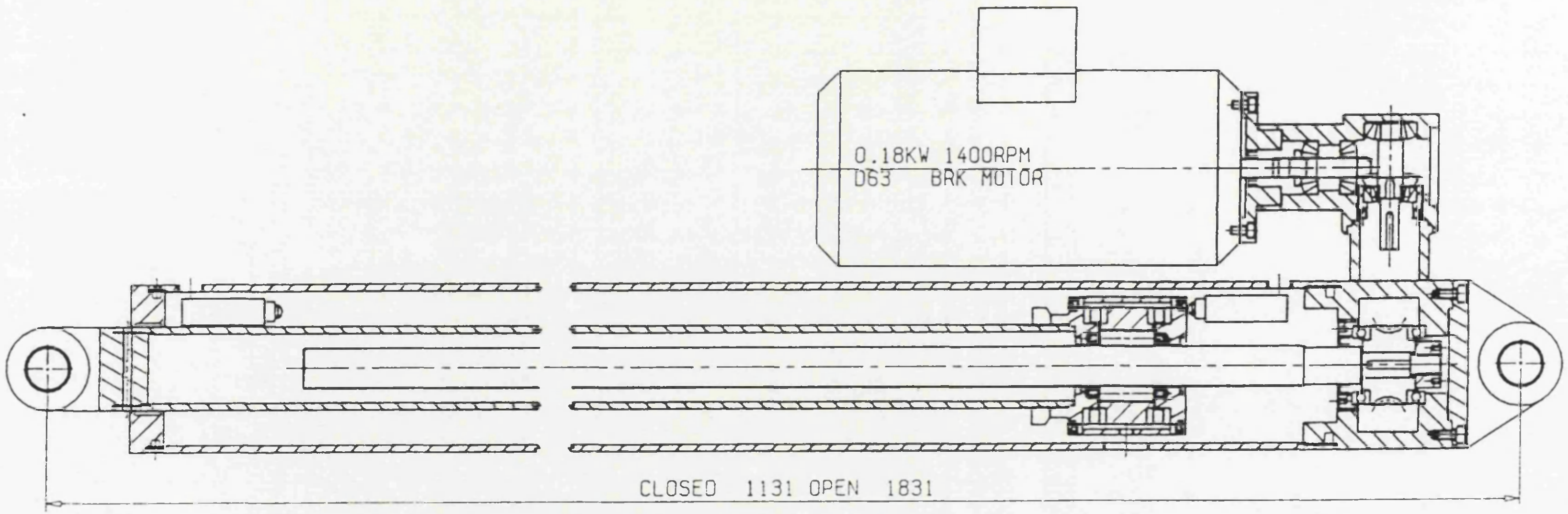

Figure A13 Rolaram Actuator Assembly Drawing (a)

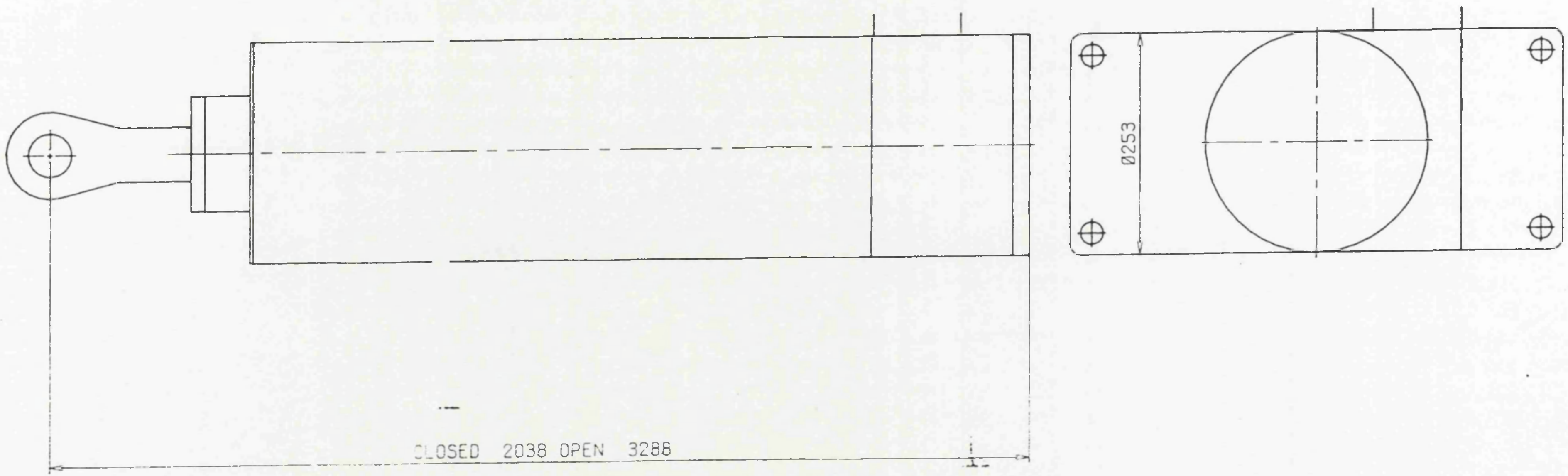

Figure A14 Rolaram Actuator Assembly Drawing (b)

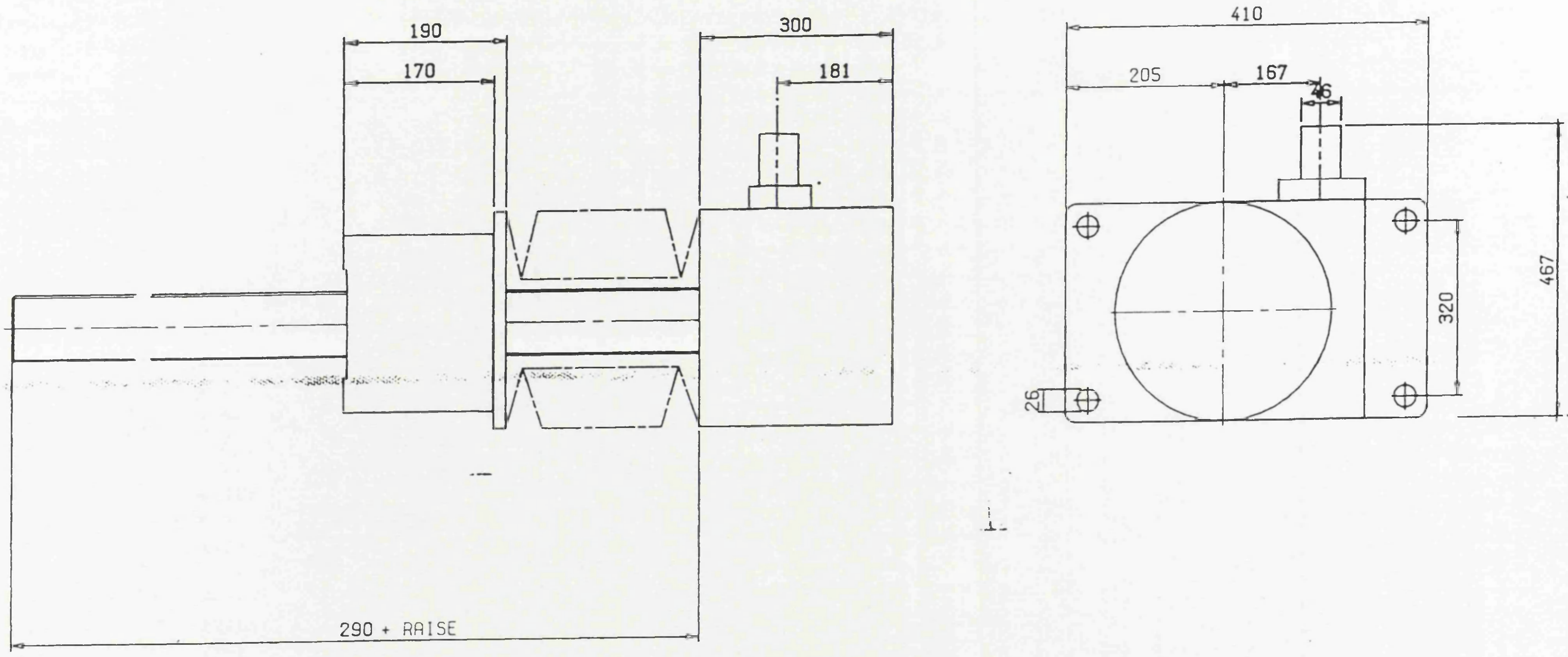

Figure A15 Rolaram Actuator Assembly Drawing (c)

Figure A16 Costed Rolaram Bill of Materials

Costed BOM

Part Number : A075021521 Issue Number : 000

Description : MODEL A075 ACTUATOR

Total :1836.10

	Part	Description	Qty	P Cost	Set	B/S	Run	M Cost	Total
1	18556	LOCK NUT	1.000	0.00	0	40	10	3.37	3.93
2	12937	RM 100 DIA	0.051	0.56	0	0	0	0.00	0.00
1	21522	SCREW	1.000	0.00	0	40	780	262.99	394.36
2	21523	SCREW GRIND	1.000	0.00	0	40	120	40.46	0.00
3	21524	SCREW HEAT	1.000	14.60	0	0	0	0.00	0.00
4	18386	3"DIA BRIGH	1.711	76.31	0	0	0	0.00	0.00
1	21525	GEARBOX	1.000	0.00	0	40	180	60.69	217.14
2	21526	CASTING FOR	1.000	156.45	0	0	0	0.00	0.00
1	21527	WORM WHEEL	1.000	215.00	0	0	0	0.00	215.00
2	21528	WORM WHEEL	1.000	0.00	0	40	0	0.00	0.00
3	21529	AB2 SPUN CA	1.000	0.00	0	0	0	0.00	0.00
1	21530	WORM SHAFT	1.000	220.00	0	0	0	0.00	220.00
2	21531	WORM SHAFT	1.000	0.00	0	0	0	0.00	0.00
3	21532	WORM SHAFT	1.000	0.00	0	0	0	0.00	0.00
4	21533	WORM SHAFT	1.000	0.00	0	0	0	0.00	0.00

Save(1) Print(2)

The Costed Bill of Materials can then be printed out and used in costing the complete customer enquiry or filed in the Customer files.

A1.2 Drawing Office Management System

When an order is placed with Fortune Engineering the Sales department then determine whether the order is for standard or special products. Standard products do not enter the Drawing Office but are passed directly to the production department for processing in the Materials Requirements Planning System. Orders for special products are passed directly to the Drawing Office, (see Figure A17).

A1.2.1 Component Part Register

All manufactured, purchased parts and raw materials have an alphanumeric part number. The part number is derived from the product group that the part is used on, a sequential six figure number and a three figure issue number, ie S010 023944 / 001 , part for 10 tonne Screw Jack, Part Number 23944, engineering issue 1.

Part definitions require to be stored, created, updated and retrieved. Part numbers are created by a CAD design programs or manually for all new parts. Part numbers can have a CAD drawing, Bill of Materials, design data, CNC programs and tooling information associated with them.

A1.2.2 Life Cycle of Part

A part number can have several versions or issues defined by the three figure issue number. When the part is created the part is a "working" version, issue '000'.

If the component part number has a drawing then the issue of the drawing is the same as the issue of the part. When the engineering drawing is checked then the part remains issue '000'. When the engineering drawing is issued the part then becomes issue '001'.

In the event that an issued part is changed then the issued part is changed back to issue '000' which is called a "working" version. The part remains issue '000' until a design engineer has checked and issued the engineering drawing. Upon issue the part then becomes the next available issue number.

Only the issued versions and the latest working version, if the part is subject to a change, are stored on the system. Previous issues of engineering drawings are unavailable for change. There can only be one working version of a part at any one time.

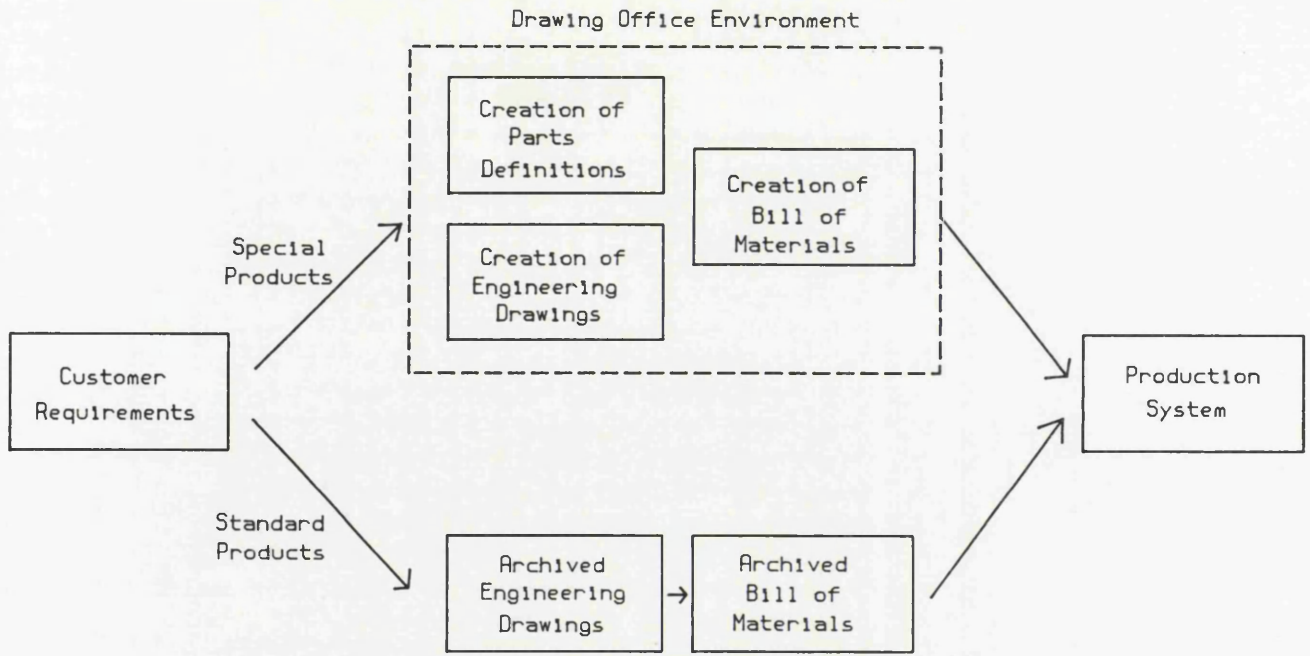

Figure A17 Drawing Office Data Creation Flow Diagram

A1.2.3 Creating a New Component Part

This menu option is used to manually create a part number in the engineering data base. A valid part number has to be created before and engineering drawing can be generated.

The Drawing Office Management system retrieves the next available part number for the user. The user, normally a design engineer, then inputs an alphanumeric description which best describes the part.

The system will then save the part in the internal system tables as issue '000'. At this stage the part can be used for creating engineering drawings or a bill of materials but the part cannot be accessed by the engineering shop floor until the part is checked and formally issued.

A1.2.4 Issuing a Component Part

When a part has been created then a design engineer will then check the engineering drawing and issue the part.

The issue procedure has to be executed using the Drawing Office Management system. The formal issue of the part then creates;

An Add-A-Part report for the Material Requirements Planning system. This report informs the system of the new parts and the new issues.

An Engineering Change Notice, an integral part of BS5750, this report informs all personnel of the changes made when a part was changed from one issue to another.

In addition the issue of the part then ensures that the part is available for manufacture.

A1.2.5 Changing a Component Part

This menu option is used when a part requires to be changed, other than for engineering reasons. eg if the part description requires minor modification or a unit of measure requires changing.

This menu option does not change the component part issue number or create any audit trail information.

A1.2.6 Part Number Register

```
+---------------------------------+
|      Part Number Register       |
+---------------------------------+

    1.  Create New Part

    2.  Issue Part

    3.  Change Part

    4.  Find Part by Number

    5.  Find Part by Description

    6.  Working/Checked Parts

    7.  List Add-A-Parts

    Select (1-7) :

BOMs(Key1)  Drawings(Key2)  ECNs(Key3)
```

A1.2.7 Create a New Component Part

```
+--------------------------------+
|        Create New Part         |
+--------------------------------+

  Part Number    : R060020905

  Issue Number   : 000

  Description    : ROLLER SCREW ASSEMBLY

  Unit           : E       Status : Working

  CAD Drawing    : NO      BOM    : NO
```

Create(Key1)

A1.2.8 Issue a Component Part

```
+--------------------------------+
|           Issue Part           |
+--------------------------------+

Part Number    : R060020905

Issue Number   : 001

Description    : ROLLER SCREW ASSEMBLY

Unit           : E         Status : Issued

CAD Drawing    : NO        BOM    : NO


Issue(Key1)
```

A1.2.9 Change a Component Part

```
+--------------------------------+
|          Change Part           |
+--------------------------------+

Part Number     : R060020905

Issue Number   : 001

Description    : ROLLER SCREW ASSEMBLY

Unit            : E               Status : Issued

CAD Drawing    : NO              BOM    : NO

Change(Key1)  Working(Key2)  List(Key3)
```

A1.2.10 Find Component Parts by Number

This menu option is used if a design engineer wishes to enquire on the description, latest issue or part history of a component part number.

A1.2.11 Find Component Part by Description

This option displays the part number and the full description of the latest versions of all component part numbers that match the search description.

The search can one or two search strings with a logical operator such as 'And', 'Or' or 'Not'.

A1.2.12 List Working/Checked Component Parts

Display the part number, description and status of all parts which have a working or a checked version status.

In practice this is the Drawing Office action list. Parts are added to this list when they are first created or a change to an issued version is made. Parts can be removed from this list by deleting the working version or issuing to manufacture.

A1.2.13 List Add-a-Parts Report

This menu option displays the part number, description and unit of measure of each part that has been issued in the Drawing Office Management system but the part is not logged into the Material Requirements Planning system.

Parts are removed from this list when a successful report has been generated.

A1.2.14 Find Component Part by Number Example Screen

```
            +--------------------------------+
            |      Find Part by Number       |
            +--------------------------------+
     Part Number    : R060020905
+-----+--------------------+----+--------+-------+---+---+
|Issue|Description         |Unit|Status  |ECN No|CAD|BOM|
+-----+--------------------+----+--------+-------+---+---+
|001  |ROLLER SCREW ASSEMBL|EACH|Issued  |0      |NO |YES|
|002  |ROLLER SCREW ASSEMBL|EACH|Issued  |1600   |NO |YES|
|000  |ROLLER SCREW ASSEMBL|EACH|Working |0      |NO |YES|
|     |                    |    |        |       |   |   |
|     |                    |    |        |       |   |   |
+-----+--------------------+----+--------+-------+---+---+
```

A1.2.15 Find Component Part by Description Example Screen

```
+--------------------------------+
|    Find Part by Description    |
+--------------------------------+
  Description    : BALL

+--------------+------------------------------+
|Part Number   |Description                   |
+--------------+------------------------------|
|S999000069/001|BALL BEARING 6003             |
|S999000163/001|BALL BEARING 6202-2Z          |
|S999000212/001|BALL BEARING 6001-ZZ          |
|A000002582/001|16 X 5 BALL NUT SFBA          |
|S002002618/001|BALL SCREW 25 DIA X 10 LEAD   |
|S999002621/001|SKF BALLNUT 25X10             |
|A000002687/001|INNER TUBE BALL SCREW         |
|A000002688/003|BALL SCREW 16 X 5 SKF         |
|B002002786/001|BALL NUT 25 X 25 SCCA         |
|S002002790/002|TOP PLATE FOR BALL SCREW JACKS|
|B001002798/002|BALL NUT FLANGE               |
|S999002892/001|25X25 BALL NUTS               |
|S005003028/001|BALL SCREW SHELL CAP          |
|S999003032/001|40X8 BALL NUTS                |
|B005003036/002|BOT. GUIDE BUSH INV BALL SCREW|
+--------------+------------------------------+
And(Key1)  Or(Key2)  Not(Key3)  Find(Key4) Print(Key5)
```

A1.2.16 Working/Checked Parts Example Screen

Working/Checked Parts

Part Number	Description	Status	!
R060020659/000	SCREW INT M/C.	Working	!
R060020660/000	SCREW STRESS RELIEVE	Checked	
R060020662/000	ROLLER SCREW ASSEMBLY	Working	!
R060020663/000	NUT ASSEMBLY	Working	!
R060020664/000	ROLLER	Checked	!
R060020665/000	ROLLER HEAT TREAT	Checked	!
R060020666/000	ROLLER BLANK	Checked	
R060020667/000	RETAINING RING	Working	*
R060020668/000	WIPER RING	Working	*
S999020669/000	100DIA INTERNAL CIRCLIP	Working	
R060020670/000	NUT HOUSING	Working	!
R060020671/000	NUT HOUSING HARDEN	Working	!
R060020672/000	NUT HOUSING INT. M/C	Working	!

Issue(Key1) Delete(Key2) Print(Key3)

A1.2.17 List Add-a-Parts Example Screen

List Add-A-Parts

Part Number	Description	Unit
R060020659/001	SCREW INT M/C.	EACH
R060020660/001	SCREW STRESS RELIEVE	EACH
R060020662/001	ROLLER SCREW ASSEMBLY	EACH
R060020663/001	NUT ASSEMBLY	EACH

Print(Key1)

A1.2.18 Bill of Materials Product Structure

The Drawing Office Management system, as discussed earlier, manages the component part register. Additionally the system also manages the creation, storage, update and retrieval of indented Bills of Materials.

The Bills of Materials defines component parts, assemblies, sub-assemblies and levels of manufacturing operation.

The system stores the bills of materials for all Fortune's product variations. Some bills of materials are called 'link-file', bills of materials. A link file is a bill of materials that has one or more component parts defined optional, this is denoted by the 'Y' status flag in the Y column, see Bill of Material Example Screen.

A1.2.19 Bill of Materials Product Structure Main Menu

This main menu displays a number of options to the user. There are options to create, update or retrieve bills of materials. Additionally the user has the option to move to an alternative menu ie Component Part Register.

A1.2.20 Product Structure Main Menu Example Screen

```
+---------------------------------+
|        Product Structure        |
+---------------------------------+

    1.  Create/Change BOM

    2.  Find BOM by Number

    3.  Where Used

    4.  Global Issue

    5.  Global Replace/Delete

     Select (1-5) :

Parts(Key1)  Drawings(Key2)  ECNs(Key3)
```

A1.2.21 Create/Change Bill of Material

The design engineer is responsible for the creation of engineering drawings and the creation bill of materials structures on the system. This menu option is used to create a bill of materials. When the bill of materials is created then the design engineer can use this same option to make changes to the bill of materials.

A1.2.22 Create/Change Bill of Materials Example Screen

```
          +--------------------------------+
          |       Create/Change BOM        |
          +--------------------------------+
      Part Number : R062020924  Issue Number : 000
      Description : SPIRACON NUT ASSEMBLY
```

Level	Part Number	Description	Unit	Qty	Y
*1	B010010098/001	DOWELPIN 6 DIA	EACH	2.000	
*1	R062020925/003	ROLLER	EACH	6.000	
*1	R062020928/000	LOAD BEARING EL	EACH	1.000	
*1	R062020933/000	OUTER SHELL	EACH	1.000	
*1	R062020935/002	ROLLER LOCATOR1	EACH	1.000	
*1	R062020936/002	ROLLER LOCATOR2	EACH	1.000	
*1	R062020937/002	WIPER RING 1	EACH	1.000	
*1	R062020938/001	WIPER RING 2	EACH	1.000	
*1	R062020939/001	LOCKING RING	EACH	2.000	
*1	S999011248/001	INA NEEDLE ROLL	EACH	12.000	
*1	S999014135/001	DOWEL PIN 6X14	EACH	4.000	
*1	S999016032/001	1/8" BSPT PRESS	EACH	1.000	
*1	S999018266/001	INA K81122 ROLL	EACH	2.000	
*1	S999018267/001	INA WS81122 THR	EACH	4.000	

Save(Key1) Copy(Key2) New(Key3) Delete(Key4) Print(Key5)

A1.2.23 Find Bill of Materials by Number

This option displays the single or multi level bill of material for a given component part, denoted by its part number and issue number. Parts on the BOM are sorted into alphanumeric part number order.

A1.2.24 Find Bill of Material by Number Example Screen

Find BOM by Number

Part Number : R062020924 Issue Number : 000

Description : SPIRACON NUT ASSEMBLY

Level	Part Number	Description	Unit	Qty	Y
*1	R062020928/000	LOAD BEARING ELEM	EACH	1.000	
**2	R062020929/000	L.B.E. HARDEN	EACH	1.000	
***3	R062020930/000	L.B.E. INT. M/C	EACH	1.000	
****4	R062020931/000	L.B.E. STRESS REL	EACH	1.000	
*****5	R062020932/001	L.B.E. BLANK	EACH	1.000	
******6	S999016862/001	160.0DIA EN19C	MTRS	0.077	
*1	R062020933/000	OUTER SHELL	EACH	1.000	
**2	S999020934/001	159DIAx149ID MS T	MTRS	0.151	
*1	R062020935/002	ROLLER LOCATOR 1	EACH	1.000	
**2	S999009572/001	RM MS 160 DIA	MTRS	0.059	
*1	R062020936/002	ROLLER LOCATOR 2	EACH	1.000	
**2	S999009572/001	RM MS 160 DIA	MTRS	0.040	
*1	R062020937/002	WIPER RING 1	EACH	1.000	
**2	S999014143/001	100 DIA DELRIN (N	MTRS	0.016	

Single(Key1) Multi(Key2) Print(Key3)

A1.2.25 Where Used

This menu option displays the single or multi level where a user defined part number is used. This option may be used when a design engineer wishes to interrogate the data base for all the bills of materials that have a unique part number that forms part of the bill, ie before a part is substituted for another or a change to a component part.

A1.2.26 Where Used Example Screen

```
        +--------------------------------+
        |           Where Used           |
        +--------------------------------+
      Part Number : R062020930  Issue Number : 000
      Description : L.B.E. INT. M/C
+--------+--------------+-------------------------------+
|Level   |Part Number   |Description                    |
|--------+--------------+-------------------------------|
|*1      |R062020929/000|L.B.E. HARDEN                  |
|**2     |R062020928/000|LOAD BEARING ELEMENT           |
|***3    |R062020924/000|SPIRACON NUT ASSEMBLY          |
|        |              |                               |
|        |              |                               |
|        |              |                               |
|        |              |                               |
|        |              |                               |
+--------+--------------+-------------------------------+
       Single(Key1)  Multi(Key2)  Print(Key3)
```

A1.2.27 Global Issue

This option is used by the design engineer to issue the complete bill of materials to manufacturing. This global function is much quicker than issuing each component part individually.

When the part is issued then this prevents further change to these versions.

A1.2.28 Global Issue Example Screen

```
        +---------------------------------+
        |          Global Issue           |
        +---------------------------------+
      Part Number : R062020924  Issue Number : 000
      Description : SPIRACON NUT ASSEMBLY

+--------+--------------+---------------------+-------+-+
|Level   |Part Number   |Description          |Status |!|
|--------+--------------+---------------------+-------+-|
|*1      |B010010098/001|DOWELPIN 6 DIA X 18  |Issued | |
|*1      |R062020925/000|ROLLER               |Working|!|
|*1      |R062020928/000|LOAD BEARING ELEMENT |Working|!|
|*1      |R062020933/000|OUTER SHELL          |Working| |
|*1      |R062020935/002|ROLLER LOCATOR 1     |Issued | |
|*1      |R062020936/002|ROLLER LOCATOR 2     |Issued | |
|*1      |R062020937/000|WIPER RING 1         |Working|*|
|*1      |R062020938/000|WIPER RING 2         |Checked| |
|*1      |R062020939/001|LOCKING RING         |Issued | |
|*1      |S999011248/001|INA NEEDLE ROLLER HK |Issued | |
|*1      |S999014135/001|DOWEL PIN 6X14 WDS204|Issued | |
|*1      |S999016032/001|1/8" BSPT PRESSURE PL|Issued | |
|*1      |S999018266/001|INA K81122 ROLLER CAG|Issued | |
|*1      |S999018267/001|INA WS81122 THRUST WA|Issued | |
+--------+--------------+---------------------+-------+-+
     Single(Key1)  Multi(Key2)  Select(Key3)  All(Key4)
```

A1.2.29 Global Replace/Delete

This option is very useful if the design engineer wishes to replace one component part with another on all the bill of materials that the component part is used.

The design engineer can also delete the component part whenever it is used on a bill of materials.

In practice, if a component part is no longer to be used, ie in the case of a product redesign or value engineering task, then the component part can be replaced by another more suitable part or deleted completely. This powerful menu item will change all the bill of materials and is only used by authorised personnel.

A1.2.30 Global Replace/Delete Example Screen

```
        +--------------------------------+
        |      Global Replace/Delete     |
        +--------------------------------+

      Part to be Replaced : S999016032 Issue : 001
      Description : 1/8" BSPT PRESSURE PLUG

      Replacement Part    : S999000403 Issue : 001
      Description : GREASE NIPPLE 1/8" BSP //

    +--------------+------------------------------+
    |Part Number   |Description                   |
    +--------------+------------------------------|
    |A045017880/002|MODEL A045 ACTUATOR           |
    |A045019811/001|ASSY. PARTS IF PARALLEL DRIVE |
    |A075019502/004|MODEL A075 ACTUATOR           |
    |R062020924/000|SPIRACON NUT ASSEMBLY         |
    |              |                              |
    |              |                              |
    |              |                              |
    |              |                              |
    |              |                              |
    |              |                              |
    +--------------+------------------------------+
         Select(Key1)  All(Key2)
```

A1.2.31 Engineering Drawing Management

This option controls the storage and retrieval of CAD-generated drawings by part number and issue number.

Although drawings are not stored physically in the database application tables, they can only be stored and retrieved under database application control.

The system overcomes problems of sharing drawings, simultaneous update and storage location.

All drawings must have a part number and issue number. This prevents creating, changing or destroying a CAD drawing without the correct system control and prevents saving a CAD drawing against the wrong part number.

All engineering drawings must be checked on the system before the part can be issued. The checker's initials, usually a design engineer, will the be automatically saved and marked on the drawing.

When an engineering drawing has been checked and saved, a view-only drawing file is created. This view only format is only made available to manufacturing when the part is issued.

A1.2.32 Drawing Management Example Screen

```
+---------------------------------+
|       Drawing Management        |
+---------------------------------+

 Part Number    : R060020905

 Issue Number   : 001

 Description    : ROLLER SCREW ASSEMBLY

 Unit            : E             Status : Issued

 CAD Drawing    : NO             BOM    : NO

View(1) Save(Key2) Check(Key3) Frame(Key4)Recover(Key5)
```

A1.2.33 Engineering Change Control

When a working version of an issued part is checked and re-issued, an ECN, Engineering Change Notice, number and report are generated to document the change. This report is for two reasons;

i) Report informs the production department of a part change in order that they may update their system.

ii) The report provides suitable audit information when personnel wish to enquire about the history of the part.

The ECN is assigned the next sequential number from the register on the system.

When an ECN is created the number is added to the "action list". When the ECN report is printed, the number is deleted from this list. The ECN Report shows the part number concerned, its old and new issue levels and the reason for and details of the change.

The BOM and part number details are compared with the previous issue, and any changes are automatically shown on the ECN report. In addition, text can be typed on the ECN to describe the change.

ECN Reports can be created, stored, updated and retrieved by part number or ECN number.

A1.2.34 ECN Action List

This option retrieves all the ECNs that have been created but not printed.

An individual ECN Report can be retrieved for viewing, update or printing by selecting from the table, specifying the part number or the ECN number.

A1.2.35 ECN Action List Example Screen

```
               +---------------------------------+
               |         ECN Action List          |
               +---------------------------------+
              Part Number :                ECN Number :

+-------+---------------+-------------------------------+
|ECN No|Part Number     |Description                    |
|-------+---------------+-------------------------------|
|1600  |R060020905/001|ROLLER SCREW ASSEMBLY           |
|1601  |A045017893/002|GEARBOX COVER PLATE             |
|1602  |A035018008/001|SHELL CAP                       |
|1603  |R062020925/001|ROLLER                          |
|      |              |                                |
|      |              |                                |
|      |              |                                |
|      |              |                                |
|      |              |                                |
|      |              |                                |
+-------+---------------+-------------------------------+
    Select(Key1)
```

A1.2.36 Engineering Change Notice Report

This report, as discussed earlier, documents the changes to the component part. Changes to the part description, unit and bill of material are recorded automatically by the system when the part is re-issued.

A1.2.37 Engineering Change Report Example Screen

```
+-------------------------------------------------------+
|ECN Report| ECN No: 1600  Description: ROLLER SCREW ASS|
|  Part Number : R060020924/004                          |
|  Replaced By Part Number : R060020924/005              |
+-------------------------------------------------------+
|  Reason for Change                                     |
+-------------------------------------------------------+
|  ADD EXTRA LUBRICATION POINT                           |
|  CHANGE DOWEL SIZE                                     |
|                                                        |
|                                                        |
+-------------------------------------------------------+
|                                                        |
+-------------------------------------------------------+
|  Details of Change                                     |
+-------------------------------------------------------+
| ADD TO BOM                                             |
|  S999010707  6 DIA DOWEL PIN X 15 LONG  4.000          |
|  DELETE FROM BOM                                       |
|  B010010098  DOWELPIN 6 DIA X 18  4.000                |
|  CHANGE QUANTITY ON BOM                                |
|  S999016032  1/8" BSPT PRESSURE PLUG  1.000 TO 2.000   |
|                                                        |
|                                                        |
|                                                        |
+-------------------------------------------------------+
 Save(Key1)  Add(Key2)  Delete(Key3)  Print(Key4)
```

A1.3 Material Requirements Planning System

The MRP system at Fortune is not currently integrated with the Engineering Data Base. It is a stand alone system developed and maintained by Weir Group Management Systems Limited and is known as 'Impcon'.

There is also a financial system which integrates with Impcon, this is known as 'Fincon'.

The system in part is very relevant to the progression of customer orders from the Sales and Drawing Office systems to the Shop Floor Scheduling and Cell systems. The two systems consist of a number of modules described in the following paragraphs.

It should be noted that Fortune Engineering have not purchased all modules in the system and these will not be referenced.

A1.3.1 Fincon Main Menu Example Screen

```
+-------------------------------------------------------------+
|                FINCON : AVAILABLE MODULES                   |
+-------------------------------------------------------------+
                  1. Sales Order Processing
                  2. Sales Ledger
                  3. Sales Control
                  4. Purchase Ledger
                  5. Purchase Control
                  6. Nominal Ledger
                  7. Nominal Control
                  8. Order and Sales Analysis
                  9. Periodic Programs
                 10. Fincon Manager

              Select Number (or Esc): _
```

A1.3.2 Impcon Main Menu Example Screen

```
+------------------------------------------------------------+
|                IMPCON : AVAILABLE MODULES                   |
+------------------------------------------------------------+
                  1. Parts Control
                  2. Purchase Control
                  3. Works Order Control
                  4. Movement Inward
                  5. Movement Outward
                  6. Bills of Material
                  7. Materials Requirements Planning
                  8. Production Planning
                  9. Work in Progress
                 10. Costing
                 11. Stock Location Control
                 12. Forecasting
                 13. Periodic Programs
                 14. Miscellaneous
                 15. Manager

              Select Number (or Esc): _
```

A1.3.3 Supporting Data

Part register of all Fortunes parts including standard descriptions and part codes. Safety levels, re-order levels, order quantities, order increments and lead times are also stored against each part. List of all preferred suppliers including branch, addresses. Bill of materials files for all Fortunes standard products. These are stored in a master file listing all possible options available. Records of all stock values of parts in the system. Customer records, invoice addresses, delivery addresses, contacts and credit limits.

A1.3.4 Sales Order Processing

This module is used to enter customer codes and branch numbers, these are then validated against the customer details to identify account details, payment terms and discounts. (see Figure A18)

After the customer details have been accepted by the system the Products ordered can then be logged against the Sales Order number. These products could be manufactured items, proprietary items or services.

AEW ENGINEERING CO. LTD.

aew United Kingdom

Gresham House, Pinetrees Business Park, Salhouse Road, Norwich, Norfolk NR7 9BB.
Telephone: (0603) 700755 Telex: 97254 AEWENG G. Fax: (0603) 700844

PURCHASE ORDER

No.	6849
DATE	03/05/91
REFERENCE	40-630-01
CODE	

FORTUNE ENGINEERING CO LIMITED
FIRDT ROAD
BLANTYRE INDUSTRIAL ESTATE
BLANTYRE
GLASGOW

SUPPLIER No. FORT01

STOCK CODE	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	DISC %	TOTAL VALUE	DUE DATE
01567	SCREWJACK ELEVATOR PLN001 1TONNE PLAIN UPRIGHT PLN001US0080TP 80MM RAISE C/W BELLOWS & TOP PLATE S9013481	4.00	EACH	154.2700	10.00	555.37	07/06/91

IMPORTANT
1. The Purchase Order No, must appear on Invoices, Packages, Packing Slips and Correspondence.
2. We reserve the right to cancel this Order or any portion of same if delivery is not made when specified.
3. Include packing slip with each shipment.
4. Unless otherwise stated, the prices shown above include carriage to our works and are exclusive of V.A.T.

FOR AND ON BEHALF OF
AEW ENGINEERING.

GOODS £	555.37
CARRIAGE	
V.A.T	97.19
TOTAL VALUE £	652.56

Figure A18 Customer Purchase Order.

A1.3.5 Sales Order Processing Example Screen

```
+------------------------------------------------------------+
|                FINCON : Sales Order Processing             |
+------------------------------------------------------------+
         Sales Order Number : 9013481
         Customer Code : A016
         Branch: 1           Customer Order Number: 6849
         Special Narrative Line 1:
                              2: Deliver To
                              3: AEW ENGINEERING CO LTD
                              4: GRESHAM HOUSE
                              5: PINETREE BUSINESS PARK
                              6: SALHOUSE ROAD
                              7: NORWICH
                              8: NR7 9BB
         Delivery Area Code: 0000
```

A1.3.6 Sales Order Processing Example Screen contd.

```
+--------------------------------------------------------------+
|              FINCON : Sales Order Processing                 |
+--------------------------------------------------------------+
```

Item	Order Code	Sell Price	Order Qty	Disc%	Due date
1	PLN001US0801P	154.45	4	10.0	13/6/91

The system then identifies the product code of the pre-loaded Bill of Materials that will satisfy the requirement. If the Bill of Materials does not exist then the product is not standard and the Bill of Materials should be added to the system before the Sales Order can progress.

When adding a new Bill of Materials an existing Bill can be retrieved and edited to reflect the new Bill of Materials or the Bill of Material can be keyed in manually.

At this stage of processing, an Order has been logged and a Bill of Materials identified which will satisfy the order. The Bill of Material is known as a 'Master Bom'.

The Master Bom may consist of 30 standard parts and 5 options. Options may include; Inverted shell caps, Bellows, Clevis's or Fork End. The sales operative then identifies the options from the Master Bom which will exactly match the customer requirements. These are written onto a pre-printed form and the form is used to aid the input task. An example of the pre-printed form, Edit Sheet', can be found in (Figure A19).

When the Sales Order has been committed to the system the Order is placed into a Sales Production Interface File, (see Figure A20). This is the only interface between the Sales Processing module and Production.

Periodically, usually once a day, this file is printed for the Production department to analyse. At a convenient time in the working day the Sales processing operative then executes the printing of Order Acknowledgements. These acknowledgements are then sent to the customer to confirm that their order has been placed into the system, (see Figure A21).

This concludes the Sales Order processing of a customer order.

EDIT DATE: 9-5-91

PRODUCT CODE: 1

PW 001 US0080 TP

1 Tonne jack.

DESCRIPTION

QUANTITY: 4

UNIT PRICE: 154-45

DISCOUNT: 10.

CUSTOMER ORDER NO. 6849

SALES ORDER NO. S9013481

SPECIAL NARATIVE

PROJECT REF. NO.:

IS THIS A STANDARD PART

YES ✓ NO

B.O.M. NUMBER

SCREW	.	192
BOTTOM PIPE	.	099
BELLOWS	.	080
OUTER TUBE	.	
INNER TUBE	.	

ANY SPECIAL DELIVERY INSTRUCTION?

CARRIAGE CHARGED YES/~~NO~~

PACKING CHARGED ~~YES~~/NO

DELIVERY DATE: 4 WKS

TEST CERTIFICATES ~~YES~~/NO

CERTIFICATES OF CONFORMITY ~~YES~~/NO

INVOICE TO: AEW.

DELIVER TO:

Figure A19 Customer Edit Sheet.

A1.3.7 Pre-Manufacture Order Generation

Once a day the Sales Production Interface File is processed. Each customer order and related Bill of Materials are exploded to produce a series of recommendations to manufacture engineering parts and assemble products, (see Figure A22) and purchase or subcontract (see Figure A23).

The recommendations are printed if the stock requested is greater than the stock available or the stock levels have decreased below the reorder level.

The Production department review the report and identify if the orders have to progress or should be deleted. The orders may be deleted if the Production department wish to reduce stock levels.

The system at this stage has received sales order details, determined material requirements based on current stock holdings and generated the relevant orders.

The internal quantity available parameters are decreased by the quantity required and the quantity allocated is increased by the quantity required. If the parts required are proprietory parts then a Purchase Order (PO) is raised, (see Figure A24). If the parts are sub-contracted then a Purchase Subcontractors Order (SO) is raised, this order is identical to the Purchase Order.

If the part is manufactured in-house then a Manufacturing Order (MO) is produced, (see Figure A25).

FORTUNE

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10-Jul-91 REPORT BY SALES ORDERS PAGE 1

EFFECTIVE MARGIN : 44.00%

DATE	REF NUMBER	CUST CODE	NAME	INVOICE VALUE	ACTUAL MARGIN	MARGIN	EFFECTIVE INV VALUE
10/07/91	S9013869	P050	PILKINGTON INSULATION LTD	326.41			
10/07/91	S9013870	P053	PURFLEET BOARD MILLS	3399.78			
10/07/91	S9013871	P053	PURFLEET BOARD MILLS	1214.00			
10/07/91	S9013872	P053	PURFLEET BOARD MILLS	384.21			
10/07/91	S9013873	P053	PURFLEET BOARD MILLS	476.35			
10/07/91	S9013874	P053	PURFLEET BOARD MILLS	72.00			
10/07/91	S9013875	P053	PURFLEET BOARD MILLS	32.00			
10/07/91	S9013876	V003	VECTOR AANDRIJVINGSTECHNIEK BV	305.60			
10/07/91	S9013877	M116	MORTON ROLLS	52.92			
10/07/91	S9013878	M116	MORTON ROLLS	137.13			
10/07/91	S9013879	V003	VECTOR AANDRIJVINGSTECHNIEK BV	346.46			NA
10/07/91	S9013880	B115	BLACKFRIARS ENG CO. LTD	450.00			
10/07/91	S9013881	B115	BLACKFRIARS ENG CO. LTD	430.00			
10/07/91	S9013882	V003	VECTOR AANDRIJVINGSTECHNIEK BV	11.13			
10/07/91	S9013883	V003	VECTOR AANDRIJVINGSTECHNIEK BV	131.33			
10/07/91	S9013884	B020	BSC PORT TALBOT	2861.00			
10/07/91	S9013885	B022	BLACK CLAWSON INTERN. LTD	0.00			
10/07/91	S9013886	V006	S.A. VERMEIRE - BELTING NV	173.14			
10/07/91	S9013887	S037	STARKEY'S TECHNICAST LTD	708.64			
10/07/91	S9013888	H006	HURCO EUROPE LTD	260.00			
10/07/91	S9013889	H006	HURCO EUROPE LTD	488.00			

Registration No. 65959 (Scotland)
VAT Registration No. 315 2629 63

Figure A20 Customer Sales Order Report.

FORTUNE
MECHANICAL ACTUATION SYSTEMS

ORDER
ACKNOWLEDGEMENT

Fortune Engineering Limited
First Road,
Blantyre Industrial Estate,
Blantyre
Glasgow G72 0BW
Telephone: (0698) 829811
Facsimile: (0698) 829775

INVOICE TO:
AEW ENGINEERING CO LTD
GRESHAM HOUSE
PINETREE BUSINESS PARK
SALHOUSE ROAD
NORWICH
NR7 9BB

DELIVER TO:
AEW ENGINEERING CO LTD
GRESHAM HOUSE
PINETREE BUSINESS PARK
SALHOUSE ROAD
NORWICH
0000 NR7 9BB 0000

PAGE: 1

DATE: 09/05/91 SALES ORD: S9013481 CUST ORD NO: 6849 A/C: A016

ITEM	DESCRIPTION	QTY	UNIT PRICE	DISC%	VALUE
1	PLN001US00801P 1 TONNE SCREWJACK	4	154.45	10.00	556.02

221-22

PLANNED DESPATCH DATE : 13/06/91 556.02

Registration No. 65059 (Scotland)
VAT Registration No. 316 2029 93

Figure A21 Customer Order Acknowledgement.

05-Jul-91 [illegible] A27

PARTCODE	DESCRIPTION	ITEMS	QTY / ITEM	TOTAL REQD	ORDER TOTAL	COST PRICE	DUE DATE	[illegible]
A065021795/001	PARTS FOR STABILITY TEST	1	1.0000	1.0000	1.0000	0.00	02/08/91	EACH
A065021796/001	THROUGH PIN 200	1	1.0000	1.0000	1.0000	0.00	19/07/91	EACH
A065021797/001	THROUGH PIN 300 NO	1	1.0000	1.0000	1.0000	0.00	19/07/91	EACH
A065021798/001	TWO PART PIN	1	1.0000	1.0000	1.0000	0.00	19/07/91	EACH
A065021799/001	TWO PART PIN BLOCK	1	1.0000	1.0000	1.0000	0.00	19/07/91	EACH
C999000648/001	NO.19 COUPLING BORED & KEYED SPARES	1	4.0000	4.0000	4.0000	[illegible]	[illegible]	EACH
NSS90138550001	KEY [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15/08/91	EACH
NSS90138560001	PLN [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23/08/91	EACH
NSS90138570001	PLN 002 [illegible] ~~[illegible]~~	[illegible]	2.0000	2.0000	[illegible]	[illegible]	[illegible]	EACH
NSS90138580001	C999000648/001	1	4.0000	4.0000	4.0000	0.00	23/08/91	EACH
NSS90138590001	KEY 002 US 0100 [illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	19/08/91	EACH
NSS90138600001	A065021795/001	1	1.0000	[illegible]	[illegible]	0.00	16/08/91	EACH
NSS90138610001	R999017198/001	1	[illegible]	[illegible]	[illegible]	0.00	16/08/91	EACH
NSS90138620001	R999017198/001	1	[illegible]	[illegible]	1.0000	0.00	16/08/91	EACH
NSS90138630001	R999017198/001	1	1.0000	[illegible]	1.0000	0.00	16/08/91	EACH
NSS90138640001	PLN 001 US 0200 T P	1	2.0000	2.0000	2.0000	0.00	20/09/91	EACH
NSS90138650001	PLN [illegible] SPECIAL	1	4.0000	4.0000 1	4.0000	0.00	30/08/91	EACH
NSS90138660001	S020000640/001	1	4.0000	4.0000	4.0000	0.00	30/08/91	EACH
S000000207/001	BOTTOM PIPE	4	0.0570	[illegible]	[illegible]	0.00	15/08/91	EACH
S00[illegible]0218/004	KEYED LIFTING SCREW	4	0.1360	0.5440	0.5440	0.00	15/08/91	EACH
S000005213/006	WORM WHEEL STC RATIO	1	7.0000	7.0000	25.0000	0.00	15/08/91	EACH
S000006110/002	WORM WHEEL BLANK NO	1	27.0000	27.0000	150.0000	3.00	25/07/91	EACH
S001000158/002	BOTTOM PIPE	2	0.3190	0.6380	[illegible]	0.00	19/09/91	EACH

Figure A22 Work/Manufacturing Orders Report.

Figure A23 Purchase Orders to be Created Report

```
05-Jul-91
                    P U R C H   O R D E R S   T O   B E   C R E A T E D
                    ===================================================

 SUPPLIER CODE: H040  HARDING ENGINEERING
        BRANCH: 01    GREEN LANE

PART           DESCRIPTION                  ITEMS  QTY
----------------------------------------------------------
S999000251/001 SKT HD CAP SCW M10X1.5X30  1    16.000

ORDER TOTAL   COST PRICE DUE DATE UNIT
----------------------------------------
400.0000          0.12    23/8/91  EACH
```

Fortune
Engineering
Limited

First Road,
Blantyre Industrial Estate
Blantyre G72 0BW
Telephone: (0698) 829811
Telex: 777180
Fax: (0698) 829775

Manufacturers of screw
& ratchet jacks

registration no 65059 (Scotland)
VAT registration no 316 2029 93

H043 /01
HARDING ENGINEERING
GREEN LANE
STUDLEY
WARKS

our reference: A001416 | your reference | date: 08/07/91

ORDER No P06736

part no/description	quantity	price	DUE DAT
S999000251/001 SKT HD CAP SCW M10X1.5X30	400.0000 EACH	0.1207	23/08/9

ORDER TOTAL : 48.28

special instructions

deliver to

signed

THIS ORDER IS SUBJECT TO OUR STANDARD CONDITIONS OVERLEAF

Figure A24 Purchase Order.

MANUFACTURING ORDER

WORKS ORDER No. M0023926

PART CODE: S9990187?23/001

DESCRIPTION KEY 12 X 8 X 50 PLN// 2RD ENDS

Fortune Engineering Limited

QTY: 1.0000

No. OF ITEMS 1

OPERATION	INITIALS	TIME DATE STARTED	TIME DATE FINISHED	TOTAL TIME	DATE INSPECTED
SAW					
TURN					
DRILL					
TAP					
MILL					
BROACH					
GEARCUT					
THREAD WHIRL					
DEBURR					
GRIND					
THREAD GRIND					
ASSEMBLY					
FINAL INSPECTION					

TOTAL TIME TAKEN	
STANDARD TIME	
WORKS ORDER	
DATE	

Figure A25 Manufacturing Order.

A1.3.8 Post Manufacture System

When the MO's have been completed satisfactory to the Engineering Drawings the MO is again logged into the system to identify the part is available for kitting.

In addition when PO's are fulfilled then these are also logged into the system to identify the parts availability.

The Production Director then requests that the Kit is assembled and executes the command to print the Works Order (WO) (see Figure A26). The Works Order is issued to the fitting area where the product is assembled.

The Order then follows the product to the despatch area.

The Production department then issue the despatch note (see Figure A27).

The Product is then despatched and the Financial department informed to print the invoice to the customer. (see Figure A28).

Limited

ORDER No.	S9013481	ORDER CODE	PLN001US00801P
CUSTOMER	A016 /0000	DESCRIPTION	PLN 001 US 0080 1
NAME	AEW ENGINEERING CO LTD GRESHAM HOUSE PINETREE BUSINESS PARK SALHOUSE ROAD	BASE PART	S001000513/005
		BASE DESCRIPTION	GA PLN 001 US

PART CODE NSS90134810001 QUANTITY 4 DUE DATE 13/06/91 STA

COMPONENT	DESCRIPTION		No. OF ITEMS	QUANTITY/ITEM	TOTAL QUANTI
S001000151/001	TOP PLATE	A	1	4.0000	4.0000
S001000153/006	1T PLN UPRIGHT SHELL CAP	A	1	4.0000	4.0000
S001000158/002	BOTTOM PIPE	A	1	0.3960	0.3960
S001000168/004	JACK SCREW THREADED END	A	1	0.7680	0.7680
S001000171/001	KEY 5X5X27 PLN // 1 RD END	A	2	4.0000	8.0000
S001000630/001	BELLOWS BOOT GREY PVC	A	1	0.3200	0.3200
S001005164/007	WORMWHEEL STD RATIO	A	1	4.0000	4.0000
S001005166/005	WORM SHAFT STANDARD RATIO	A	1	4.0000	4.0000
S001009233/002	1 TON JACK BODY	A	1	4.0000	4.0000
S001012123/001	SHIM 20 O.DX 15.5ID X 0.1THK	A	2	4.0000	8.0000
S888000695/001	NAME PLATE	B	1	4.0000	4.0000
S999000054/001	M5 X 10 DOG PT SKT HD SET SC	B	4	4.0000	16.0000
S999000163/001	BALL BEARING 6202-2ZR	A	2	4.0000	8.0000
S999000185/001	THRUST BEARING 51106	A	2	4.0000	8.0000
S999000188/001	CIRCLIP SEEGER JK35	B	2	4.0000	8.0000
S999000403/001	GREASE NIPPLE 1/8" BSP //	B	1	4.0000	4.0000
S999000703/001	JUBILEE CLIP SIZE 1	A	1	4.0000	4.0000
S999000707/001	JUBILEE CLIP SIZE 3X	A	1	4.0000	4.0000
S999006764/001	HAM.DRV EL/BRSS SCREW 3/16 '	B	2	4.0000	8.0000
S999006822/001	LABOUR	A	1	4.0000	4.0000

1 TONNE SCREWJACK

J9014341

ASSEMBLY TIME					SERIAL Nos.
INITIALS	STARTED	FINISHED	TOTAL TIME	DATE INSPECTED	538362
				13 JUN 1991	to 365.

Figure A26 Kitting List.

FORTUNE
MECHANICAL ACTUATION SYSTEMS

DESPATCH NOTE

Fortune Engineering Limited
First Road,
Blantyre Industrial Estate,
Blantyre
Glasgow G72 0BW
Telephone: (0698) 829811
Facsimile: (0698) 829775

INVOICE TO:	DELIVER TO:	PAGE:
AEW ENGINEERING CO LTD GRESHAM HOUSE PINETREE BUSINESS PARK SALHOUSE ROAD NORWICH NR7 9BB	AEW ENGINEERING CO LTD GRESHAM HOUSE PINETREE BUSINESS PARK SALHOUSE ROAD NORWICH 0000 NR7 9BB	0000

DATE: 09/05/91 SALES ORD: S9013481 CUST ORD NO: 6849 A/C: A016

ITEM	DESCRIPTION	QTY	UNIT PRICE	DISC%	VALUE
1	PLN001US00801P 1 TONNE SCREWJACK	4			

PLANNED DESPATCH DATE : 13/06/91

NHolden

Registration No. 65059 (Scotland)
VAT Registration No. 316 2029 93

Figure A27 Despatch Note.

FORTUNE
MECHANICAL ACTUATION SYSTEMS

East Road
Blantyre Industrial Estate
Blantyre
Glasgow G72 0BW
Telephone (0698) 829611
Facsimile: (0698) 829775

INVOICE TO: | DELIVER TO: | PAGE: 1

AEW ENGINEERING CO LTD
GRESHAM HOUSE
PINETREE BUSINESS PARK
SALHOUSE ROAD
NORWICH
NR7 9BB 0000

AEW ENGINEERING CO LTD
GRESHAM HOUSE
PINETREE BUSINESS PARK
SALHOUSE ROAD
NORWICH
NR7 9BB 0000

DATE: 19/06/91 SALES ORD: S9013481 CUST ORD NO: 6849 A/C: A016

ITEM	DESCRIPTION	QTY	UNIT PRICE	DISC%	VALUE
1	PLN 001 US 0080 1 P 1 TONNE SCREWJACK	4	154.45	10.00	556.02

221-22

GOODS TOTAL	556.02
CARRIAGE & PACKING	30.00
VAT @ 17.50%	102.55
GRAND TOTAL	688.57

Registration No. 65059 (Scotland)
VAT Registration No. 316 2029 93

Figure A28 Customer Invoice.

A1.4 Spiracon/Rolaram Parametric Design System

The Parametric design process is very similar to the manual process, with the exception that Engineering Drawings are plotted automatically from design criteria input into dedicated design programs. A number of design programs are available to the user, these are custom written in Fortran which embed design rules and use graphic calls to a standard CAD package, (see Figure A29).

A1.4.1 Design and Draw Screw

This program reads spiracon screw data from a file and then prompts the user for end machining details. End machining may include thread portions,keyways or spline. When the program is complete the screw data file is created, (see Figure A30).

To create the engineering drawing for the screw another program reads the screw data file and plots the engineering drawing, (see Figure A31).

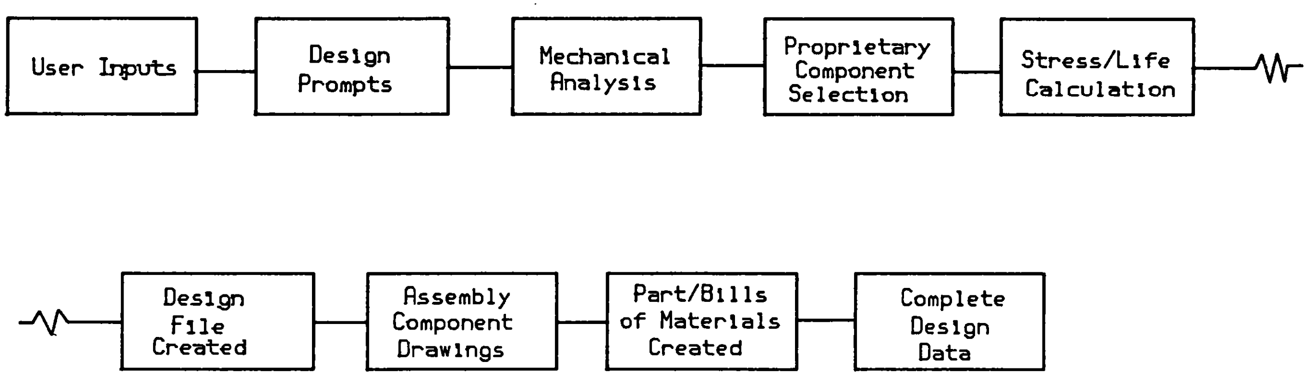
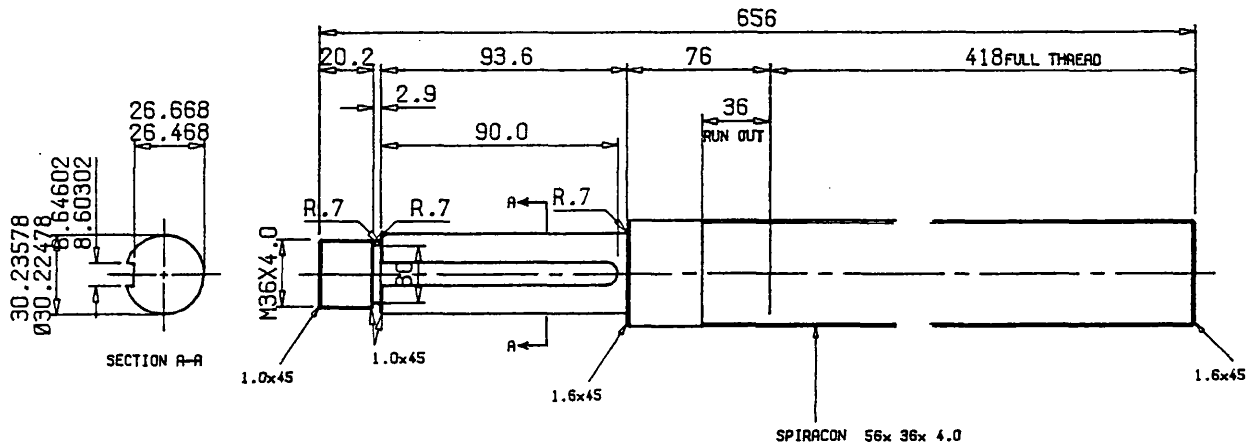


Figure A29 Parametric Design System Flow Diagram

Figure A30 Spiracon Screw Design Data

```
=============== Screw Design Data ==== 2010 =====
        5         No of Sections
------------------------------------------------
        E         Section Type
  62.5000         Diameter
                  Fit
 422.0000         Length
   0.0000         Thread Pitch
------------------------------------------------
        B         Section Type
  58.0000         Diameter
      H11         Fit
  11.0000         Length
------------------------------------------------
        D         Section Type
  50.0000         Diameter
       G5         Fit
  85.0000         Length
  83.0000         Keyway Length
------------------------------------------------
        B         Section Type
  48.0000         Diameter
                  Fit
   5.0000         Length
------------------------------------------------
        E         Section Type
  48.0000         Diameter
                  Fit
  54.0000         Length
   5.0000         Thread Pitch
------------------------------------------------
   0.0000         Hole Diameter LH end
   0.0000         Tapped Hole Diameter LH end
   0.0000         Hole length LH end
   0.0000         Hole Diameter RH end
   0.0000         Tapped Hole Diameter RH end
   0.0000         Hole length RH end
===============================================
```



OUTSIDE DIAMETER	:	56.100
LEAD	:	36.000
NO. OF THREADS	:	9.000
AXIAL TOOTH THICKNESS	:	1.799
ROOT RADIUS	:	0.670
AXIAL TIP WIDTH	:	0.636
AXIAL PRESSURE ANGLE	:	39.094
PITCH DIAMETER	:	54.670

MATERIAL - EN19C
UNTOLERANCED DIMENSIONS +-0.1
∀ ALL OVER

ROS6018182

1 - - - SCREW

1:2

Figure A31 Spiracon Screw Engineering Drawing

A1.4.2 Design and Draw Spiracon Nut

This program designs a Spiracon roller screw assembly. The program prompts the user for the application parameters. From the parameters the contact and shear stresses are calculated, and the roller length is increased until the contact stresses are below 250000 lbs/sq.in and the shear stress below 14 tons.

Bearings are then selected (Spiracon type 2) from catalogue data to fit the nut and handle the required loads.

If the nut is to be used in a Rolaram actuator, no mounting holes, a location diameter and a thread must be selected.

The program then calculates the thread geometry for the screw, roller and load bearing element (Spiracon type 2) or nut housing (Spiracon type 1).

The program then selects bearings (Spiracon type 2) and fasteners from data files, then checks the stresses and dimensions to ensure the components are correct.

When the design is complete a detailed data file is created. This file list all the design data used to construct the nut assembly and all component drawings, (see Figure A6).

A bill of materials can then be constructed automatically and saved into the Drawing Office Management system.

After the design program has been the executed then the design engineer may decide to run the program again, to optimise the design, or draw the Spiracon nut.

The Spiracon draw program reads the data file and plots all Spiracon parts and all the drawings for unique manufacturing levels, including manufacturing tolerances, (see Figure A8).

A1.4.3 Design and Draw Rolaram Actuator

This program designs a Spiracon actuator (Rolaram) assembly using an existing Spiracon nut design.

The program prompts the user for a number of design sizes ie actuator stroke, linear speed, gear type and ratio.

The program then performs design calculations and selects parts to create a data file fully defining the assembly. In addition a data file is created for the actuator screw.

A standard range of screw sizes with matched gears and stocked components are defined in the system and the user is requested to use these standard components whenever possible.

When the design is complete the design data file is created, (see Figure A11).

The Draw Actuator program is then executed, this program reads the design files and plots the Rolaram assembly drawing and all the component drawings, (see Figure A13,A14 & A15).

When a trail product is designed no parts are created or added to the system. When the design is run for a customer order the parts and bill of materials are created into the system using the same data.

The engineering drawings are then plotted and checked by a design engineer. It should be noted that the checking process is minimised considerably because the parametric programs have been used many times and the problems have been eradicated. Checking times have thus been reduced by 60 - 80 percent, (see Figure A32).

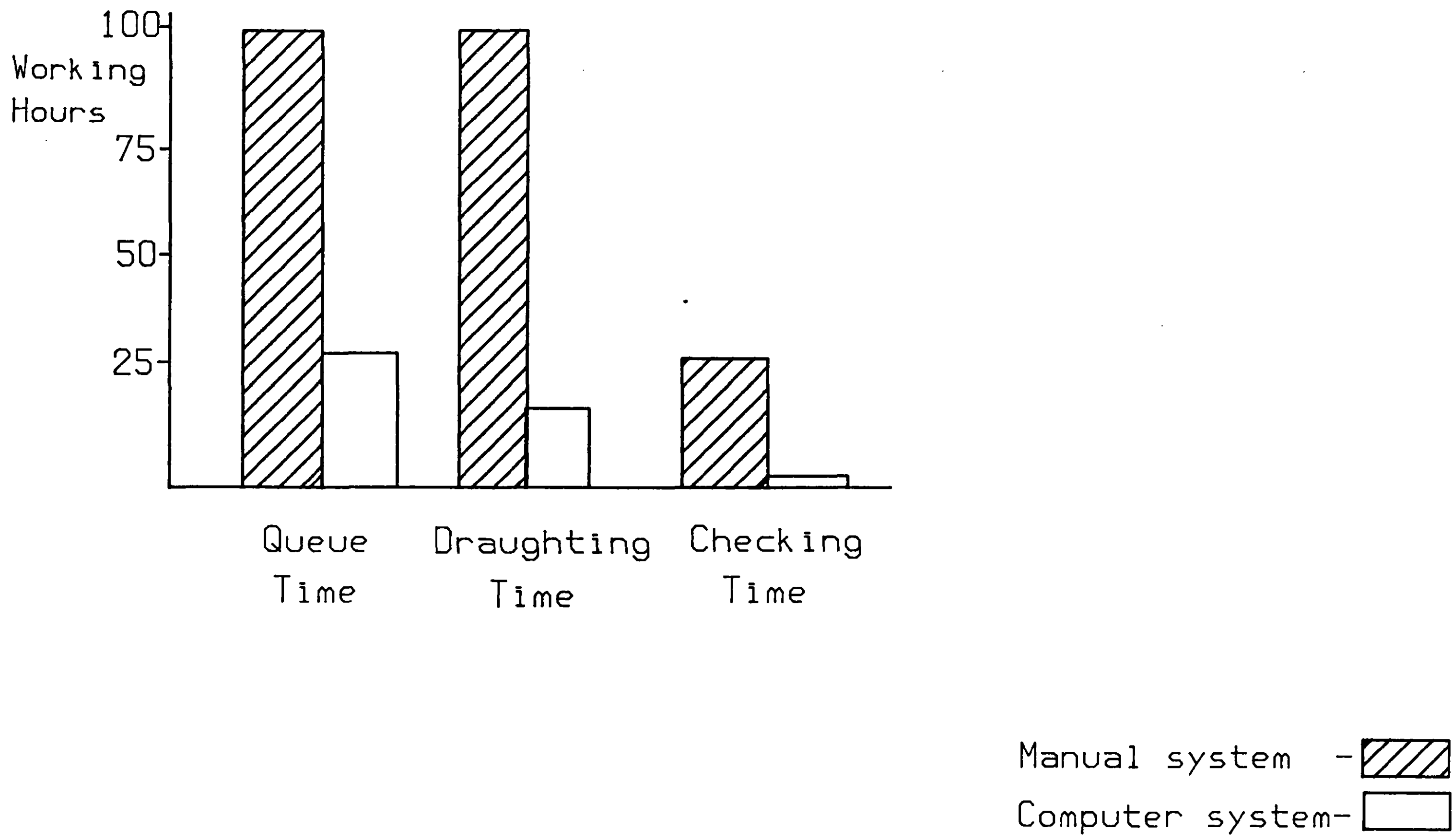


Figure A32 Drawing Office Performance Statistics

A1.4.4 Design Changes

There are four main ways of changing a roller screw or actuator design created using the programs above :

A. Program Change : if there is a desirable enhancement in the design or drawing process, or a commonly used design feature or manufacturing method is not reflected in the program then the Fortran program can be changed.

B. Run Program Again : if a major change is needed to drawings and data that have already been created, it is often easier to begin again with the spiracon design program than to change and check parts of drawings and data files.

C. Edit Data File : minor changes (e.g. no. of holes) which can take advantage of the parametric drawing method are best made by editing the design files. The drawing program can then be executed to create the correct drawings.

D. Modify Drawing : other changes can simply be made to the engineering drawings concerned. It should be noted that a change to a component drawing is not reflected in the assembly drawing or the associated design files.

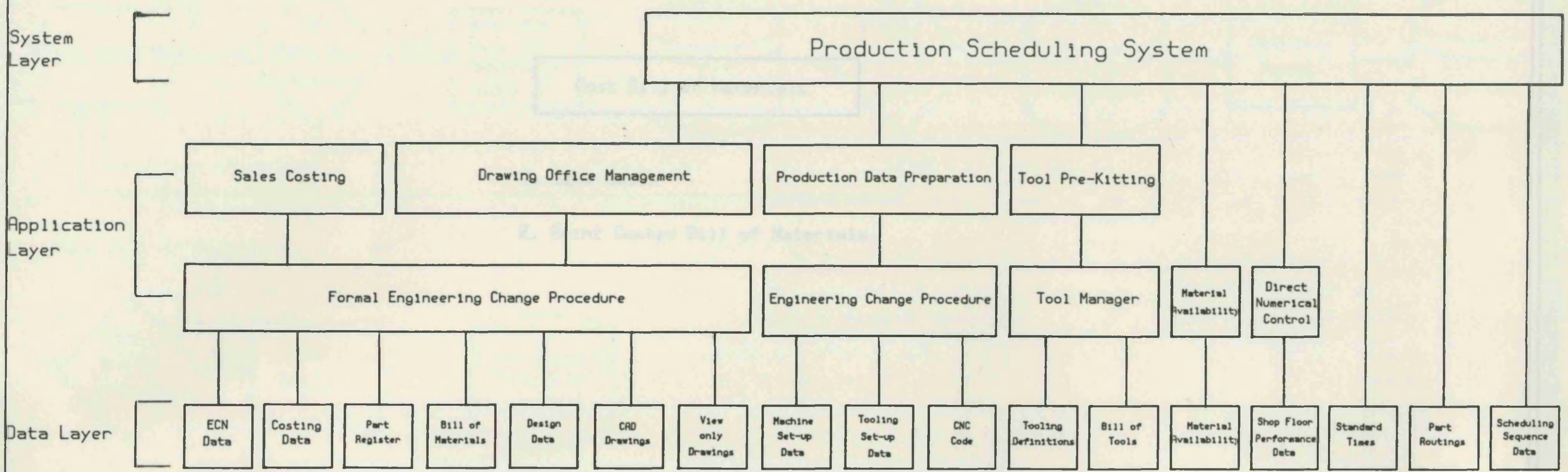
Appendix A2

System Access Mechanisms

and

Data Structures

Fortune Engineering Integrated Business Environment



Sales Costing Menu Structure

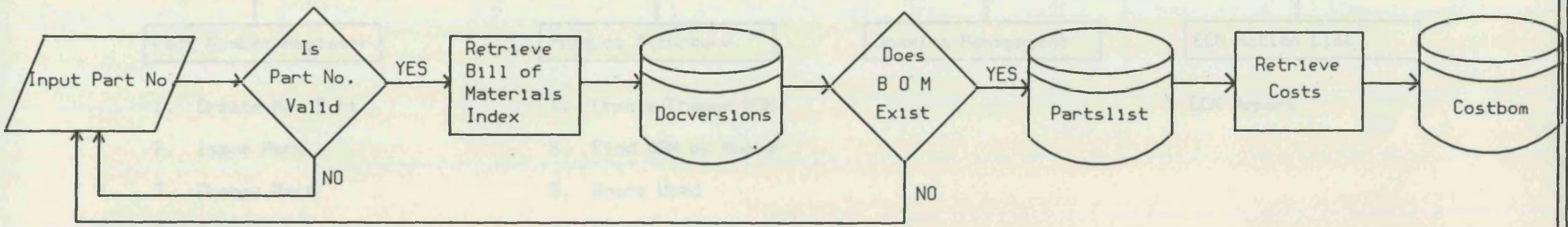
Cost Bill of Materials

1. Save Costs

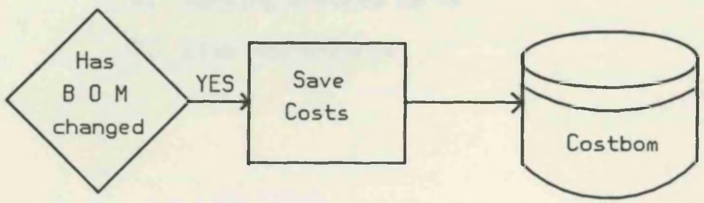
2. Print Costed Bill of Materials

Sales Costing Data Access

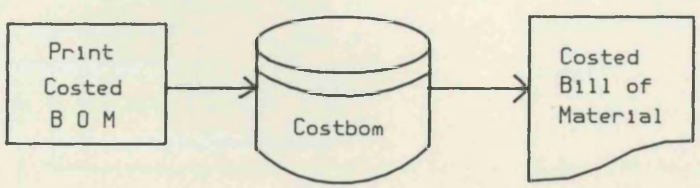
Retrieve Bill of Materials



Save Bill of Materials



Print Costed Bill of Materials



Drawing Office Management Menu Structure

Part Number Register

1. Create New Part
2. Issue Part
3. Change Part
4. Find Part by Number
5. Find Part by Description
6. Working/Checked Parts
7. List Add-A-Parts

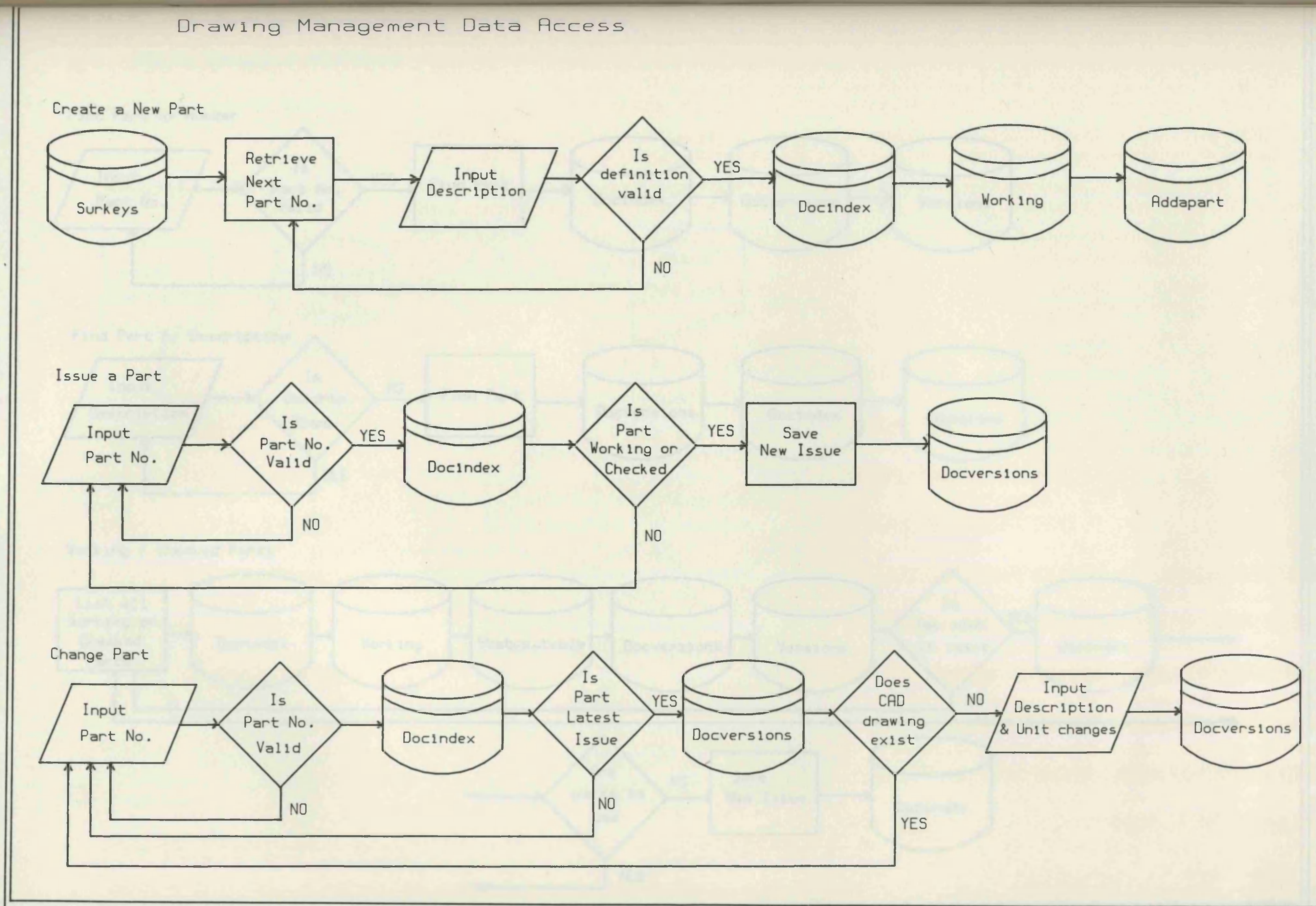
Product Structure

1. Create/Change BOM
2. Find BOM by Number
3. Where Used
4. Global Issue
5. Global Replace/Delete

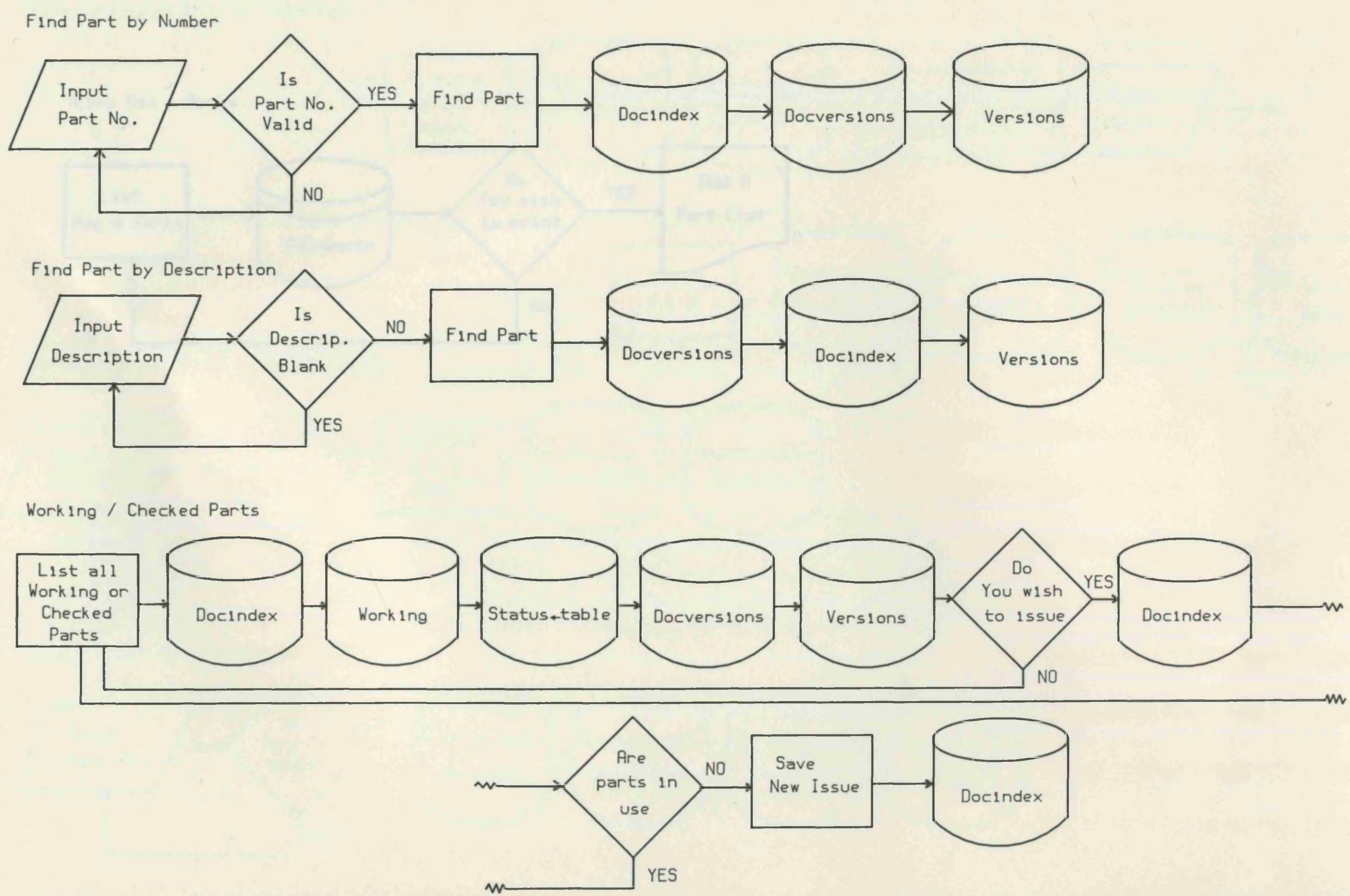
Drawing Management

ECN Action List

ECN Report

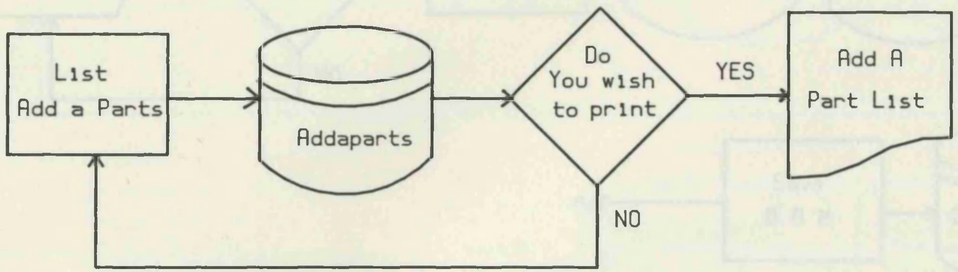

Drawing Management Data Access
Create a New Part
Surkeys
Retrieve Next Part No.
Input Description
Is definition valid
YES
NO
DocIndex
Working
Addapart
Issue a Part
Input Part No.
Is Part No. Valid
YES
NO
DocIndex
Is Part Working or Checked
YES
NO
Save New Issue
Docversions
Change Part
Input Part No.
Is Part No. Valid
NO
DocIndex
Is Part Latest Issue
YES
NO
Docversions
Does CAD drawing exist
NO
YES
Input Description & Unit changes
Docversions

Drawing Management Data Access



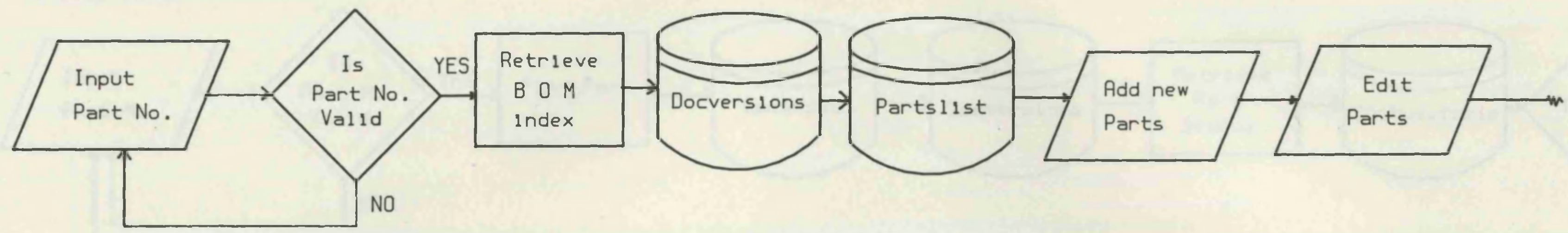
Drawing Management Data Access

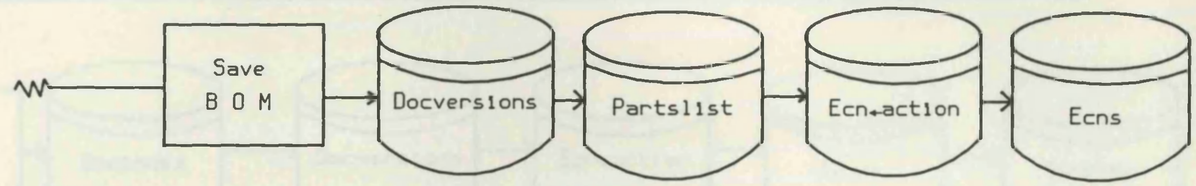
List Add a Parts



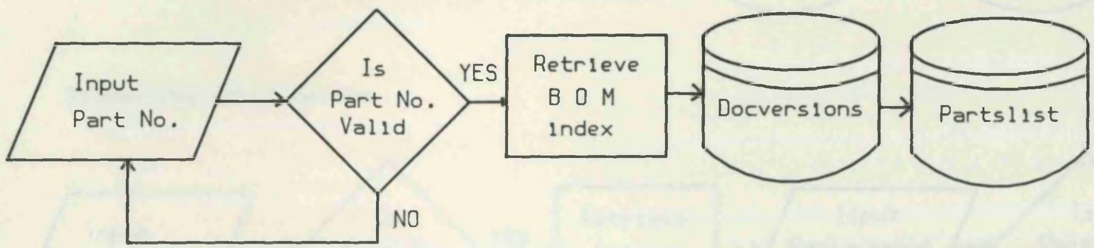
Drawing Management Data Access

Create / Change Bill of Materials

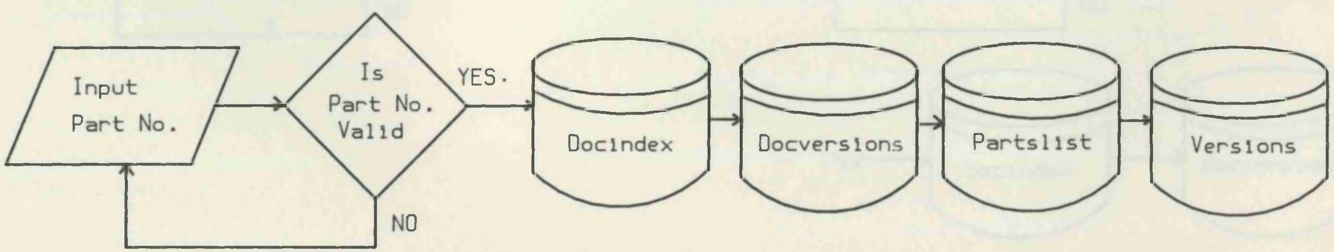




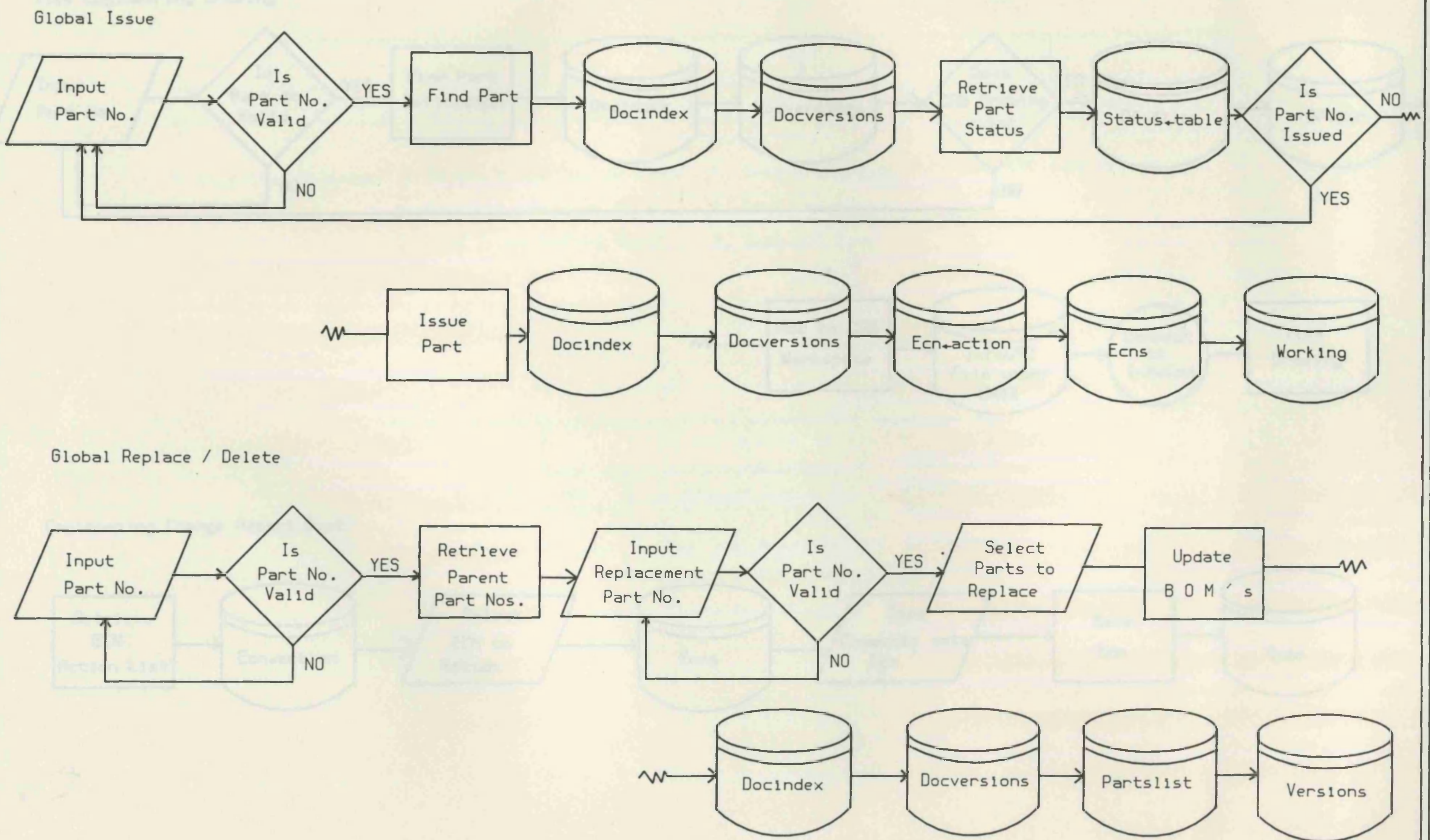
Find Bill of Materials by Part Number



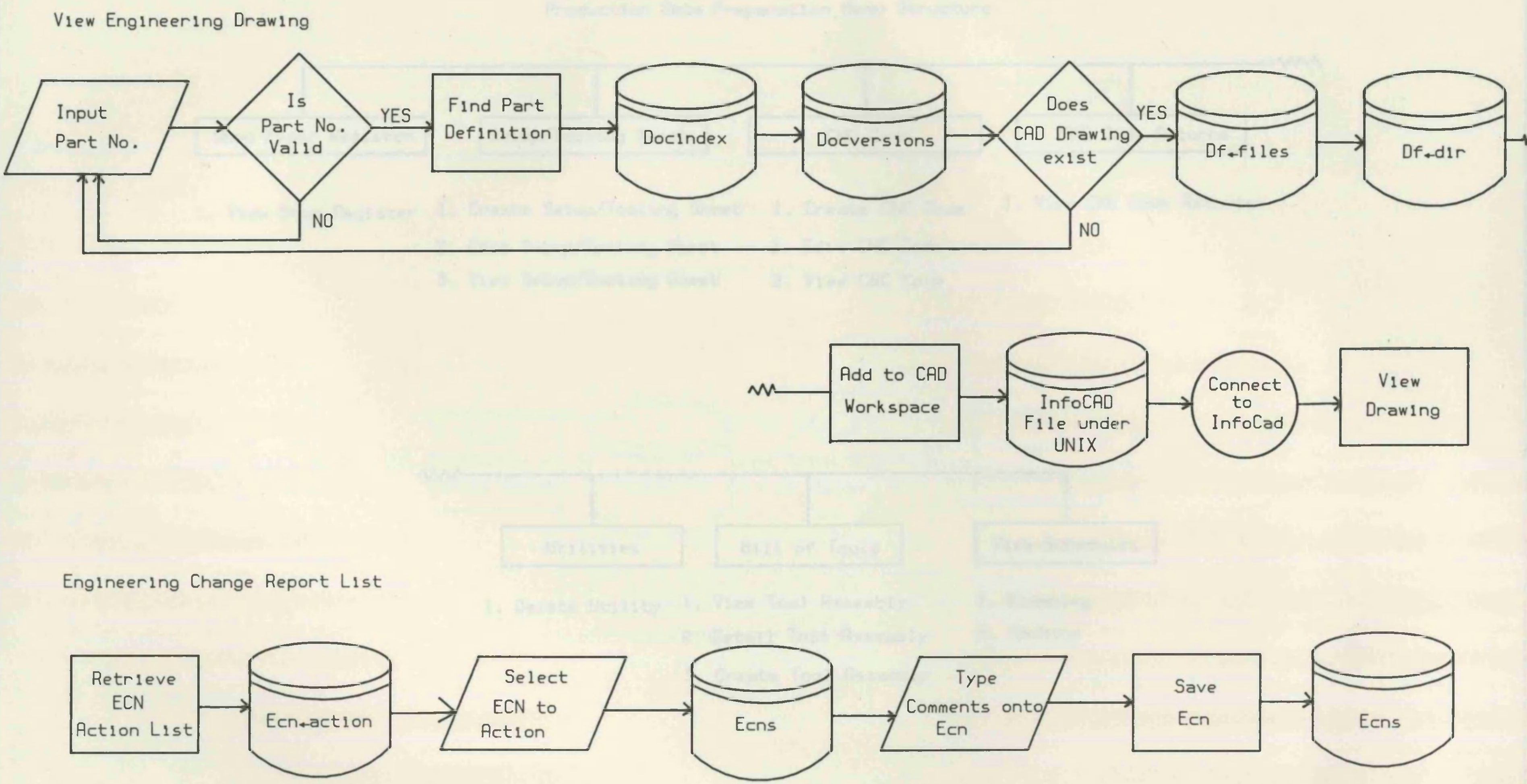
Locate Where Part Number is used

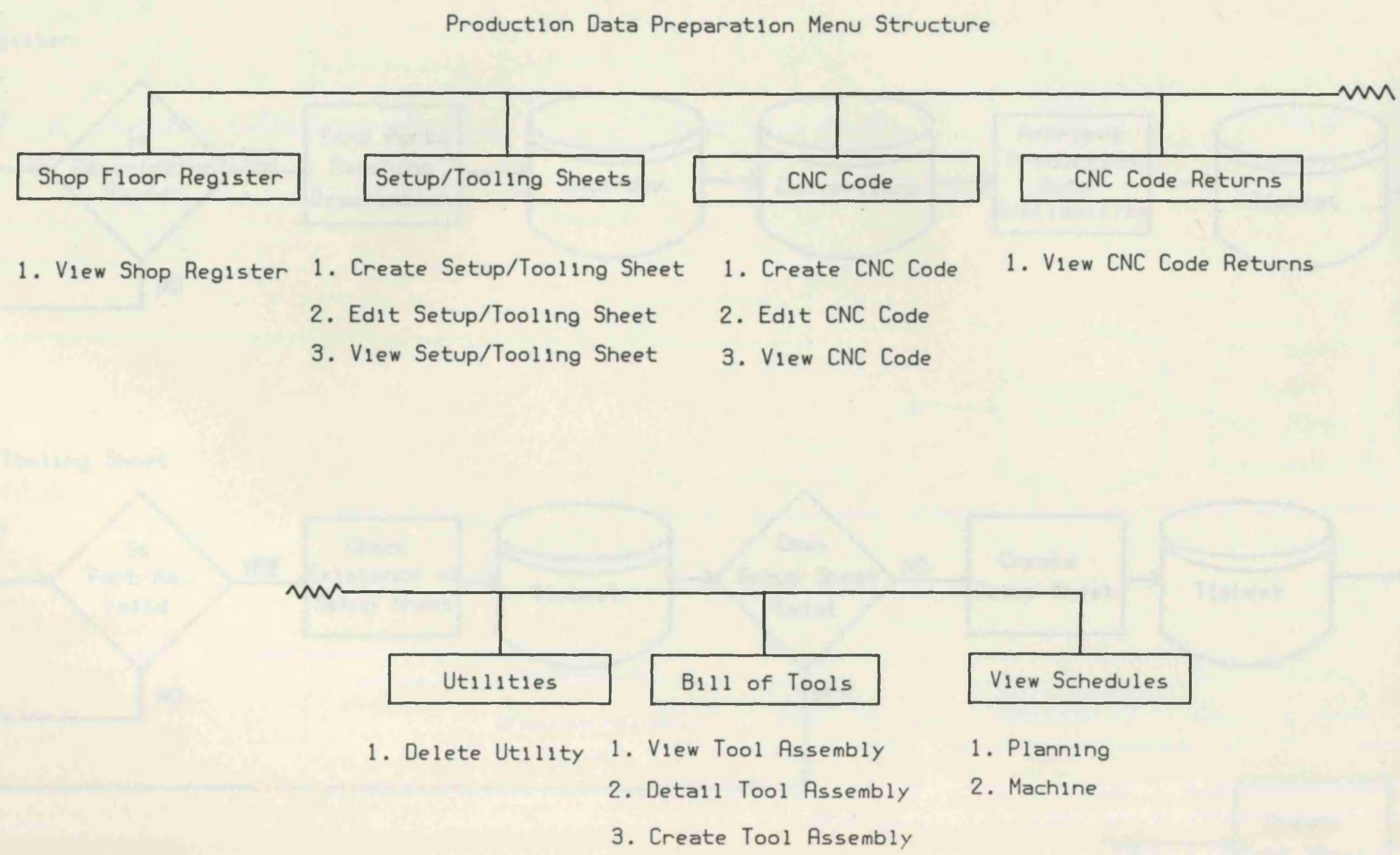


Drawing Management Data Access

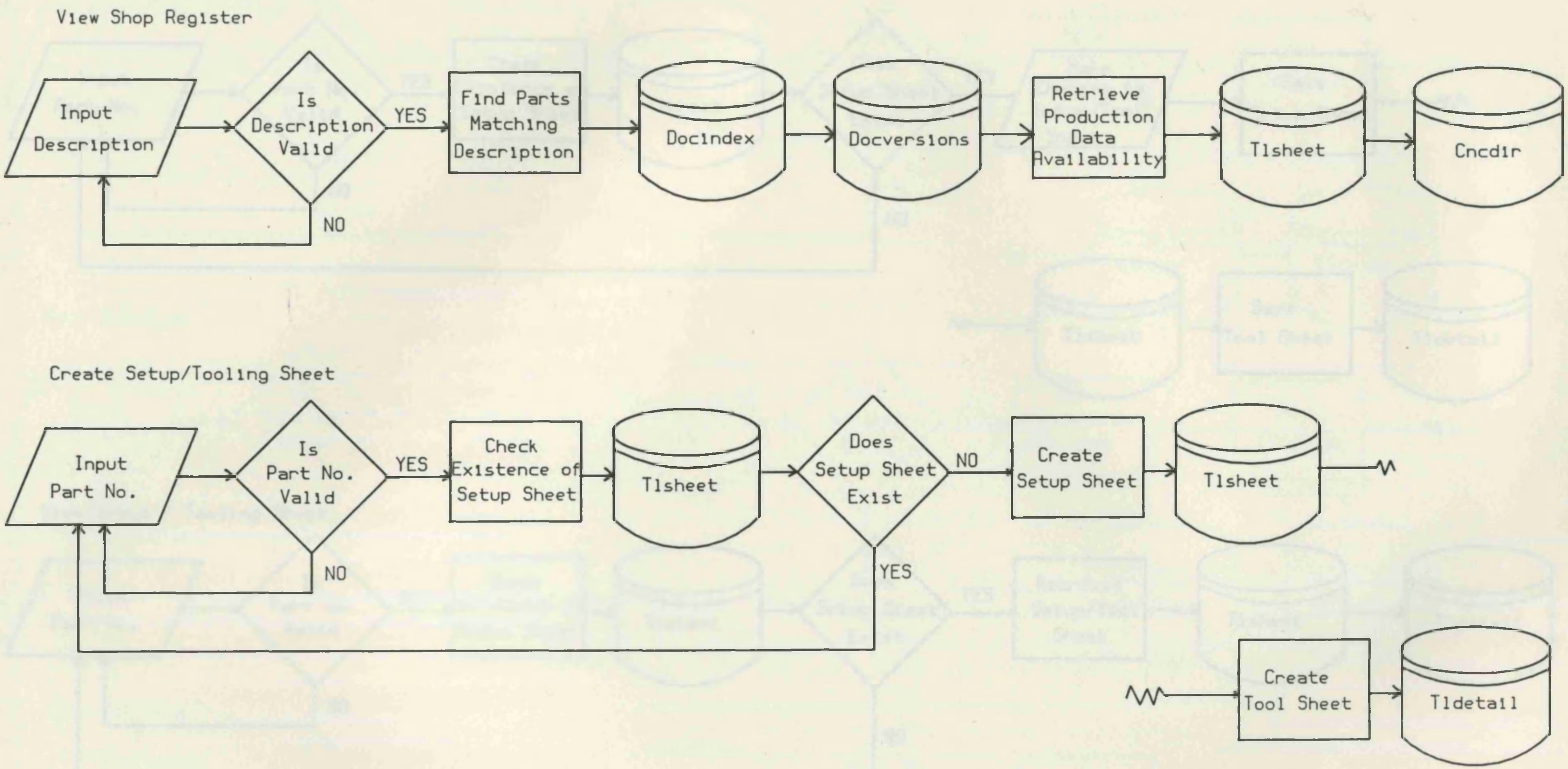


Drawing Management Data Access

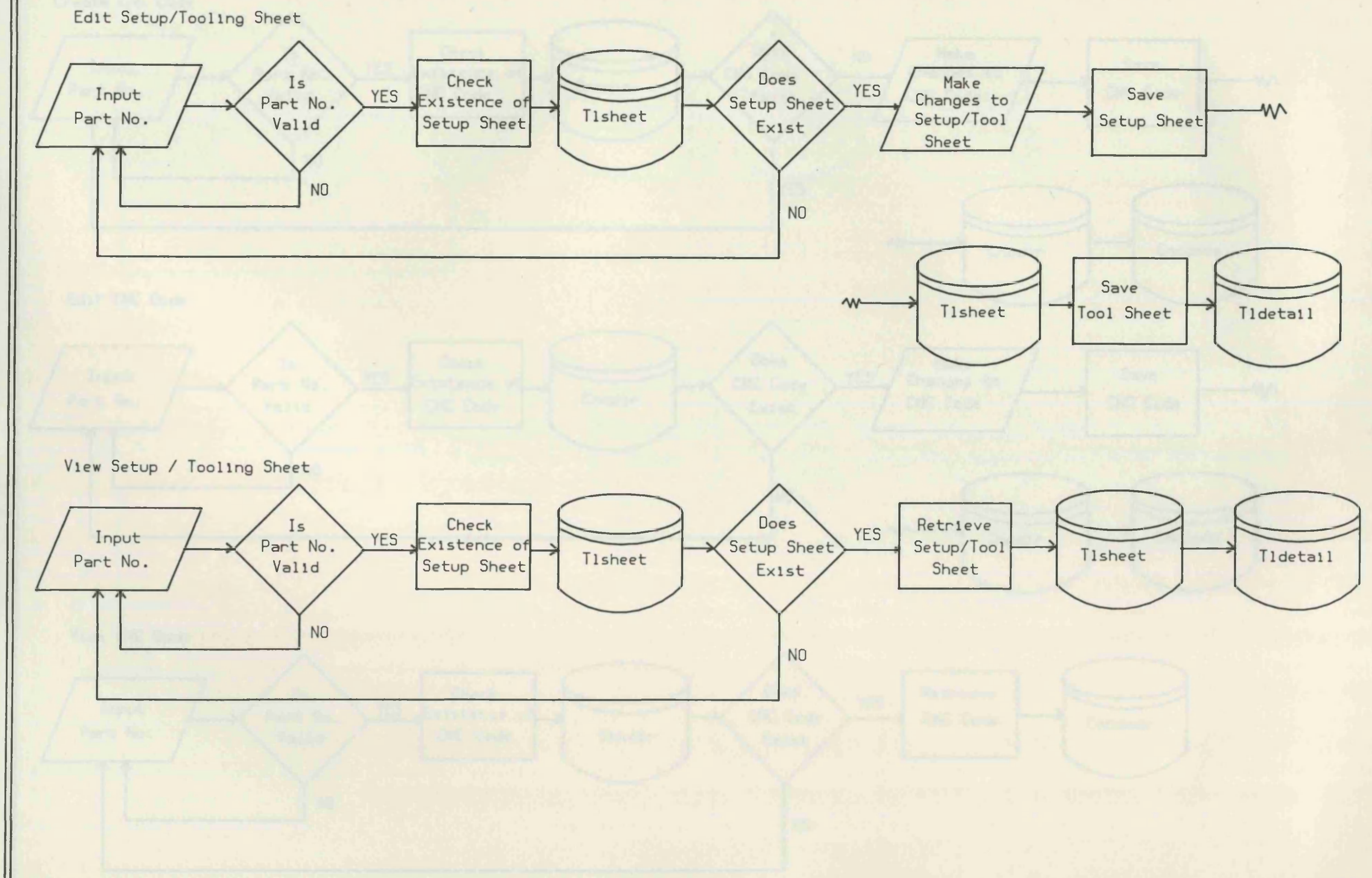



Production Data Preparation Menu Structure
Shop Floor Register
1. View Shop Register
Setup/Tooling Sheets
1. Create Setup/Tooling Sheet
2. Edit Setup/Tooling Sheet
3. View Setup/Tooling Sheet
CNC Code
1. Create CNC Code
2. Edit CNC Code
3. View CNC Code
CNC Code Returns
1. View CNC Code Returns
Utilities
1. Delete Utility
Bill of Tools
1. View Tool Assembly
2. Detail Tool Assembly
3. Create Tool Assembly
View Schedules
1. Planning
2. Machine

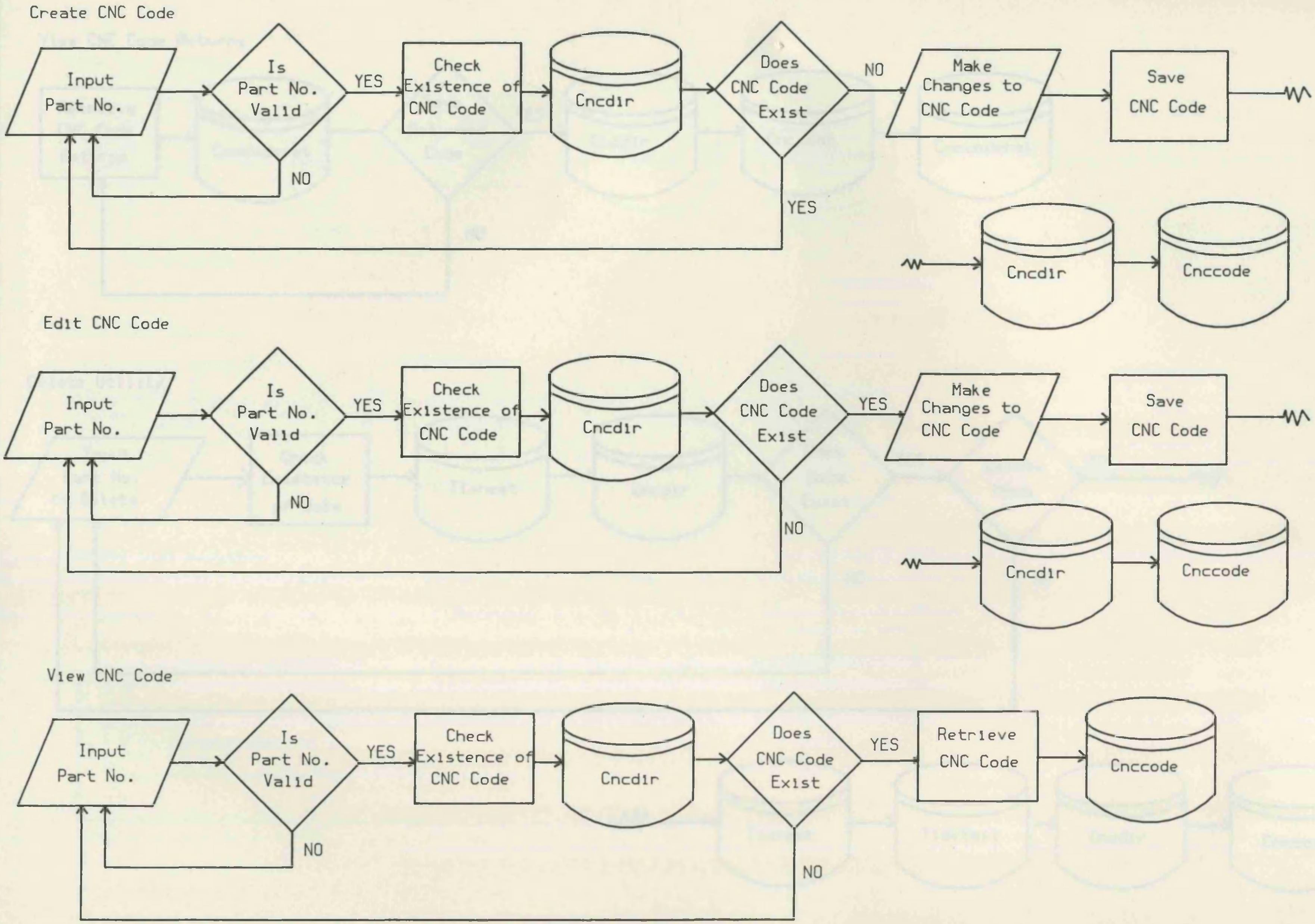
Production Data Preparation Data Access



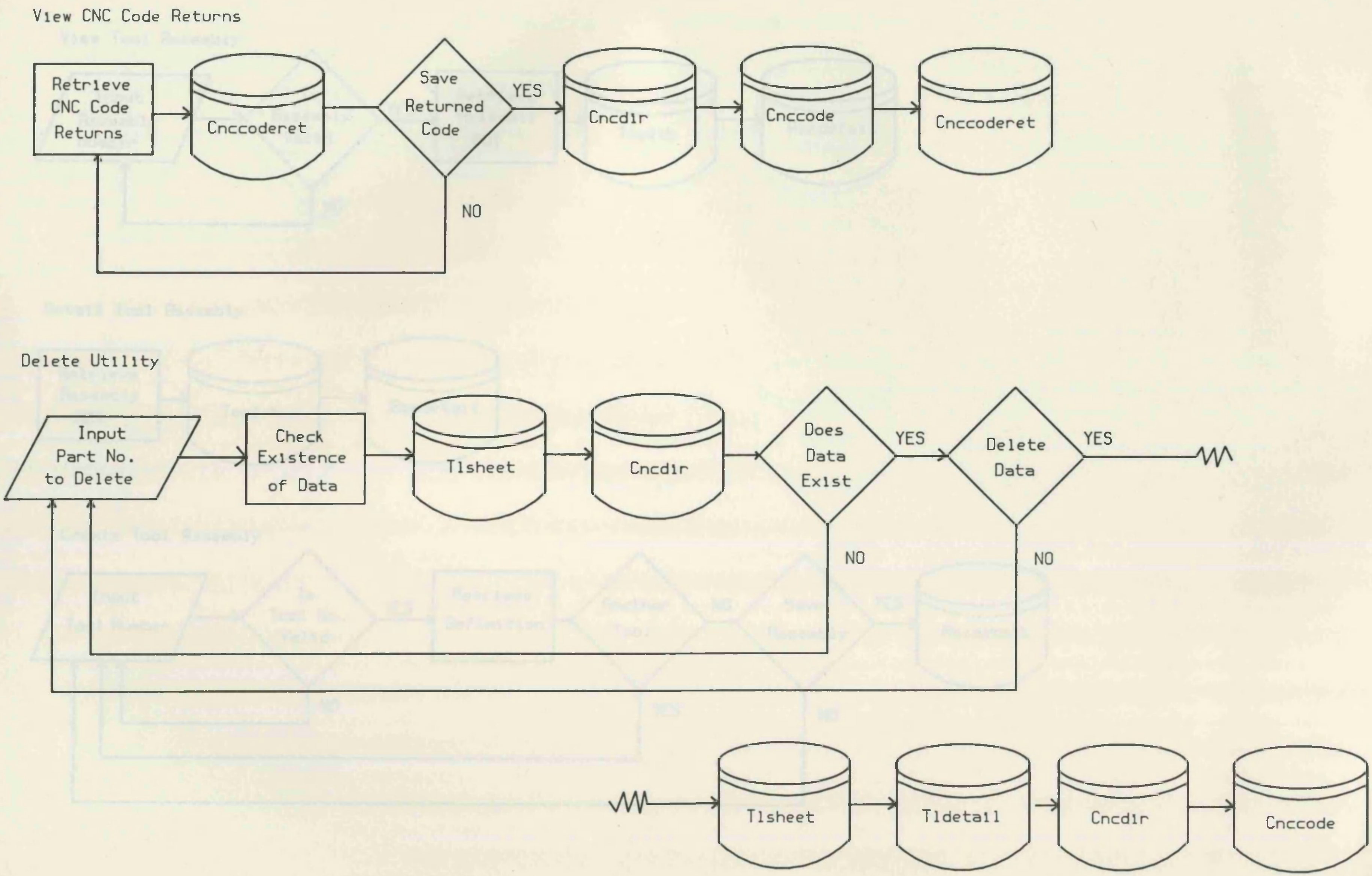
Production Data Preparation Data Access



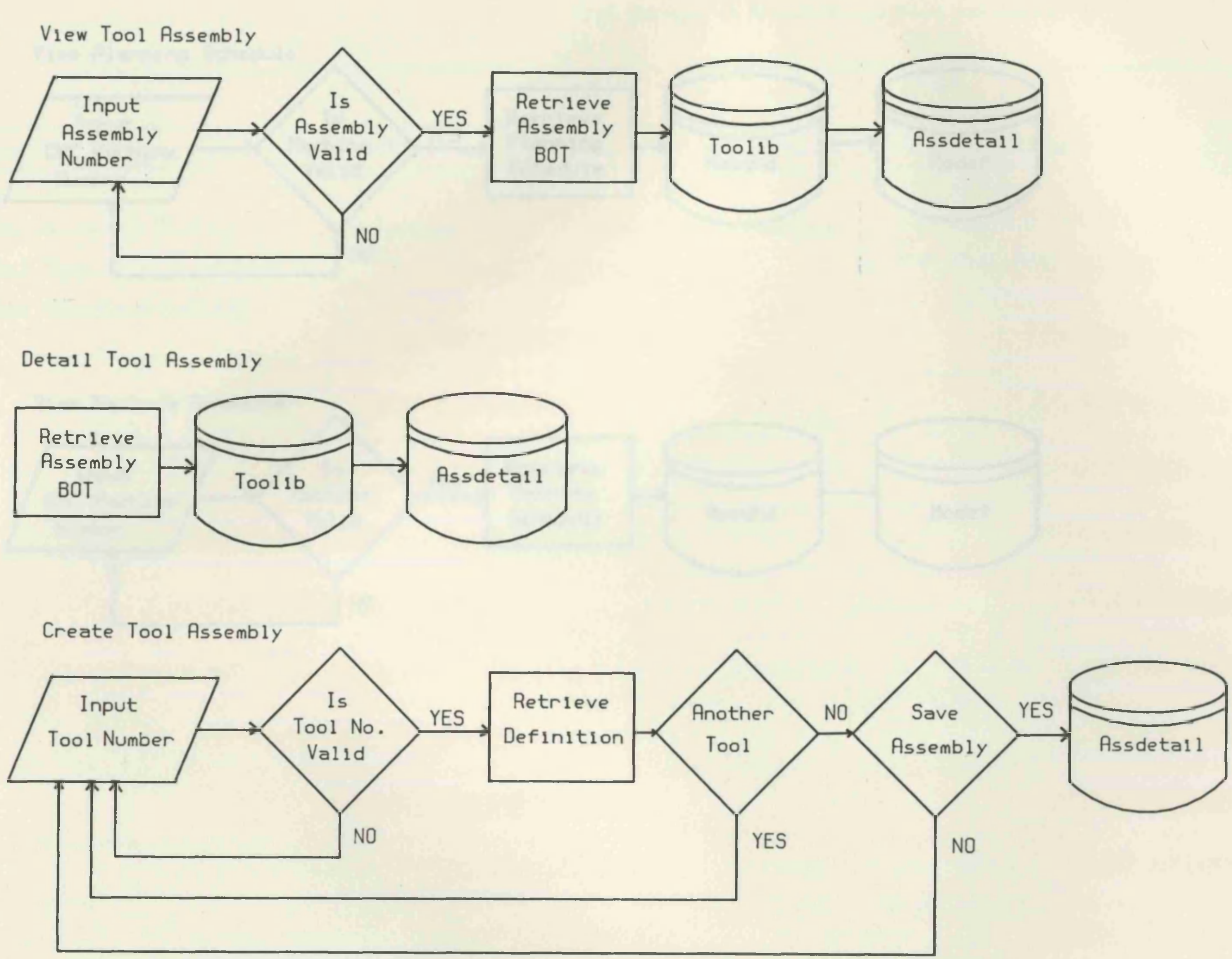
Production Data Preparation Data Access



Production Data Preparation Data Access

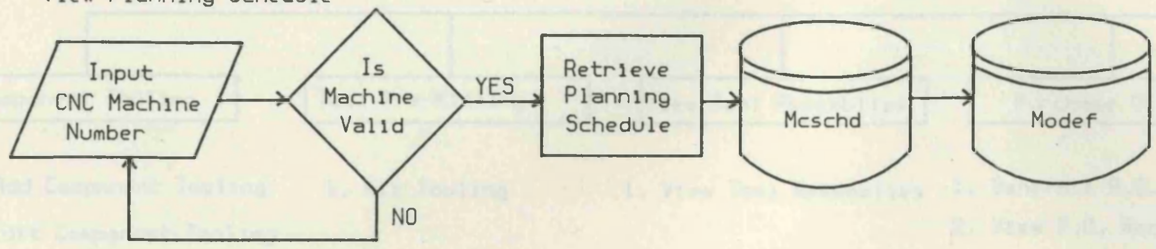


Production Data Preparation Data Access

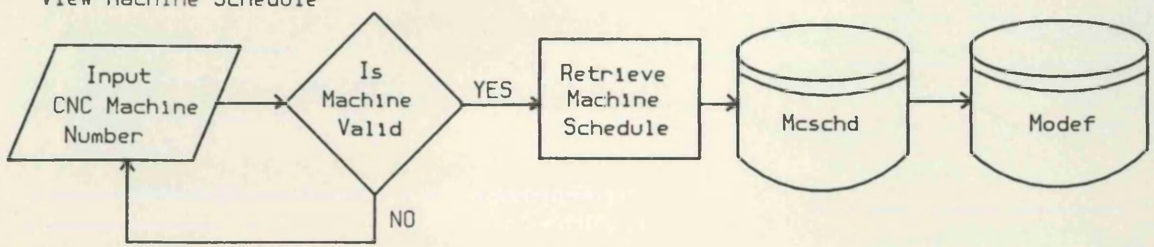


Production Data Preparation Data Access

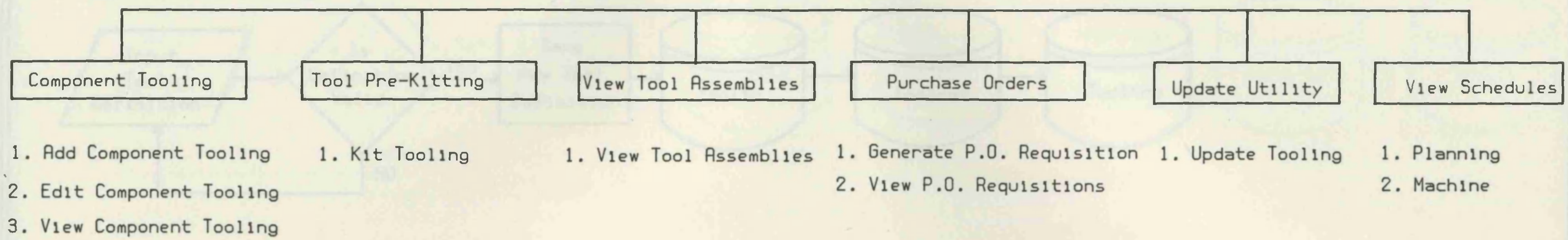
View Planning Schedule

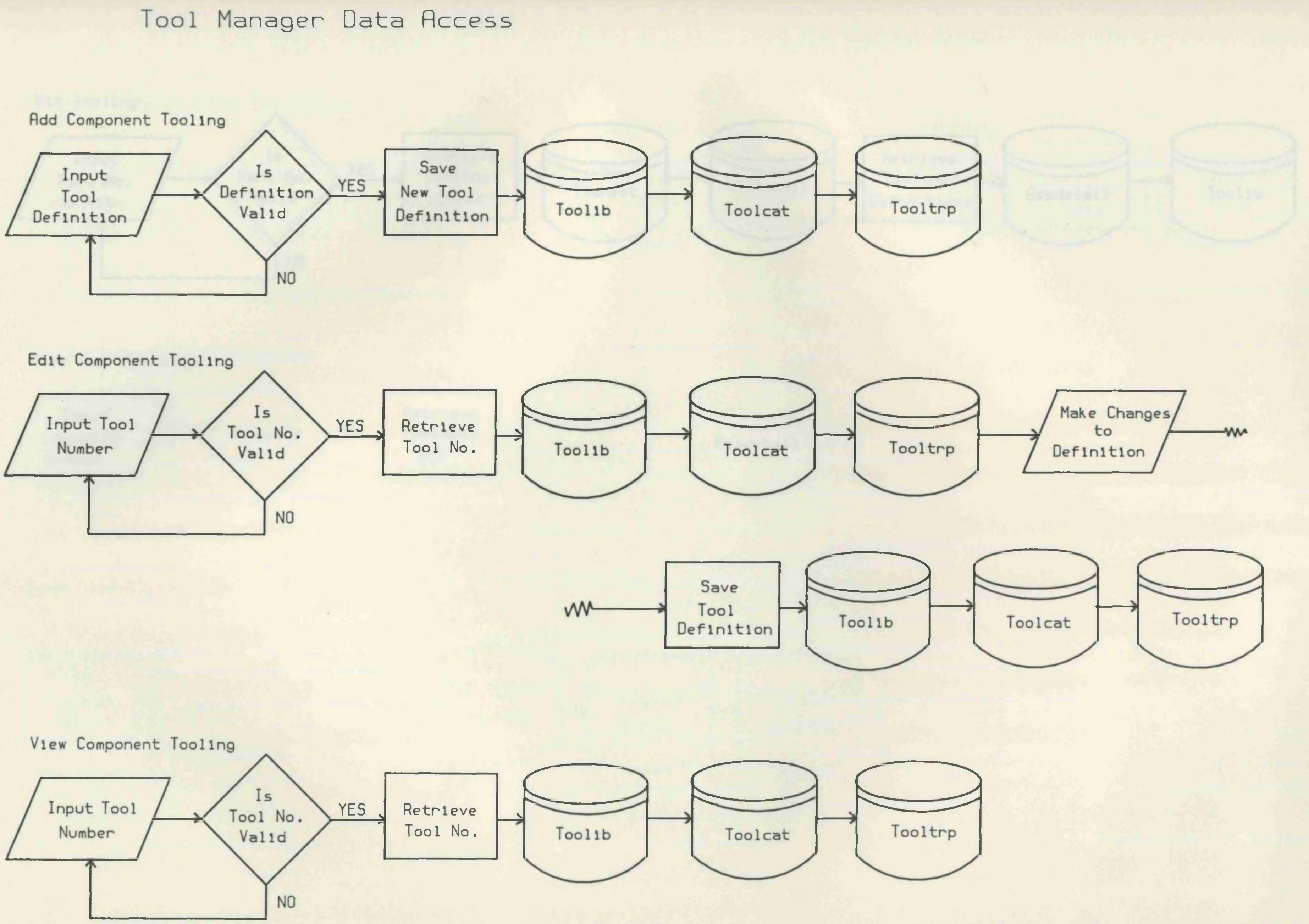


View Machine Schedule



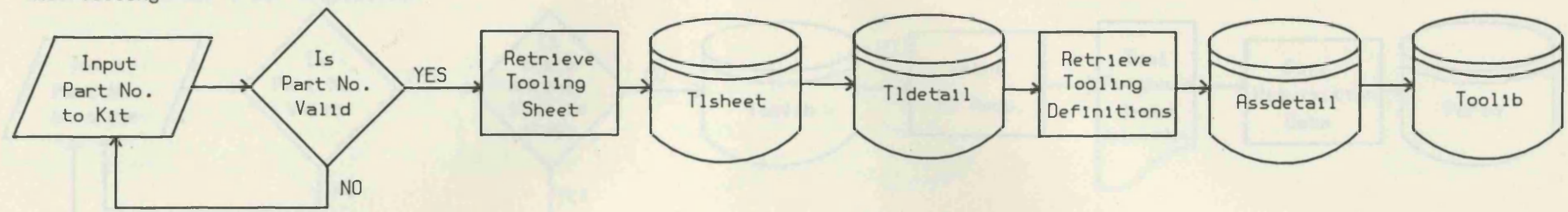
Tool Manager & Pre-Kitting Menu Structure



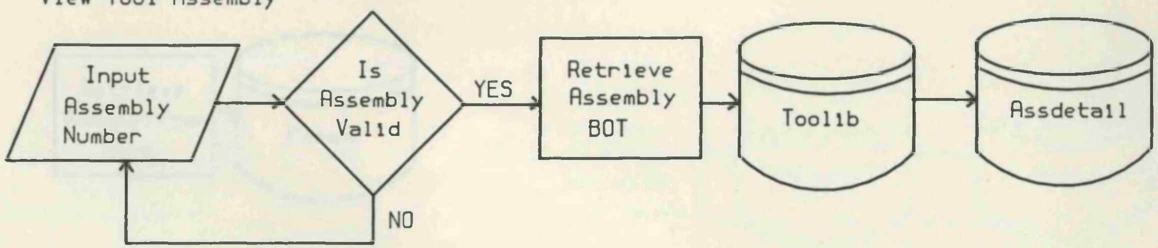

Tool Manager Data Access
Add Component Tooling
Input Tool Definition
Is Definition Valid
YES
NO
Save New Tool Definition
Toolib
Toolcat
Tooltrp
Edit Component Tooling
Input Tool Number
Is Tool No. Valid
YES
NO
Retrieve Tool No.
Toolib
Toolcat
Tooltrp
Make Changes to Definition
Save Tool Definition
Toolib
Toolcat
Tooltrp
View Component Tooling
Input Tool Number
Is Tool No. Valid
YES
NO
Retrieve Tool No.
Toolib
Toolcat
Tooltrp

Tool Manager Data Access

Kit Tooling

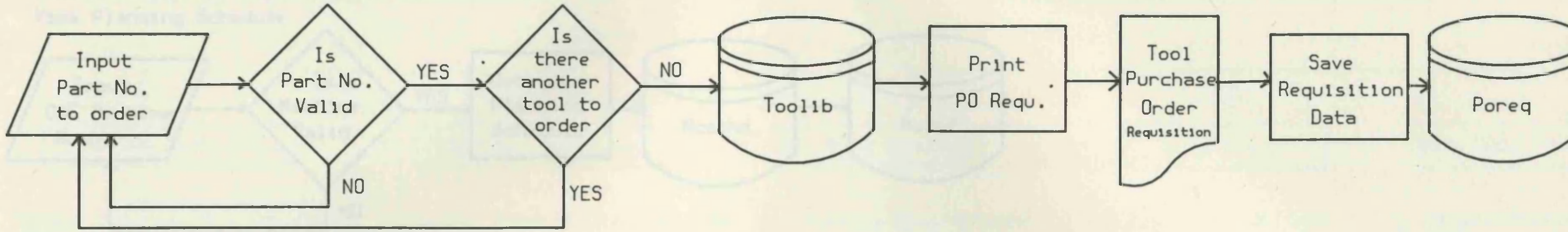


View Tool Assembly

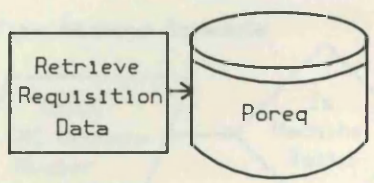


Tool Manager Data Access

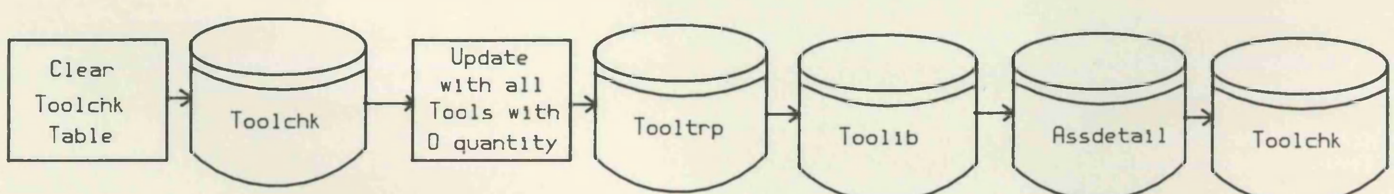
Generate Purchase Order Requisition



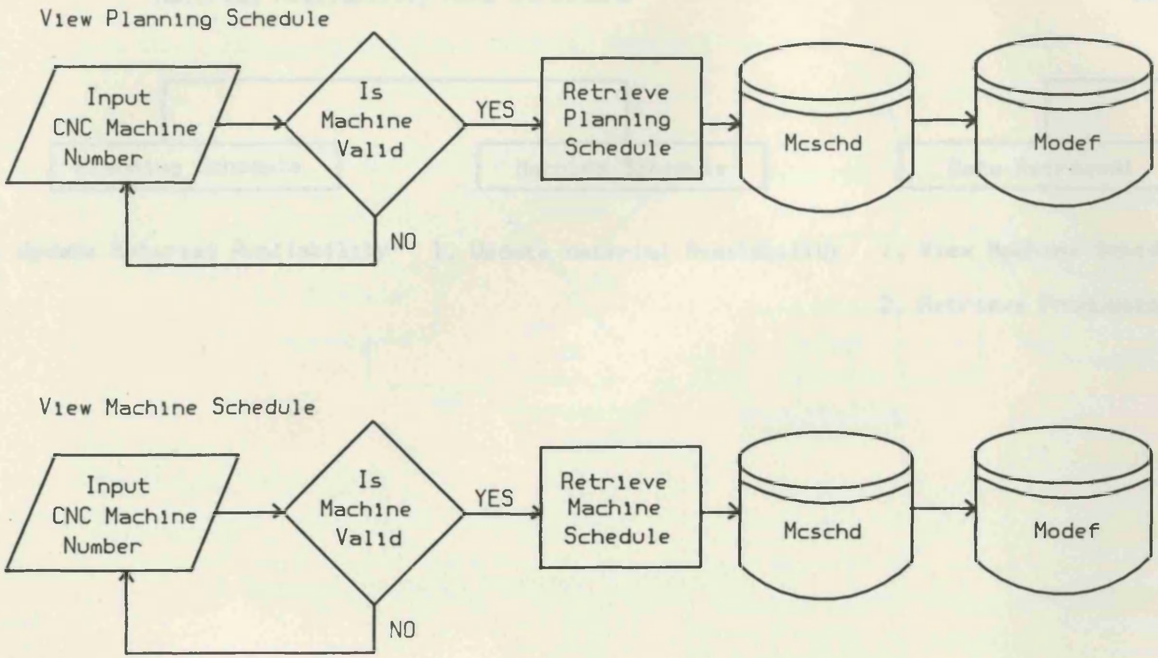
View Purchase Order Requisition

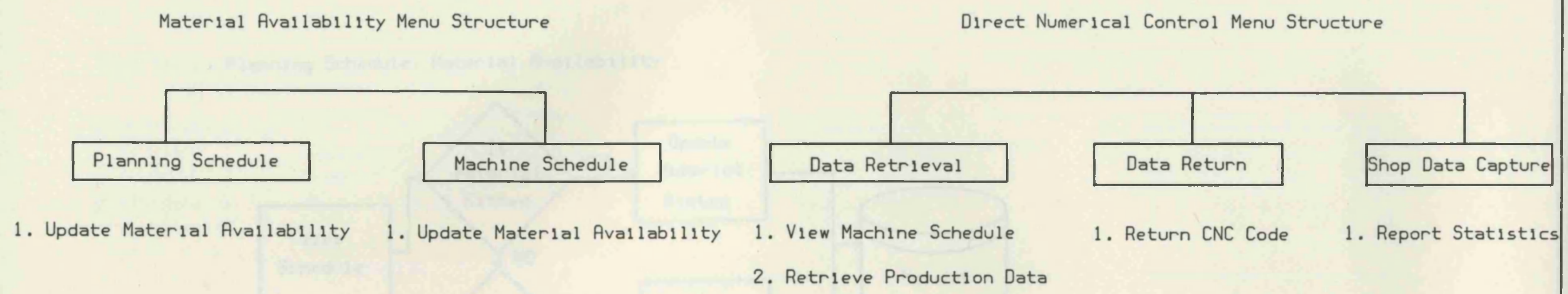


Update Tooling Utility



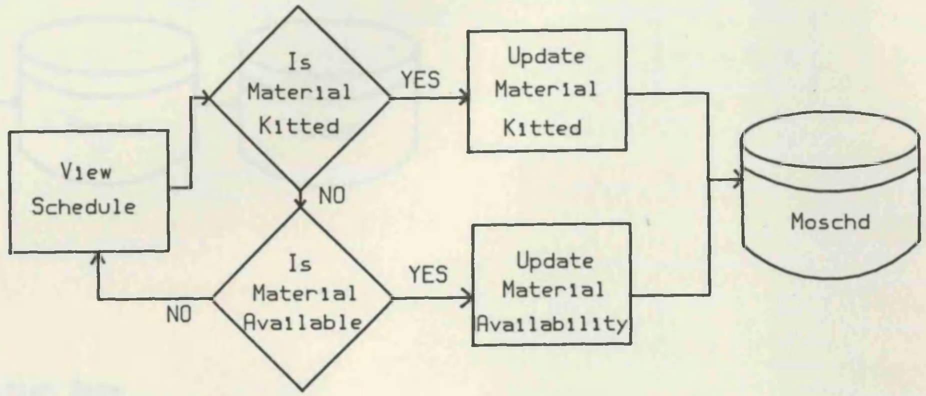
Tool Manager Data Access



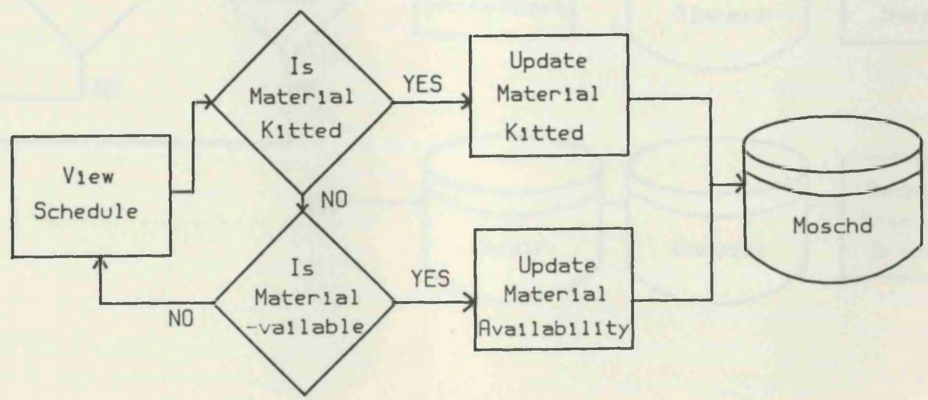

Material Availability Menu Structure
Planning Schedule
1. Update Material Availability
Machine Schedule
1. Update Material Availability
Direct Numerical Control Menu Structure
Data Retrieval
1. View Machine Schedule
2. Retrieve Production Data
Data Return
1. Return CNC Code
Shop Data Capture
1. Report Statistics

Material Availability Data Access

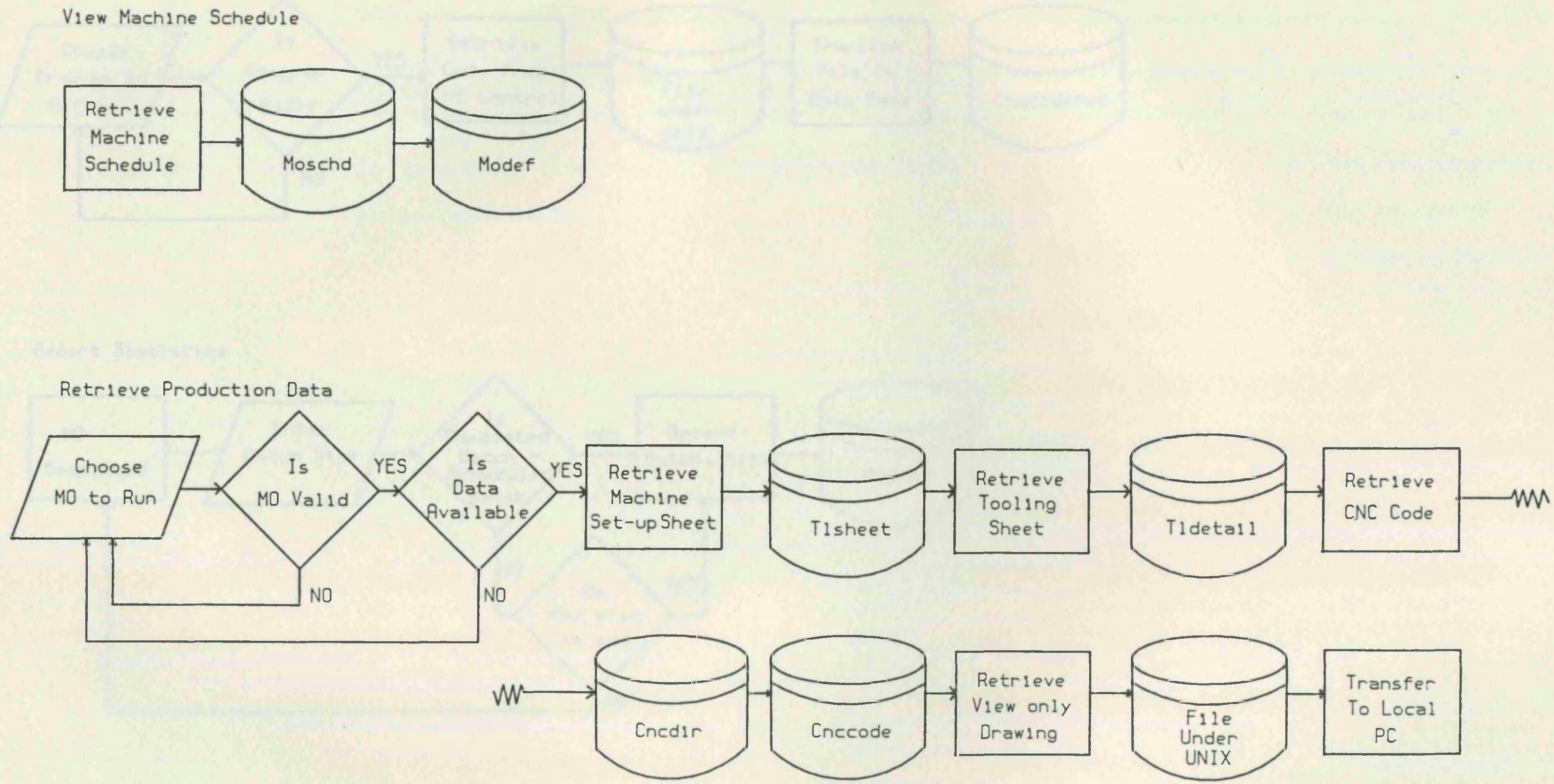
Planning Schedule, Material Availability



Machine Schedule, Material Availability

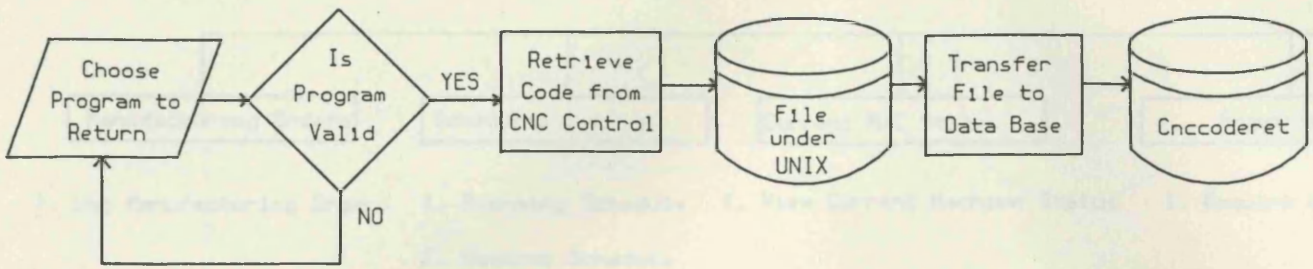


Direct Numerical Control Data Access

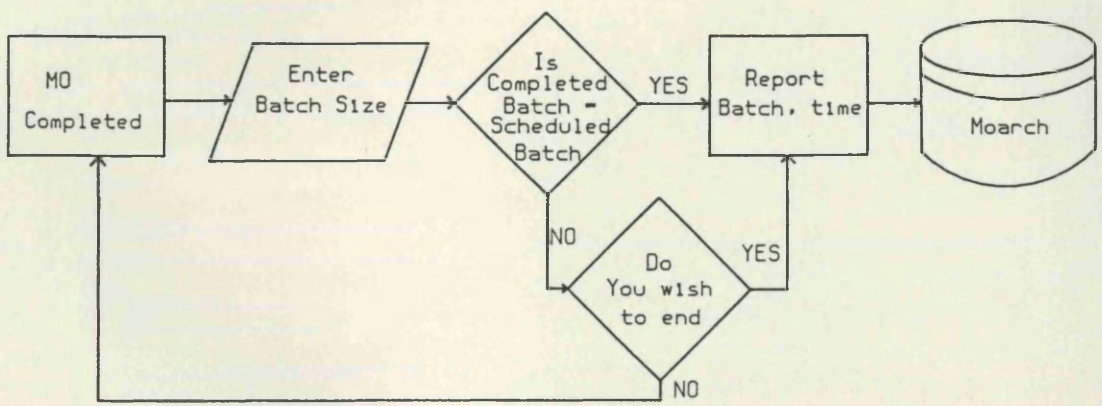


Direct Numerical Control Data Access

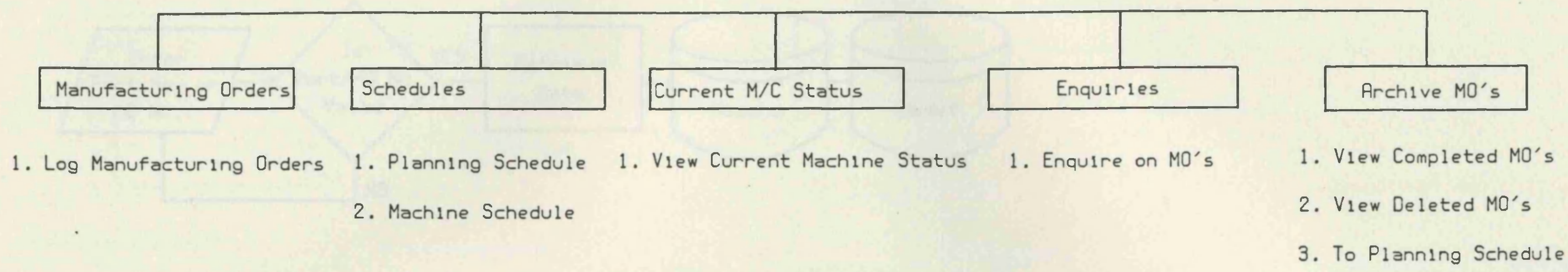
Return CNC Code



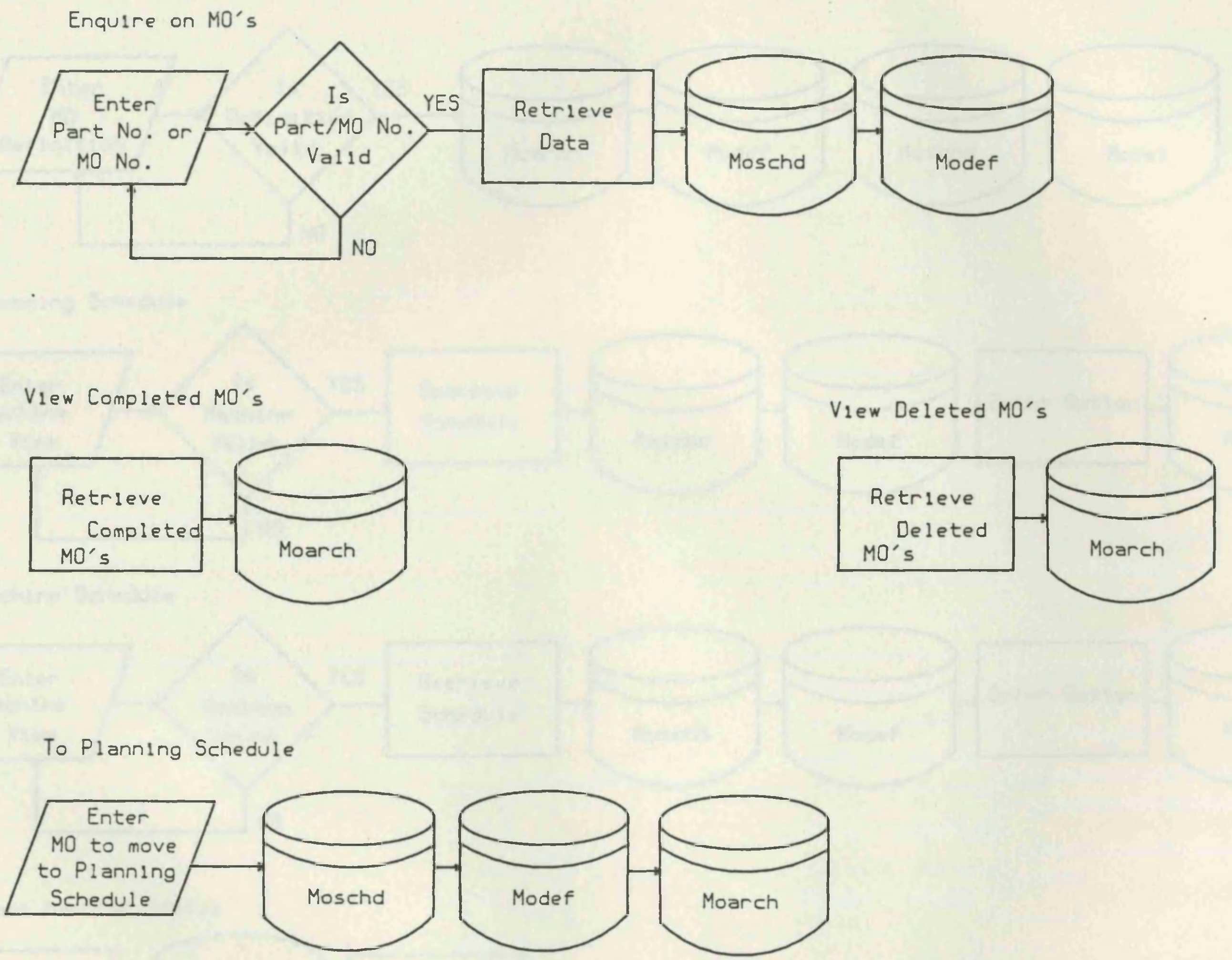
Report Statistics



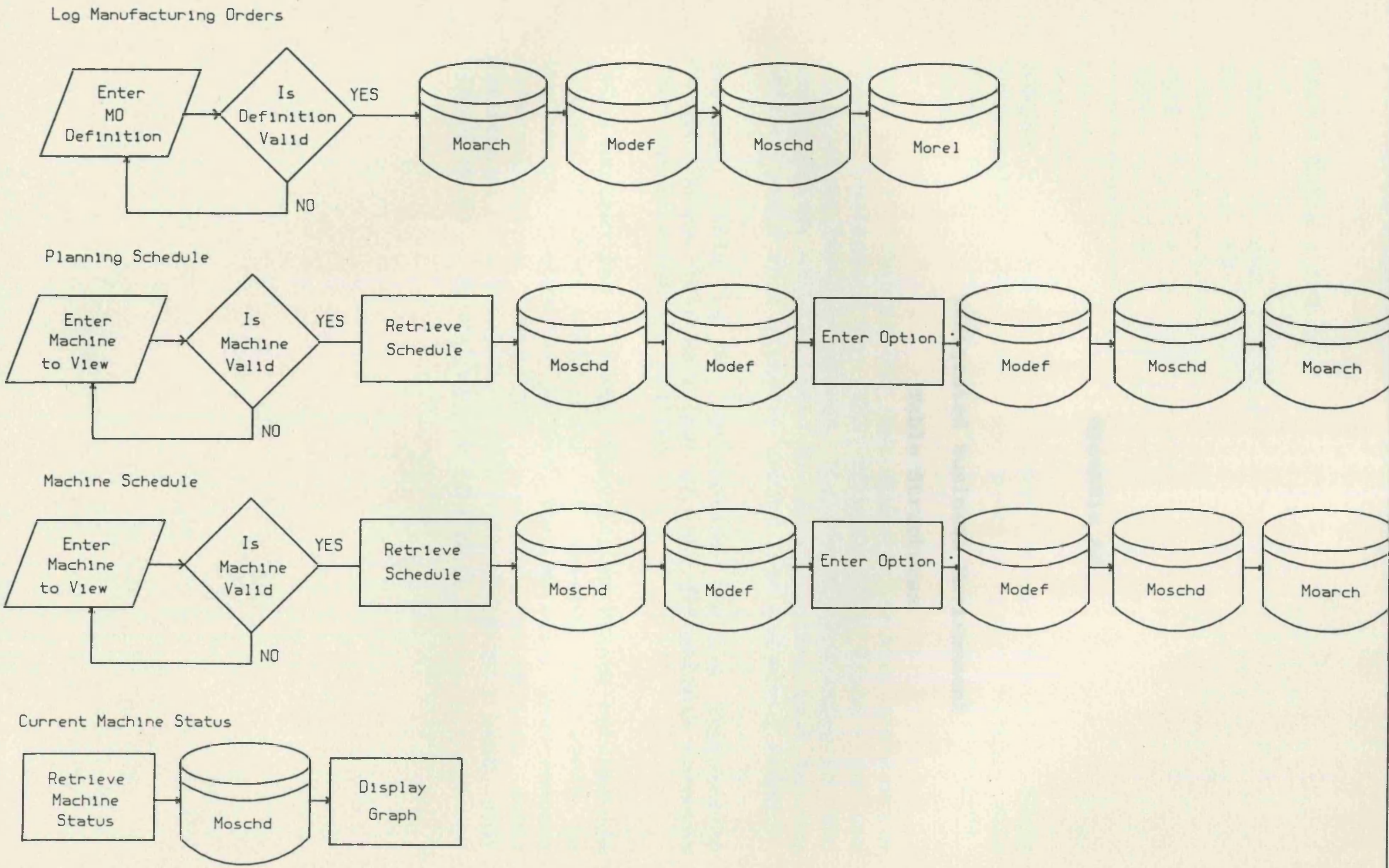
Scheduling System Menu Structure



Scheduling System Data Access



Scheduling System Data Access



Appendix A3

Integrated Business Environment

Table Structures

A3.1 Engineering Change

A3.1.1 Table : ECN

ecn_no	row	changes
i4	i2	c75
1670	1	ADD TO BOM
1670	2	R060019001

ecn_no - Engineering Change Notice number. Every Engineering Change notice is given a unique number. This field relates to the 'ecn_no' field in the 'Docversions' table.

row - This is the row number for the Engineering Change notice. As the draughtsman types in the explanation for the change, the row numbers refer to the line numbers of the text. To retrieve the text in the correct order this field is sorted into ascending order.

changes - This is the explanation for the Engineering Change Notice. This is a list of the draughtsman comments from the relevant application.

Table explanation : Formal Engineering Change notices are stored in this table. ECN is printed and given to Production Control to update the Material Requirements Planning System. This data is stored for quality audit reasons in this table, in addition there is a hard copy placed on file in the Drawing Office.

A3.1.2 Table : ECN_ACTION

```
ecn_no
i4
--------
1670
1675
1677
--------
```

ecn_no - Engineering Change Notice number. Every Engineering Change notice is given a unique number.

Table Explanation : This table stores all Engineering Changes that have been automatically created by the issuing of a part. Interrogating this table informs the Drawing Office staff that an Engineering Change has been generated. One of the staff then inputs the reason for the issue of the part. The reasons ('changes') are then stored in the 'ecn' table as noted above.

A3.2 Costing

A3.2.1 Table : COSTBOM

docidx	purch	setup	batch	run
i4	f4	i4	i4	i4
19500	0.00	60	12	5
19501	20.50	0	0	0

docidx - Document index number, this is a relational field with docidx in 'Docversions' table.

purch - Part purchase price if the part is proprietary.

setup - Machine setup and machine stripping time in minutes. Costs are calculated from a blanket cost of approximately 20 pounds an hour.

batch - This is the batch size of the customers order or if the part is a standard part the batch size is the normal production quantity manufactured at any one time.

run - This is the part run time in minutes. The run time can be used to calculate the cost of the part.

Table Explanation : This table is used for the Bill of Materials Costing application. A Bill of Materials is initially retrieved from the 'Partslist' and 'Docversions' Tables.

The key field 'docidx' in these tables is used in the 'Costbom' table to store part purchase prices, for proprietary parts and Production information.

A3.3 Part Number Register

A3.3.1 Table DOCINDEX

docidx i4	docid c4	cr_date date	alloc i1	last_iss i2	state i1
19500	A045	10-Jun-1990	1	2	1
19501	S999	11-Jun-1990	0	1	3

docidx - The document index number is the 6 figure number retrieved from the standard Fortune part number.

This is a relational field which is used extensively in many tables throughout the Engineering Data Base. eg 'Modef' and 'Tlsheet' tables call this field 'partno'.

N.B. 'Docidx' and 'partno' are exactly the same.

docid - Document identity code. This field again is retrieved from the Fortune part number and defines the Fortune product and the capacity of the product.

cr_date- Part creation date. Used for audit purposes only to establish when the part was created in the Engineering Data Base.

alloc - Allocated field. If a drawing is in use at one of the Computer Aided Design draughting stations this flag is set from 0 to 1. When the drawing has been finished, the flag is set back to 0. While a part is at status 1 no other draughting station can gain access.

last_iss - The latest issue of the part. This field is updated automatically when a new part or document is issued.

N.B. The latest issue can be found by interrogating 'Docversions' for the maximum 'doc_issue' for any part or drawing. The purpose of this field is thus to eliminate this time consuming search.

state - The part status. The part status is an integer flag which is used in the look-up table, 'Status_table'.

This table is created as a look-up table and can be extended if the Drawing Office system every requires more intermediate part status's to be established.

A3.3.2 Table : DOCVERSIONS

docvers i4	docidx i4	issue i2	iss date	title c30	plvers i4	unit c1	ecn_no i4	draw i1
15843	19500	1	14/6/90	ACTUATOR	1049	E	1670	0
15844	19500	2	16/6/90	ACTUATOR	1050	E	1677	1
15845	19500	0	18/6/90	ACTUATOR	1050	E	0	1
15846	19501	1	12/6/90	125DIA M	0	M	0	0

docvers - This field is an internal index which increments by one every time a new version of a part is issued or made a working version.

docidx - The document index number is the 6 figure number retrieved from the standard Fortune part number. This is a relational field which is used extensively in many tables throughout the Engineering Data Base. eg 'Modef' and 'Tlsheet' tables call the docidx field 'partno'.

doc_issue- This is the document or Part issue number. When parts are created they are status 0, (refer to 'status_table'), when a part is issued the part definition is changed to 1. When a part is made issue 0 again and then re-issued the old issue definitions remains for audit purposes and a new definition is added in this table to reflect the new issue.

iss_date - Document or Part issue date, this is used for audit purposes.

title - The is the document or part description. These descriptions are entirely at the discretion of the draughtsman and have no exacting standards. These descriptions are for general searches only to aid document or part number retrieval.

plvers - Parts list version number. This number defines all the Parts that are one level below the 'docidx'. This field directly relates to 'pl_vers' in the 'Partslist' table, for the retrieval of Bills of Materials.

unit - This is the unit of measure for the part.

For example if a part is purchased or manufactured as unique parts then the unit is 'E', if a part is purchased or manufactured in lengths then the unit is 'M'.

ecn_no - Engineering change notice number. This number refers directly to the 'ecns' table to define the changes made to a part to initiate the re-issuing of a document or part.

drawing - This status flag is status 1 or 0, Status 1 means that a Computer Aided Design drawing is available and status 0 means that a Computer Aided Design drawing is not available.

N.B. The Document or Drawing Management applications are driven solely by part number definitions. A Document therefore cannot exist without the creation of the relevant part number. In addition only one document can exist for every 'docvers' which is a unique 'docidx' and 'doc_issue'.

A3.3.3 Table : ADDAPARTS

partno c10	issue c3	title c30	unit c1
A045019500	001	ACTUATOR ASSEMBLY	E
S999019501	001	125DIA M.S.BAR	M

partno - This field is the Part number as defined by the Fortune standard part number. This field has been formatted from 'docidx' and 'docid' fields in the 'Docindex' table to reflect the correct format for the Data General Material Requirements Planning system.

When new parts are created and added to the Engineering Data Base the definition is placed in this table.

issue - This is the part issue for the created part. Again the issue is in a character format suitable for the Data General Material Requirements Planning System.

title - The is the document or part description. These descriptions are entirely at the discretion of the Draughtsman and have no exacting standards. These descriptions are for rough searches only to aid Document or Part number retrieval.

unit - This is the unit of measure that the part is defined in. For example if a part is purchased or manufactured as unique parts then the unit is 'E', if a part is purchased or manufactured in lengths then the unit is 'M'.

A3.3.4 Table : CHANGEPARTS

partno c10	issue c3	title c30	unit c1
A045019500	001	ACTUATOR ASSEMBLY	E
S999019501	001	125DIA M.S.BAR	M

partno - This field is the part number as defined by the Fortune standard part number. This field has been formatted from 'docidx' and 'docid' fields in the 'Docindex' table to reflect the correct format for the Data General Material Requirements Planning system.

issue - This is the part issue for the part.

title - The is the document or part description.

unit - This is the unit of measure that the part is defined in. For example if a part is purchased or manufactured as unique parts then the unit is 'E', if a part is purchased or manufactured in lengths then the unit is 'M'.

A3.3.5 Table : STATUS_TABLE

num	status
i1	c7
1	Working
2	Checked
3	Issued

num - Number or Status. This field is for look-up purposes and is directly accessed from 'state' field in 'Docindex' table.

status - Status of a document or part. See 'state' in 'Docindex' table.

A3.3.6 Table : VERSIONS

version	issue
i2	c3
0	000
1	001
2	002
3	003
4	004

version - Version number of document or part. This table is a look-up table to format an issue number to a format acceptable or similar to the Data General Material Requirements Planning System.

issue - Look-up field with Data General Material Requirements Planning System field format.

A3.3.7 Table : WORKING

```
docidx
i4
------
19499
19500
------
```

docidx - The Document index number is the 6 figure number retrieved from the standard Fortune part number.

N.B. The working versions can be found by interrogating 'Docversions' for all 'docidx' with 'doc_issue' = 0. The purpose of this field is thus to eliminate this time consuming search.

A3.3.8 Table : SURKEYS

```
colid   last_value
c12     i4
-----------------
plvers  1060
docvers 15846
docidx  19501
ecn_no  1677
----------------
```

colid - Column identification. This field identifies the column or field name in other Engineering Data Base tables. 'plvers' and 'docvers' see table 'Docversions'. 'docidx' see table 'Docindex' and 'ecn_no', see table 'Ecns'

last_value - This is a look-up column to eliminate Data Base applications interrogating on the main base tables.

A3.4 Bill of Materials

A3.4.1 Table : PARTSLIST

plvers i4	docidx i4	quantity f4	variable c1
1049	10472	4.205	Y
1049	9701	1.000	
1050	10472	4.205	Y

plvers - Parts list version number. All related Bill of Materials have the same 'plvers' number. This field directly relates to 'plvers' in the 'Docversions' table, for the retrieval of Bills of Materials.

docidx - The Document index number is the 6 figure number retrieved from the standard Fortune part number.

quantity - This is the quantity of parts or 'docidx' on the unique Bill of Materials. If the quantity is a whole number then this usually refers to a part that is has a unit of measure 'E' or each in 'unit' 'Docversions' table. If the quantity is a decimal number then this usually means that the part has a unit of measure 'M', metres, litres or similar decimal measure.

variable - This is variable flag, adopted from the Data General Materials Requirements Planning system, this denotes that a part or parts vary in length depending on the finished sizes of the Product. The addition of this variable eliminates the need to have different Bill of Materials for products with an infinite number of strokes or options.

eg A Precision screw jack has different strokes, the main body of the jack will be the same while the screw and bottom pipes will vary with the stroke.

A3.5 Engineering Design

A3.5.1 Parametric Design Data

Parametric design programs are available to design, Spiracon Nuts, Screws and Rolaram actuators. These programs create part numbers and Bill of Materials in the Engineering Data Base, as discussed in other sections, but in addition the programs also make extensive use of American Standard Code for Information Interchange (ASCII) files.

When a product is designed all design data is stored in a file. When the product is drawn then the design file is read and plotted on the screen.

In addition the creation of Thread Grinder data files involves the interrogation of the Spiracon .nut file.

The main design files include;

12345.nut - Spiracon nut design file (see Users Manual for complete explanation)
12346.scr - Spiracon screw design file (see Users Manual for complete explanation)
12380.act - Rolaram Actuator design file (see Users Manual for complete explanation)

These files can be found in the Infocad home directory
'//node_21ba8/work/do '

A3.5.2 Table : CLASSES

docidx	class
i4	c24
19500	SHELL CAP
19501	BELL HOUSING CASTING

docidx - The Document index number is the 6 figure number extracted from the standard Fortune part number.

class - Fortunes parts are split into a variety of separate classes. eg Shell Caps, Top Plates, Worm Wheels, Screws, Nuts etc. A dedicated Design program can retrieve the 'class' and with design expertise coded into the program can read the 'Templates' and 'Specials' table and draw the part.

A3.5.3 Table : TEMPLATES

class c24	num i1	name c20
SHELL CAP	1	OUTER DIAMETER
SHELL CAP	2	LENGTH

class - Every class, as described in 'Classes', has a unique set of features to describe it. This table has a row for every feature of the particular class.

num - Every feature for a unique class has a number. The Design program reads the numbers in order to identify which features have been included for each class.

name - This field is the name of the feature. The design program does not require this field for drawing the component but it is used extensively when users are inputting data or retrieving data.

eg The Draughtsman is more acquainted with the 'Outer Diameter' of a Shell Cap than 'dimension 1' of the Shell Cap.

A3.6 Computer Aided Design Drawings

A3.6.1 Table : DF_FILES

docvers	df_dirind	file_name
i4	i4	c8
15844	1	19500002
15845	1	19500000

docvers - This field is purely an internal number which increments by one every time a new version of a part is issued or made a working version.

df_dirind - Drawing Files Directory Indicator. This number directly accesses the look-up table 'df_dir' to identify which directory the drawing has been placed in.

The drawing files are stored in the same format that Infocad generates but access, for the common user, can only be gained by using the Drawing Management Application.

N.B. It should be noted that under extreme circumstances and for backup purposes the drawings can still be accessed using the normal operating system search path functions. The list of the directories used can be found in the 'Df_dir' table.

file_name - Drawing Filename. The Drawing Management Application reads the filename and the directory name 'phydir' in the 'df_dir' table to access the Infocad file directly.

A3.6.2 Table : DF_DIR

df_dirind	phydir
i4	c40
1	/work/draw1/
2	/work/draw2/
3	/work/draw3/

df_dirind - Drawing Files Directory Indicator. (see 'Df_files' table)

phydir - Physical directory. This is the directory on the Workstation node that all the drawings are stored in.

Under the Aegis Operating System version 9.7 only 1300 files can be stored in any one directory. When a directory is full then another row is added to the table using Interactive Structural Query Language. The new row will have a 'df_dirind' equal to the maximum plus one and the 'phydir' can be any directory of the users choice.

A3.7 View Only Drawings

A3.7.1 Overview

View only drawings are managed in a similar fashion to conventional Computer Aided Design drawings. The drawings are stored as unique files under control of the operating system.

A3.7.2 Management

Every Computer Aided Design (CAD) drawing has a View only Drawing also. When a CAD drawing is changed in any way the old View only Drawing is deleted and a new one is created. It should be noted that the View only Drawing can only be created by the Infocad application, as supplied by Ferranti.

Whereas the Cad drawings are saved in chronological order in arbitrary directories the View only Drawings are stored in unique directories which reflect the Part number of the Drawing.

All parts with a part number less than 18000 are stored in a directory /work/shopdraw18.
All parts with a part number less than 20000 are stored in a directory /work/shopdraw20.
All parts with a part number less than 22000 are stored in a directory /work/shopdraw22.
All parts with a part number less than 24000 are stored in a directory /work/shopdraw24.

N.B. Before part number exceed 24,000 another directory will have to be established to hold these files. The Physical directory will have to be created using a suitable operating system command, (eg CRD //c/work/shopdraw26).

A3.7.3 Data Structure

The View only Drawing files are stored as American Standard Code for Information Interchange (ASCII) structure. The files are modified Infocad plot files. The only modification is that all Drawing Text is stored as ASCII characters and not X and Y plot movements. This reduces the file size, in some cases, by up to 50%.

A3.7.4 Drawing Application

The View only Drawing package that reads the plot files is called 'Shopdraw', written using the Disk Operating System (DOS) environment. The program first copies the plot file from the correct directory to the Hard Disk on the Personal Computer (PC). The file is then opened and read one line at a time and plotted to the screen. When the application reads ASCII text this is then converted into the text font in the application program to plot the discrete X and Y movements.

A3.8 Machine Setup

A3.8.1 Table : TLSHEET

Sheet	Partno	Issno	Machine	Material	Progno
i4	i4	i2	c7	c15	i2
1273	16449	1	2000	EN8 BAR	1
1274	16449	1	2000	EN8 BAR	2

Maxprogno	Operation	Jawsno	Jawsnotes
i2	c40	i4	c50
2	FACE OD	1023	EXTERNAL
2	TAP HOLES	1033	INTERNAL

Gaugeno	Gaugenotes	Chuck	Chuckpress	Tail
i4	c40	c10	c10	c10
1673	MEASURE OD	INTERNAL	5 BAR	YES
2176		EXTERNAL		NO

Tailpress	Sudrawing	Creator	Notes	Status	Crdata
c10	i4	c10	c160	i1	date
7 BAR HI	12222	JOHN		1	12/06/90
		GEORGE		1	23/11/90

sheet - This is an internal number which starts at one and increases by every time a new Set up Sheet is created. There is a unique Set up sheet for every instance of a unique part number, '(partno'), issue number, ('issno'), machine, ('machine') and program number, ('progno').

For example if any one of these four fields is different then a new sheet number, ('sheet') is created.

partno - Part number is the six figure number retrieved from the standard Fortune part number.

issno - Issue number is the issue number of the part or component. If the part is re-issued because of some design changes then a new set of Set up sheets are created.

machine - This the Computer Numerical Control (CNC) Machine that the Set up sheet has been written for. Every CNC machine has a code assigned to it which aids Data Base retrieval.

650A	-	Colchester 650A Turning Centre with C-axis
650B	-	Colchester 650B Turning Centre with C-axis
2000	-	Colchester 2000 Turning Centre
550H	-	Bridgeport Horizontal Milling Machining Centre.
DAT90	-	Binns and Berry Data 90 Turning Centre with C-axis.
5708	-	Matrix Churchill Thread Grinding Machine.

material - Material is a comment field where the CNC Programmers define the material and raw material size that should be used for the CNC program.

progno - Program number is the number of the Program and Set up sheet in the suite of data required for the production of the component.

maxprogno - This is the maximum program number in the suite of data required for the production of the component.

Eg. To Produce a component numbered 16449 issue 1 for the Colchester 2000, production require 2 set-up sheets 1 of 2 and 2 of 2. In addition for every set-up sheet there is corresponding CNC Code.

operation - This is a brief description of what the CNC Code has been programmed to do.

jawsno - Every set of production jaws has a Tool number assigned to it. The Tool number is entered here to identify the correct set of jaws.

jawsnotes - Brief description or comment about the production jaws.

gaugeno - Every gauge in the factory has a Tool number assigned to it. This Tool number is entered here to identify the correct gauge.

gaugenotes - Brief description or comment pertaining to gauge.

chuck - Brief description of chuck used and mounting.

chuckpress - This is the pressure the chuck should be set to.

tail - Comment pertaining to the machine Tailstock.

tailpress - The tailstock pressure the machine should be set to.

sudrawing - This is the set-up drawing that details the layout of the job.

creator - The creator of the set-up sheet. This name should be an authorised CNC Programmer.

notes - Any additional notes are placed here.

status - The status of the set-up sheet. 1 - proven, 0 - unproven.

crdate - Creation date is the date the Set-up sheet was created.

lastedit - The last date and time the set-up sheet was modified using the Edit option.

A3.8.2 Table : TLSHEETNOTES

Sheet	Notes1	Notes2	Notes3
i4	c158	c158	c158
1273	00053 IS PROG		
1274	INPUT CORRECT WEAR OFFSET CHANGE START POSITION		

sheet - This is an internal number is identical to the 'sheet' number in 'tlsheet'. This table stores all additional notes, if required, to the main Set-up sheet in the 'tlsheet' table.

notes1 - Any additional notes are placed here.

notes2 - Any additional notes are placed here.

notes3 - Any additional notes are placed here.

A3.9 Tooling Setup

A3.9.1 Table : TLDETAIL

sheet	turretpos	tassno	minlen	setdia	ora	vara	orb	varb
i4	i2	i4	f4	f4	i2	f4	i2	f4
1273	2	2679	100.00	0	2	.8	14	.6
1273	3	2833	0	23.5	3	0	0	0

sheet - This is an internal number, identical to the 'sheet' number in 'tlsheet'. For every Tool Assembly (TA) defined on a Tooling Sheet there is a unique row in this table. Every TA has a number of attributes assigned to it as per the following columns.

turretpos - This is a number of the turret position on the CNC machine where the Tool Assembly is mounted.

tassno - Tool Assembly number. This number is defined in the Tool Library. A unique TA has a Bill of Tools associated with it in which the Tool Kitters uses to pre-kit the Tooling.

minlen - This is the minimum length the Tool Assembly should be protruding from the Tool holder or Pot. This is an optional field.

setdia - This is the setting diameter of the Tool Assembly. Again this is optional.

ora-orf - These are offset registers. The CNC Controllers have numerous offset registers, the Programmer has to define which registers he has selected when writing the CNC program.

vara-varf - Variance, every offset may be a variance on the optimal size of a tool.
eg the Programmer may use the same TA but call on different registers, with different offsets, to hold the tool back from its true position. (see GE Fanuc CNC Controller manual for complete explanation).

A3.10 CNC Code

A3.10.1 Table : CNCDIR

sheet i4	description c50	status i2	creator c10	crdate date	lastedit date
1273	FACE OD AND KEYW	0	JOHN	24/11/90	3:45:22
1274	BORE HOLE 10 MM	1	JOHN	24/11/90	3:48:32

sheet - This is an internal number, identical to the 'sheet' number in 'tlsheet'. For every Set up sheet there should be corresponding CNC Code. For every row in the 'tlsheet' table there is a row in 'cncdir', CNC Code directory table.

description- This is a brief description of what the program has been programmed to do.

status - The status of the CNC Code. 1 - proven, 0 - unproven.

creator - The creator of the CNC Code. Either John or George.

crdate - Creation date is the date the CNC Code was created using the Add option.

lastedit - The last date and time the CNC Code was modified using the Edit option. Every time the CNC Code is saved, then the 'lastedit' time is updated to the current time.

A3.10.2 Table : CNCCODE

sheet	code	codeindex
i4	c100	i4
1273	%	1
1273	00053(53/001)	2
1273	G21M41	3
1273	G92S2000	4

sheet - This is an internal number, identical to the 'sheet' number in 'tlsheet'. For every Set up sheet there should be corresponding CNC Code. For every row in the 'tlsheet' table there are multiple rows in the cnccode table which stores the whole part program.

code - This is the CNC Code used to manufacture the parts.

codeindex - This is the CNC Code index number. The first line of the Code is index 1, subsequent rows are increment by one.

A3.10.3 Table : CNCCODERET

sheet	code	codeindex	retdate
i4	c100	i4	date
1273	%	1	15/3/91 3:23:23
1273	00053(53/001)	2	15/3/91 3:23:23
1273	G21M40	3	15/3/91 3:23:24
1273	G92S2500	4	15/3/91 3:23:25

sheet - This is an internal number, identical to the 'sheet' number in 'tlsheet'. Not all 'sheets' in the 'tlsheet' table have returned code.

code - This is the CNC Code returned from the CNC Cells. Code is returned if minor changes have been made to the Code.

codeindex - This is the CNC Code index number. The first line of the Code is index 1, subsequent rows are incremented by one.

retdate - This is the date the CNC Code is returned. It should be noted that because there are multiple rows saved to the data base table the returned times may have a variance of a couple of seconds.

A3.11 Tooling Definitions

A3.11.1 Table : TOOLIB

toolno	class	description	location
i4	c20	c60	c15
1001	TURNING TOOL	EXT PCLNR 25 25 M12	360
1002	TURNING TOOL	EXT CKJNR 25 25 M16	255

toolno - Every CNC Production tool has a Tool number assigned to it and engraved onto the tool. This field is for the unique Tool number. The numbering started at 1000 and every time a new Tool is defined the Tool number increments by one.

class - All the Production Tools are subdivided into approximately 50 groups. When a tool is defined the Tool Store person also defines a 'class' from the list of standard classes.

description - This is a Fortune Tool description which is used on the Production Shop Floor.

location - This is the physical location of the Tool in the store room.

A3.11.2 Table : TOOLCAT

toolno i4	manufacturer c25	manpartno c50	cost money	delivery i2
1001	SANDVIK	PCLNR 25 25 M12	0.00	0
1002	SANDVIK	CKJNR 25 25 M16	0.00	0

toolno - Every CNC Production tool has a Tool number assigned to it and engraved onto the tool. This field is for the unique Tool number.

manufacturer - This is the manufacturer of the Tool. This is used for re-stocking purposes.

manpartno - This is used when Purchase Order requisitions are placed. The manufacturers part number is invaluable for re-stocking purposes.

cost - This is the cost of the Tool, again used when re-stocking and stock taking.

delivery - This is the delivery time in weeks. Used for re-stocking.

A3.11.3 Table : TOOLTRP

toolno i4	quant i2	quantavail i2	quantrolevel i2	quanteoq i2	quantonorder i2
1001	3	3	1	1	3
1002	1	1	1	1	0

toolno - Every CNC Production tool has a Tool number assigned to it and engraved onto the tool. This field is for the unique Tool number.

quant - This is the quantity that exists in the factory, this includes tooling at the CNC machines, in the Pre-kitting area and in the Tool store.

quantavail- This is the quantity available for the kitting of jobs. This value should equal the quantity in the Tool Store.

quantrolevel- This is the quantity reorder level. Used for Tool Requirements Planning this field stores the re-order point for that unique tool.

quanteoq - Tool Economic Order Quantity. When re-ordering Tooling this field is used to order tooling in multiples of the EOQ.

quantonorder - This field stores the quantity of Tooling that is on order with a supplier.

A3.11.4 Table : TOOLCHK

```
tassno
i4
-------
2344
2321
-------
```

tassno - This table is used to store the Tool Assembly numbers of all Tools which have one or more Tools in their Bill of Tools with quantity 'quant' = 0 in the 'tooltrp' table.

A3.11.5 Table : POREQ

poreqno i4	printdate date	toolno i4	quant i2	daterqd c8	authority c20
6	26/6/91	1293	10	1/7/91	JIM
7	27/6/91	1296	5	1/7/91	JIM

poreqno - Purchase Order Requisition number. This is a unique number which increments by one every time a new Purchase Order Requisition is requested.

printdate - This is the date the PO Requisition was printed.

toolno - This is the Tool Number requested on the PO Requisition.

quant - This is the quantity required on the PO Requisition.

daterqd - Date that the Tools are required.

authority - When a PO Requisition is requested the application requests an authority name. This is the name of the person who authorised the PO Requisition .

A3.12 Bill Of Tools

A3.12.1 Table : ASSDETAIL

toolno i4	tl1 i4	tl2 i4	tl3 i4	tl4 i4	tl5 i4	tl6 i4	tl7 i4
1637	1001	1269	0	0	0	0	0
1001	2398	2405	2486	2402	1544	2356	0

toolno - This toolno is the Tool Assembly number. This is the Parent Tool number. Against every Parent Tool there are a number of component Tools.

tl1-tl7 - These fields define up to 7 tools which make up the Bill of Tools.

The example shown has a structure like this;

```
                              1637
                                |
                                |
                   ------------------------------
                   |                            |
                 1001                         1269
                   |
                   |
    -------------------------------
    |     |     |     |     |     |
  2398  2405  2486  2402  1544  2356
```

A3.13 Material Availability

A3.13.1 Table : MOSCHD

moidx	machine	schdseq	ts	cc	tl	mt	machwip
i4	c6	i2	c1	c1	c1	c1	c1
6	2000	1	Y	Y	K	A	N
7	550H	2	Y	N	K	K	N

toolpo	matlpo	schedule	prodcom	progcom	toolcom	matlcom
i4	i4	i2	c50	c50	c50	c50
1033		1	-	-	-	-
1733	1732	2	-	-	-	-

moidx - Every Manufacturing Order that exists in the Scheduling System has an index number attributed to it. An index number exists for very instance of a unique Manufacturing Order and Operation.

machine - This is the CNC Machine that the Production Department have planned the MO to be produced on.

schdseq - This is the schedule sequence of the MO. Schedule sequence 1 is first to run on the machine.

ts - Tool Sheet status code. This may be N for not available, A for available or Y for available and proven.

cc - CNC Code status code. This may be N for not available, A for available or Y for available and proven.

tl - This is the Tooling status code. N for not available, Y for available and K for available and kitted.

mt - Material availability code. N for not available, Y for available and K for available and kitted.

N.B. The availability of Tool sheets, Code and Tooling are directly retrieved from data base tables. Material availability is logged by the Material Kitter. Although the table stores the availability of Materials, they are not directly retrievable from Material stock tables.

machwip - Machine Work in Progress flag. If a CNC machine is running the MO then the status is Y. If the MO has been run and then suspended due to unforeseen circumstances then the status is S for suspended. If the MO is not in progress the status is N, for No.

prodcom - Production Controllers comments are stored here for viewing by other operators.

progcom - CNC Programmers comments are stored here for viewing by other operators.

toolcom - Tool Store Person comments are stored here for viewing by other operators.

matlcom - Material Kitters comments are stored here for viewing by other operators.

toolpo - This is the Tool Purchase order requested for the Tooling to run the MO. Generally the Tooling will be available and will not require purchase.

matlpo - Material Purchase Order for the Material required to produce the parts.

schedule - This schedule number corresponds to the schedules in the Scheduling System. 0 - Planning schedule, 1 - Machine Schedule, 2 - No Schedule, the MO is a child or relation of a parent MO. The Schedule for a child MO is always the same as the corresponding parent.

A3.14 Standard Times

A3.14.1 Table : STDTIMES

partno	operation	machine	setuptime	comptime	striptime
i4	i1	c6	i2	i2	i2
16449	1	2000	40	5	30
16449	2	550H	120	10	50

partno - The standard times are stored relative to each part number. Consequently the re-issue of the part does not effect the standard times to a great degree. If the re-issue of a part would substantially decrease or increase the times then the Production Controller will edit.

operation-This is a sequential number which identifies the ordering of the processes to complete the part.

machine - This is the machine code for the recommended CNC machine that will run the operation.

setuptime-Set up time is the time in minutes to set the CNC machine for the production of the operation.

comptime- Component time is then time, in minutes, to machine the part.

striptime-Time in minutes to strip the CNC machine after production of the part.

A3.15 Part Routings

A3.15.1 Table : STDTIMES

(see Section A3.14)

A3.16 Schedule Sequence

A3.16.1 Table : MOSCHD

(see Section A3.13.1)

Appendix A4

Screen Layouts

Title : Master Programmers Main Menu
Source Code : /fortune/source2/mastprog.osq
Help File : /sys/help/mastprog.hlp
Ingres Form : mastprog

```
+---------------------------------+
|  Programmers Application v 2.0 |
+---------------------------------+

 1.  View Shop Floor Register

 2.  Tooling Sheet Application

 3.  Cnc Code Application

 4.  Cnc Code Returns

 5.  Delete Utility

    Select (1-5) : _
```

A4.1 Master Programmers Main Menu

Title : Shop Floor Register
Source Code : /fortune/source2/sr1.osq
Help File : /sys/help/mastprog.hlp
Ingres Form : srform

Shop Floor Register

Prefix- S002 Partno- ________ Description-*SHELL*CAP*___

Partno	Description	TS	CC	Drawing	Status
S002000056/004	SHELL CAP PLAIN	Y	Y	No	Issued
S002000057/004	SHELL CAP (KEYED	A	A	No	Issued
S002000677/003	SHELL CAP INVERT	Y	Y	No	Issued
S002000678/003	SHELL CAP (KEYED	Y	Y	Yes	Issued
S002001394/001	SHELL CAP B/LASH	Y	Y	No	Issued
S002001395/001	SHELL CAP B/LASH	Y	Y	No	Issued
S002002296/002	SHELL CAP ROTATI	Y	Y	No	Issued
S002002512/001	SHELL CAP ROTATI	Y	Y	No	Issued
S002003057/001	SPECIAL SHELL CA	A	A	No	Issued
S002004265/001	SHELL CAP UPRIGH	Y	A	No	Issued
S002006735/001	SHELL CAP	Y	Y	No	Issued
S002009285/001	SHELL CAP & GUID	A	Y	No	Issued
S002010550/001	SHELL CAP MOD	A	Y	No	Issued
S002010893/001	SPECIAL SHELL CA	A	N	No	Issued

Options :
Search(1) Clear(2) Detail by Machine(3)

Key:
TS - Tooling sheet availability.
CC - CNC Code availability.
Drawing - CAD drawing availability.
Status - Component part status.

A4.2 Shop Floor Register

Title : Tooling Sheet
Source Code : /fortune/source2/ts1.osq
Help File : /sys/help/tlsheet.hlp
Ingres Form : tlsheet

PARTNO-53 ISSNO-1 MACHINE-650 PROG NO-2 OF 4 EDIT
OPERATION-FIN TURN & C/AXIS WORK MATERIAL-EN8
JAWSNO- 0 JAW / FIXTURE NOTES- 12MM GRIP ON 40DIA

TP	TA NO	MN_LEN	SET_DIA	RA	VAR A	RB	VAR B	RC	VAR C	RD	VAR
1	1622	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1637	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	2506	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	1780	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00
11	1623	0.00	0.00	0	0.00	0	0.00	0	0.00	0	0.00

CHUCK-EXTERNAL TAIL- NO GAUGENO- 0 CREATOR-GEORGE
PRESSURE-16 BAR HI TAILPRESS- GNOTES-
SU DRAWING- 0 SU ISSUE- STATUS- 0
NOTES-
SCREW TOOL MAY COME INTO OVER TRAVERSE TILL CORRECT WEAR
OFFSET IS PUT IN.OVER
COME THIS BY CHANGING STARTING POSITION TO X17.2

Options :
Search (1) Save (2) Clear(3) Tool Assembly (4) CNC Code (5)

A4.3 Setup and Tooling Sheet

Key :

TP	- Turret or Tool Position.
TA NO	- Tool Assembly number.
MN_LEN	- Minimum Length of Tool Assembly from Turret.
SET_DIA	- Tool Setting diameter.
RA/RF	- Tool Offset Register Number.
VAR A/VAR F	- Tool variance input into Tool register.
SU DRAWING	- Set up drawing number.

```
Title          : Bill of Tools Structure
Source Code    : /fortune/source2/ta1.osq
Help File      : /sys/help/tlsheet.hlp
Ingres Form    : ta1
```

```
+------------------------+    +-------------------------------+
|TURRET POSITION:-11     |    |TOOL ASSEMBLY NUMBER:- 1623    |
+------------------------+    +-------------------------------+

  TOOL   CLASS        DESCRIPTION
  ------------------------------------------------------
1 1127   POT          BORING BAR POT OD-85MM,ID-10MM
2 1040   TURNING TOOL INTERNAL TURNING TOOL (80MM) S10K-STFCD
3 1297   INSERT       INSERT (.2MM RAD) TCMT 110202-UF
4
5
6
7
```

A4.4 Bill of Tools Structure

Title : View Bill of Tools Structure
Source Code : /fortune/source2/ta2.osq
Help File : /sys/help/tlsheet.hlp
Ingres Form : ta2

```
          +------------------------------------+
          |        View Tool Assemblies        |
          +------------------------------------+

    +--------------+
    |T No:- 1001   |
    +--------------+
    Class .....- TURNING TOOL EXT

    Man Part No- PCLNR 25 25 M12

    Description- PCLNR 25 25 M12 (150MM LONG)

    +---------------+
    |TA No:- 1637   |
    +---------------+

    TOOL   CLASS               DESCRIPTION
    1001   TURNING TOOL EXT    PCLNR 25 25 M12 (150MM LONG)
    1269   TURNING INSERT      CNMG 120408 MR 415 (0.8MM RAD)


 Options :
 Search (1) Clear (2) Return TA(3)
```

A4.5 View Bill of Tools Structure

Title : Creation of CNC Code
Source Code : /fortune/source2/cc1.osq
Help File : /sys/help/cncode.hlp
Ingres Form : cc1

```
PARTNO:- 53   ISSNO:- 1   PROGNO:- 1   MACHINE:- 650         ADD
DESCRIPTION:- COPIED FROM SHOP AUDIO TAPE      STATUS:- UNPROVEN
CREATOR:- GEORGE                 CREATION DATE:- 20/11/90 06:41:54
                                 LAST EDITED   :- 11/12/90 11:33:01
+---+--------------------------------------------------------------+
|IDX|CNC CODE                                                      |
|---+--------------------------------------------------------------|
|1  |%                                                             |
|2  |O0053(1ST*SIDE*T/PLATE)                                       |
|3  |(S0020053)                                                    |
|4  |G21M41                                                        |
|5  |G92S2000                                                      |
|6  |(FIN*FCE&SPIG)                                                |
|7  |N0002G00G95G96X500.Z300.T0200M03S350F.2                       |
|8  |X106.Z2.T0202M08                                              |
|9  |G01X-1.6                                                      |
|10 |G00X106.Z3.                                                   |
|11 |Z.1                                                           |
|12 |G01X-1.6                                                      |
|13 |G00X106.Z2.                                                   |
|14 |G77X100.Z-17.9F.25                                            |
|15 |X94.                                                          |
+---+--------------------------------------------------------------+
```

Options :
Search(1) Add Row(2) Clear R(3) Delete Row(4) View Tooling Sheet(5) Save(6)

Key :
PROGNO - Unique program number.
IDX - CNC Code index or row number.

A4.6 Creation of CNC Code

Title : Return of CNC Code from DNC system.
Source Code : /fortune/source2/cr1.osq
Help File : /sys/help/cncode.hlp
Ingres Form : cr1

```
+---------------------------------+
|         CNC Code Returns        |
+---------------------------------+
```

PARTNO	ISSNO	PROGNO	MACHINE	DATE / TIME RETURNED
1089	1	2	650	12/12/90 15:45:56
53	2	1	650	12/12/90 16:48:06
53	2	2	650	12/12/90 16:50:22

Options :

Add(1) Edit(2) View(3) Delete(4)

A4.7 Return of CNC Code from DNC System

Title : SHOPDNC Main Menu
Source Code : /qc2/source/stuart/functdnc.c
Help File : No on-line help available.
Ingres Form : No ingres form

```
MO 21344  Partno 53 Issue 1
Shell Cap
=========================================

VIEW PART PROGRAM . . . . . . . . . . . . . 1
VIEW SET UP SHEETS  . . . . . . . . . . . . 2
VIEW TOOLING SHEETS . . . . . . . . . . . . 3
VIEW ENGINEERING DRAWINGS . . . . . . . . . 4

PROGRAMS TO FANUC . . . . . . . . . . . . . 5
PROGRAMS FROM FANUC . . . . . . . . . . . . 6

EXIT PROGRAM . . . . . . . . . . . . . . . 7

ENTER THE FUNCTION NUMBER ...
```

A4.8 Shopdnc Main Menu

Title : SHOPDNC View CNC Code
Source Code : /qc2/source/stuart/codednc.c
Help File : No on-line help available.
Ingres Form : No ingres form

```
==========================================
              VIEW CNC CODE
==========================================
 %
 O0053(1ST*SIDE*T/PLATE)
 (53/001)
 G21M41
 G92S2000
 (FIN*FCE&SPIG)
 N0002G00G95G96X500.Z300.T0200M03S350F.2
 X106.Z2.T0202M08
 G01X-1.6
 G00X106.Z3.
 Z.1
 G01X-1.6
 G00X106.Z2.
 G77X100.Z-17.9F.25
 X94.

Press any key to CONTINUE ...
```

A4.9 Shopdnc View CNC Code

Title : SHOPDNC View Setup Sheet
Source Code : /qc2/source/stuart/sheetdnc.c
Help File : No on-line help available.
Ingres Form : No ingres form

```
==========================================
              SET UP SHEET    1
==========================================
Part Number -    53 / 1    Status - 1
Material - AL/BRONZE
Machine - 650     Program -  1  of  1
Operation - THREAD INT & C/AXIS
Jaws no. - 12124  notes - HOLD ON SPIGOT
Gauge no. - 0     notes -
Chuck - EXTERNAL  Chuck Pressure - 14 BAR
Tailstock - NO    Tailstock Pressure -
Setup drawing - 0

Notes - T0900 IS OFFSET IN T0909 & T0914
        SUB PROGRAMS O0010 C/DRILL

Press any key to EXIT ...
```

A4.10 Shopdnc View Setup Sheet

Title : SHOPDNC View Tooling Sheet
Source Code : /qc2/source/stuart/tooldnc.c
Help File : No on-line help available.
Ingres Form : No ingres form

```
==============================================================
                       TOOLING SHEET    1
==============================================================

TP TA NO MN_LEN  SET_DIA RA VAR A RB VAR B ...   RF VAR F
--------------------------------------------------------------
1  |1622   | 20.00 | 0.00 |1  |0.00 |12|0.00        0 |0.00 |
2  |1637   |120.00 | 0.00 |2  |0.00 |0 |0.00        0 |0.00 |
3  |2506   |  0.00 |45.00 |3  |0.00 |15|0.00        0 |0.00 |
7  |1780   |  0.00 | 0.00 |7  |0.00 |16|0.00        0 |0.00 |
11 |1623   | 32.00 | 0.00 |11 |0.00 |0 |0.00        0 |0.00 |
   |       |       |      |   |     |  |              |     |
--------------------------------------------------------------
```

A4.11 Shopdnc View Tooling Sheet

Title : Tool Managers Main menu.
Source Code : /fortune/source2/toolman.osq
Help File : /sys/help/toolib.hlp
Ingres Form : toolman

```
+--------------------------------+
| Tool Manager Application v 2.0|
+--------------------------------+

  1.  Add Component Tooling

  2.  Edit Component Tooling

  3.  View Component Tooling

  4.  View Tool Assembly Details

  5.  Generate Purchase Order Req.

  6.  Update utility

  7.  Kit Tooling

     Select (1-7) : _
```

A4.12 Tool Managers Main Menu

Title : Add Component Tool Definition.
Source Code : /fortune/source2/tl1.osq
Help File : /sys/help/toolib.hlp
Ingres Form : tl1

```
                +--------------------------------+
                |      Add Component Tool        |
                +--------------------------------+
+-------------------------+
|TOOL NUMBER:-  1001      |   CLASS:-TURNING TOOL EXT
+-------------------------+
DESCRIPTION:-PCLNR 25 25 M12 (150MM LONG)

MANUFACTURER:- SANDVIK                       COST:- 0.00

PART No.:-PCLNR 25 25 M12

QUANTITY:-   3        LOCATION:-1
```

A4.13 Add Component Tool Definition

```
Title        : Edit Component Tool Definition.
Source Code : /fortune/source2/tl2.osq
Help File    : /sys/help/toolib.hlp
Ingres Form : tl2


            +---------------------------------+
            |       Edit Component Tool       |
            +---------------------------------+
 +--------------------------+
 |TOOL NUMBER:-  1001       |   CLASS:-TURNING TOOL EXT
 +--------------------------+
 DESCRIPTION:-PCLNR 25 25 M12 (150MM LONG)

 MANUFACTURER:- SANDVIK                    COST:- 0.00

 PART No.:-PCLNR 25 25 M12

 QUANTITY:-   3        LOCATION:-1
```

A4.14 Edit Component Tool Definition

```
Title        : View Tool Definition and Related Tooling.
Source Code : /fortune/source2/tl3.osq
Help File    : /sys/help/toolib.hlp
Ingres Form : tl3
```

```
             +---------------------------------+
             |      View Tool Library          |
             +---------------------------------+
  +-------------------------+
  |TOOL NUMBER:-  1001      |   CLASS:-TURNING TOOL EXT
  +-------------------------+
  DESCRIPTION:-PCLNR 25 25 M12 (150MM LONG)
  MANUFACTURER:- SANDVIK                      COST:- 0.00
  PART No.:-PCLNR 25 25 M12
  QUANTITY:-   3        LOCATION:-1

 RELATED TOOLING / 'WHERE USED'
+-----------+-----------------+-----------------+-------+
|CLASS      |DESCRIPTION      |MAN_PART NO      |TOOLNO|
|-----------+-----------------+-----------------+-------|
|TURNING INS|CNMG 120408 MR 41|CNMG 120408 MR 415|1269  |
|TURNING INS|CNMG 120412 MR 41|CNMG 120412 MR 415|1271  |
|TURNING INS|CNMG 120404 QF 41|CNMG 120404 QF 415|1274  |
|           |                 |                 |       |
|           |                 |                 |       |
+-----------+-----------------+-----------------+-------+
```

A4.15 View Tool Definition and Related Tooling

Title : Create Purchase Order Requisition.
Source Code : /fortune/source2/tl10.osq
Help File : /sys/help/toolib.hlp
Ingres Form : tl10

```
Fortune         PURCHASE ORDER REQUISITION      Fortune
Actuation       --------------------------      Engineering
Systems                                         Limited
Technology      RAISED BY:____________________________
                DEPARTMENT:__Tooling Room_____________
                NOMINAL CODE:_________________________
                APPROVED BY:__________________________
```

TOOLNO	MANUFACTURER	MANPARTNO	COST	QUANT	DATE RQD
1001	SANDVIK	PCLNR 25 25 M1	20.00	3	23/4/91
1002	SANDVIK	CKJNR 25 25 M1	24.00	5	5/5/91
1269	SANDVIK	CNMG 120408 MR	3.03	20	5/5/91
1274	SANDVIK	CNMG 120404 QF	5.88	25	5/5/91

A4.16 Create Purchase Order Requisition

Title : Kit Tooling for Manufacturing Order.
Source Code : /fortune/source2/tk1.osq
Help File : /sys/help/tlkit.hlp
Ingres Form : tk1

PARTNO-53 ISSNO-1 MACHINE-2000 PROG NO-1 OF 2 KITTER APP
OPERATION-FACE,TURN 40DIA,DRILL BORE MATERIAL-
JAWSNO- 0 JAW / FIXTURE NOTES- 7MM GRIP ON 100DIA

TP	TA NO	MN_LEN	SET_DIA	RA	VAR A	RB	VAR B		RF	VAR F
2	2192	0.00	0.00	0	0.00	0	0.00		0	0.00
5	2362	0.00	0.00	0	0.00	0	0.00		0	0.00
7	2519	0.00	0.00	0	0.00	0	0.00		0	0.00

CHUCK-EXTERNAL TAIL- NO GAUGENO- 0
PRESSURE-6 BAR HI TAILPRESS- GNOTES-
SU DRAWING- 0 SU ISSUE- CREATOR-
STATUS- 0 NOTES-

A4.17 Kit Tooling for Manufacturing Order

Title : Kit Tooling, Bill of Tools structure.
Source Code : /fortune/source2/tk2.osq
Help File : /sys/help/tlkit.hlp
Ingres Form : tk2

```
+-------------++-------------------++--------------------+
|SHEET:- 634  ||TURRET POSITION:- 2||TOOL A NUMBER:- 2192|
+-------------++-------------------++--------------------+
                               ASSEMBLY LOCATION:-
TOOL   CLASS              DESCRIPTION            LOCATION
---------------------------------------------------------
1 1148   TOOL HOLDER(200  SHORT EXT TURNING        148

2 1019   TURNING TOOL EX  PCLNR 16 16H 12M          19

3 1269   TURNING INSERT   CNMG 120408 MR 415       269

4

5

6

7
    ENTER TOOL NUMBER FOR DETAIL:-
```

A4.18 Kit Tooling, Bill of Tools Structure

Title : Scheduling Application main menu.
Source Code : /fortune/source2/schedule.osq
Help File : /sys/help/schedule.hlp
Ingres Form : schedule

```
+--------------------------------+
|       Shop Scheduler v1.0      |
+--------------------------------+

   1.  Log MO's to System

   2.  View Planning Schedule

   3.  View Machine Schedule

   4.  Current M/C Loading

   5.  Enquire on MO's

   6.  View Archive
```

A4.19 Scheduling Application Main Menu

```
Title        : Log Manufacturing Orders to system.
Source Code  : /fortune/source2/sc1.osq
Help File    : /sys/help/schedule.hlp
Ingres Form  : sc1
```

```
                +--------------------------------+
                |      Log MO's to System        |
                +--------------------------------+
     MO number             - 21033
     Part Number           - S002000053 __1    TOP PLATE
     Batch size            - 50_
     Due date              - 30 91
     Customer / Stock      - BELOIT
     Sales Order Number    - SO1253
     Project Ref Number    - P076
     Material              - ON ORDER P10002

      OP  Machine      SU      RT      ST
       1  650A_        40      3.3     45
       2  2000_        23      3.4     23
       3  _____        ___     ___     ___
       4  _____        ___     ___     ___
       5  _____        ___     ___     ___
```

Options :

Log MO (1) Update Routing(2)

A4.20 Log Manufacturing Orders to System

Key :

OP	- Operation number in component part routing.
SU	- Machine/Process Setup time, in minutes.
RT	- Component part run time, in minutes.
ST	- Machine/Process Strip time, in minutes.

Title : View Planning Schedule.
Source Code : /fortune/source2/sc2.osq
Help File : /sys/help/schedule.hlp
Ingres Form : sc2

Planning Scheduled

M	MO	OP	PART	ISS	DESCRIPTION	BACH	MACH	TS	CC	TL	MT	S
	00024	1	20024	3	TOP PLATE	14	2000	Y	Y	A	A	*
	00034	1	20024	3	TOP PLATE	14	2000	Y	Y	A	A	*
	00004	1	00024	3	TOP PLATE	14	2000	Y	Y	A	A	*
	00022	1	01234	1	ROLLER	1	650B	Y	Y	A	N	
	00002	1	00134	1	SCREW	1	650B	Y	Y	A	N	
	00032	1	02314	1	SCREW	1	650B	Y	Y	A	N	
	22346	1	00355	2	ROLLER COMPLE	22	DAT90	Y	Y	A	N	
	00023	1	00034	3	SHELL CAP	101	650A	Y	N	N	A	
	00033	1	00034	3	SHELL CAP	101	650A	Y	Y	A	A	*
	00003	1	00034	3	SHELL CAP	101	650A	Y	Y	A	A	*
*	00001	1	00056	4	SHELL CAP (KE	66	650A	Y	N	N	N	
	00002	2	00134	1	SCREW	1	2000	Y	N	N	N	
	00021	1	00056	4	SHELL CAP (KE	66	650A	Y	N	N	N	
	00022	2	01234	1	ROLLER	1	2000	Y	N	N	N	
*	00031	1	04056	4	SHELL CAP	66	650A	Y	N	N	N	
	00032	2	02314	1	SCREW	1	2000	Y	N	N	N	
	00005	1	00057	4	SHELL CAP (KE	83	2000	N	N	N	N	
	00025	1	00057	4	SHELL CAP (KE	83	2000	N	N	N	N	
	00035	1	02357	4	SHELL CAP	83	2000	N	N	N	N	

Options :
Redisplay(1) Detail(2) Launch(3) Material A(4) Transfer(5)
Delete MO(6) MV/PL(7) Bch(8)

A4.21 View Planning Schedule

Key :

M	- MO is a master eg More than one MO represented with the same component part number.
OP	- Component part operation number.
TS	- Tool sheet status column.
CC	- CNC Code status column.
TL	- Tooling status column.
MT	- Material status column.

Status Codes :

Y (Yes), N (No), A (Available), K (Kitted), D (De-Kit).

* (Job can progress), ! (ECN Pending).

Option Descriptions

Redisplay :- This function redisplays the screen to reflect changes in the Data Base. eg if the Production Controller is working on the Planning Schedule and the CNC Programmers have written more programs then the Production Controller will have to redisplay his screen to see the current System Status.

Detail :- The physical size of the screen and the large quantities of data available in the system restricts display of all data on one screen. If the user keys 'detail' then all additional data will be retrieved, see MO Detail form.

Launch :- This function moves the MO from the Planning Schedule to the Machine Schedule which triggers the Kitting of Tooling, Material and the processing of the MO at the CNC Machines.

Transfer :- There may be a time when the MO is logged to the system as Colchester 2000 and maintenance or breakdown would require the transfer of the MO to another machine. If the MO is to be retained within the CNC Cell then the MO can be transferred. If the MO will be moved outside of the CNC Cell then the MO will have to be deleted. The Production Controller can transfer the MO to a new machine and the Data Base will identify if there are any Tooling Sheets, CNC Code and Tooling for the new machine. If this data was available for the old CNC machine and not for the new machine then the Production Controller will be prompted if he still wishes to transfer to the new machine, thus entailing additional programming time and may result in restricted tooling availability.

Delete MO :- This function allows an MO to be deleted from the system.

Material A :- The Production Controller when logging an MO identifies if material is available. If the Production Controller or buyer knows there is no material when the MO is logged the material is marked as "N". Any time after the MO is logged the Production Controller or buyer can use this function to inform the system that material is now available. This function 'toggles' between Material available "A" and not available "N". If the Buyer/Controller keys that material is available by mistake he can change the status back to not available again with the same function key.

Move/Place :- This function is used to move an MO from one scheduled position and place in another position.

Batch :- This function will allow the Production Controller to update a batch size on an MO. This function will only be available in the Planning Schedule.

Title : Manufacturing Order Detail.
Source Code : /fortune/source2/sc7.osq
Help File : /sys/help/schedule.hlp
Ingres Form : sc7

```
+--------------------------------+
|        MO   20436  Detail      |
+--------------------------------+
Part number            - S002000134 001   SHELL CAP
Batch size             - 100
Due date               - 30 91
Customer name          - BELOIT________________________
Sales Order Number     - SO1253
Project Ref Number     - P076
Production Comments    - AWAITING MATL KELVIN__________
Material Comments      - ON ORDER P10002_______________
Tooling Comments       - ON ORDER P10034_______________
Programmers Comments-  AWAITING TOOLING GEOMETRY _____
```

MO	PART NUMBER	ISS	DESCRIPTION	BACH SIZE
20436	134	1	SHELL CAP ROTATING INVERT	50
20625	134	1	SHELL CAP ROTATING INVERT	10
8	134	1	SHELL CAP ROTATING INVERT	5
20635	134	1	SHELL CAP ROTATING INVERT	10
20826	134	1	SHELL CAP ROTATING INVERT	25

Options :
Update Comments(1)

A4.22 Manufacturing Order Detail

<u>Option Descriptions</u>

Update Comments :- The Controller can update unique comment fields only. eg the material kitter may wish to add notes about material but is restricted in adding notes in tooling and programmers comment fields.

Title : View Machine Schedule.
Source Code : /fortune/source2/sc3.osq
Help File : /sys/help/schedule.hlp
Ingres Form : sc3

Machine Schedule

M	MO	OP	PART	ISS	DESCRIPTION	BACH	MACH	TS	CC	TL	MT	S
	00003	1	00034	3	SHELL CAP	101	650A	Y	Y	K	K	*
*	00011	1	02326	4	SHELL CAP (K	56	650A	Y	Y	A	N	
	00023	1	00056	4	SHELL CAP (K	66	650A	Y	Y	A	N	
	00163	1	00134	1	SCREW	1	650B	Y	Y	K	K	!
	00027	1	00134	1	LBE	5	650B	Y	Y	K	A	
	00222	1	00134	1	ROLLER	6	650B	Y	Y	A	A	
	00072	1	20024	3	TOP PLATE	14	2000	Y	Y	A	K	
	00735	1	00057	4	SHELL CAP (K	83	2000	Y	Y	K	K	*
	00394	2	00134	1	SCREW	1	2000	Y	Y	K	K	!
	22266	1	00355	2	ROLLER COMPL	22	DAT90	Y	Y	K	K	*
	22276	1	00355	2	SHELL CAP	100	DAT90	Y	Y	A	K	
	22565	1	00355	2	ROLLER	77	DAT90	Y	Y	K	N	
	22926	1	00355	2	CASTING	200	550H	Y	Y	D	K	*
	23812	1	00355	2	BODY CASTING	150	550H	Y	Y	A	K	
	23276	1	00355	2	CLEVIS	5	550H	Y	Y	A	N	

Options :
Redisplay(1) Detail(2) UnLaunch(3) MV/PL(4)

Status Codes - Y (Yes), N (No), A (Available), K (Kitted),
D (De-Kit). ('N' Default)
- * (Job can progress), ! (ECN Pending).
(' ' Default)

A4.23 View Machine Schedule

Option Descriptions

Redisplay :- This function redisplays the screen to reflect changes in the Data Base. eg if the Production Controller is working on the Planning Schedule and the CNC Programmers have written more programs then the Production Controller will have to redisplay his screen to see the current System Status.

Detail :- The physical size of the screen and the large quantities of data available in the system restricts display of all data on one screen. If the user keys detail then all additional data will be retrieved.

UnLaunch :- This function moves the MO chosen from the Machine Schedule back to the Planning Schedule. If Tooling or Material has been kitted then the Controller will be prompted if he wishes to Unschedule at the risk of having kitted materials in process and to Unkit pre-set tooling. This function may be used prior to deletion of MO , to place in Planning if the Controller does not wish MO processed for days or weeks or if the MO is to be scheduled to another machine.

Move/Place :- This function is used to move an MO from one scheduled position and place in another position. The Production Controller will use this to resequence the machine schedule. If the Controller tries to schedule an MO before an MO that already has Tooling Kitted he will prompted if he wishes to continue, thus triggering the Pre-kitted (K) tools to be De-kitted (D).

```
Title       : Current Machine Loading.
Source Code : /fortune/source2/sc4.osq
Help File   : /sys/help/schedule.hlp
Ingres Form : sc4
```

```
                +--------------------------------+
                |    Current Machine Loading     |
                +--------------------------------+

         -
 60 Hours-  *
         -  *
         -  *                           *
         -  *                           *
         -  *                           *
 40 Hours-  *                           *
         -  *        *                  *
         -  *        *                  *
         -  *        *                  *
         -  *        *                  *               *
 20 Hours-  *        *         *        *               *
         -  *        *         *        *       *       *
         -  *        *         *        *       *       *
         -  *        *         *        *       *       *
         -  *        *         *        *       *       *
     --------------------------------------------------------
           650A     650B      2000     DAT90    550H    5708
```

A4.24 Current Machine Loading

Title : Enquire on Manufacturing Order.
Source Code : /fortune/source2/sc5.osq
Help File : /sys/help/schedule.hlp
Ingres Form : sc5

```
        +--------------------------------+
        |         Enquiry on MO's        |
        +--------------------------------+
Enter MO number - 0  Part Number - 0  Customer - BEUFORD_
```

MO NO	OP	PART	IS	DESCRIPTION	BCH	MACH	TS	CC	TL	MT	STAT
00003	1	00034	3	SHELL CAP	101	650A	Y	Y	K	K	SCHD
00011	1	02326	4	SHELL CAP (KE	56	650A	Y	Y	A	N	PLAN
00023	1	00056	4	SHELL CAP (KE	66	650A	Y	Y	A	N	PLAN
10163	1	02334	1	SCREW	1	650B	Y	Y	K	K	SCHD
00027	1	25634	1	LBE	5	650B	Y	Y	K	A	!
00222	1	40134	1	ROLLER	6	650B	Y	Y	A	A	PLAN

A4.25 Enquire on Manufacturing Order

Title : View Manufacturing Order Archive.
Source Code : /fortune/source2/sc6.osq
Help File : /sys/help/schedule.hlp
Ingres Form : sc6

Completed MO's

MO NO	OP	PART	IS	DESCRIPTION	JOB STARTED	HRS	BACH	COMP
12347	3	00056	4	SHELL CAP	12/3/90 12:34	8 45	100	98
176	1	00176	3	ROLLER	13/3/90 07:50	1 20	12	12
12367	2	00106	2	SCREW	13/3/90 09:30	2 53	45	44
7	2	00007	4	SHELL CAP PL	13/3/90 12:25	5 25	80	80

Option :
Force to Planning Schedule(1)

A4.26 View Manufacturing Order Archive

Option Descriptions

Force to Planning Schedule: - This function will be used to move an MO from the Completed System Catalogue back to the Planning Schedule. The Production Controller may have identified that a CNC Operator had logged off an MO when the MO had not been completed. The incomplete MO can be forced back to the Planning Schedule.