The Management Of Tool Flow

In Highly Automated

Batch Manufacturing Systems

Volume II

User Interface, Case Studies & Published Papers

by

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THE TOOL MANAGEMENT DESIGN FACILITY
- THE USER INTERFACE

2A.1 Introduction

This appendix provides the user of the tool management design facility with a description of the hardware and software configurations. Instructions which are intended to guide the user in the use of this facility are also presented. Some knowledge of the IBM operating system is required.

2A.2 The Modelling Medium

The computer models were originally written for a PRIME computer facility using standard Pascal. The model was then sucessfully transferred to a dedicated workstation configuration.

The dedicated workstation configuration is shown in *figure 2B.1* . The configuration comprises of the following elements :

(a) *IBM Personal Computer AT*: This is one of the most powerful members of the IBM personal computer family. This enhanced model has 640 Kb of usable memory, a 10.5 Mb RAM disk capacity, two 1.2 Mb diskette drives, one 20 Mb fixed disk drive and one 30 Mb fixed disk drive, referred to as drives *A,B,C* and *D* respectively. The system is supported by an *IBM Personal Computer Enhanced Graphics Adapter (EGA)* and an *Enhanced Colour Display.* The display and the EGA together provide a palette of 64 colours, and 640 x 350 picture elements at high resolution.

(b) A very versatile *Hewlett Packard* plotter, the *HP 7550A* graphics and text plotter.

(c) A colour printer with sheet feed facility, the *OKIDATA 292 Elite.*

The software configuration is based on the initial choice of Pascal as the modelling medium. Pascal was chosen as the modelling medium because of its highly structured and modular capabilities. Pascal is a general purpose, high level programming language. Pascal aids a systematic approach to computer programming, specifically introducing structured programming. It can be used to program almost any task on almost any computer and it is today estabilished as one of the most foremost high-level languages.

A specific variant of standard Pascal has been selected for the software environment, viz. *Turbo Pascal.* This Pascal closely follows the definition of standard Pascal as defined by K. Jensen and N. Wirth in the '*Pascal User Manual and Report*', with few and but important differences particularly in the handling of strings and random access files. *Turbo Pascal* is ideal as it offers a friendly interactive environment, and in the hands of a programmer it becomes an extremely effective development tool providing fast compilation and execution times. The language is designed to suit all categories of users. This is important as it will allow users to include company-specific modules within the overall suite of software relatively easily. Supporting the *Turbo Pascal* environment are a number of software packages which have been utilised to take full advantage of this medium and to enhance user-friendliness. These packages are described below.

(a) *Turbo Screen* : Developed by *PasCom Computing*, *Turbo Screen* is an input / output screen development environment for *Turbo Pascal*. This package has been used extensively to develop the soft-keys conversational interface. *Turbo Screen* allows the programmer to design as sophisticated an *i/o* screen as is possible for the *IBM PC AT*. An advanced source code interface makes pre-written screen management, data entry / editing, and maintenance procedures available to the user. *Turbo Screen* allows the setting up of default initial, minumum, and maximum values for data fields, as well as designating a sequence for gathering inputs at run time.

(b) *Turbo Extender* : *Turbo Pascal* provides excellent quick prototyping. It offers the structural clarity of Pascal and provides enough extensions to the standard language that direct machine access is straightforward. *Turbo Pascal* starts to have difficulties where large programs and large data structures like those required are concerned. The major thrust of *Turbo Extender* is to overcome these limitations while retaining all of the strengths for which *Turbo Pascal* has become famous. The centrepiece of *Turbo Extender* goes by the name of *BIGARRAY*. This provides the ability to transparently access one and two dimensional arrays of any type and any conceivable size. This facility is used to represent the major tool stores such as the cell secondary tool store and the central tool store. These arrays use disk files to hold the bulk of the array (the tool store contents). Pages of the array are swapped into and out of RAM as required, in an intelligent manner which maximises the performance. With the *BIGARRAY* include files the arrays can be as large as the available disk space.

(c) *Turbo Database Toolbox* : This is the suite of programs used to develop the datafiles used by the model. The routines in the *Database Toolbox* provide the body for the tool management database. The outputs from the database are ASCII text files which are directly fed to the model.

(d) *DBase III Plus* and *Reflex* : These are two user supported databases which provide the interface between other databases and the *Turbo Database*. The *Turbo Database* is designed to be company- and model- specific, whereas *DBASE III* and the interactive front end, *Reflex* contain an assortment of machines, parts and tools which are not company or cell specific. The databases are able to communicate with each other.

(e) *Lotus Freelance +* and *Microsoft Chart* : These are the main graphics output modules. The outputs from the model are of two types : alphanumerics and graphics. These packages are able to interface via ASCII files of fixed format to provide graphic representations of the outputs in histogram, layouts or x-y graphs.

(f) *Lotus 123* : This is a highly interactive, industry standard spread sheet software package used for the Computer Assisted Cluster Analysis Module.

2A.3 Workpiece-Oriented Models - Software Structure

The workpiece-oriented models are divided into four modules, viz. the iniitialisation, input, modelling and output modules. Each of these modules is described through the use of screens in the sequence in which they would appear to the user. The layout of each individual screen (figure) is not intended as an exact replica of each of the terminal screens but aimed at providing more detail than is possible at the terminal, although the information and data contained within each figure matches that presented on screen.

The main menu is entered by typing ***TMSMENU*** at the DOS prompt. The keys at the bottom of the screen enable the user to perform on-screen edit, move to the next or previous screen or obtain hardcopy. After each input the user is required to hit the ***Enter*** key.

2A.3.1 The Initialisation Module

This file initialisation module is selected by entering ***1*** at the prompt at the main menu, see *figure 2B.2*. This requires the user to enter a drive letter and to specify an existing subdirectory for output, see *figure 2B.3*. The computer performs the initialisation and on completion returns with the prompt shown in *figure 2B.4*. Pressing the ***Enter*** key returns the user to the main menu. The time which lapses between the specification of subdirectory and presentation of the prompt is proportional to the data limits set in the software, see *figure 2B.51*.

2A.3.2 The Input Module

The input module is only selected after the file initialisation module. The user enters this module by entering ***2*** at the prompt, see *figure 2B.5*. The first screen of the module is only a title screen, see *figure 2B.6*, and the user may proceed to the next screen where the summed parameters for all the cells are entered, see *figure 2B.7*.

The screen shown in *figure 2B.8* echoes the information given in the machine datafile, ***mc_a.tms*** found in the default subdirectory. This screen then merely alerts the user to the information on the machine tools.

The cell transport screen, *figure 2B.9*, requests the user to input for each cell the parameters required for modelling. The user is prompted for information by the cell number appearing in the top left hand corner.

The average tool transfer times between all the major tool stores, see *figure 2B.10*, need to be specified for each cell, in minutes, according to the cell number prompt. The user may enter ***0*** if the query is not applicable.

The tool transporter selection menu, see *figure 2B.11*, offers the user the choice of either of three rules. The rule selected affects all the transporters in the manufacturing system. It is not possible at this stage to select different rules for each cell.

The screen shown in *figure 2B.12* echoes the information given in the parts datafile, ***pt_a.tms*** found in the default subdirectory. This screen alerts the user to the information on the parts.

The part routing screen, see *figure 2B.13*, echoes the information contained within the routing file, ***route_a.tms*** found in the default subdirectory. This information is presented to the user for each machine and each machining list. An activity number or queue position is assigned to each activity on the machining list. The *item* column also indicates to the user the particular operation assignment strategy selected which becomes evident in this screen if read in conjunction with the *part number* and the *queue position* columns.

The main body of data having been input and collated the computer then *whirrs* away, setting up machining lists, rationalising tools within a machining list and working out the number of sister tools required. After a time the user is faced with a screen such as shown in *figure 2B.14* . This series of similar screens actually define the minimum tooling requirement (see chapter seventeen). The number of tools required to satisfy the total number of machining lists is given by the number of tools and the assignment to the machining lists is given by the machine number along the same row. The remainder of the data is an echo of the tool datafile, ***tl_a.tms*** found in the default subdirectory.

The screen shown in *figure 2B.15* echoes the information given in the secondary tool store file, ***ss_a.tms*** found in the default subdirectory, for each cell and merely alerts the user to the capacities specified for each cells major store.

The central tool store data is entered at the key board as shown in *figure 2B.16* . This allows the user to specify appropriate capacities on-line for this super store. This facility is particularly useful if it is found that the minimum tooling requirement exceeds the secondary tool store capacity.

The specification of the CTS completes the data entry for the model and the user is faced with the prompts shown in *figure 2B.17.* On pressing the ***Enter*** key the user is returned to the main menu shown in *figure 2B.18.*

2A.3.3 The Modelling Module

This module is selected by entering the value ***3*** at the keyboard as shown in *figure 2B.18.* This module can only be selected after the previous two modules. This module permits some changes to be made to run under different operating conditions, if so desired. The changes would have to be coded into the ***mcmodela.pas*** module and then recompiled. Alternatively, some of the major parameters may be changed from the keyboard without recompilation. These parameters such as transporter capacity and tool magazine size may be changed in response to two queries, thus allowing alternative sizes and capacities to be specified without going through the rigours of the input module. In order to use this facility it is necessary to save the inputs, indexed with the extension ****.par*** and ****.dt1***, in a different subdirectory and even on a different drive, because the files are invariably altered in the due course of modelling. The drive and directory may be specified through editing of the text file titled ***dir.par*** . The ****.par*** files are found in the same (default) directory as the ****.com*** or modelling files.

The module *whirrs* away for a length of time proportional to the number of entities involved. The user is offered on-screen information as to the part being machined, the tool used and the tool life requirement. On completion of the modelling the prompt shown in *figure 2B.19* is returned.

2A.3.4 The Output Module

This module selected as ***4*** on the main menu, see *figure 2B.20*, may be selected any number of times, but only on completion of the modelling module. The outputs for previous runs may be recalled through editing of the ***dir.par*** text file and if previously saved.

Selection of the output module leads the user to a sub-menu of options as shown in *figure 2B.21*. Any of these options may be selected in any order and any number of times by the user. The outputs offered range from the specific to the more general summary outputs. The interpretation of these outputs is open to the user for his or her judgement and decision-making. A general interpretation of the output options is described below. This is by no means the sole interpretation.

The final primary tool store contents, *figure 2B.22*, is selected by entering ***1*** at the outputs module options screen, *figure 2B.21* . This output illustrates for every machine in every cell the tools held, their location within the tool store and their current life and status. The tool number corresponds to that in output option two which provides the tool identity. This screen also provides capacitity and over and under utilisation. The latter measure requires to be read in conjunction with output option eight which together with this screen provides transient capacities and contents. The user is returned to the output module options menu after the last machine's tool store contents have been offered to the user.

The final tooling details and status, *figure 2B.24*, is selected by entering ***2*** at the outputs module screen, *figure 2B.23*. This screen provides the user with the tool numbers and their identities, their initial and final status, their initial and final tool life, their frequency of usage, the number of tools available of this type, the number of regrinds carried out and finally whether the tool has been refurbished.

The third output option selected by entering ***3*** at the output menu, *figure 2B.25*, is a two-fold menu. The first details the machining history, *figure 2B.26*, and indicates for each machining list, given by the machine number, the part number sequence, and the breakdown of this sequence into batch (pallet) item and operation number. Two other columns indicate the operation time and the activity number. Additionally and perhaps more importantly, the screen provides not only the tool sequence used by each of the spindles but also the usage of a particular tool within a given machining list. The other menu offered as part of this third option is of a global nature and concerned with utilisations and performance times for the machines and transporters. This screen, *figure 2B.27*, thus provides a measure of the ability of the tooling system under consideration to meet its target. This output is of further use particularly when comparing performance and utilisation figures with the outputs of simulations which do not explicitly consider tool flow. The user is returned after this screen to the output options menu.

The fourth output option selected by entering ***4*** at the output options screen, *figure 2B.28*, provides a detailed view into the timing of the machining activities, *figure 2B.29*. The start and finish times of the machine for each activity are provided. The start time of the activity is also given as more often than not it is possible to commence the activity earlier than the that required for machine and tool set-up. This time is thus provided only as identifying *slack*.

The fifth option, see *figure 2B.30*, provides the user with a detailed cell tool transfer schedule, *figure 2B.31*. This screen provides the user with the information of when the tool transfer was effected, the cart used, the cart usage, the machine requesting the transfer and the availability of the secondary tool store. This information may suggest to the user the number of carts, the capacities and the number of secondary tool store servers required.

The sixth, *figure 2B.32*, and the seventh, *figure 2B.34*, provide an echo of the machines, *figure 2B.33*, and the parts, *figure 2B.35*, used in the modelling.

The user having been returned to the output module options, *figure 2B.36*, may select ***8*** to gain insight into the contents of the cart and its specific origin and destination. This output thus provides more detail, *figure 2B.37*, about each journey detailed in the fifth output selection.

A two-fold output is offered when the user enters ***9*** at the output module options screen, *figure 2B.38*. The first output provides a general summary of the contents of each cell, *figure 2B.39*, in regard to the tools in the cell, the number of transporters specified and the distribuition of those tools at the end of the modelling. The second part of this output option provides the user with a cell tool status report for each cell, *figure 2B.40*. The cell tool input specifies the minimum tooling requirement, the tools in cell provides the actual number of tools current in the cell, and the added tools count provides ameasure of the number of tools that had to be introduced into the cell to overcome flow or other problems.

If the user does not wish to proceed with his examination of outputs he enters a ***0*** which returns him to the main menu, *figure 2B.41*. Entering a ***0*** at the main menu reurns the user to the DOS prompt.

2A.4 The CACA Module

The use of the Computer Assisted Cluster Analysis (CACA) module has been described in chapter seventeen and through use of the case studies in appendix two. The use of this module requires the user to have some knowledge of the spreadsheet package, *Lotus 123*. This package is the industry standard spreadsheet software widely used in accounting practices. The software which is very user friendly is entered by typing ***123*** at the DOS prompt in the directory that contains the Lotus software. The user is immediately taken into a blank spreadsheet. The CACA module is retrieved by typing / and then responding to the prompt with ***CACAMAC.WK1*** . This file contains the main macros for use in the CACA module. Other *worksheets* may also be retrieved with this command. It is worth noting that the / command presents the user with the main 123 menus and sub-menus accessible by the cursor and ***Enter*** key.

The ***CACAMAC.WK1*** worksheet permits the user to input upto twenty-five part types along the primary row and one-hundred tool types along the primary column (this may be extended by altering the macros provided within the worksheet). The only information required at this stage is for the user to input a ***1*** for usage of a tool type on a part type. This entry is inserted into a *cell* (the point of intersection between relevant row and column) as shown in *figure 2B.42*. The user then alternatively ranks rows and columns till no further ranking is possible.

A checking procedure has been implemented, see *figure 2B.43*, which aids the user in examining if there were any changes in row order after ranking of columns and column order after ranking of rows. The user is required to enter/update the iteration after each ranking. If tools have to be *removed* in order to permit ranking (see chapter seventeen) then the user simply enters a ***0*** (not a blank space) to indicate the removal of this cell value from the analysis but retain its position in the overall schema.

When no further ranking is possible the user is required to specify the batch sizes or order requirement for each part type on the row above the re-ordered primary row (orders), see *figure 2B.44*. On accomplishment of this task the user substitutes the ***0*** and ***1*** values with the accumulated tool usage time for that cell. The *min. tcs reqt.* macro is then selected and the spreadsheet advanced to position ***DA1***.

At this stage the user is presented with the minimum number of tools required for each cluster set. The *sis. tool reqt.* macro is then initiated to translate this minimum tool requirement in the number of sister tools and the total number of tools required, see *figure 2B.45*. This in effect completes the cluster analysis.

On completion of this initial run the spreadsheet may be saved and modified for different data values. For example, the effects of changes in order requirements, tool life and maximum permissible tool life values may be changed to obtain new tooling configurations.

2A.5 Data File Formats

The data file formats are presented for machines in *figure 2B.46*; parts in *figure 2B.47*; tools in *figure 2B.48*; the secondary tool store in *figure 2B.49* and for the part routes in *figure 2B.50*. These files are all given the extension ***.TMS*** to indicate current modelling files are respectively titled as *mc_a.tms, pt_a.tms, tl_a.tms, ss_a.tms* and *route_a.tms* . As previously mentioned these files may either be generated directly with a text editor or indirectly via a database.

2A.6 Entity Data Limits

For modelling purposes and with respect to compiler and hardware limitations it is necessary to set upper limits on the number of entities that can be modelled. It may also be preferred in some instances to modify these limits to suit particular configurations. These limits are set in the ***global.inc*** file. Modifications to these limits implies recompilation of all the files with the ***.pas*** extension. The limits set according to the largest case study handled are shown in *figure 2B.51*.

Appendix 2B:

THE TOOL MANAGEMENT DESIGN FACILITY

FIGURES

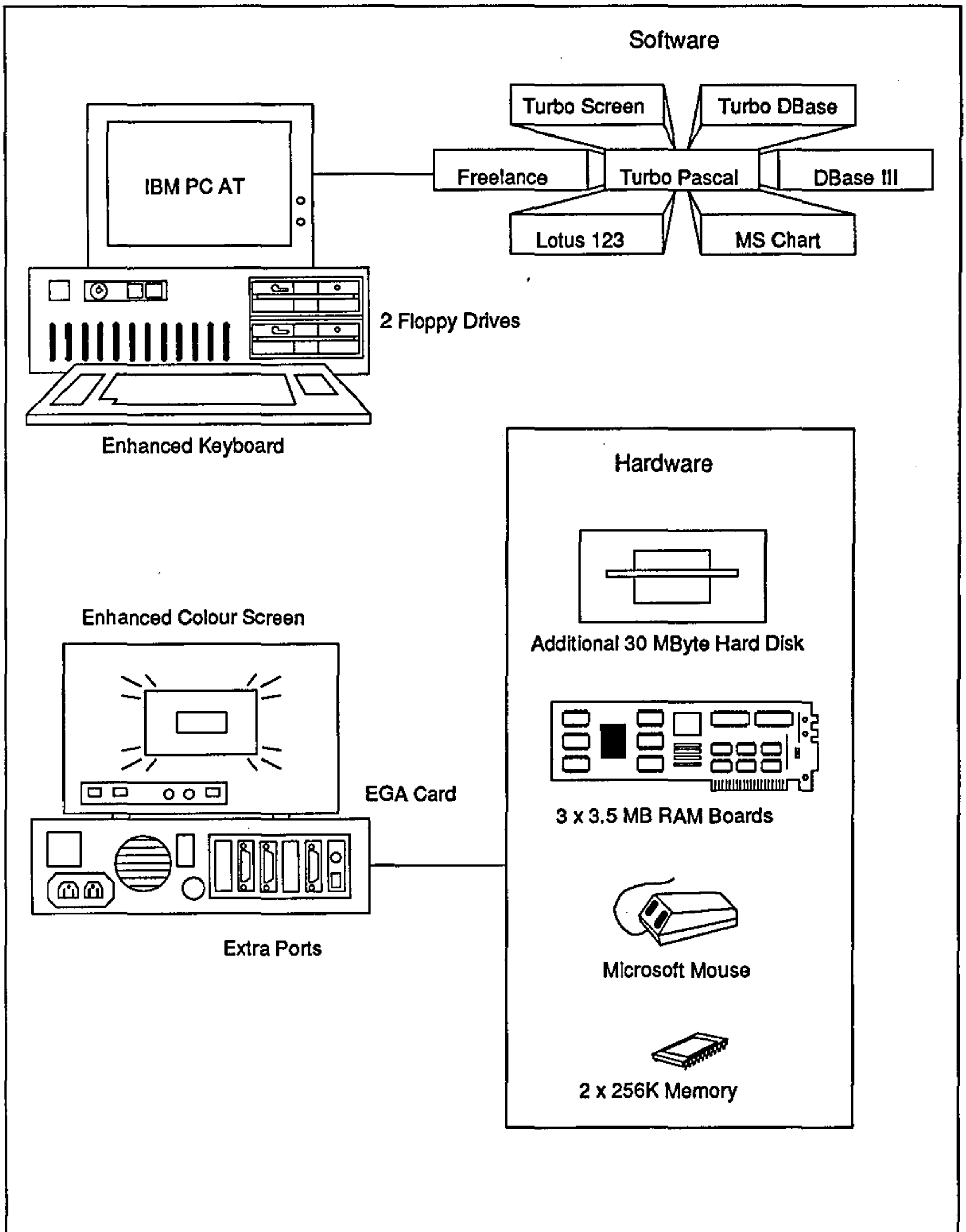


Figure 2B.1	TMS WORKSTATION CONFIGURATION	LUT-FMS RESEARCH GROUP

1. Run Initialisation Module

2. Run Input Module

3. Run Model

4. Run Output Module

Select Option : 1

Next	Edit Screen	Hard Copy	Prev. Screen
Enter	CTRL-B	Shift-PrtSc	P

Figure 2B.2	MAIN MENU	LUT - FMS Research Group

Input Drive Letter for Output :

Input Subdirectory for Output :

Next	Edit Screen	Hard Copy	Prev. Screen
Enter	CTRL-B	Shift-PrtSc	P

Figure 2B.3	FILE INITIALISATION MODULE	LUT - FMS Research Group

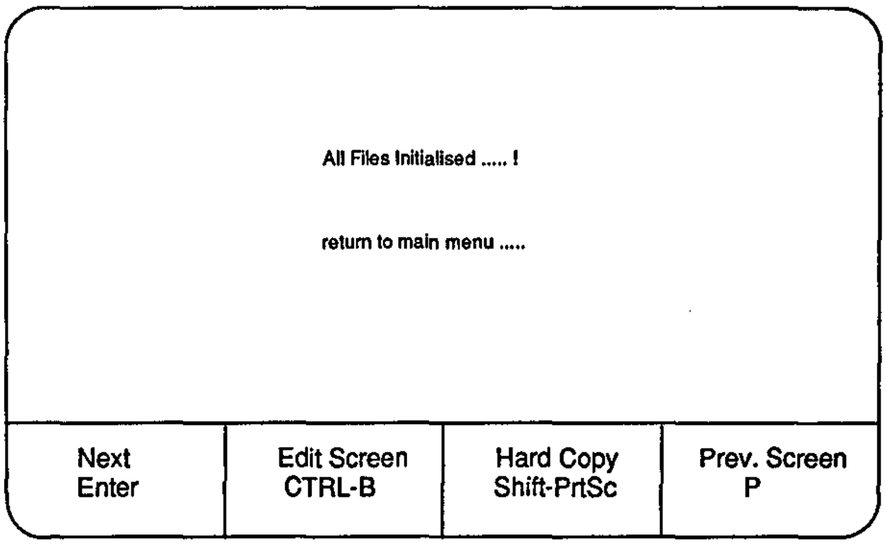


Figure 2B.4	FILE INITIALISATION MODULE	LUT - FMS Research Group

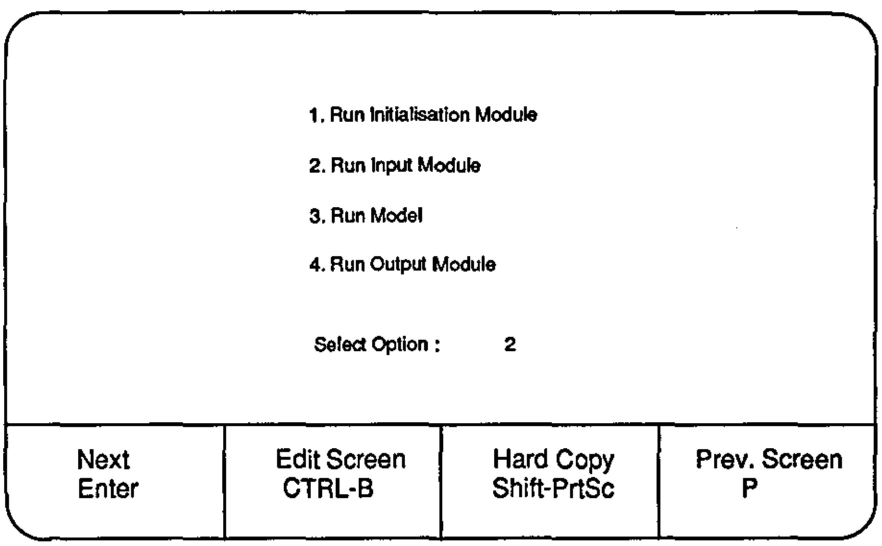


Figure 2B.5	MAIN MENU	LUT - FMS Research Group

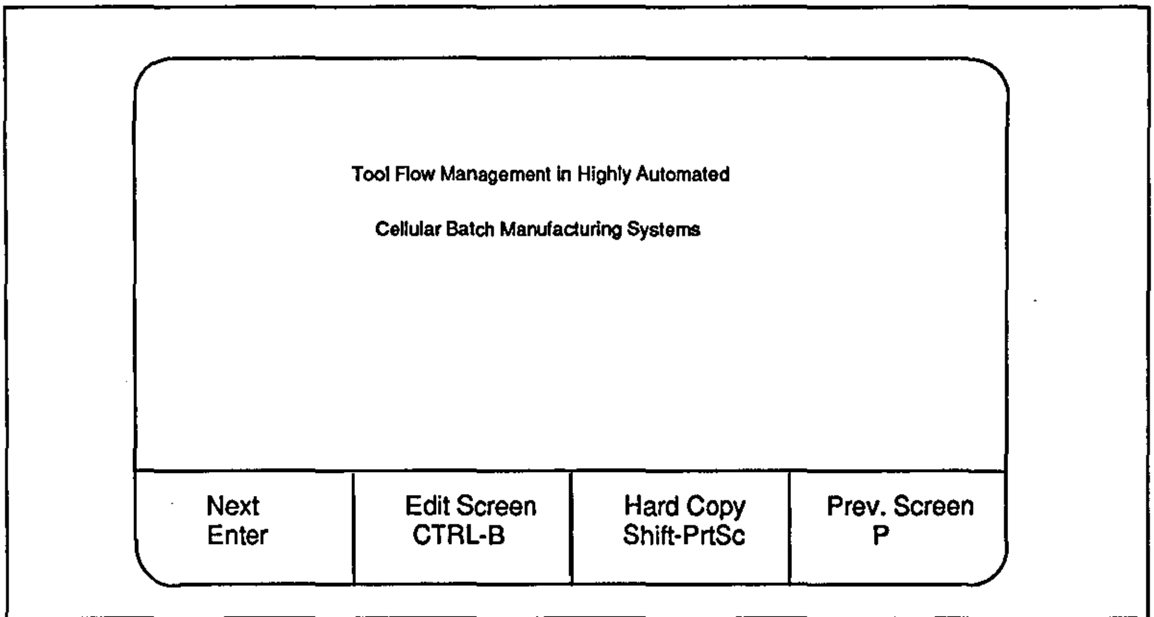


Figure 2B.6 | TITLE SCREEN | LUT - FMS Research Group

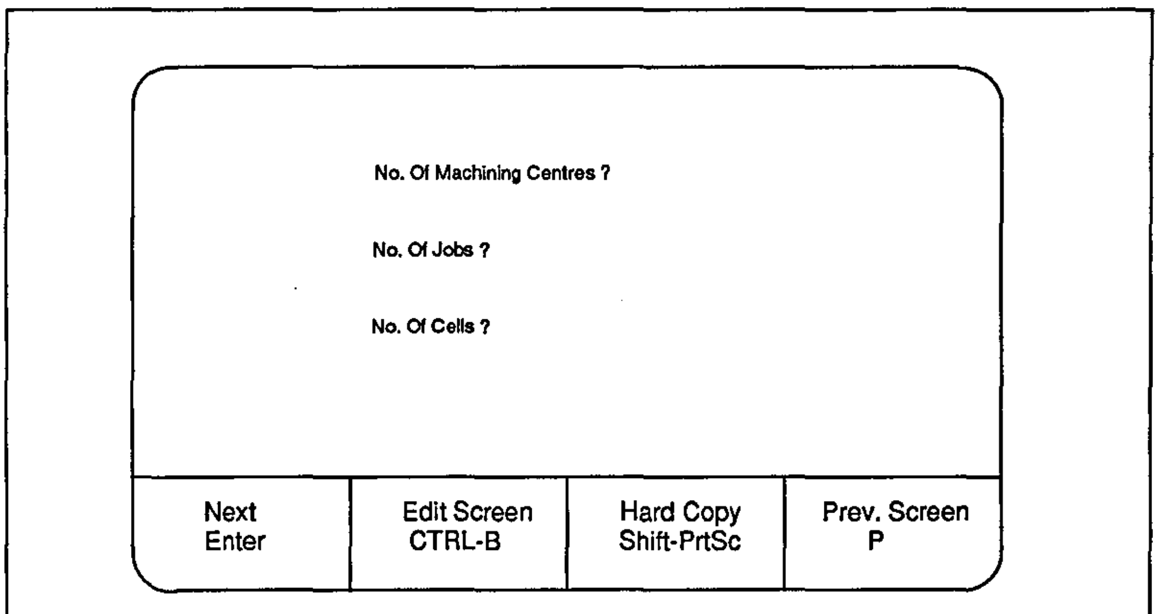


Figure 2B.7 | SYSTEM PARAMETERS | LUT - FMS Research Group

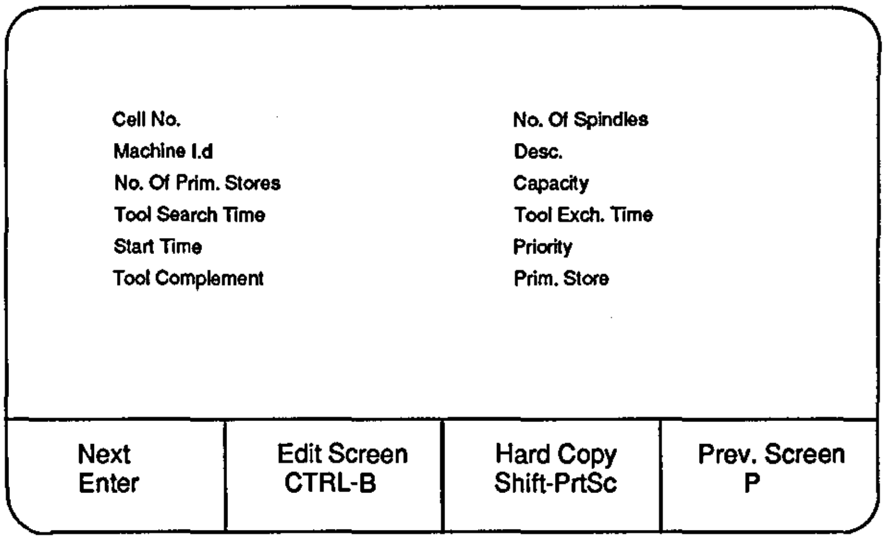


Figure 2B.8	ECHO OF MACHINE DATA	LUT - FMS Research Group

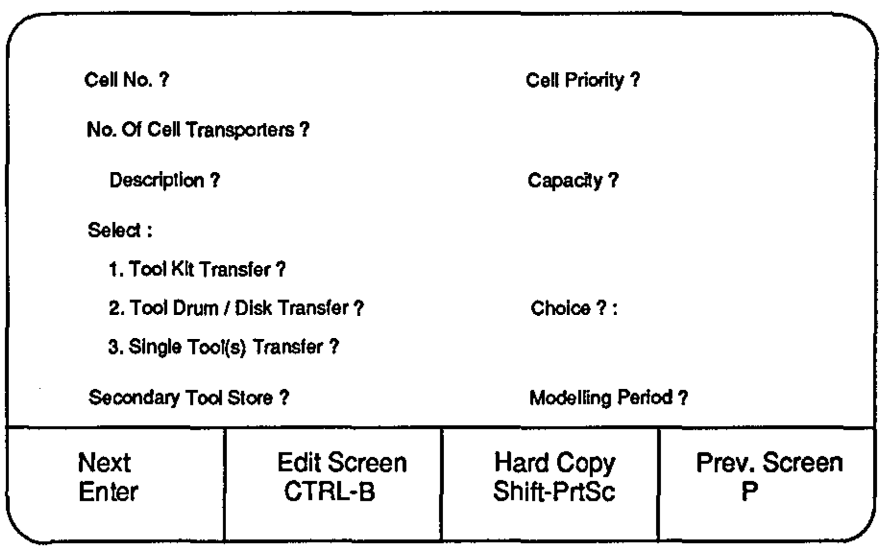


Figure 2B.9	CELL TOOL TRANSPORT	LUT - FMS Research Group

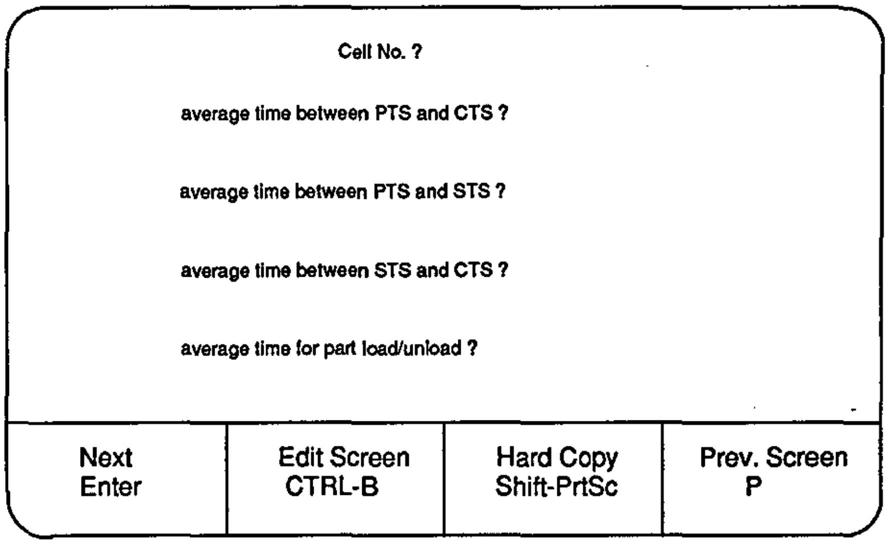


Figure 2B.10	AVERAGE TOOL TRANSFER TIMES	LUT - FMS Research Group

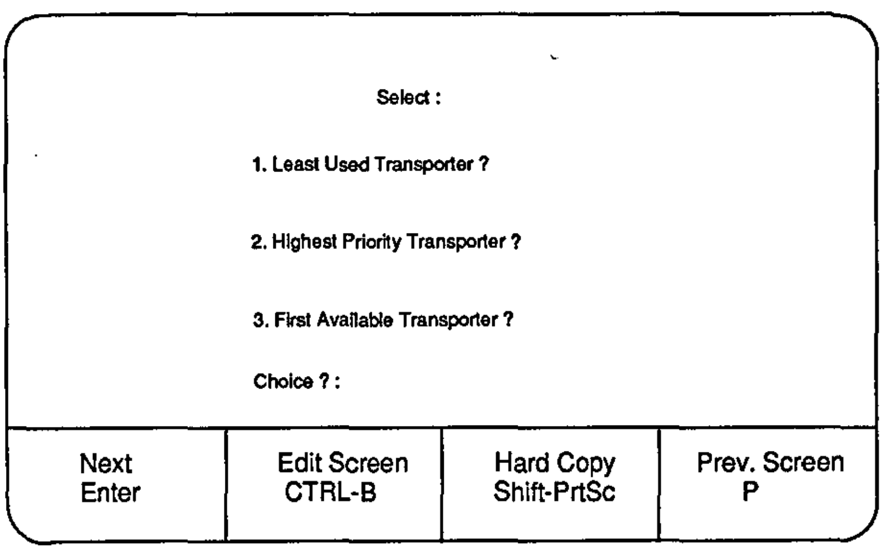


Figure 2B.11	TOOL TRANSPORTER SELECTION	LUT - FMS Research Group

Part No.	Part Id.	Batch Size (BS)	No. Of Ops.	Priority	Cell

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.12	ECHO OF PART DATA	LUT - FMS Research Group

Part No.	Op. Desc.	Mc. No.	Item	Op. No.	Queue Pos.	Op. Time

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.13	ECHO OF PART ROUTING DATA	LUT - FMS Research Group

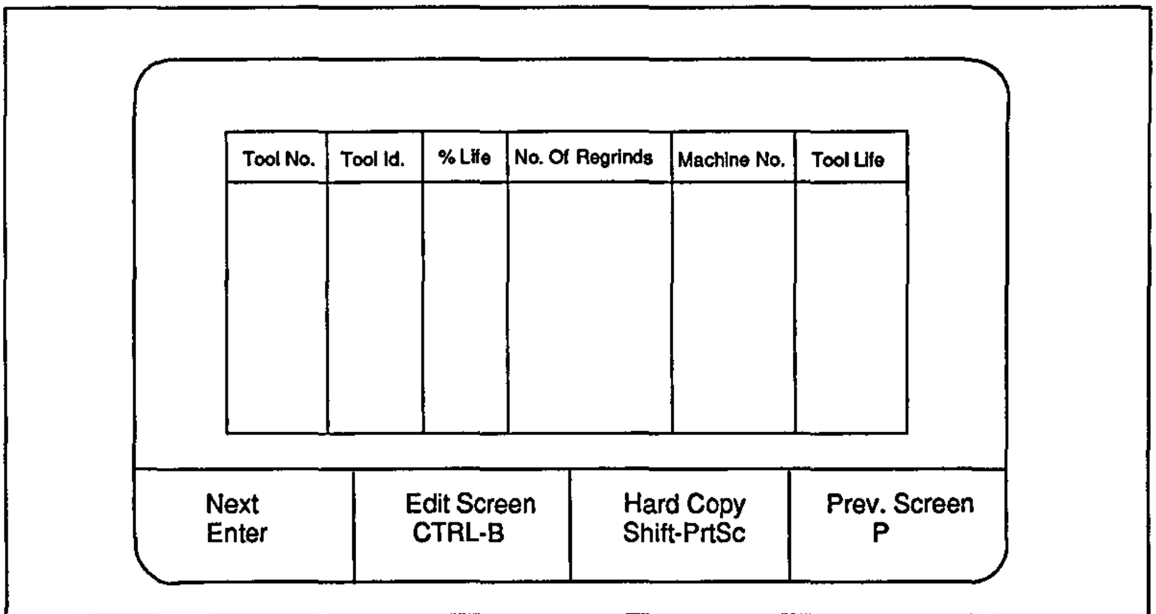


Figure 2B.14 — MINIMUM TOOLING REQUIREMENT — LUT - FMS Research Group

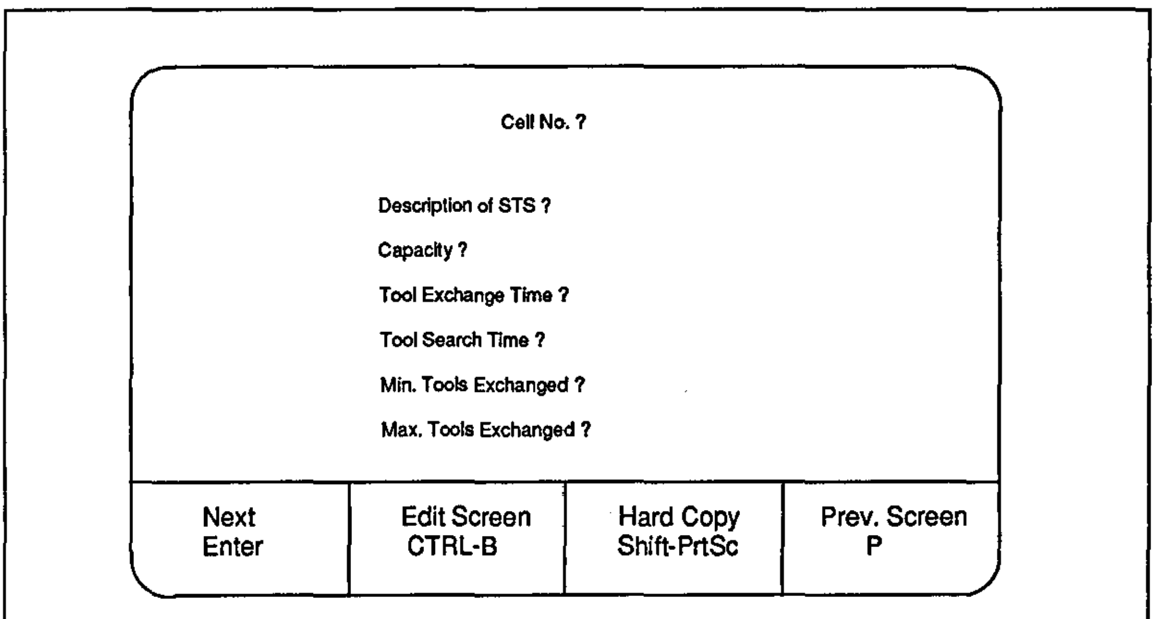


Figure 2B.15 — ECHO OF STS DATA — LUT - FMS Research Group

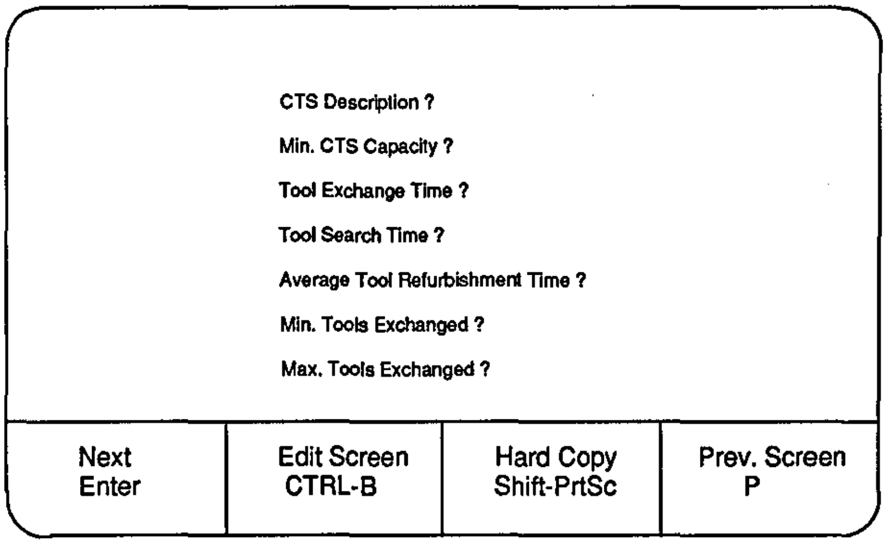


Figure 2B.16	CTS DATA INPUT	LUT - FMS Research Group

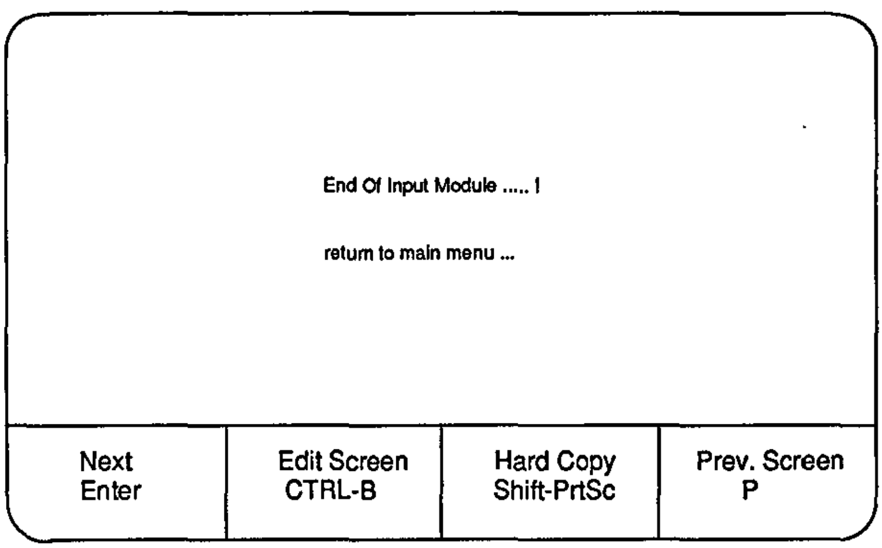


Figure 2B.17	INPUT MODULE	LUT - FMS Research Group

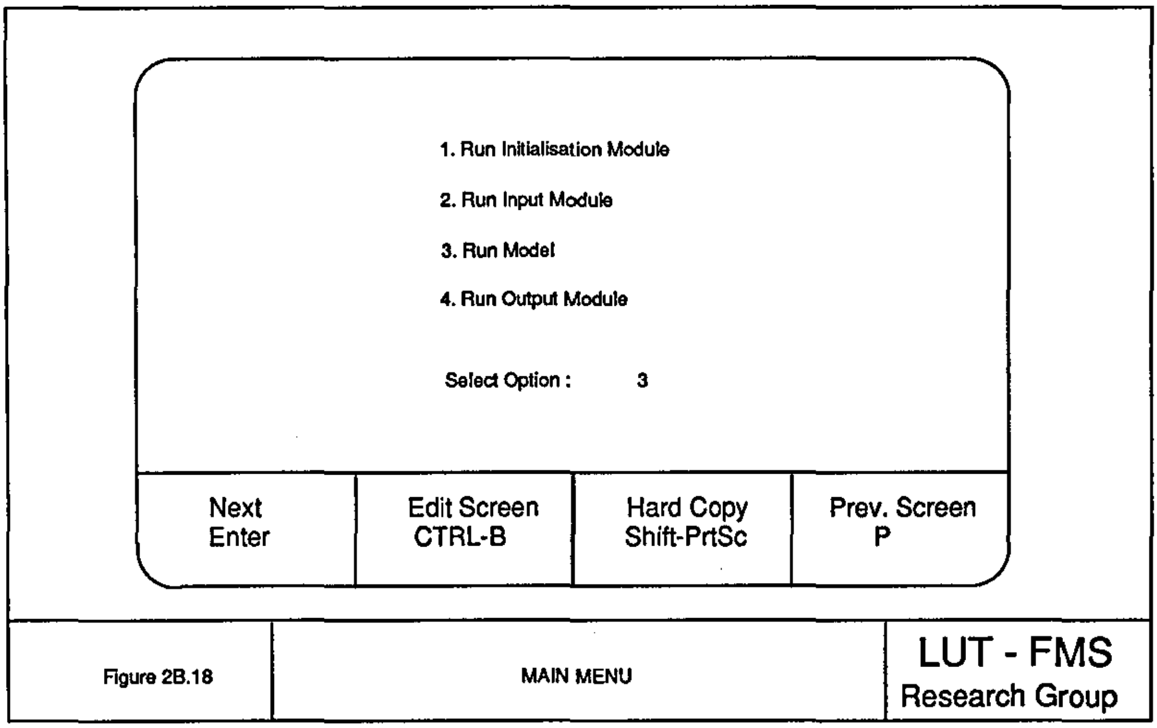


Figure 2B.18 MAIN MENU

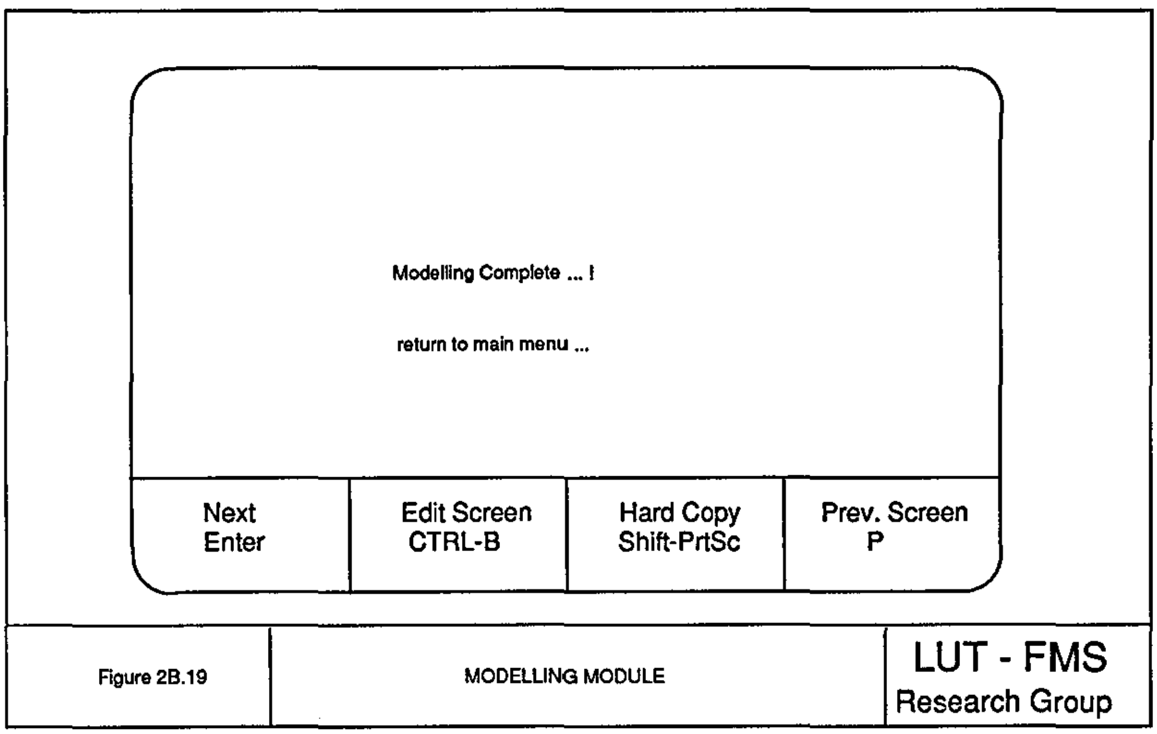


Figure 2B.19 MODELLING MODULE

1. Run Initialisation Module

2. Run Input Module

3. Run Model

4. Run Output Module

Select Option : 4

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.20	MAIN MENU	LUT - FMS Research Group

1. Final PTS Contents

2. Final Tooling Details and Status Values

3. Machining History and Cell Performance Measures

4. Machine Activities

5. Cell Tool Transfer Activities

6. List Of Machines In Each Cell

7. List Of Scheduled Parts for Each Cell

8. Tool Transporter Contents and Schedule

9. Cell Tool Summary and Status Report

Select Option : 1

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.21	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Tool Store : Store Desc. : Status :

Capacity : Tools Held : Under/Over by :

pocket #	Tool #	Life	Status	pocket #	Tool #	Life	Status

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.22	OUTPUT 1 - FINAL PTS CONTENTS	LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines in Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 2

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.23	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

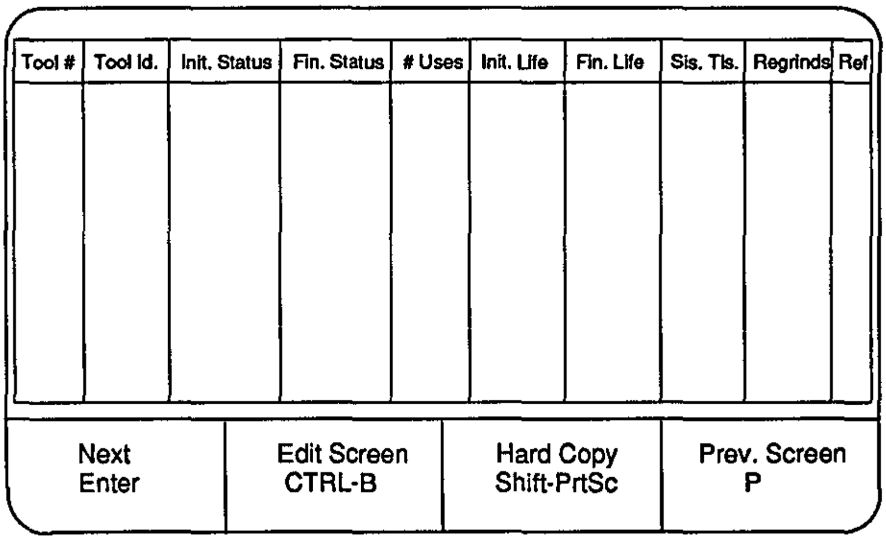


Figure 2B.24	OUTPUT 2 - FINAL TOOLING DATA	LUT - FMS Research Group

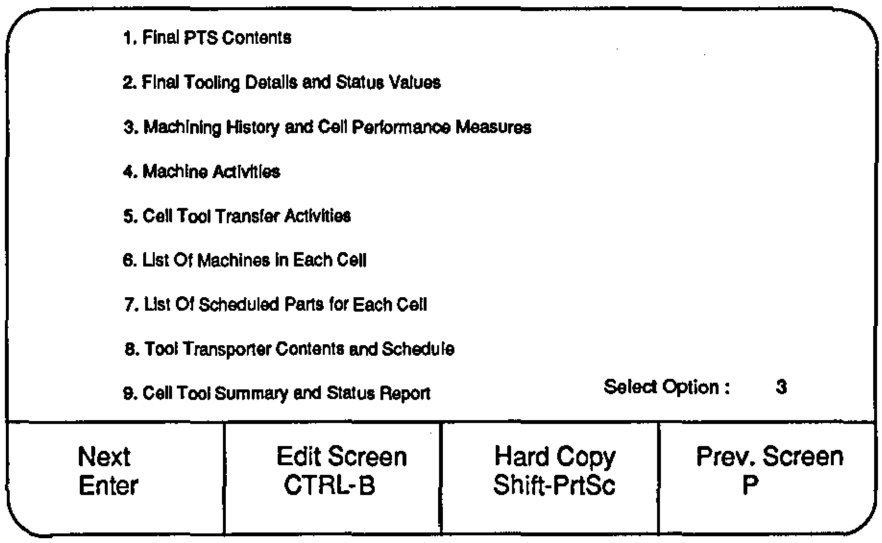


Figure 2B.25	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

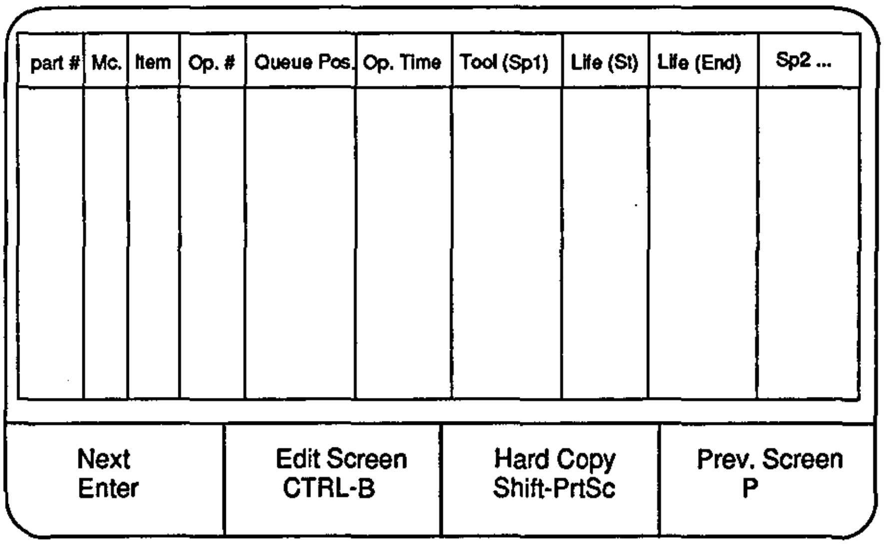


Figure 2B.26 | OUTPUT 3A - MACHINING HISTORY | LUT - FMS Research Group

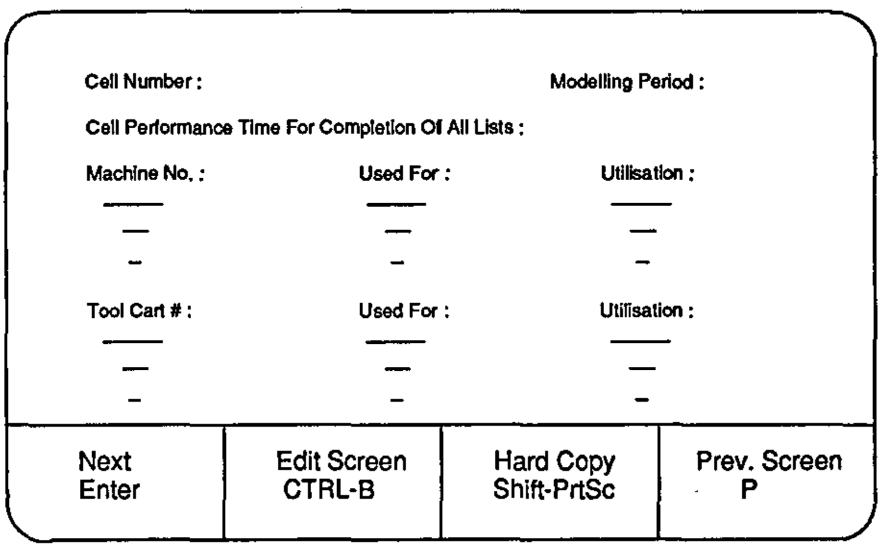


Figure 2B.27 | OUTPUT 3B - CELL PERFORMANCE MEASURES | LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines in Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 4

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.28	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Part #	Item	Op. No.	Op. Time	Machine	Queue #	Mc. St.	Act. St.	Mc. Fin.

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.29	OUTPUT 4 - MACHINE ACTIVITIES	LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines in Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 5

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.30	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Cell #	Cart #	Mc.	Queue Pos.	Cart AvT	Ld Tls	Unld Tls	Rtn Tls	Cart AvT

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.31	OUTPUT 5 - CELL TOOL TRANSFER	LUT - FMS Research Group

1. Final PTS Contents

2. Final Tooling Details and Status Values

3. Machining History and Cell Performance Measures

4. Machine Activities

5. Cell Tool Transfer Activities

6. List Of Machines in Each Cell

7. List Of Scheduled Parts for Each Cell

8. Tool Transporter Contents and Schedule

9. Cell Tool Summary and Status Report

Select Option : 6

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.32	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Cell	Mc. Id.	Mc. #	M or F	No. Of Spindles	Priority	Cap.

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.33	OUTPUT 6 - LIST OF MACHINES	LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines In Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 7

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.34	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Part No.	Part Id.	Batch Size (BS)	No. Of Ops.	Priority	Cell

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.35	OUTPUT 7 - LIST OF SCHEDULED PARTS	LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines In Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 8

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.36	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Cart Dest. : Cart Origin : Cart # :

Capacity : Tools Held : St. Time : Fin. Time :

pocket #	Tool #	Life	Status	pocket #	Tool #	Life	Status

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.37	OUTPUT 8 - CELL TOOL TRANSPORTER SCHEDULE	LUT - FMS Research Group

1. Final PTS Contents
2. Final Tooling Details and Status Values
3. Machining History and Cell Performance Measures
4. Machine Activities
5. Cell Tool Transfer Activities
6. List Of Machines In Each Cell
7. List Of Scheduled Parts for Each Cell
8. Tool Transporter Contents and Schedule
9. Cell Tool Summary and Status Report

Select Option : 9

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.38	OUTPUT MODULE OPTIONS	LUT - FMS Research Group

Cell No : Run # :
Machines in Cell : Parts Scheduled :
Tools in Cell : Transporters :

Tools on Machine # : Capacity :

Tools in STS : Capacity : Spare Capacity :

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.39	OUTPUT 9A - CELL TOOLING DETAILS	LUT - FMS Research Group

Cell Tool Input :

Tools in Cell :

Worn Tools :

Refurbished Tools :

Added Tools :

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.40	OUTPUT 9B - CELL TOOL STATUS REPORT	LUT - FMS Research Group

1. Run Initialisation Module
2. Run Input Module
3. Run Model
4. Run Output Module

Select Option : 0 (QUIT)

Next Enter	Edit Screen CTRL-B	Hard Copy Shift-PrtSc	Prev. Screen P

Figure 2B.41	MAIN MENU	LUT - FMS Research Group

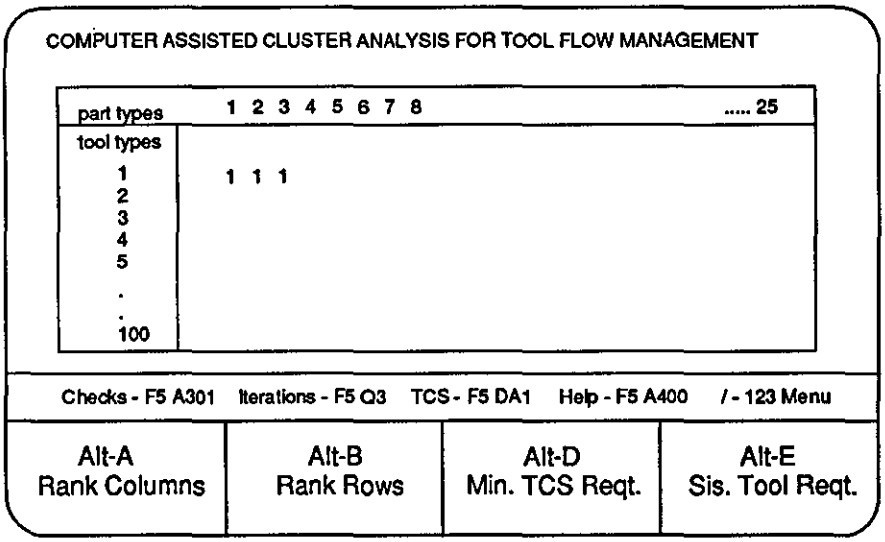


Figure 2B.42 | CACA MODULE - INITIAL ROC MATRIX | LUT - FMS Research Group

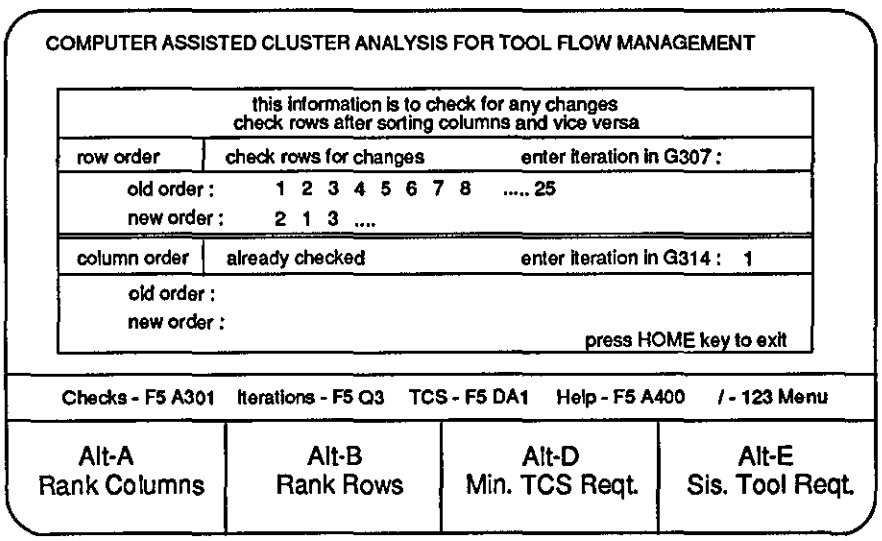


Figure 2B.43 | CACA MODULE - ROC CHECKING PROCEDURE | LUT - FMS Research Group

COMPUTER ASSISTED CLUSTER ANALYSIS FOR TOOL FLOW MANAGEMENT

batch size	1 1 2 1 1 1 1 1
part types	2 1 3 4 5 6 7 8 25
tool types 1 2 3 4 5 . . 100	 5 7 2

Checks - F5 A301 Iterations - F5 Q3 TCS - F5 DA1 Help - F5 A400 / - 123 Menu

Alt-A Rank Columns	Alt-B Rank Rows	Alt-D Min. TCS Reqt.	Alt-E Sis. Tool Reqt.

Figure 2B.44	CACA MODULE - CUMULATIVE TOOL TIMES AND BATCH SIZES (ORDER REQUIREMENT)	LUT - FMS Research Group

COMPUTER ASSISTED CLUSTER ANALYSIS FOR TOOL FLOW MANAGEMENT

Tool Type	Max % Use	Tool Life	Cum. Use	Min. Tools	Sis. Tools	Total Tools
1 2 3 4 . . 100						

Checks - F5 A301 Iterations - F5 Q3 TCS - F5 DA1 Help - F5 A400 / - 123 Menu

Alt-A Rank Columns	Alt-B Rank Rows	Alt-D Min. TCS Reqt.	Alt-E Sis. Tool Reqt.

Figure 2B.45	CACA MODULE - TOOL LIFE UTILISATION AND SISTER TOOL PREDICTIONS	LUT - FMS Research Group

machine description (s[10])

No.Of PTS's * No. Of Pots * Cell No. * Priority * No. Of Spindles (all of type i)

machine available time in minutes (r)

PTS indexing time in minutes (r)

F(ixed) or V(ariable) PTS tool complement (c)

F(ixed) or M(ovable) PTS (c)

next machine...

s[n] = string of length n c = character i = integer r = real

* = one blank space

Figure 2B.46	MACHINE DATAFILE FORMAT	LUT - FMS Research Group

part description (s[10])

part identity (s[10])

batch size * No. Of Operations * Priority * Cell No. (all of type i)

machine identity (s[10])

next part ...

s[n] = string of length n c = character i = integer r = real

* = one blank space

Figure 2B.47	PART DATAFILE FORMAT	LUT - FMS Research Group

tool description (s[10])

tool identity (s[5])

Y(es) or N(o) for oversize tool (c)

Y(es) or N(o) for Special tool (c)

tool life (r) * max % life (i) * regrinds (i) * Refurb. time (r)

next tool ...

s[n] = string of length n   c = character   i = integer   r = real

* = one blank space

Figure 2B.48	TOOL DATAFILE FORMAT	LUT - FMS Research Group

STS description (s[10])

cell no. * no. of compartments * min. tools exch. * max. tools exch.   (all of type i)

tool load time in minutes (r)

tool search time in minutes (r)

next sts ...

s[n] = string of length n   c = character   i = integer   r = real

* = one blank space

Figure 2B.49	STS DATAFILE FORMAT	LUT - FMS Research Group

part description (s[10])

Operation number (i)

machine identity (s[10])

operation time in minutes (r)

operation identity (s[10])

tool description (s[10])

next part ...

s[n] = string of length n   c = character   i = integer   r = real

* = one blank space

Figure 2B.50	ROUTE DATAFILE FORMAT	LUT - FMS Research Group

maximum number of orders	: 102
maximum number of machines	: 11
maximum number of activities	: 750
maximum number of pts pockets	: 123
maximum number of tool carts	: 5
maximum number of cells	: 2
maximum tool cart capacity	: 123
maximum cts capacity	: 1000
maximum sts capacity	: 4000

These limits may be increased or decreased in 'Global.Inc'

Figure 2B.51	ENTITY RESTRICTIONS	LUT - FMS Research Group

Appendix 3A:
A STAND-ALONE MACHINE
INDUSTRIAL CASE STUDY

3A.1 Introduction

The work reported here is the result of a case study carried out in close collaboration with Brush Electrical Machines, Loughborough. The purpose of the work was to provide a test bed for the single machine tool flow model to examine the effects of strategy and rule selection and to provide the company with a more substantial understanding of the tool flow problems and to provide some economic solutions for their proposed stand-alone machining centre. This section is based on the actual report provided for the company's perusal and action.

3A.2 Scope of the Study

The company had recently proposed the purchase of a flexible machining centre to be integrated within the current machining facility. With no historical data with which to specify working practices for this new machine, it was decided to model this machine and examine the following :

- tool magazine capacity and its contents at the start and end of a specified period.

- tool requirements, tool life utilisation and frequency of tool usage.

- machining schedules and activities.

- correlation between the assignment of successive tool kits.

- the relative merits of alternative control and operating strategies.

- manning patterns.

3A.3 The Single Machine Cell

The proposed cell consists of a stand-alone, single-spindle Toshiba BMC-80 horizontal machining centre with a 90-tool capacity primary tool store (PTS). This primary tool store is supplied with tools from tool shelves adjacent to the machine. These tool shelves in modelling terms constitute the secondary tool store or STS. Tools are exchanged between the PTS and the STS individually by a man and according to a specified schedule. The machine has a six-pallet buffer with each respective pallet accommodating a specified batch size of a particular type of component.

3A.4 Cell Parameters

The following parameters were specified for analysis and modelling :

planning or modelling period	: 1 shift of 480 minutes (8 hours)
part load/unload time	: 2 minutes
part transfer time	: 2 minutes
tool transfer time	: 1 minute
tool refurbishment time	: 2 minutes
tool exchange time, PTS	: 0.5 minutes
tool search time, PTS	: 0.33 minutes
max. tool life utilisation	: 80% of initial tool life
initial tool life	: as specified for individual tools
number of part types	: 3
batch size (pallet capacity)	: 3 pallets each of 1,16, or 4 components
tool exchange time, STS	: 1 minute
tool search time, STS	: 1 minute
tools exchanged at a time	: 1
tool load/unload stations	: 1
men (transporters)	: 1

3A.5 Operating Rules and Strategies

The following rules and strategies as described more fully in the main text of the thesis were selected for modelling :

3A.5.1 Tool Management Strategy

A *workpiece-oriented tool management strategy* was selected as being most appropriate for the operation of the cell, (see chapter ten). Thus, the number and type of tools is determined from the machining requirements of the parts spectrum introduced.

3A.5.2 Operation Assignment Rule

Two operation assignment rules were to be examined. These rules, see chapter fifteen, can briefly be restated as :

(i) rule #1 : complete all operations of a particular operation number on each batch item on a particular pallet before proceeding onto the next operation number.

(ii) rule #2 : complete all operations on each batch item on a particular pallet before proceeding onto the next pallet batch item.

3A.5.3 Part Sequencing

Six part sequences were to be examined. The starting sequence was specified by the company. The sequences shown in *table 3A.1* illustrate all possible permutations of the specified sequence.

Table 3A.1 : Part Sequences	
Sequence Number	**Sequence**
#1	1 - 2 - 3
#2	1 - 3 - 2
#3	2 - 1 - 3
#4	2 - 3 - 1
#5	3 - 1 - 2
#6	3 - 2 - 1
1=1315704, 2=1316106/04, 3=1326734	

3A.5.4 Tool Rationalisation Rule

Tools are rationalised according to the *machine rationalisation rule* (see chapters fourteen and fifteen), i.e tool redundancy has been eliminated across all tools which have been assigned for each part operation on each batch item to be machined on this particular machine with respect to the production schedule (machining list) for the given manufacturing period and in keeping with the specified tool life management rules.

3A.5.5 Tool Issue Strategies

Three tool issue strategies, see chapter eleven, were selected for examination:

(i) *strategy #1 - tool kit issue* : The issue of tool kits for a particular pallet of batch items as and when determined by the machining schedules.

(ii) *strategy #2 - single tool issue* : The issue of all required tools upto the capacity of the PTS, at the start of the manufacturing period and subsequent issue of single tool(s) irrespective of pallet assignment but with respect to the governing machining list.

(iii) *strategy #3 - modified tool kit issue* : Possible sharing of tools in successive tool kits .

3A.5.6 Tool Refurbishment Rule

Worn tools are removed from the machine at appropriate intervals. These tools are sent for refurbishment to the tool room via the STS, in predetermined quantities. 'New' tools are added to the STS as and when necessary to replace these worn tools. The tools are removed and replaced manually by the operator.

3A.5.7 Cell Tool Transport Rule

The tools are transported individually to the machine, according to the specified tool issue strategy. Tools may be added or removed while the machine is under automatic operation.

3A.5.8 Machine Loading

A specified number of loaded pallets are available at the start of the manufacturing period. Pallets may be rmoved upon completion of the scheduled pallet activity. As the schedule is static, no pallets may be added until completion of the current schedule.

3A.6 Discussion of Results

A general discussion of results follows, based on the volume of output generated from the computer modelling under the conditions described above. The tables of output generated for each menu selection of each modelling run are summarised in histogram form and shown in appendix 3B.

3A.6.1 Tool Magazine Capacity

An analysis of tool magazine capacity by examination of tool store contents before and after each tool exchange activity showed that for cell performance times ranging from 179.6 minutes to a maximum of 328.4 minutes, that no more than 32 tool pockets were required. This figure is dependent not only upon the number and variety of tools required to satisfy the given machining list, but also the tool issue strategy selected.

3A.6.2 Cell Tool Requirements and Tool Life Management

For the given list of three component types of batch sizes 1, 16 and 4 respectively, a tool requirement of 32 tools was estabilished under the machine rationalisation algorithm, not allowing for tool breakage but only tool wear. Assuming a maximum percentage tool life utilisation factor of 80% of initially specified tool life, only three tools could be said to be near or have reached this limit. Unexpectedly but highlighted through modelling, these were the 0051 (worm drill) and 0090 (ADX drill) tools. The most frequently used tools were found to be counter bores, taps and deburring tools. The remaining tool life, number of sister tools and frequency of tool usage are illustrated via histograms in *figures 3B.1 and 3B.2* .

3A.6.3 Machining History and Activities

The detailed analysis and history of all the machining activities under different operating conditions are illustrated graphically in *figure 3B.3* and *3B.4*.

3A.6.4 Cell Performance Measures

The time taken to complete the given machining list and a subdivision of the machining activities under different operation assignment and tool issue strategies is summarised in *tables 3A.2, 3A.3 and 3A.4* and also shown graphically in *figure 3B.5*.

Table 3A.2 : Cell Performance Measures (mins)
For Part Sequence 1-2-3

Operation Assignment Rule	Tool Issue Strategy	Cell Perform. Time	Machine Idle Time	Man Utilisation Times
* 1	1 (kits)	182.3	35.8	0-57, 57-102 137.7-178.7
1	2	207.2	66.0	2-133
2	1 (kits)	306.3	41.1	0-57, 57-102 240.7-281.7
2	2	328.4	66.0	2-133

* least performance time and least idle time due to tool changeover

Table 3A.3 : Cell Tool Wait Times (mins)
For Part Sequence 1-2-3

Operation Assignment Rule	Tool Issue Strategy	Total Tool Wait	Initial Tool Wait
1	* 1 (kits)	63.8	28.0
1	2	66.0	66.0
2	1 (kits)	69.1	28.0
2	2	66.0	66.0

* least tool wait time assuming operation assignment rule #1 is selected. Tool changeover only begins at commencement of last operation on last batch item on a particular pallet.

Table 3A.4 : Machining, SetUp and Part Load Times (mins) For Part Sequence 1-2-3				
Operation Assignment Rule	Tool Issue Strategy	Mach. + Tool Indexing Time	SetUp + Pallet Indexing Time	Part Load Times onto Machine
* 1	1 (kits)	122.0	7.2	6.0
* 1	2	122.0	7.2	6.0
** 2	1 (kits)	249.8	0.6	6.0
** 2	2	249.8	0.6	6.0
* least machining and tool indexing times ** least set-up and pallet indexing times				

3A.6.5 Relative Merits Of Alternative Operating Rules and Strategies

It is apparent, from *tables 3A.1 to tables 3A.4*, that operation assignment rule #1 provides a better utilisation with less idle time, than operation assignment rule #2. This is mainly due to the lower magazine indexing and tool change times in the former rule and greater tool indexing and exchange times in the latter. Although a greater amount of time is spent in pallet indexing under rule #1, this still provides a better result and outweighs this disadvantage.

Further examination of operation assignment rule #1 reveals that the issue of tool kits (i.e tool issue strategy #1) is a much better alternative than the issue of single tools (strategy #2). The reason for this improvement in performance lies in the fact that the tools in the PTS can be added, removed or replaced whilst the machine is under automatic operation. Hence the quicker the tools are loaded, the better is the performance attained. Under tool issue strategy #2, the machine cannot satisfactorily commence machining a particular part until all the tools are loaded as it is not immediately apparent to the tool loader which tools are to be loaded or removed first. This eliminates the advantage in loading tools whilst the machine is cutting, in manual tool loading and unloading situations (except for loading of tools for parts succeding the current part). The assignment of tool kits, in this instance, thus provides greater flexibility and is more manageable as it is dependent only upon the pallet being presented to the machine.

The tool kit is the set of tools required to process one part type. Two assumptions are made : firstly, that the part processing for a given pallet will not start until the correct tool kit is available. The use of tool kits then merely acts as a convenience to reduce the volume and complexity of the data to be maintained; secondly, an assumption is made with regard to tool refurbishment and replenishment. A tool kit will contain a variety of tools of different types and regrinding complexities. It therefore follows that the variation in the regrinding and replenishment times of tools will be much less than the variation that occurs if single tools are considered. Accordingly, it is reasonable to suppose that the operator would be assigned a standard time to process or load a tool kit. In view of this, this time can be assumed to be a constant. The tool kit concept in this instance thus provides a better performance, primarily due to a significant reduction of tool wait times.

3A.6.6 Correlation Between Successive Tool Kits

The assignment of tool kits being preferable to the assignment of single tools coupled with the fact that the loading of the smallest tool kit would enable the machine to start cutting as soon as possible; and thus reduce idle and performance times; correlation, if any, was sought between successive tool kits for each part sequence. It is apparent that some tools would be common across tool kits. The tools identified by tool number and arranged in technological sequence are shown in *table 3A.5* with the common tools highlighted.

Table 3A.5 : Required Tool Sequences		
Part No.	Tools	Required Tool Sequence
1	13	***1***-2-3-4-***5***-6-7-8-***9***-10-11-***12***-***13***
2	11	14-15-16-17-18-19-20-21-***9***-22-23
3	14	***1***-24-25-26-27-28-29-***5***-30-31-***9***-***12***-***13***-32
1=1315704, 2=1316106/04, 3=1326734		

The part number with the least tools in kit is selected to load first and the correlation with successive part types is examined. From *table 3A.5* it can be seen that part number 2 requires the least number of tools and hence only the sequences, in *table 3A.1*, commencing with this part number are selected for analysis. These selected sequences are shown in *table 3A.6*.

Table 3A.6 : Part-Tool Kit Sequences		
Sequence No.	Part Sequence	Tools in Kit Sequence
3	2-1-3	11-12-9
4	2-3-1	11-13-8
1=1315704, 2=1316106/04, 3=1326734		

Part sequence number three is selected, from *table 3A.6*, as the most appropriate machining sequence because part number one requires the second smallest tool kit. The results using this sequence is compared with that selected by the company for operation assignment rule #1 and for the tool kit issue strategy.

Table 3A.7 : Cell Performance Measures (mins) For Part Sequences 1-2-3 and 2-1-3				
Operation Assignment Rule	Tool Issue Strategy	Cell Perform. Time	Machine Idle Time	Man Utilisation Times
* 1	1	182.3	35.8	0-57, 57-102 137.7-178.7
** 1	1	179.6	37.8	0-49, 82.8-135.8, 135.8-176.8
* Part Sequence 1-2-3 ** Part Sequence 2-1-3				

Table 3A.8 : Cell Tool Wait Times (mins) For Part Sequences 1-2-3 and 2-1-3			
Operation Assignment Rule	Tool Issue Strategy	Total Tool Wait	Initial Tool Wait
* 1	1	63.8	28.0
** 1	1	61.8	24.0
* Part Sequence 1-2-3 ** Part Sequence 2-1-3			

Table 3A.9 : Machining, SetUp and Part Load Times (mins) For Part Sequences 1-2-3 and 2-1-3				
Operation Assignment Rule	Tool Issue Strategy	Mach. + Tool Indexing Time	SetUp + Pallet Indexing Time	Part Load Times onto Machine
* 1	1	122.0	7.2	6.0
** 1	1	122.0	7.2	6.0
* Part Sequence 1-2-3 ** Part Sequence 2-1-3				

3A.6.7 Manning Patterns

The manning patterns for operation assignment rule #1 under three alternative tool issue strategies is shown in *figure 3B.6* . The tool issue strategy labelled '*s1-Kits*' is selected as the most appropriate by the model because of the least machine idle time. The strategy labelled '*s1-all*' refers to the loading of individual tools at the start of the manufacturing period. This strategy was initially specified by the company. Strategy *'s1-kits'* provides a better alternative to *'s1-all'* but is less efficient than strategy *'*s1-kits'*. This is because the correlation between successive tool kits is not considered as is the case in *'*s1-kits'*.

The tool kitting concept, unlike the single tools concept allows time for pallet loading and unloading during the machining cycle, but this time allowance is dependent the number of pallets to be loaded/unloaded and the machining requirements of the current pallet. In the case of *'s1-all'* the operator (man) is kept continuously busy with tool loading till all tools are loaded and the machine can commence cutting. Hence, although this strategy provides better manageability in terms of division of tasks, such as pallet load, tool load, pallet unload/load, tool unload/load and so on and so forth, it is less efficient in the time taken to complete a given machining list. Therefore, if the tool kit issue strategy is employed, the man becomes a very critical factor in the activity cycle if only one man is assigned the tasks of loading and unloading the tools and pallets. This is as a result of the variation in times between loading successive tool kits and also the variations in actual times allowed, which in some instances may be insufficient to achieve this task and thus result in added man idle time.

Company policy as to labour usage and the possibility of a second man interacting with the first would need to be further examined if continuous operation is to be achieved across shifts or manufacturing periods, although in this case the performance time for the given machining list is well within the specified manufacturing period and sufficient time is available to load/unload all pallets.

3A.7 Summary of Results and Conclusions

The case study provided valuable insight into the selection of operating rules and strategies and provided a useful test bed for the single machine model. The following conclusions may be drawn from the case study :

3A.7.1 Selection Of Operation Assignment Rule

Operation assignment rule #1 is selected as the most appropriate and is particularly effective in situations where the batch size (pallet capacity) is high. In other circumstances, particularly in the case of *batch of one,* operation assignment rule #2 might provide a better solution.

3A.7.2 Selection of Tool Issue strategy

The differential kit concept or tool issue strategy #1, provides a better alternative than the assignment of single tools (tool issue strategy #2). The tool kit concept copies the approach conventionally used in job shops, and is particularly suited in differential kit form to this situation, where different parts are machined in fixed sequences.

The assignment of single tools is more progressive in the sharing of identical tools among several batches of parts and is based on group technology principles. A chosen mix of parts is delivered to the machining centre in a fixed period of time and this part mix is serviced by a rationalised tool complement. This strategy has not been selected in this case because, as proved, it suffers from large tool wait times.

3A.7.3 Selection Of Machine

The selection of a tool issue strategy directly affects the selection of an appropriate machining centre or vice versa, as discussed in the main text. The single tools issue strategy calls for a large tool magazine capacity (80-140 tools), similar to the machining centre under consideration, The Toshiba BMC-80; and is more suitable for high volume - mid-variety part mix. Tool issue strategy #1 calls for a very different type of machine, where the tool magazine is of a lower capacity, possibly removable and transportable. This type of machine such as the Marwin Automax machine found at British Aerospace in Preston (see chapter two), finds its application in the area of low volume - high variety production. A newer machine perhaps more suitable for the suggested differential kitting strategy which finds its application in the mid-volume - mid-variety production area, would be of the type offered by the Okuma Design Concept (see chapter two). This machine would provide a transportable magazine (differential kit) supplying a fixed fixed primary tool magazine. This type of machine would combine the advantages of the two previously described machining centres and the flexibility in choice of strategies and rules for particular situations but demand a higher degree of tool flow automation.

3A.7.4 Selection of Part Sequence

The determination of an optimum part sequence with respect to the correlation between successive tool kits is a critical factor in the time taken to complete a given parts list. This part assignment depends for its effectiveness upon the availability of sufficient pallets and fixtures.

3A.7.5 Manning

The possibility of a second worker interacting with the first in the tasks of tool and pallet loading and unloading may be necessary, given the choice of machine and if more pallets are considered than those included in the given parts list.

3A.7.6 Tool Life Utilisation

The choice of a maximum percent tool life utilisation would require further examination as it would significantly effect the determined tool requirement. This analysis was not carried out in this case because the emphasis of the study was to be the selection of appropriate operating rules and strategies.

3A.7.7 Integration of Other Machines

Emphasis has been laid on the analysis of different control rules and operating strategies which may be applied for the effective operation of the stand-alone machining centre. If other machines are to be in parallel with this machine in a conventional FMC configuration or even if this machine is to run unmanned for extended periods, it is necessary to plan for tool and part storage and their transfer. Two basic alternatives can be used for providing this storage, that is by interstage buffers at each machine or a common storage which is accessible by all machines. Some systems employ both common and local storage. Manning, transfer and control strategies rules and strategies, for all these various configurations would need to be evaluated.

Appendix 3B:

RESULTS AND FIGURES

STAND-ALONE MACHINE INDUSTRIAL CASE STUDY

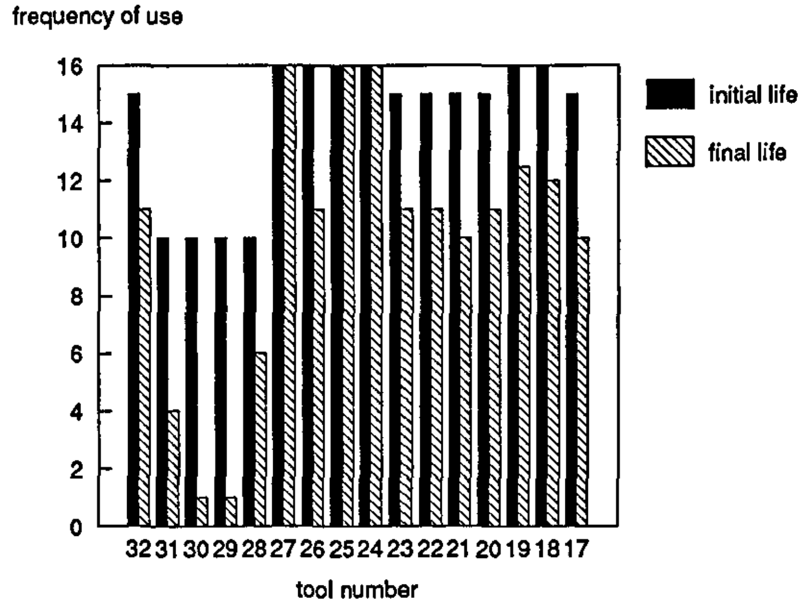


Figure 3B.1	TOOL LIFE UTILISATION	LUT - FMS Research Group

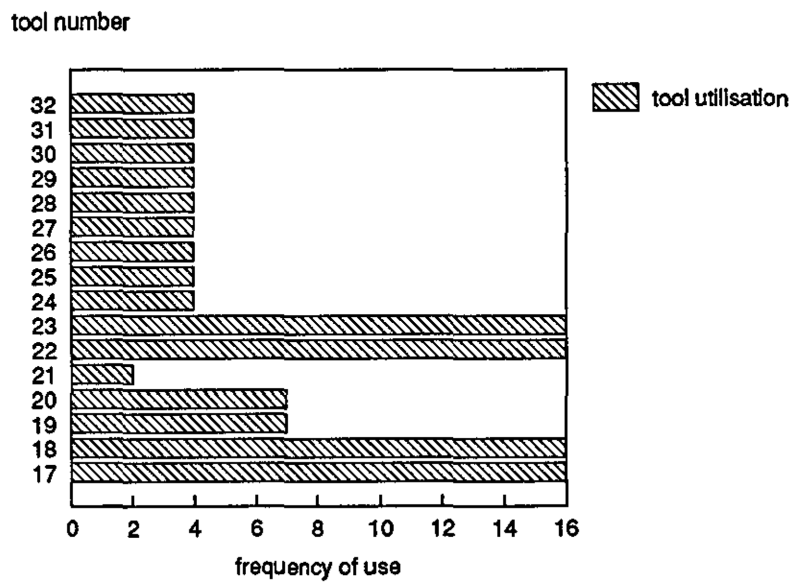


Figure 3B.2	TOOL UTILISATION	LUT - FMS Research Group

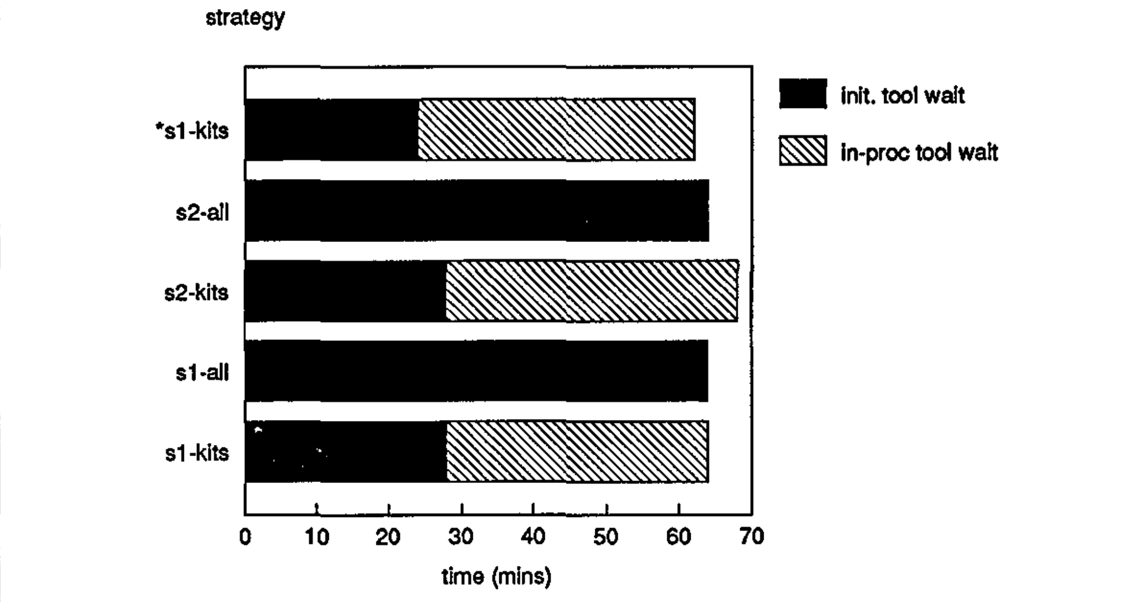


Figure 3B.3

CELL TOOL WAIT TIMES

LUT - FMS
Research Group

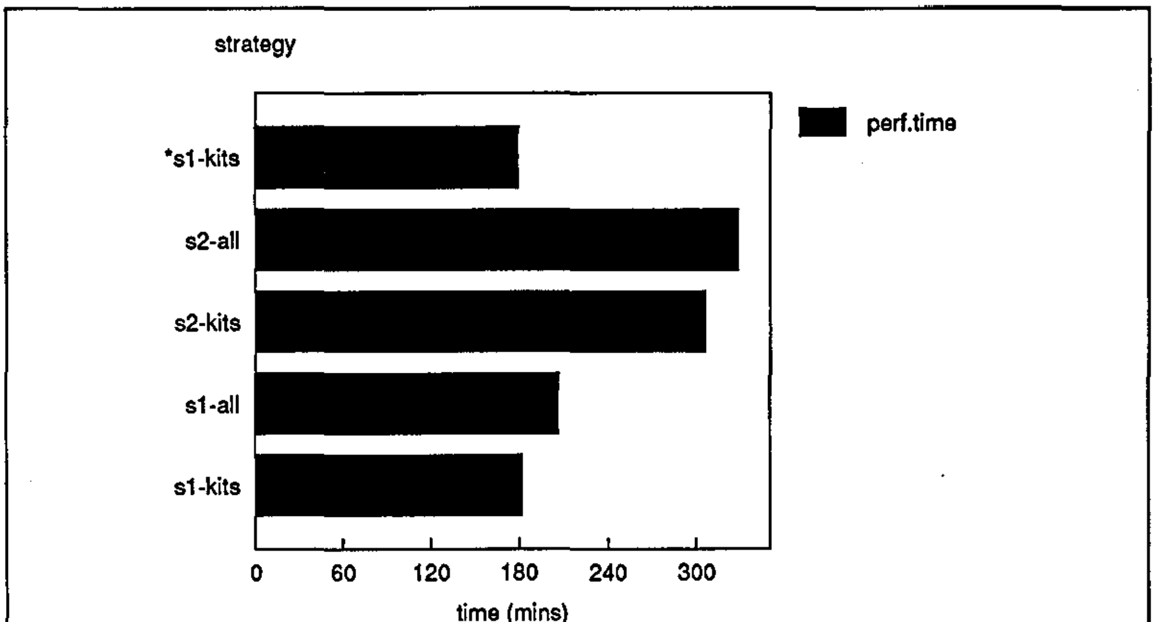


Figure 3B.4

STRATEGY PERFORMANCE TIMES

LUT - FMS
Research Group

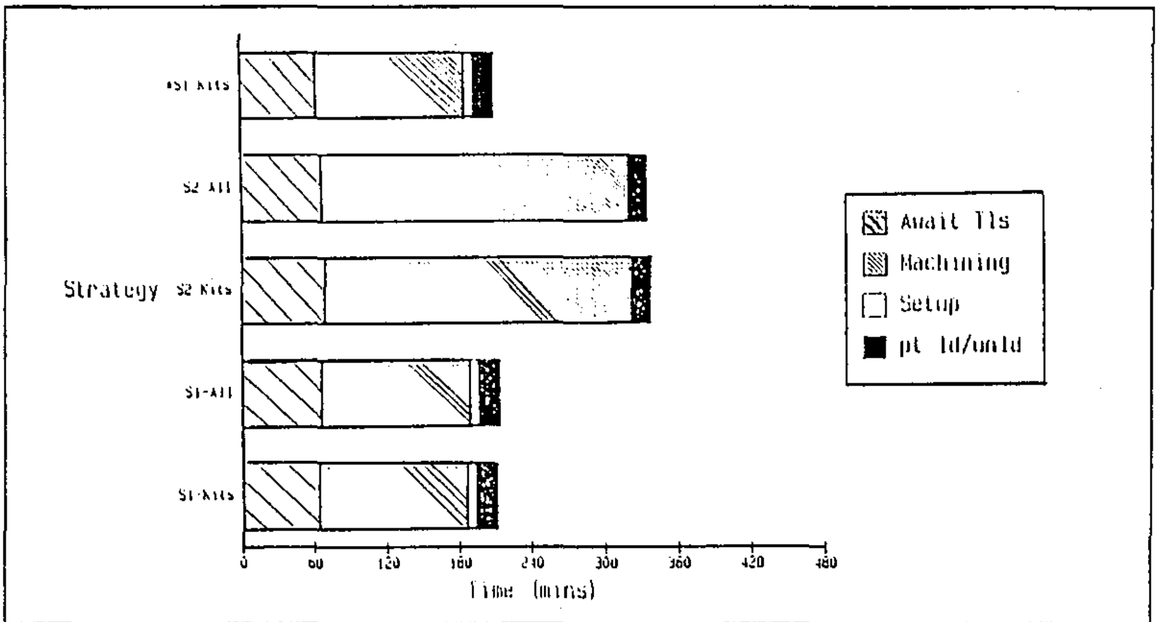


Figure 3B.5	BREAKDOWN OF MACHINING ACTIVITIES	LUT - FMS Research Group

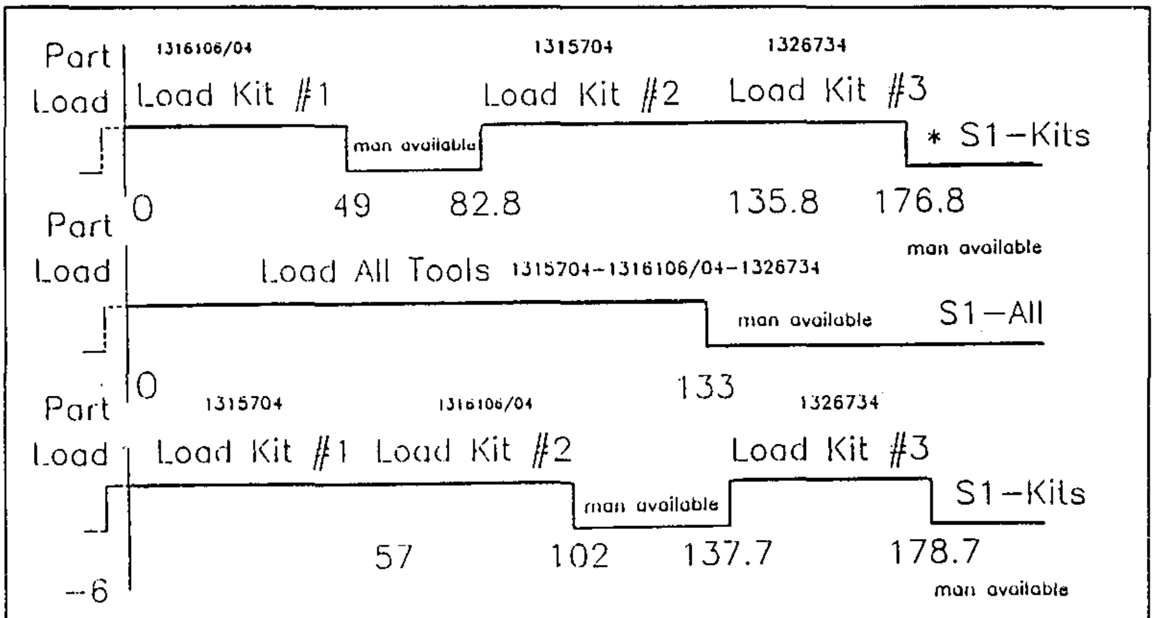


Figure 3B.6	MANNING PATTERNS OPERATION ASSIGNMENT STRATEGY #1	LUT - FMS Research Group

Appendix 4A:
A SINGLE CELL
INDUSTRIAL CASE STUDY

4A.1 Introduction

The work reported here is the result of a case study carried out with data supplied by Cummins Engine Company, Daventry. The purpose of the work was to compare and examine the tooling requirements generated under each of the two tool management strategies identified; viz. workpiece-oriented and tool-oriented.

4A.2 Scope of the Study

The company had recently purchased a flexible machining cell to be integrated within the current machining facility. The cell was commisioned during 1987 and replaced a number of manual and N.C machines. The cell based on Makino machining centres was set up to run on detailed analysis carried out by the suppliers. The scope of the study was to examine the basis of this analysis and to explore, by modelling over a 24-hour period, the relative merits and flexibilities under either of the tool management strategies.

4A.3 The Three Machine Cell

The cell comprises of three Makino MC1210 horizontal machining centres, see *figure 4B.1*, serviced by a rail guided pallet transporter. Work fixturing and defixturing is performed manually at either of the two load/unload stations, see *figure 4B.3*.

Each machine is equipped with a 123 tool capcity tool magazine or primary tool store. Tool change between the PTS and the spindle is performed by a double ended arm which selects the required tool from the magazine whilst machining is in progress, then changes the tool when the spindle has stopped.

The cell can accommodate upto 22 pallets on each of which a single component-specific fixture may be permanently mounted. Pallet interchange between the pallet transporter and machines executed via a pallet changer. This provides a buffer area so that the machine need not be kept waiting for the vehicle befor part load/unload can take place.

The cell uses six pallets, one for each of four part families and two for the fifth family. The operating strategy is such that a fully machined part is obtained for each visit to a machine. Workflow within the cell is carried out by a pallet transfer vehicle. Other supporting activities such as fixturing, defixturing, inspection and cleaning is wholly manual. Tool transfer, loading and unloading is also carried out manually.

4A.4 Cell Parameters

4A.4.1 Part and Pallet Requirements

The cell produces five families of parts. A fixed number of parts from each family are required for every engine. Therfore cell output, over a specified period can be reliably predicted. The majority of components produced are from a basic set of seven parts, a sample database entry shown in *figure 4B.2* . One part has been split up into two because it entails two visits to a machine. *Table 4A.1* shows the quantities required for a 24 hour period and the pallet type required for each part type.

Table 4A.1 : Part Requirements

Part Type	Quantity/Day	Pallet Type
1	4	1
2	4	1
3	8	2
4	8	3
5	5	4
6	3	4
7	4	5
8	4	6

4A.4.2 Machining List

A requirement for the operation of the model under the workpiece-oriented tool management strategy is that a prescheduled machining list is required to be set up for each machine to work to over the modelling period. This machining list was obtained from running the part flow Emulator of a parallel research programme under FIFO scheduling conditions. A description of this emulator is given in the literature survey. The output from the emulation run generated the machining list for the cell as given in *table 4A.2* . The total number of parts entering over the modelling period were found to number 40.

Table 4A.2 : Machining Lists by Part Type (partnumber)		
Machine 1	**Machine 2**	**Machine 3**
5 (1)	3 (13)	1 (29)
7 (2)	4 (14)	8 (30)
5 (3)	3 (15)	1 (31)
7 (4)	4 (16)	8 (32)
5 (5)	3 (17)	1 (33)
7 (6)	4 (18)	8 (34)
5 (7)	3 (19)	1 (35)
7 (8)	4 (20)	8 (36)
5 (9)	3 (21)	2 (37)
6 (10)	4 (22)	2 (38)
6 (11)	3 (23)	2 (39)
6 (12)	4 (24)	2 (40)
	3 (25)	
	4 (26)	
	3 (27)	
	4 (28)	
12 assignments	16 assignments	12 assignments

4A.4.3 Tool Flow Parameters

The tool flow parameters necessary for the operation of the workpiece-oriented tool management strategy are shown in *figure 4B.4* . Only a subset of these parameters is necessary for the Computer Assisted Cluster Analysis (CACA) Module which determines the clusters necessary for operation of the tool-oriented tool management strategy.

The inputs to the CACA module are based on group technology principles and the requirements of the Rank Order Clustering (ROC) algorithms, see chapter seventeen. The eight basic parts are entered along the primary row and the one hundred basic tools along the primary column. '1' entries indicate the tool types (basic tools) used on each part type not necessarily in order of technological precedence.

4A.5 Summary of Results

A general discussion of results follows, based on the output generated from the computer modelling and from the CACA module. The tables of output generated for each menu selection of the modelling run under the workpiece-oriented strategy is presented in appendix 4B, and the iterative stages of ranking of rows and columns and the final determination of tool cluster sets under the tool-oriented tool management strategy within the CACA module is shown though a series of stages in chapter seventeen (figures 17.9 to 17.17).

4A.5.1 Workpiece - Oriented Tool Management

A summary of the results obtained from the modelling run is given in *figure 4B.5* . It was found that a maximum of fifty-eight tools was required on any one machine over the twenty-four hours and that very little tool flow was evident, because all of the cutting tools necessary for the machining of the parts could easily be accommodated within the 123-tool capacity magazines. As all the tools were to be loaded into the magazines at the start of the manufacturing (modelling) period, added to the fact that only one server position is available at the secondary tool store accounted for the large stepped delays at the start of the production cycle at each machine.

The total number of tools required to satisfy the machining lists was determined as one-hundred and forty-five. No *New* tools had to be created to account for delays in the transportation network as an adequate number of tools and their transporters were available. The utilisation of the tool transporters was fairly low, ranging from 23.86% to 33.3%, in comparison to the times taken to complete the given machining lists. Thus it was found that with these fairly low utilisations the operators could easily perform tool load and unload as well as service the part load / unload stations.

Only one tool was found to be worn on completion of all the machining lists, although a number of tools, not classed as worn, possessed tool life insufficient for further machining.

4A.5.2 Tool - Oriented Tool Management

The initial ROC matrix set up for eight part types an 100 basic tools produced after three row and three column iterations some cluster formations, at this stage no further ranking of rows or columns was possible as confirmed by the checking routines. Scrutiny of the ROC matrix after the first set of iterations, shows that either of two cluster set formations are possible. These are shown in *table 4A.3* .

Table 4A.3A : Cluster Set Formation #1		
Tool Cluster Set #	**Parts In Cluster**	**No. Of Basic Tools**
1	2 - 1 - 3 - 4	49
2	8 - 7 - 5 - 6	50
Table 4A.3B : Cluster Set Formation #2		
Tool Cluster Set #	**Parts In Cluster**	**No. Of Basic Tools**
1	2 - 1 - 3	41
2	4 - 8 - 7	28
3	5 - 6	35

Either of the cluster set formations are suitable. An arbitrary choice was made to select cluster set formation #2. In order to achieve this formation a number of tools were deselected from the analysis to force formation of clusters, and after further row and column iterations, the three tool cluster sets are obtained. The removed tools are reinstated within each tool cluster set to give a fully ranked final matrix.

It can be seen from *table 4A.3* that the number of basic tools required is 104. The substitution of the entries with accumulated tool usage time for each tool type on each part and subject to the order requirements given in *table 4A.1* is given in *table 4A.4*.

Table 4A.4 : Tool Cluster Set
Basic and Total Tool Requirements

Tool Cluster Set #	Basic Tools	Total Tools
1	41	50
2	28	39
3	35	49

4A.6 Discussion of Results

The tabular and graphical results presented in appendix 4B and in chapter seventeen can be discussed under the following categories :

4A.6.1 Magazine Capacity

From the results it is apparent that two very different magazine capacities and the associated number of tools required arise from usage of a particular tool management strategy. Given the company requirement that a part should be able to be processed on any two out of the three machines, then it becomes necessary, under tool-oriented tool management to have a magazine capacity of around 41 tools, i.e the size of the largest tool cluster set with only basic tool type included, upto a maximum of 104 tools, i.e the size of all the clusters, plus some specified capacity to allow for sister tool placement.

Under the workpiece-oriented tool management and with the same constraint as previous, no more than 58 tools were ever used on any one machine over the 24 hour period. The selection of the large tool tool magazine capacity of 123 for each one of the Makino machining centres can thus be assumed to be based on the maximum flexibility provided by tool cluster analysis. This should not lead one to the conclusion that tool-oriented tool management requires large tool magazine capacities. This large capacity would be required if tool changeover were to be minimised particularly in cases where manual tool replacement and replenishment takes place as is true in the said cell. This is also true for the workpiece-oriented system. Smaller magazine capacities could be specified in this instance for the workpiece-oriented system and in the case of the tool-oriented system then priority hysteresis, see chapters ten and eleven, could be applied to minimise tool cluster set changeovers. The capacities suggested under the two strategies are given in *table 4A.5*.

Another observation made is that the number of tools required differs under both tool management strategies. The tool-oriented system produces a requirement of 138 tools whereas the workpiece-oriented system produces a requirement of 145. The requirements differ for several reasons not least of which is the assignment of clusters or single tools. Other reasons include flow and transport requirements, machine selection and part assignment to the machines.

Table 4A.5 : Basic and Total Tool Requirements for Workpiece or Tool Oriented Strategies			
Tool-Oriented Strategy		Workpiece-Oriented Strategy	
TCS #	Basic (Total) Tools	Machine #	Total Tools
1	41 (50)	1	58
2	28 (39)	2	46
3	35 (49)	3	41
Suggested Capacity 41 (50)		Suggested Capacity 58	

4A.6.2 Flexibility of Routing

The issue of flexibility of routing is paramount in choosing which of the tool management strategies to select. The workpiece-oriented strategy particularly operating under the machine rationalisation algorithm is inflexible in terms of assignment and sequencing of parts to the machines. This is because the strategy is based invariably on a static prescheduled machining list for each machine. The tool-oriented strategy is much more flexible and well suited to dynamically scheduled environments as it is insensitive to sequencing of parts to a machine which has the required tool cluster set so long as the part assigned are contained within the cluster set of parts which gave rise to the tool cluster set. This situation was obviously desirable to Cummins as they were particularly cautious about machine breakdown and laid the prerequisite that every part should be able to be assigned to either of two machines. This strategy thus becomes effective in dynamically changing environments and is not suited to situations where prescheduled work-to lists is the norm, except in the case of breakdowns which are handled as exceptions rather than as planned situstions.

Having thus decided on the suitability of a tool-oriented tool management strategy, a further study was carried out to analyse the company specification of alternative machines for each part type. This is given in *table 4A.6* . Scrutiny of this table and investigation of the basic tool contents of each tool magazine specified in the Cummins Makino cell revealed that two *cluster sets* were present as shown in *table 4A.7.* This result coincides with that obtained from the CACA module, shown in *table 4A.8* , and confirmed that the operation of the cell was based on tool cluster analysis carried out by Makino who are exponents and practitioners of this technique.

Table 4A.6 : Company Part Assignments			
Part #	Machine #1	Machine #2	Machine #3
1	-	*	*
2	-	*	*
3	*	*	-
4	*	*	-
5	*	-	*
6	*	-	*
7	*	-	*
8	*	-	*
* = possible machine			

Table 4A.7 : Company Tool Cluster Set Assignment		
Tool Cluster Set #	Part Capability	Machines
1	2 - 1 - 3	2 - 3
2 (2,3)	4 - 7 - 8 - 5 - 6	1 - 3

Table 4A.8 : CACA Results - Tool Cluster Set Assignment		
Tool Cluster Set #	Part Capability	Machines
1	2 - 1 - 3	2 - 3
2	4 - 7 - 8	1 - 3
3	5 - 6	1 - 3

4A.6.3 Tool Economy

Tool economy is practiced under both tool management strategies but in different forms. Under the workpiece-oriented strategy a machine rationalisation algorithm is employed to eliminate unnecessary tool duplication and to ensure that sufficient tools are present at the outset to service the given machining lists. A different picture arises under the tool-oriented strategy. Tool economy here is based on multiple cluster assignments to a single machine at one time. This combination of clusters, shown in *table 4A.9*, is thus necessary to service the requirements as specified by the company in *table 4A.6*. As parts 3 and 4 are of the same type, the basic tools for 3 and 4 would have to be added to machines 1 and 2 respectively to complete the tool cluster set.

Table 4A.9 : Cluster Set Combinations on Machine			
TCS #	Machine #1	Machine #2	Machine #3
1		*	*
2	*		*
3	*		*

When clusters are combined the minimum cluster size is the number of basic tools contained in the merged cluster plus the rationalised, not added, number of sister tools. In the extreme all of the clusters may be combined as is the case for machine number 3, to give added routing flexibility.

Tool economy through combination of clusters has two added advantages : firstly, they allow machining to continue with the overlap of tools, if any, between clusters thus minimising the downtime occassioned by tool cluster set changeover; and secondly, magazine capacity permitting, if all clusters can be accommodated within a single magazine not only is flexibility enhanced through having the ability to machine any part type but also tool changeover is reduced to tool replenishment of sister tools for the basic tool types. This greatly simplifies the tool management when the cell operates in this resident kit mode.

4A.7 Concluding Remarks

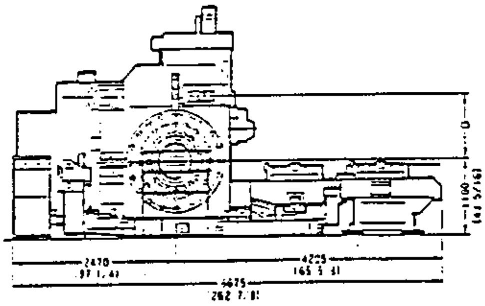
The cluster set assignments are based on the assumption that whole part machining is performed at each visit to a machine. This was the case specified by Cummins. Different cluster sets might arise if each part type had to make several visits to a machine or to several machines. The clusters would then have to be derived from grouping of operations or even suboperations rather than of whole parts.

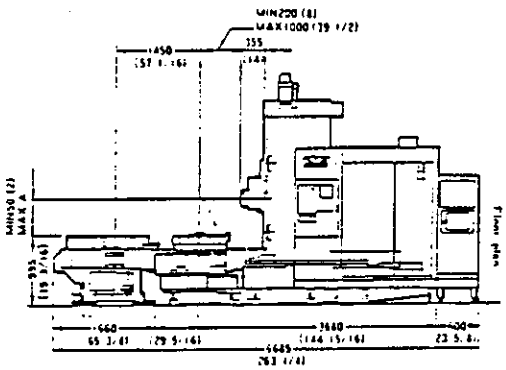
The three machine study has recently been extended to study a five-machine cell and to run over a longer time period. The three-machine cell was also validated in an exercise in comparison against the Emulator for part flow (248) and a knowledge-based model for part and tool flow (316). The results were found to be consistent and reliable across all three models and computing hardware. The number of tool transporters used differed in the case of the knowledge based model, but this did not significantly effect the results as very little tool flow was evident in any case. A further more detailed comparison is being carried out for the five-machine cell. This is reported in two forthcoming theses by the authors who developed the respective models. The results of the comparison for the three-machine model are shown for workpiece-oriented tool flow in *figure 4B.6* through to *figure 4B.15*.

Appendix 4B:

RESULTS AND FIGURES

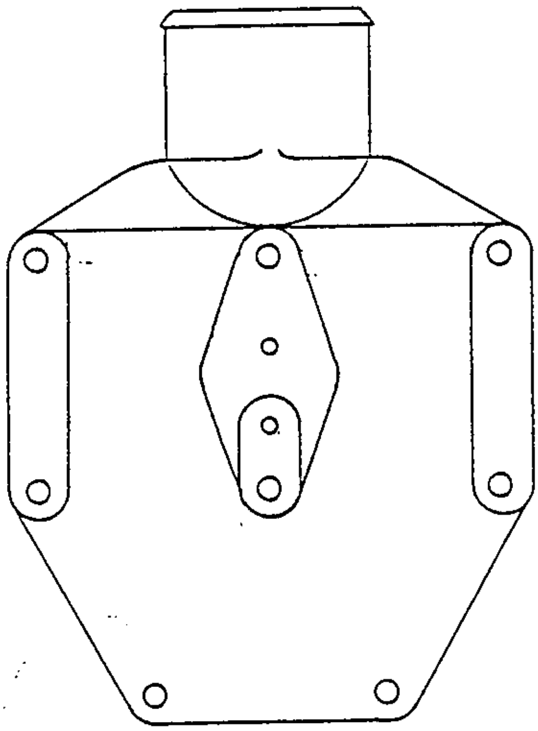
SINGLE CELL INDUSTRIAL CASE STUDY





machine number :	1,2,3
machine desc. :	MC1210
machine id. :	MC1,MC2,MC3
prim. stores :	1
PTS capacity :	40
PTS index time :	0.5
tool exchange time :	0.26
cell number :	1
priority :	1,1,1
tool complement fixed/variable :	V
PTS fixed/movable :	F
number of spindles :	1
number of type in cell :	3
machine load time :	1
machine unload time :	1
buffer type :	dual pallet exchange
buffer load time :	0.27
buffer unload time :	0.27

Figure 4B.1	A TYPICAL DATABASE ENTRY FOR A MACHINE (MC1210) IN THE 3-MACHINE CELL	LUT-FMS RESEARCH GROUP



Op.	Time	Op.Desc.	tool id
1	16	rough&fin	0001
2	3	9.5 drill	0012
3	7	roughbore	0053
4	8	finbore	0054
5	13	29/64dr	0049
6	3	3/4 dr	0046
7	2	3/4taperR	0047
8	1	3/4TaperT	0048

total machining time for 3035844 = 53 min.

Figure 4B.2	A TYPICAL DATABASE ENTRY FOR A WORKPIECE IN THE 3-MACHINE CELL	LUT-FMS RESEARCH GROUP

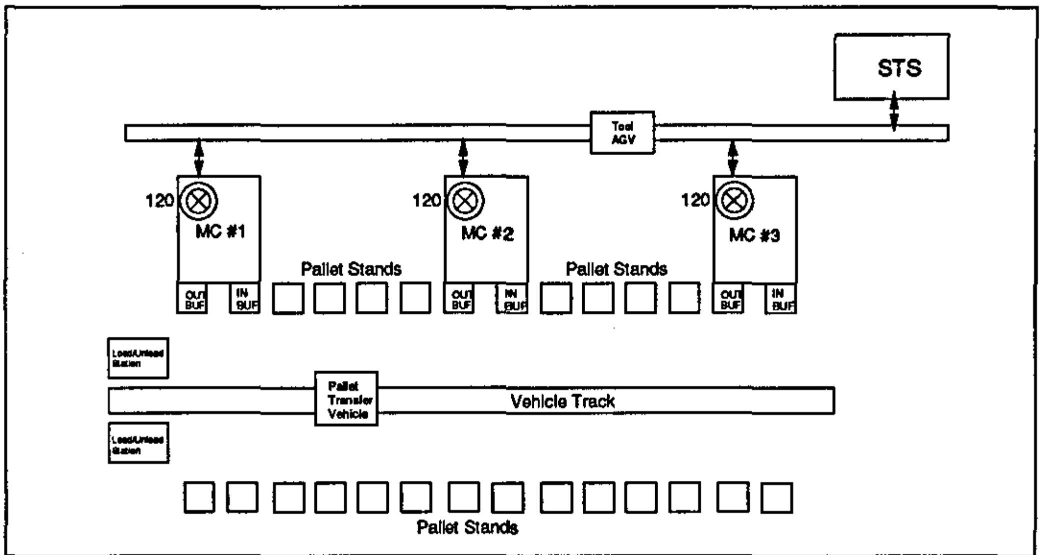


Figure 4B.3	CUMMINS CELL AT DAVENTRY	LUT - FMS Research Group

TOOL MANAGEMENT	WORKPIECE-ORIENTED
PLANNING HORIZON	24 HOURS (1440 MINUTES)
PART ASSIGNMENT	BY MACHINING LIST
TOOL ISSUE	SINGLE TOOL(s)
CELL PARAMETERS	3 MACHINES 120 TOOL PTS ON EACH - MUTUALLY EXCLUSIVE TOOL AND PART FLOW - STS OF UNLIMITED CAPACITY - 3 TRANSPORTERS (MEN) - 1 STS SERVING POINT
OP. ASSIGNMENT	ALL ITEM OPERATIONS
TOOL MANAGEMENT	PERMISSIBLE LIFE 90% - TOOL LIFE AS SPECIFIED - REFURBISHMENT IN-HOUSE - MACHINE RATIONALISATION
TOOL ASSIGNMENT	MINIMUM TOOLING REQT> ASSIGNED TO STS

Figure 4B.4	TOOL FLOW MODEL SYSTEM PARAMETERS	LUT-FMS RESEARCH GROUP

Machine No.	1	2	3
No. of Tools on Machine	58	46	41
Tool Numbers Req'd	1-58	59-104	105-145
Start	0.3	2.3	4.3
Tool Wait at Start	239.8	626.8	951.8
Finish Last Acticity	1543.1	1980.6	1890.8
Parts Assigned	1-12	13-28	29-40
AGV Used	3	2	1
Performance Time	1303.3	1353.8	934.7

Total Tools Req'd: 145

Worn Tools: 1

Added Tools: 0

Figure 4B.5	TOOL FLOW MODEL SUMMARY OF OUTPUT	LUT-FMS RESEARCH GROUP

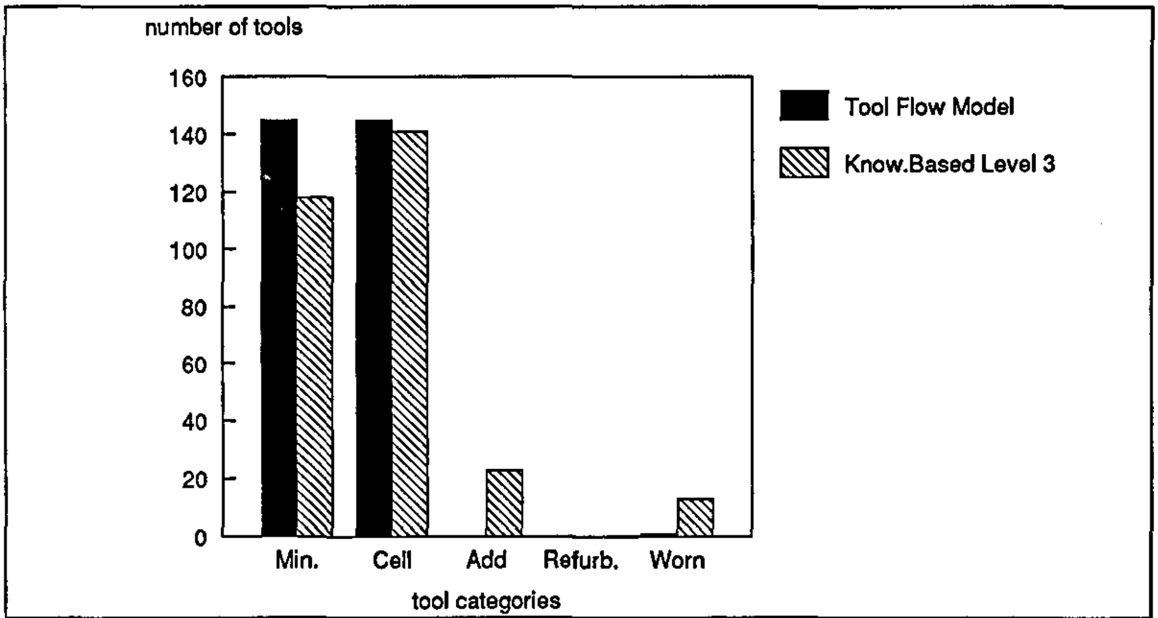


Figure 4B.6	'24 HOUR' CELL TOOL REQUIREMENT	LUT - FMS Research Group

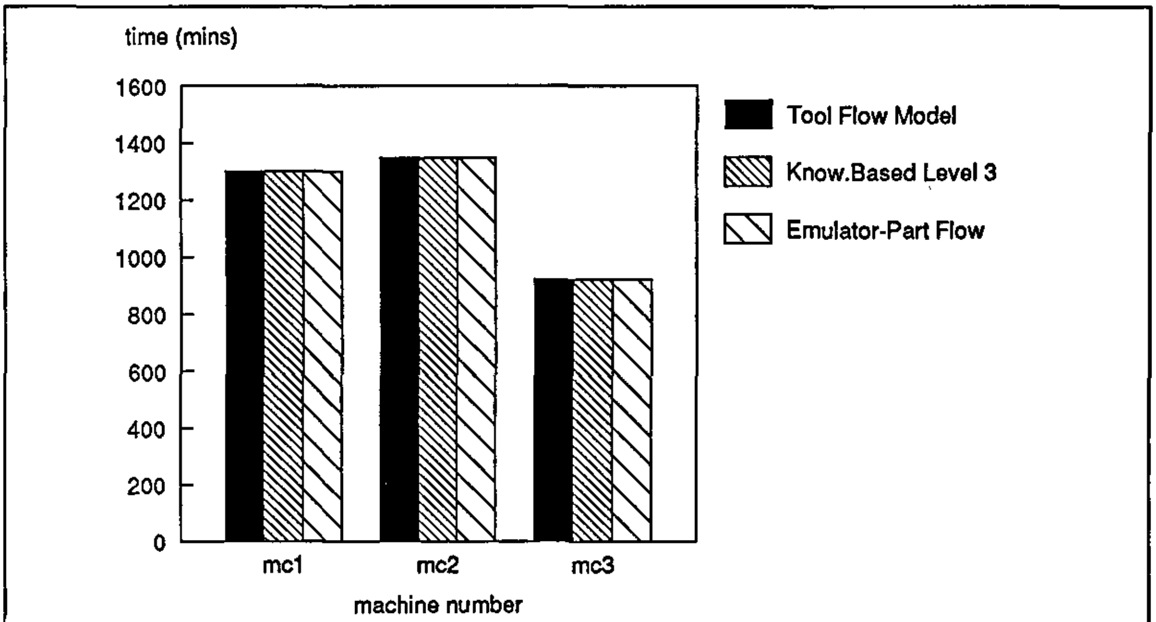


Figure 4B.7	'24 HOUR' CELL PERFORMANCE TIMES	LUT - FMS Research Group

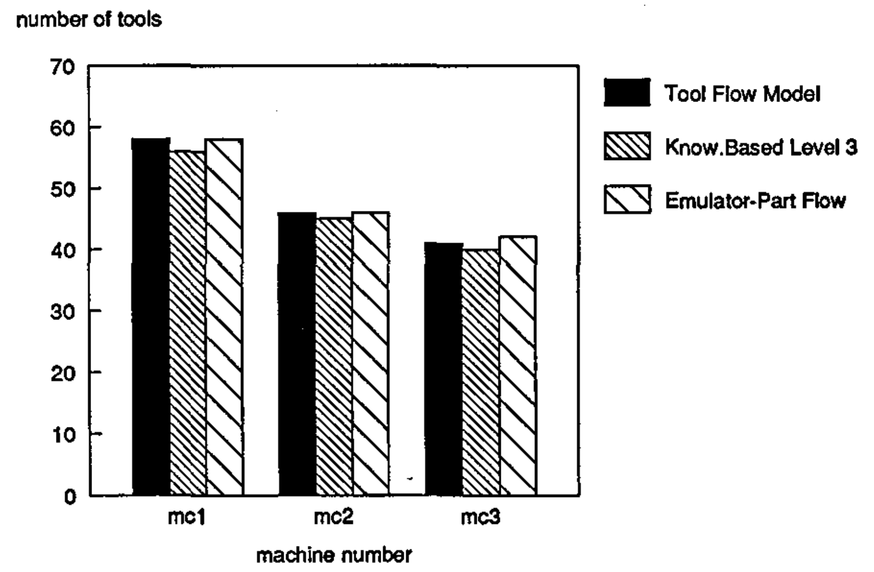


Figure 4B.8	'24 HOUR' TOOL UTILISATION	LUT - FMS Research Group

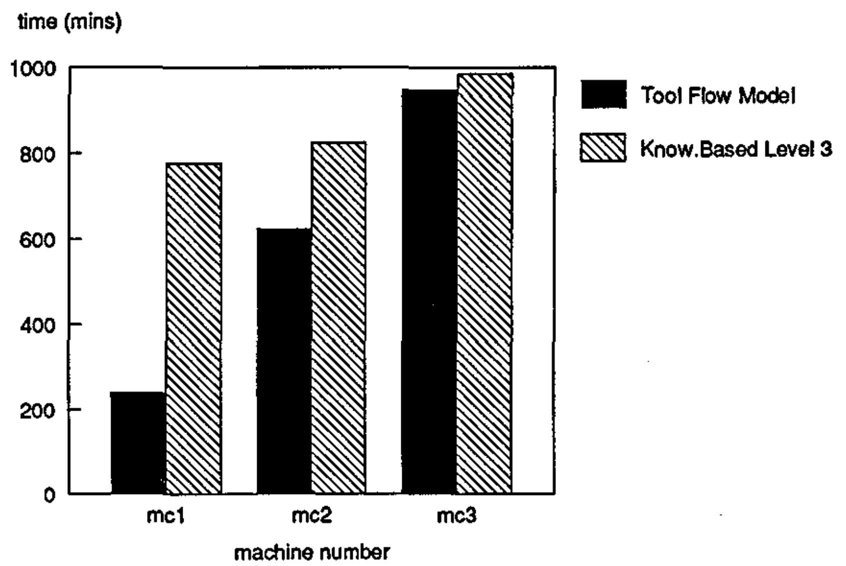


Figure 4B.9	'24 HOUR' CELL TOOL WAIT TIMES	LUT - FMS Research Group

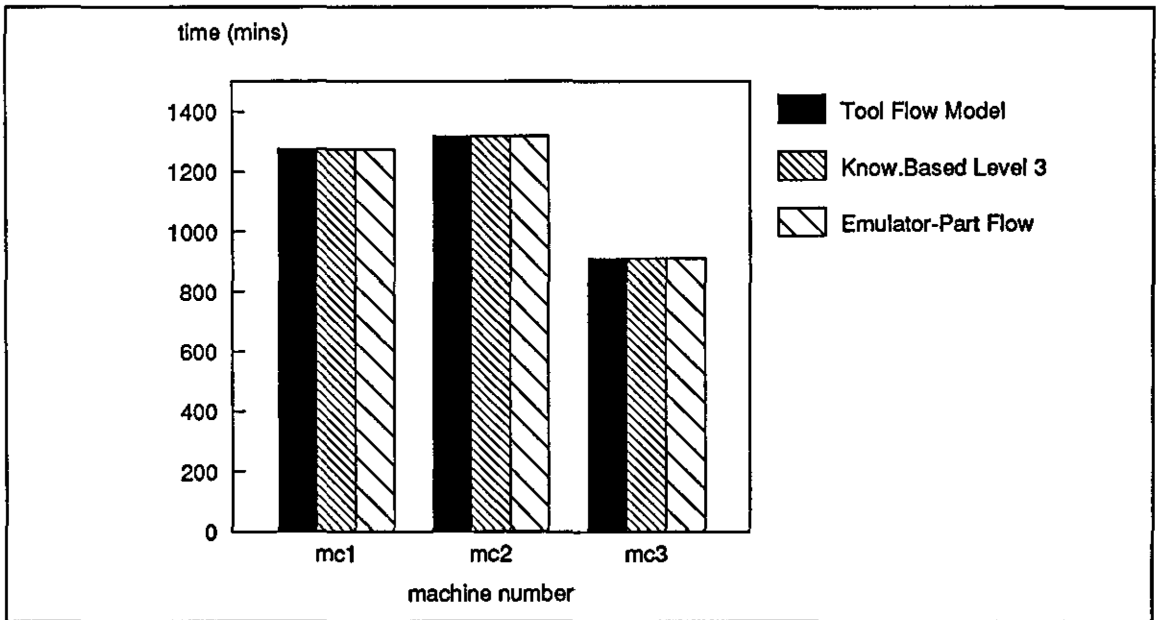


Figure 4B.10	'24 HOUR' MACHINING TIMES	LUT - FMS Research Group

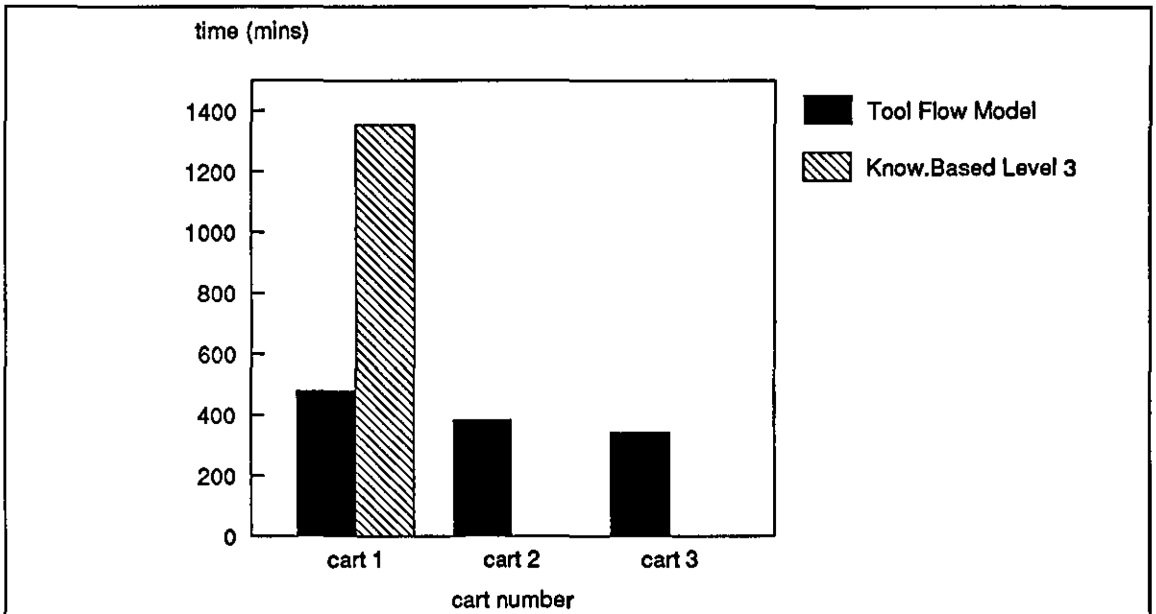


Figure 4B.11	'24 HOUR' TOOL TRANSPORTER TIMES	LUT - FMS Research Group

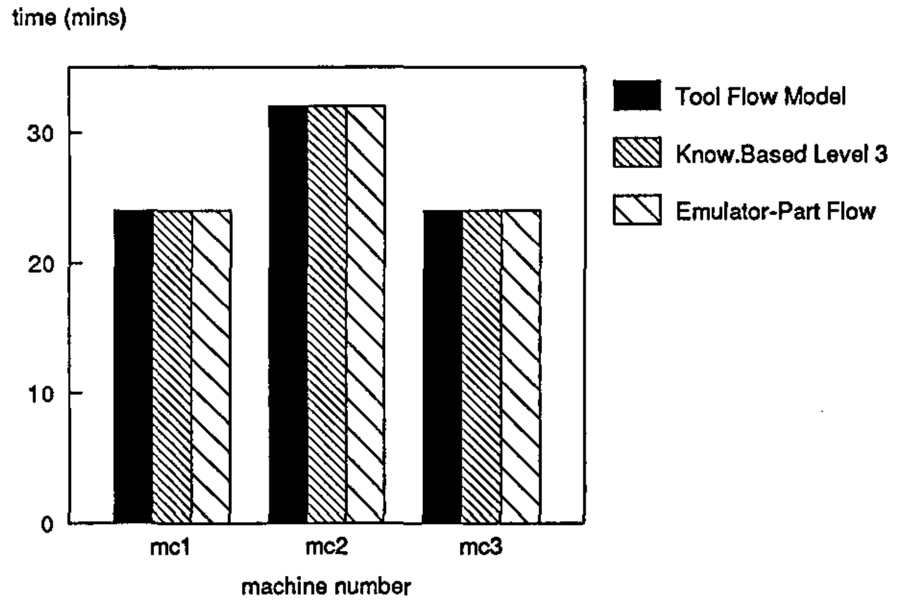


Figure 4B.12	'24 HOUR' PART LOAD / UNLOAD TIMES	LUT - FMS Research Group

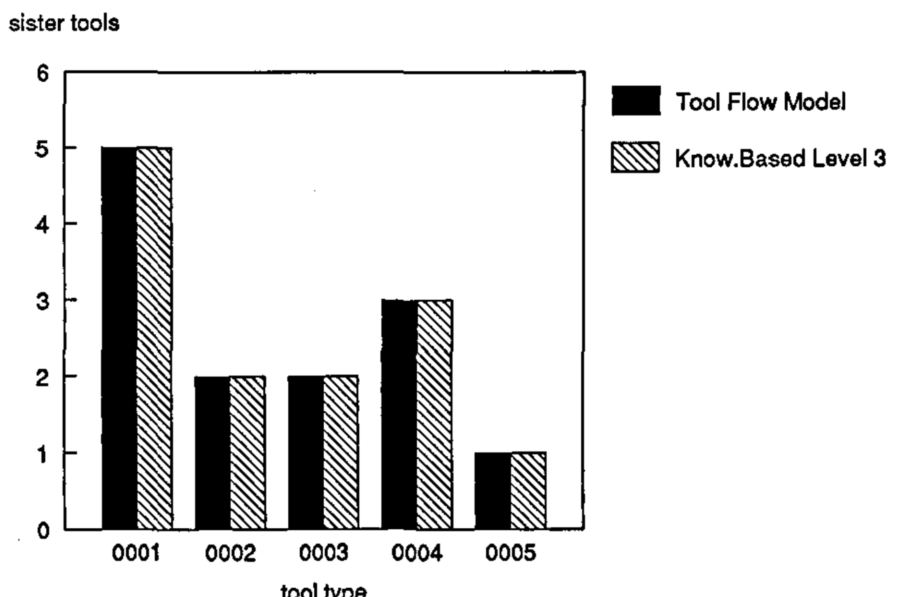


Figure 4B.13	'24 HOUR' SISTER TOOL PREDICTIONS	LUT - FMS Research Group

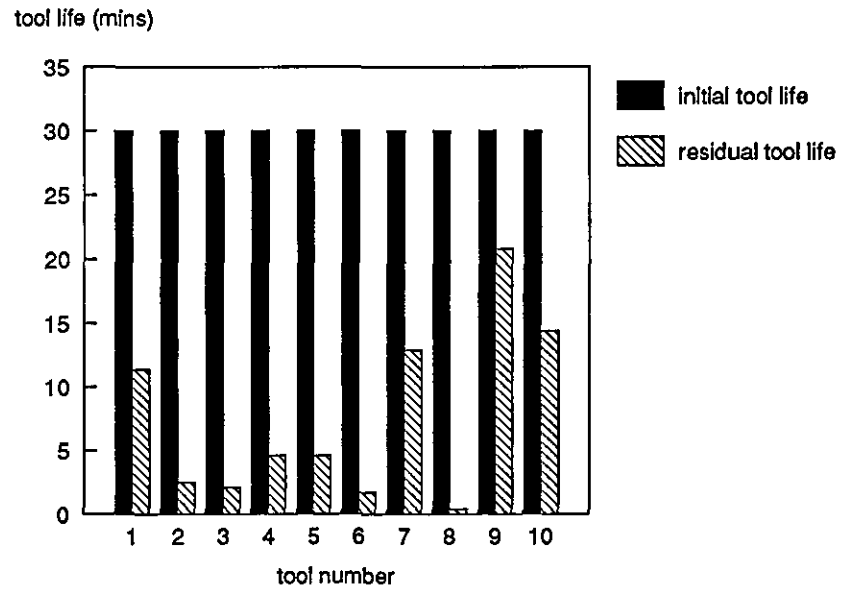


Figure 4B.14	'24 HOUR' TOOL LIFE UTILISATION	LUT - FMS Research Group

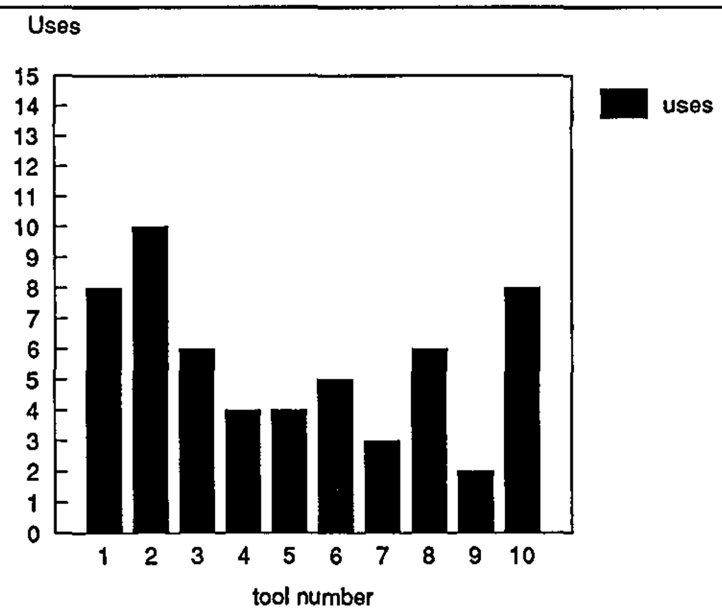


Figure 4B.15	'24 HOUR' TOOL USAGE FREQUENCY	LUT - FMS Research Group

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 1

Tool Store Contents

Tool Store : MC1 | Desc. : primary | Status : final

Capacity : 123 | Tools in Store : 0 | Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
1	1	11.40	R	11	18	1.40	R	21	29	16.60	R
2	2	2.50	R	12	19	17.40	R	22	30	19.80	R
3	4	4.60	R	13	20	3.00	R	23	31	8.60	R
4	8	0.40	R	14	22	37.60	R	24	32	9.40	R
5	10	14.40	R	15	23	3.00	R	25	33	3.00	R
6	11	14.70	R	16	24	17.40	R	26	34	2.50	R
7	12	2.00	R	17	25	38.00	R	27	36	3.50	R
8	15	15.80	R	18	26	22.20	R	28	38	2.00	R
9	16	21.00	R	19	27	15.00	R	29	40	8.10	R
10	17	8.25	R	20	28	17.40	R	30	41	6.00	R

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC1 Desc. : primary Status : final
Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
31	44	10.90	R	41	57	19.00	R	51	39	8.10	R
32	45	17.40	R	42	58	23.00	R	52	9	20.80	R
33	46	11.00	R	43	5	4.60	R	53	13	12.50	R
34	47	8.60	R	44	55	1.00	R	54	21	19.00	R
35	48	9.40	R	45	42	3.70	R	55	7	12.90	R
36	49	42.00	R	46	51	20.00	R	56	35	18.00	R
37	50	6.00	R	47	53	19.00	R	57	43	8.40	R
38	52	3.00	R	48	6	1.70	R	58	14	12.50	R
39	54	1.00	R	49	3	2.10	R	59	0	0	0
40	56	15.00	R	50	37	9.90	R	60	0	0	0

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC1 Desc. : primary Status : final
Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
61	0	0	0	71	0	0	0	81	0	0	0
62	0	0	0	72	0	0	0	82	0	0	0
63	0	0	0	73	0	0	0	83	0	0	0
64	0	0	0	74	0	0	0	84	0	0	0
65	0	0	0	75	0	0	0	85	0	0	0
66	0	0	0	76	0	0	0	86	0	0	0
67	0	0	0	77	0	0	0	87	0	0	0
68	0	0	0	78	0	0	0	88	0	0	0
69	0	0	0	79	0	0	0	89	0	0	0
70	0	0	0	80	0	0	0	90	0	0	0

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC1 Desc. : primary Status : final

Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
91	0	0	0	101	0	0	0	111	0	0	0
92	0	0	0	102	0	0	0	112	0	0	0
93	0	0	0	103	0	0	0	113	0	0	0
94	0	0	0	104	0	0	0	114	0	0	0
95	0	0	0	105	0	0	0	115	0	0	0
96	0	0	0	106	0	0	0	116	0	0	0
97	0	0	0	107	0	0	0	117	0	0	0
98	0	0	0	108	0	0	0	118	0	0	0
99	0	0	0	109	0	0	0	119	0	0	0
100	0	0	0	110	0	0	0	120	0	0	0

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC1 Desc. : primary Status : final

Capacity : 123 Tools in Store : 58 Under [-] : -65

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
121	0	0	0								
122	0	0	0								
123	0	0	0								

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC2 — Desc. : primary — Status : final

Capacity : 123 — Tools in Store : 0 — Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
1	59	9.75	R	11	73	21.00	R	21	84	24.04	R
2	62	7.60	R	12	74	10.20	R	22	85	22.60	R
3	63	11.44	R	13	75	37.44	R	23	86	23.64	R
4	64	42.00	R	14	76	28.16	R	24	87	22.36	R
5	65	48.00	R	15	77	36.64	R	25	88	23.16	R
6	66	46.80	R	16	78	33.76	R	26	89	23.00	R
7	67	0.59	R	17	79	34.64	R	27	90	16.44	R
8	69	0.05	R	18	80	38.00	R	28	91	11.56	R
9	71	23.00	R	19	81	6.68	R	29	92	19.96	R
10	72	49.36	R	20	83	23.00	R	30	93	20.20	R

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC2 — Desc. : primary — Status : final

Capacity : 123 — Tools in Store : 0 — Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
31	94	26.64	R	41	100	10.41	R	51	0	0	0
32	95	26.64	R	42	82	6.68	R	52	0	0	0
33	96	38.40	R	43	70	8.91	R	53	0	0	0
34	97	9.16	R	44	61	42.50	R	54	0	0	0
35	98	40.40	R	45	101	24.94	R	55	0	0	0
36	99	10.41	R	46	68	51.25	R	56	0	0	0
37	102	43.76	R	47	0	0	0	57	0	0	0
38	103	19.00	R	48	0	0	0	58	0	0	0
39	104	45.20	R	49	0	0	0	59	0	0	0
40	60	9.75	R	50	0	0	0	60	0	0	0

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC2 — Desc. : primary — Status : final

Capacity : 123 — Tools in Store : 0 — Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
61	0	0	0	71	0	0	0	81	0	0	0
62	0	0	0	72	0	0	0	82	0	0	0
63	0	0	0	73	0	0	0	83	0	0	0
64	0	0	0	74	0	0	0	84	0	0	0
65	0	0	0	75	0	0	0	85	0	0	0
66	0	0	0	76	0	0	0	86	0	0	0
67	0	0	0	77	0	0	0	87	0	0	0
68	0	0	0	78	0	0	0	88	0	0	0
69	0	0	0	79	0	0	0	89	0	0	0
70	0	0	0	80	0	0	0	90	0	0	0

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC2 — Desc. : primary — Status : final

Capacity : 123 — Tools in Store : 0 — Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
91	0	0	0	101	0	0	0	111	0	0	0
92	0	0	0	102	0	0	0	112	0	0	0
93	0	0	0	103	0	0	0	113	0	0	0
94	0	0	0	104	0	0	0	114	0	0	0
95	0	0	0	105	0	0	0	115	0	0	0
96	0	0	0	106	0	0	0	116	0	0	0
97	0	0	0	107	0	0	0	117	0	0	0
98	0	0	0	108	0	0	0	118	0	0	0
99	0	0	0	109	0	0	0	119	0	0	0
100	0	0	0	110	0	0	0	120	0	0	0

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC2   Desc. : primary   Status : final
Capacity : 123   Tools in Store : 46   Under [-] : -77

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
121	0	0	0								
122	0	0	0								
123	0	0	0								

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC3   Desc. : primary   Status : final
Capacity : 123   Tools in Store : 0   Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
1	105	14.00	R	11	116	17.40	R	21	128	7.00	R
2	106	2.00	R	12	117	3.00	R	22	130	6.00	R
3	107	19.00	R	13	119	11.00	R	23	132	15.00	R
4	108	30.00	R	14	120	23.00	R	24	133	11.00	R
5	109	1.50	R	15	121	20.60	R	25	134	23.00	R
6	111	23.80	R	16	122	23.40	R	26	135	46.00	R
7	112	24.60	R	17	123	23.40	R	27	136	23.00	R
8	113	41.80	R	18	124	891.10	R	28	137	3.00	R
9	114	46.80	R	19	125	0.00	W	29	138	15.00	R
10	115	18.00	R	20	126	7.00	R	30	139	19.00	R

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Tool Store Contents

Tool Store : MC3 Desc. : primary Status : final

Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
31	140	3.00	R	41	118	19.00	R	51	0	0	0
32	141	7.00	R	42	0	0	0	52	0	0	0
33	142	11.00	R	43	0	0	0	53	0	0	0
34	127	7.00	R	44	0	0	0	54	0	0	0
35	129	7.00	R	45	0	0	0	55	0	0	0
36	131	20.00	R	46	0	0	0	56	0	0	0
37	143	23.00	R	47	0	0	0	57	0	0	0
38	144	13.40	R	48	0	0	0	58	0	0	0
39	145	23.40	R	49	0	0	0	59	0	0	0
40	110	22.50	R	50	0	0	0	60	0	0	0

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC3 Desc. : primary Status : final

Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
61	0	0	0	71	0	0	0	81	0	0	0
62	0	0	0	72	0	0	0	82	0	0	0
63	0	0	0	73	0	0	0	83	0	0	0
64	0	0	0	74	0	0	0	84	0	0	0
65	0	0	0	75	0	0	0	85	0	0	0
66	0	0	0	76	0	0	0	86	0	0	0
67	0	0	0	77	0	0	0	87	0	0	0
68	0	0	0	78	0	0	0	88	0	0	0
69	0	0	0	79	0	0	0	89	0	0	0
70	0	0	0	80	0	0	0	90	0	0	0

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC3 Desc. : primary Status : final
Capacity : 123 Tools in Store : 0 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
91	0	0	0	101	0	0	0	111	0	0	0
92	0	0	0	102	0	0	0	112	0	0	0
93	0	0	0	103	0	0	0	113	0	0	0
94	0	0	0	104	0	0	0	114	0	0	0
95	0	0	0	105	0	0	0	115	0	0	0
96	0	0	0	106	0	0	0	116	0	0	0
97	0	0	0	107	0	0	0	117	0	0	0
98	0	0	0	108	0	0	0	118	0	0	0
99	0	0	0	109	0	0	0	119	0	0	0
100	0	0	0	110	0	0	0	120	0	0	0

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : MC3 Desc. : primary Status : final
Capacity : 123 Tools in Store : 41 Under [-] : -82

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
121	0	0	0								
122	0	0	0								
123	0	0	0								

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 2

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
1	0107	R	F	8	30.00	11.40	1	0	N
2	0080	R	F	10	30.00	2.50	2	0	N
3	0080	R	F	6	30.00	2.10	2	0	N
4	0076	R	F	4	30.00	4.60	4	0	N
5	0076	R	F	4	30.00	4.60	4	0	N
6	0076	R	F	5	30.00	1.70	4	0	N
7	0076	R	F	3	30.00	12.90	4	0	N
8	0101	R	F	6	30.00	0.40	2	0	N
9	0101	R	F	2	30.00	20.80	2	0	N
10	0064	R	F	8	30.00	14.40	1	0	N
11	0084	R	F	8	30.00	14.70	1	0	N
12	0088	R	F	6	30.00	2.00	3	0	N
13	0088	R	F	1	30.00	12.50	3	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
14	0088	R	F	1	30.00	12.50	3	0	N
15	0072	R	F	8	30.00	15.80	1	0	N
16	0081	R	F	8	30.00	21.00	1	0	N
17	0087	R	F	8	30.00	8.25	1	0	N
18	0071	R	F	16	30.00	1.40	1	0	N
19	0085	R	F	16	30.00	17.40	1	0	N
20	0079	R	F	6	30.00	3.00	2	0	N
21	0079	R	F	2	30.00	19.00	2	0	N
22	0001	R	F	12	120.00	37.60	5	0	N
23	0082	R	F	8	30.00	3.00	1	0	N
24	0083	R	F	8	30.00	17.40	1	0	N
25	0028	R	F	8	60.00	38.00	3	0	N
26	0106	R	F	8	30.00	22.20	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
27	0105	R	F	8	30.00	15.00	1	0	N
28	0029	R	F	8	30.00	17.40	3	0	N
29	0043	R	F	8	30.00	16.60	4	0	N
30	0044	R	F	8	30.00	19.80	3	0	N
31	0065	R	F	8	30.00	8.60	1	0	N
32	0067	R	F	8	30.00	9.40	1	0	N
33	0066	R	F	8	30.00	3.00	1	0	N
34	0100	R	F	6	30.00	2.50	2	0	N
35	0100	R	F	2	30.00	18.00	2	0	N
36	0078	R	F	5	30.00	3.50	2	0	N
37	0078	R	F	3	30.00	9.90	2	0	N
38	0077	R	F	5	30.00	2.00	2	0	N
39	0077	R	F	3	30.00	8.10	2	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
40	0086	R	F	8	30.00	8.10	1	0	N
41	0075	R	F	3	30.00	6.00	3	0	N
42	0075	R	F	3	30.00	3.70	3	0	N
43	0075	R	F	2	30.00	8.40	3	0	N
44	0069	R	F	8	30.00	10.90	1	0	N
45	0068	R	F	8	30.00	17.40	1	0	N
46	0074	R	F	8	30.00	11.00	1	0	N
47	0073	R	F	8	30.00	8.60	1	0	N
48	0070	R	F	8	30.00	9.40	1	0	N
49	0012	R	F	4	60.00	42.00	3	0	N
50	0053	R	F	3	30.00	6.00	2	0	N
51	0053	R	F	1	30.00	20.00	2	0	N
52	0054	R	F	3	30.00	3.00	2	0	N

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
53	0054	R	F	1	30.00	19.00	2	0	N
54	0049	R	F	2	30.00	1.00	2	0	N
55	0049	R	F	2	30.00	1.00	2	0	N
56	0046	R	F	4	30.00	15.00	2	0	N
57	0047	R	F	4	30.00	19.00	2	0	N
58	0048	R	F	4	30.00	23.00	2	0	N
59	0001	R	F	9	120.00	9.75	5	0	N
60	0001	R	F	9	120.00	9.75	5	0	N
61	0001	R	F	6	120.00	42.50	5	0	N
62	0002	R	F	8	60.00	7.60	2	0	N
63	0003	R	F	24	60.00	11.44	2	0	N
64	0004	R	F	8	60.00	42.00	3	0	N
65	0005	R	F	8	60.00	48.00	1	0	N

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Final Tool Details

£	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
66	0006	R	F	8	60.00	46.80	2	0	N
67	0007	R	F	22	60.00	0.59	3	0	N
68	0007	R	F	2	60.00	51.25	3	0	N
69	0008	R	F	14	30.00	0.05	3	0	N
70	0008	R	F	10	30.00	8.91	3	0	N
71	0043	R	F	8	30.00	23.00	4	0	N
72	0012	R	F	8	60.00	49.36	3	0	N
73	0009	R	F	8	30.00	21.00	1	0	N
74	0030	R	F	8	30.00	10.20	1	0	N
75	0031	R	F	8	60.00	37.44	1	0	N
76	0032	R	F	8	60.00	28.16	1	0	N
77	0033	R	F	8	60.00	36.64	1	0	N
78	0034	R	F	8	60.00	33.76	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

£	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
79	0035	R	F	8	60.00	34.64	1	0	N
80	0036	R	F	8	60.00	38.00	1	0	N
81	0010	R	F	4	60.00	6.68	2	0	N
82	0010	R	F	4	60.00	6.68	2	0	N
83	0011	R	F	8	30.00	23.00	1	0	N
84	0015	R	F	8	30.00	24.04	1	0	N
85	0013	R	F	8	30.00	22.60	1	0	N
86	0014	R	F	8	30.00	23.64	1	0	N
87	0016	R	F	8	30.00	22.36	1	0	N
88	0017	R	F	8	30.00	23.16	2	0	N
89	0018	R	F	8	30.00	23.00	2	0	N
90	0019	R	F	8	30.00	16.44	2	0	N
91	0020	R	F	8	30.00	11.56	2	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

£	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
92	0021	R	F	8	30.00	19.96	2	0	N
93	0022	R	F	8	30.00	20.20	2	0	N
94	0023	R	F	8	60.00	26.64	1	0	N
95	0102	R	F	8	60.00	26.64	1	0	N
96	0024	R	F	8	60.00	38.40	1	0	N
97	0025	R	F	8	30.00	9.16	1	0	N
98	0027	R	F	8	60.00	40.40	1	0	N
99	0026	R	F	3	60.00	10.41	3	0	N
100	0026	R	F	3	60.00	10.41	3	0	N
101	0026	R	F	2	60.00	24.94	3	0	N
102	0028	R	F	8	60.00	43.76	3	0	N
103	0029	R	F	8	30.00	19.00	3	0	N
104	0103	R	F	8	60.00	45.20	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

£	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
105	0002	R	F	8	60.00	14.00	2	0	N
106	0003	R	F	12	60.00	2.00	2	0	N
107	0059	R	F	8	30.00	19.00	1	0	N
108	0060	R	F	8	60.00	30.00	1	0	N
109	0004	R	F	5	60.00	1.50	3	0	N
110	0004	R	F	3	60.00	22.50	3	0	N
111	0055	R	F	8	30.00	23.80	1	0	N
112	0056	R	F	8	30.00	24.60	1	0	N
113	0006	R	F	12	60.00	41.80	2	0	N
114	0012	R	F	12	60.00	46.80	3	0	N
115	0007	R	F	8	60.00	18.00	3	0	N
116	0008	R	F	8	30.00	17.40	3	0	N
117	0063	R	F	6	30.00	3.00	2	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
118	0063	R	F	2	30.00	19.00	2	0	N
119	0062	R	F	8	30.00	11.00	1	0	N
120	0019	R	F	8	30.00	23.00	2	0	N
121	0020	R	F	8	30.00	20.60	2	0	N
122	0021	R	F	8	30.00	23.40	2	0	N
123	0022	R	F	8	30.00	23.40	2	0	N
124	0200	R	F	8	999.00	891.10	1	0	N
125	0001	R		4	120.00	0.00	5	0	N
126	0043	R	F	2	30.00	7.00	4	0	N
127	0043	R	F	2	30.00	7.00	4	0	N
128	0044	R	F	2	30.00	7.00	3	0	N
129	0044	R	F	2	30.00	7.00	3	0	N
130	0042	R	F	3	30.00	6.00	2	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

E	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
131	0042	R	F	1	30.00	20.00	2	0	N
132	0051	R	F	4	30.00	15.00	1	0	N
133	0050	R	F	4	30.00	11.00	1	0	N
134	0052	R	F	4	30.00	23.00	1	0	N
135	0028	R	F	4	60.00	46.00	3	0	N
136	0029	R	F	4	30.00	23.00	3	0	N
137	0046	R	F	4	30.00	3.00	2	0	N
138	0047	R	F	4	30.00	15.00	2	0	N
139	0048	R	F	4	30.00	19.00	2	0	N
140	0045	R	F	4	30.00	3.00	1	0	N
141	0017	R	F	4	30.00	7.00	2	0	N
142	0018	R	F	4	30.00	11.00	2	0	N
143	0057	R	F	4	30.00	23.00	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

£	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
144	0061	R	F	4	30.00	13.40	1	0	N
145	0099	R	F	4	30.00	23.40	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 3

Machining History

Pt E	Mc. ID	Mc	It	Op E	O	Op min	T1E1	Life1S	Life1F	T1E2	Life2S	Life2F
1	MC1	1	1	1	1	1.80	1	27.0	25.2			
1	MC1	1	1	2	2	1.80	2	27.0	25.2			
1	MC1	1	1	3	3	6.50	4	27.0	20.5			
1	MC1	1	1	4	4	4.70	8	27.0	22.3			
1	MC1	1	1	5	5	3.10	2	25.2	22.1			
1	MC1	1	1	6	6	1.80	10	27.0	25.2			
1	MC1	1	1	7	7	1.20	11	27.0	25.8			
1	MC1	1	1	8	8	2.10	12	27.0	24.9			
1	MC1	1	1	9	9	1.40	15	27.0	25.6			
1	MC1	1	1	10	10	0.75	16	27.0	26.3			
1	MC1	1	1	11	11	2.10	17	27.0	24.9			
1	MC1	1	1	12	12	1.60	18	27.0	25.4			
1	MC1	1	1	13	13	0.60	19	27.0	26.4			

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machining History

Pt £	Mc. ID	Mc	It	Op £	Q	Op min	T1£1	Life1S	Life1F	T1£2	Life2S	Life2F
1	MC1	1	1	14	14	4.00	20	27.0	23.0			
1	MC1	1	1	15	15	0.80	22	108.0	107.2			
1	MC1	1	1	16	16	3.00	23	27.0	24.0			
1	MC1	1	1	17	17	1.20	24	27.0	25.8			
1	MC1	1	1	18	18	4.70	4	20.5	15.8			
1	MC1	1	1	19	19	2.00	25	54.0	52.0			
1	MC1	1	1	20	20	0.60	26	27.0	26.4			
1	MC1	1	1	21	21	1.50	27	27.0	25.5			
1	MC1	1	1	22	22	1.20	28	27.0	25.8			
1	MC1	1	1	23	23	1.30	29	27.0	25.7			
1	MC1	1	1	24	24	0.90	30	27.0	26.1			
1	MC1	1	1	25	25	2.30	31	27.0	24.7			
1	MC1	1	1	26	26	2.20	32	27.0	24.8			

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - 8	Enter	Shift - PrtSc		P

Machining History

Pt £	Mc. ID	Mc	It	Op £	Q	Op min	T1£1	Life1S	Life1F	T1£2	Life2S	Life2F
2	MC1	1	1	1	40	16.00	22	107.2	91.2			
2	MC1	1	1	2	41	3.00	49	54.0	51.0			
2	MC1	1	1	3	42	7.00	50	27.0	20.0			
2	MC1	1	1	4	43	8.00	52	27.0	19.0			
2	MC1	1	1	5	44	13.00	54	27.0	14.0			
2	MC1	1	1	6	45	3.00	56	27.0	24.0			
2	MC1	1	1	7	46	2.00	57	27.0	25.0			
2	MC1	1	1	8	47	1.00	58	27.0	26.0			
3	MC1	1	1	1	48	1.80	1	25.2	23.4			
3	MC1	1	1	2	49	1.80	2	22.1	20.3			
3	MC1	1	1	3	50	6.50	4	15.8	9.3			
3	MC1	1	1	4	51	4.70	8	22.3	17.6			
3	MC1	1	1	5	52	3.10	2	20.3	17.2			

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - 8	Enter	Shift - PrtSc		P

Machining History

Pt £	Mc. ID	Mc	It	Op £	Q	Op min	T1£1	Life1S	Life1F	T1£2	Life2S	Life2F
4	MC1	1	1	6	92	3.00	56	24.0	21.0			
4	MC1	1	1	7	93	2.00	57	25.0	23.0			
4	MC1	1	1	8	94	1.00	58	26.0	25.0			
5	MC1	1	1	1	95	1.80	1	23.4	21.6			
5	MC1	1	1	2	96	1.80	2	17.2	15.4			
5	MC1	1	1	3	97	6.50	5	27.0	20.5			
5	MC1	1	1	4	98	4.70	8	17.6	12.9			
5	MC1	1	1	5	99	3.10	2	15.4	12.3			
5	MC1	1	1	6	100	1.80	10	23.4	21.6			
5	MC1	1	1	7	101	1.20	11	24.6	23.4			
5	MC1	1	1	8	102	2.10	12	22.8	20.7			
5	MC1	1	1	9	103	1.40	15	24.2	22.8			
5	MC1	1	1	10	104	0.75	16	25.5	24.8			

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Cell Performance Measures

Cell No. : 1 Planning Horizon : 1440.00

Cell Performance Time : 2008.35

Machine No. : 1	Used for : 1564.90	Utilisation :	108.67
Machine No. : 2	Used for : 2008.35	Utilisation :	139.47
Machine No. : 3	Used for : 1908.59	Utilisation :	132.54
Machine No. : 0	Used for : 0.00	Utilisation :	0.00
Tool Cart £ : 1	Used for : 343.52	Utilisation :	23.86
Tool Cart £ : 2	Used for : 383.52	Utilisation :	26.63
Tool Cart £ : 3	Used for : 479.52	Utilisation :	33.30
Tool Cart £ : 0	Used for : 0.00	Utilisation :	0.00

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 4

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
1	1	1	1.80	1	1	0.3	239.8	241.8	241.8	244.3	244.3	244.3
1	1	2	1.80	1	2	244.3	244.3	244.3	244.3	246.9	246.9	246.9
1	1	3	6.50	1	3	246.9	246.9	246.9	246.9	254.1	254.1	254.1
1	1	4	4.70	1	4	254.1	254.1	254.1	254.1	259.6	259.6	259.6
1	1	5	3.10	1	5	259.6	259.6	259.6	259.6	263.5	263.5	263.5
1	1	6	1.80	1	6	263.5	263.5	263.5	263.5	266.0	266.0	266.0
1	1	7	1.20	1	7	266.0	266.0	266.0	266.0	268.0	268.0	268.0
1	1	8	2.10	1	8	268.0	268.0	268.0	268.0	270.8	270.8	270.8
1	1	9	1.40	1	9	270.8	270.8	270.8	270.8	273.0	273.0	273.0
1	1	10	0.75	1	10	273.0	273.0	273.0	273.0	274.5	274.5	274.5
1	1	11	2.10	1	11	274.5	274.5	274.5	274.5	277.4	277.4	277.4
1	1	12	1.60	1	12	277.4	277.4	277.4	277.4	279.7	279.7	279.7
1	1	13	0.60	1	13	279.7	279.7	279.7	279.7	281.1	281.1	281.1

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt E	It	OpE	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
1	1	27	3.00	1	27	316.7	316.7	316.7	316.7	320.4	320.4	320.4
1	1	28	4.00	1	28	320.4	320.4	320.4	320.4	325.2	325.2	325.2
1	1	29	4.70	1	29	325.2	325.2	325.2	325.2	330.6	330.6	330.6
1	1	30	5.00	1	30	330.6	330.6	330.6	330.6	336.4	336.4	336.4
1	1	31	2.10	1	31	336.4	336.4	336.4	336.4	339.3	339.3	339.3
1	1	32	7.00	1	32	339.3	339.3	339.3	339.3	347.0	347.0	347.0
1	1	33	2.00	1	33	347.0	347.0	347.0	347.0	349.8	349.8	349.8
1	1	34	1.20	1	34	349.8	349.8	349.8	349.8	351.7	351.7	351.7
1	1	35	2.00	1	35	351.7	351.7	351.7	351.7	354.5	354.5	354.5
1	1	36	2.30	1	36	354.5	354.5	354.5	354.5	357.6	357.6	357.6
1	1	37	1.60	1	37	357.6	357.6	357.6	357.6	359.9	359.9	359.9
1	1	38	0.60	1	38	359.9	359.9	359.9	359.9	361.3	361.3	361.3
1	1	39	2.20	1	39	361.3	361.3	361.5	361.5	364.4	366.4	366.4

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt E	It	OpE	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
2	1	1	16.00	1	40	366.4	364.4	366.4	366.4	383.2	383.2	383.2
2	1	2	3.00	1	41	383.2	383.2	383.2	383.2	387.0	387.0	387.0
2	1	3	7.00	1	42	387.0	387.0	387.0	387.0	394.7	394.7	394.7
2	1	4	8.00	1	43	394.7	394.7	394.7	394.7	403.5	403.5	403.5
2	1	5	13.00	1	44	403.5	403.5	403.5	403.5	417.2	417.2	417.2
2	1	6	3.00	1	45	417.2	417.2	417.2	417.2	421.0	421.0	421.0
2	1	7	2.00	1	46	421.0	421.0	421.0	421.0	423.8	423.8	423.8
2	1	8	1.00	1	47	423.8	423.8	424.0	424.0	425.7	427.7	427.7
3	1	1	1.80	1	48	427.7	425.7	427.7	427.7	430.3	430.3	430.3
3	1	2	1.80	1	49	430.3	430.3	430.3	430.3	432.8	432.8	432.8
3	1	3	6.50	1	50	432.8	432.8	432.8	432.8	440.1	440.1	440.1
3	1	4	4.70	1	51	440.1	440.1	440.1	440.1	445.6	445.6	445.6
3	1	5	3.10	1	52	445.6	445.6	445.6	445.6	449.4	449.4	449.4

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
3	1	32	7.00	1	79	525.2	525.2	525.2	525.2	533.0	533.0	533.0
3	1	33	2.00	1	80	533.0	533.0	533.0	533.0	535.8	535.8	535.8
3	1	34	1.20	1	81	535.8	535.8	535.8	535.8	537.7	537.7	537.7
3	1	35	2.00	1	82	537.7	537.7	537.7	537.7	540.5	540.5	540.5
3	1	36	2.30	1	83	540.5	540.5	540.5	540.5	543.5	543.5	543.5
3	1	37	1.60	1	84	543.5	543.5	543.5	543.5	545.9	545.9	545.9
3	1	38	0.60	1	85	545.9	545.9	545.9	545.9	547.3	547.3	547.3
3	1	39	2.20	1	86	547.3	547.3	547.5	547.5	550.4	552.4	552.4
4	1	1	16.00	1	87	552.4	550.4	552.4	552.4	569.2	569.2	569.2
4	1	2	3.00	1	88	569.2	569.2	569.2	569.2	572.9	572.9	572.9
4	1	3	7.00	1	89	572.9	572.9	572.9	572.9	580.7	580.7	580.7
4	1	4	8.00	1	90	580.7	580.7	580.7	580.7	589.5	589.5	589.5
4	1	5	13.00	1	91	589.5	589.5	589.5	589.5	603.2	603.2	603.2

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
4	1	6	3.00	1	92	603.2	603.2	603.2	603.2	607.0	607.0	607.0
4	1	7	2.00	1	93	607.0	607.0	607.0	607.0	609.7	609.7	609.7
4	1	8	1.00	1	94	609.7	609.7	609.9	609.9	611.7	613.7	613.7
5	1	1	1.80	1	95	613.7	611.7	613.7	613.7	616.3	616.3	616.3
5	1	2	1.80	1	96	616.3	616.3	616.3	616.3	618.8	618.8	618.8
5	1	3	6.50	1	97	618.8	618.8	618.8	618.8	626.1	626.1	626.1
5	1	4	4.70	1	98	626.1	626.1	626.1	626.1	631.5	631.5	631.5
5	1	5	3.10	1	99	631.5	631.5	631.5	631.5	635.4	635.4	635.4
5	1	6	1.80	1	100	635.4	635.4	635.4	635.4	638.0	638.0	638.0
5	1	7	1.20	1	101	638.0	638.0	638.0	638.0	639.9	639.9	639.9
5	1	8	2.10	1	102	639.9	639.9	639.9	639.9	642.8	642.8	642.8
5	1	9	1.40	1	103	642.8	642.8	642.8	642.8	644.9	644.9	644.9
5	1	10	0.75	1	104	644.9	644.9	644.9	644.9	646.4	646.4	646.4

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
5	1	37	1.60	1	131	729.5	729.5	729.5	729.5	731.9	731.9	731.9
5	1	38	0.60	1	132	731.9	731.9	731.9	731.9	733.2	733.2	733.2
5	1	39	2.20	1	133	733.2	733.2	733.4	733.4	736.4	738.4	738.4
6	1	1	16.00	1	134	738.4	736.4	738.4	738.4	755.1	755.1	755.1
6	1	2	3.00	1	135	755.1	755.1	755.1	755.1	758.9	758.9	758.9
6	1	3	7.00	1	136	758.9	758.9	758.9	758.9	766.7	766.7	766.7
6	1	4	8.00	1	137	766.7	766.7	766.7	766.7	775.4	775.4	775.4
6	1	5	13.00	1	138	775.4	775.4	775.4	775.4	789.2	789.2	789.2
6	1	6	3.00	1	139	789.2	789.2	789.2	789.2	792.9	792.9	792.9
6	1	7	2.00	1	140	792.9	792.9	792.9	792.9	795.7	795.7	795.7
6	1	8	1.00	1	141	795.7	795.7	795.9	795.9	797.7	799.7	799.7
7	1	1	1.80	1	142	799.7	797.7	799.7	799.7	802.2	802.2	802.2
7	1	2	1.80	1	143	802.2	802.2	802.2	802.2	804.8	804.8	804.8

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
7	1	29	4.70	1	170	883.1	883.1	883.1	883.1	888.6	888.6	888.6
7	1	30	5.00	1	171	888.6	888.6	888.6	888.6	894.3	894.3	894.3
7	1	31	2.10	1	172	894.3	894.3	894.3	894.3	897.2	897.2	897.2
7	1	32	7.00	1	173	897.2	897.2	897.2	897.2	904.9	904.9	904.9
7	1	33	2.00	1	174	904.9	904.9	904.9	904.9	907.7	907.7	907.7
7	1	34	1.20	1	175	907.7	907.7	907.7	907.7	909.7	909.7	909.7
7	1	35	2.00	1	176	909.7	909.7	909.7	909.7	912.4	912.4	912.4
7	1	36	2.30	1	177	912.4	912.4	912.4	912.4	915.5	915.5	915.5
7	1	37	1.60	1	178	915.5	915.5	915.5	915.5	917.8	917.8	917.8
7	1	38	0.60	1	179	917.8	917.8	917.8	917.8	919.2	919.2	919.2
7	1	39	2.20	1	180	919.2	919.2	919.4	919.4	922.4	924.4	924.4
8	1	1	16.00	1	181	924.4	922.4	924.4	924.4	941.1	941.1	941.1
8	1	2	3.00	1	182	941.1	941.1	941.1	941.1	944.9	944.9	944.9

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
8	1	3	7.00	1	183	944.9	944.9	944.9	944.9	952.6	952.6	952.6
8	1	4	8.00	1	184	952.6	952.6	952.6	952.6	961.4	961.4	961.4
8	1	5	13.00	1	185	961.4	961.4	961.4	961.4	975.2	975.2	975.2
8	1	6	3.00	1	186	975.2	975.2	975.2	975.2	978.9	978.9	978.9
8	1	7	2.00	1	187	978.9	978.9	978.9	978.9	981.7	981.7	981.7
8	1	8	1.00	1	188	981.7	981.7	981.9	981.9	983.6	985.6	985.6
9	1	1	1.80	1	189	985.6	983.6	985.6	985.6	988.2	988.2	988.2
9	1	2	1.80	1	190	988.2	988.2	988.2	988.2	990.8	990.8	990.8
9	1	3	6.50	1	191	990.8	990.8	990.8	990.8	998.0	998.0	998.0
9	1	4	4.70	1	192	998.0	998.0	998.0	998.0	1003.5	1003.5	1003.5
9	1	5	3.10	1	193	1003.5	1003.5	1003.5	1003.5	1007.3	1007.3	1007.3
9	1	6	1.80	1	194	1007.3	1007.3	1007.3	1007.3	1009.9	1009.9	1009.9
9	1	7	1.20	1	195	1009.9	1009.9	1009.9	1009.9	1011.9	1011.9	1011.9

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
9	1	34	1.20	1	222	1093.8	1093.8	1093.8	1093.8	1095.7	1095.7	1095.7
9	1	35	2.00	1	223	1095.7	1095.7	1095.7	1095.7	1098.5	1098.5	1098.5
9	1	36	2.30	1	224	1098.5	1098.5	1098.5	1098.5	1101.5	1101.5	1101.5
9	1	37	1.60	1	225	1101.5	1101.5	1101.5	1101.5	1103.9	1103.9	1103.9
9	1	38	0.60	1	226	1103.9	1103.9	1103.9	1103.9	1105.3	1105.3	1105.3
9	1	39	2.20	1	227	1105.3	1105.3	1105.5	1105.5	1108.4	1110.4	1110.4
10	1	1	2.20	1	228	1110.4	1108.4	1110.4	1110.4	1113.4	1113.4	1113.4
10	1	2	6.50	1	229	1113.4	1113.4	1113.4	1113.4	1120.6	1120.6	1120.6
10	1	3	4.70	1	230	1120.6	1120.6	1120.6	1120.6	1126.1	1126.1	1126.1
10	1	4	3.10	1	231	1126.1	1126.1	1126.1	1126.1	1130.0	1130.0	1130.0
10	1	5	1.80	1	232	1130.0	1130.0	1130.0	1130.0	1132.5	1132.5	1132.5
10	1	6	1.20	1	233	1132.5	1132.5	1132.5	1132.5	1134.5	1134.5	1134.5
10	1	7	2.10	1	234	1134.5	1134.5	1134.5	1134.5	1137.3	1137.3	1137.3

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
10	1	34	1.20	1	261	1238.0	1238.0	1238.0	1238.0	1240.0	1240.0	1240.0
10	1	35	2.00	1	262	1240.0	1240.0	1240.0	1240.0	1242.7	1242.7	1242.7
10	1	36	2.30	1	263	1242.7	1242.7	1242.7	1242.7	1245.8	1245.8	1245.8
10	1	37	1.60	1	264	1245.8	1245.8	1245.8	1245.8	1248.1	1248.1	1248.1
10	1	38	0.60	1	265	1248.1	1248.1	1248.1	1248.1	1249.5	1249.5	1249.5
10	1	39	2.20	1	266	1249.5	1249.5	1249.7	1249.7	1252.7	1254.7	1254.7
11	1	1	2.20	1	267	1254.7	1252.7	1254.7	1254.7	1257.6	1257.6	1257.6
11	1	2	6.50	1	268	1257.6	1257.6	1257.6	1257.6	1264.9	1264.9	1264.9
11	1	3	4.70	1	269	1264.9	1264.9	1264.9	1264.9	1270.3	1270.3	1270.3
11	1	4	3.10	1	270	1270.3	1270.3	1270.3	1270.3	1274.2	1274.2	1274.2
11	1	5	1.80	1	271	1274.2	1274.2	1274.2	1274.2	1276.8	1276.8	1276.8
11	1	6	1.20	1	272	1276.8	1276.8	1276.8	1276.8	1278.7	1278.7	1278.7
11	1	7	2.10	1	273	1278.7	1278.7	1278.7	1278.7	1281.6	1281.6	1281.6

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
11	1	34	1.20	1	300	1382.2	1382.2	1382.2	1382.2	1384.2	1384.2	1384.2
11	1	35	2.00	1	301	1384.2	1384.2	1384.2	1384.2	1387.0	1387.0	1387.0
11	1	36	2.30	1	302	1387.0	1387.0	1387.0	1387.0	1390.0	1390.0	1390.0
11	1	37	1.60	1	303	1390.0	1390.0	1390.0	1390.0	1392.4	1392.4	1392.4
11	1	38	0.60	1	304	1392.4	1392.4	1392.4	1392.4	1393.7	1393.7	1393.7
11	1	39	2.20	1	305	1393.7	1393.7	1393.9	1393.9	1396.9	1398.9	1398.9
12	1	1	2.20	1	306	1398.9	1396.9	1398.9	1398.9	1401.9	1401.9	1401.9
12	1	2	6.50	1	307	1401.9	1401.9	1401.9	1401.9	1409.1	1409.1	1409.1
12	1	3	4.70	1	308	1409.1	1409.1	1409.1	1409.1	1414.6	1414.6	1414.6
12	1	4	3.10	1	309	1414.6	1414.6	1414.6	1414.6	1418.4	1418.4	1418.4
12	1	5	1.80	1	310	1418.4	1418.4	1418.4	1418.4	1421.0	1421.0	1421.0
12	1	6	1.20	1	311	1421.0	1421.0	1421.0	1421.0	1423.0	1423.0	1423.0
12	1	7	2.10	1	312	1423.0	1423.0	1423.0	1423.0	1425.8	1425.8	1425.8

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
12	1	34	1.20	1	339	1526.5	1526.5	1526.5	1526.5	1528.4	1528.4	1528.4
12	1	35	2.00	1	340	1528.4	1528.4	1528.4	1528.4	1531.2	1531.2	1531.2
12	1	36	2.30	1	341	1531.2	1531.2	1531.2	1531.2	1534.3	1534.3	1534.3
12	1	37	1.60	1	342	1534.3	1534.3	1534.3	1534.3	1536.6	1536.6	1536.6
12	1	38	0.60	1	343	1536.6	1536.6	1536.6	1536.6	1538.0	1538.0	1538.0
12	1	39	2.20	1	344	1538.0	1538.0	1538.2	1538.2	1541.1	1543.1	1543.1
13	1	1	15.40	2	1	2.3	626.8	628.8	628.8	644.9	644.9	644.9
13	1	2	5.80	2	2	644.9	644.9	644.9	644.9	651.5	651.5	651.5
13	1	3	2.70	2	3	651.5	651.5	651.5	651.5	654.9	654.9	654.9
13	1	4	1.50	2	4	654.9	654.9	654.9	654.9	657.2	657.2	657.2
13	1	5	0.75	2	5	657.2	657.2	657.2	657.2	658.7	658.7	658.7
13	1	6	0.90	2	6	658.7	658.7	658.7	658.7	660.4	660.4	660.4
13	1	7	4.27	2	7	660.4	660.4	660.4	660.4	665.4	665.4	665.4

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
13	1	34	0.85	2	34	743.5	743.5	743.5	743.5	745.1	745.1	745.1
13	1	35	3.42	2	35	745.1	745.1	745.3	745.3	749.5	751.5	751.5
14	1	1	4.20	2	36	751.5	749.5	751.5	751.5	756.4	756.4	756.4
14	1	2	0.92	2	37	756.4	756.4	756.4	756.4	758.1	758.1	758.1
14	1	3	1.42	2	38	758.1	758.1	758.1	758.1	760.3	760.3	760.3
14	1	4	1.20	2	39	760.3	760.3	760.3	760.3	762.2	762.2	762.2
14	1	5	3.42	2	40	762.2	762.2	762.2	762.2	766.4	766.4	766.4
14	1	6	1.95	2	41	766.4	766.4	766.4	766.4	769.1	769.1	769.1
14	1	7	2.23	2	42	769.1	769.1	769.1	769.1	772.1	772.1	772.1
14	1	8	1.70	2	43	772.1	772.1	772.1	772.1	774.6	774.6	774.6
14	1	9	14.53	2	44	774.6	774.6	774.6	774.6	789.9	789.9	789.9
14	1	10	1.28	2	45	789.9	789.9	789.9	789.9	791.9	791.9	791.9
14	1	11	1.00	2	46	791.9	791.9	791.9	791.9	793.7	793.7	793.7

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
14	1	12	1.10	2	47	793.7	793.7	793.9	793.9	795.7	797.7	797.7
15	1	1	15.40	2	48	797.7	795.7	797.7	797.7	813.9	813.9	813.9
15	1	2	5.80	2	49	813.9	813.9	813.9	813.9	820.5	820.5	820.5
15	1	3	2.70	2	50	820.5	820.5	820.5	820.5	823.9	823.9	823.9
15	1	4	1.50	2	51	823.9	823.9	823.9	823.9	826.2	826.2	826.2
15	1	5	0.75	2	52	826.2	826.2	826.2	826.2	827.7	827.7	827.7
15	1	6	0.90	2	53	827.7	827.7	827.7	827.7	829.3	829.3	829.3
15	1	7	4.27	2	54	829.3	829.3	829.3	829.3	834.4	834.4	834.4
15	1	8	3.43	2	55	834.4	834.4	834.4	834.4	838.6	838.6	838.6
15	1	9	0.50	2	56	838.6	838.6	838.6	838.6	839.8	839.8	839.8
15	1	10	0.58	2	57	839.8	839.8	839.8	839.8	841.2	841.2	841.2
15	1	11	13.15	2	58	841.2	841.2	841.2	841.2	855.1	855.1	855.1
15	1	12	0.75	2	59	855.1	855.1	855.1	855.1	856.6	856.6	856.6

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
15	1	26	0.55	2	73	899.7	899.7	899.7	899.7	901.0	901.0	901.0
15	1	27	0.42	2	74	901.0	901.0	901.0	901.0	902.2	902.2	902.2
15	1	28	0.58	2	75	902.2	902.2	902.2	902.2	903.5	903.5	903.5
15	1	29	0.48	2	76	903.5	903.5	903.5	903.5	904.8	904.8	904.8
15	1	30	0.50	2	77	904.8	904.8	904.8	904.8	906.0	906.0	906.0
15	1	31	1.32	2	78	906.0	906.0	906.0	906.0	908.1	908.1	908.1
15	1	32	1.93	2	79	908.1	908.1	908.1	908.1	910.8	910.8	910.8
15	1	33	0.88	2	80	910.8	910.8	910.8	910.8	912.5	912.5	912.5
15	1	34	0.85	2	81	912.5	912.5	912.5	912.5	914.1	914.1	914.1
15	1	35	3.42	2	82	914.1	914.1	914.3	914.3	918.4	920.4	920.4
16	1	1	4.20	2	83	920.4	918.4	920.4	920.4	925.4	925.4	925.4
16	1	2	0.92	2	84	925.4	925.4	925.4	925.4	927.1	927.1	927.1
16	1	3	1.42	2	85	927.1	927.1	927.1	927.1	929.3	929.3	929.3

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
16	1	4	1.20	2	86	929.3	929.3	929.3	929.3	931.2	931.2	931.2
16	1	5	3.42	2	87	931.2	931.2	931.2	931.2	935.4	935.4	935.4
16	1	6	1.95	2	88	935.4	935.4	935.4	935.4	938.1	938.1	938.1
16	1	7	2.23	2	89	938.1	938.1	938.1	938.1	941.1	941.1	941.1
16	1	8	1.70	2	90	941.1	941.1	941.1	941.1	943.6	943.6	943.6
16	1	9	14.53	2	91	943.6	943.6	943.6	943.6	958.9	958.9	958.9
16	1	10	1.28	2	92	958.9	958.9	958.9	958.9	960.9	960.9	960.9
16	1	11	1.00	2	93	960.9	960.9	960.9	960.9	962.7	962.7	962.7
16	1	12	1.10	2	94	962.7	962.7	962.9	962.9	964.7	966.7	966.7
17	1	1	15.40	2	95	966.7	964.7	966.7	966.7	982.9	982.9	982.9
17	1	2	5.80	2	96	982.9	982.9	982.9	982.9	989.4	989.4	989.4
17	1	3	2.70	2	97	989.4	989.4	989.4	989.4	992.9	992.9	992.9
17	1	4	1.50	2	98	992.9	992.9	992.9	992.9	995.2	995.2	995.2

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
17	1	31	1.32	2	125	1075.0	1075.0	1075.0	1075.0	1077.1	1077.1	1077.1
17	1	32	1.93	2	126	1077.1	1077.1	1077.1	1077.1	1079.8	1079.8	1079.8
17	1	33	0.88	2	127	1079.8	1079.8	1079.8	1079.8	1081.4	1081.4	1081.4
17	1	34	0.85	2	128	1081.4	1081.4	1081.4	1081.4	1083.0	1083.0	1083.0
17	1	35	3.42	2	129	1083.0	1083.0	1083.2	1083.2	1087.4	1089.4	1089.4
18	1	1	4.20	2	130	1089.4	1087.4	1089.4	1089.4	1094.4	1094.4	1094.4
18	1	2	0.92	2	131	1094.4	1094.4	1094.4	1094.4	1096.1	1096.1	1096.1
18	1	3	1.42	2	132	1096.1	1096.1	1096.1	1096.1	1098.2	1098.2	1098.2
18	1	4	1.20	2	133	1098.2	1098.2	1098.2	1098.2	1100.2	1100.2	1100.2
18	1	5	3.42	2	134	1100.2	1100.2	1100.2	1100.2	1104.4	1104.4	1104.4
18	1	6	1.95	2	135	1104.4	1104.4	1104.4	1104.4	1107.1	1107.1	1107.1
18	1	7	2.23	2	136	1107.1	1107.1	1107.1	1107.1	1110.1	1110.1	1110.1
18	1	8	1.70	2	137	1110.1	1110.1	1110.1	1110.1	1112.5	1112.5	1112.5

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
18	1	9	14.53	2	138	1112.5	1112.5	1112.5	1112.5	1127.8	1127.8	1127.8
18	1	10	1.28	2	139	1127.8	1127.8	1127.8	1127.8	1129.9	1129.9	1129.9
18	1	11	1.00	2	140	1129.9	1129.9	1129.9	1129.9	1131.6	1131.6	1131.6
18	1	12	1.10	2	141	1131.6	1131.6	1131.8	1131.8	1133.7	1135.7	1135.7
19	1	1	15.40	2	142	1135.7	1133.7	1135.7	1135.7	1151.9	1151.9	1151.9
19	1	2	5.80	2	143	1151.9	1151.9	1151.9	1151.9	1158.4	1158.4	1158.4
19	1	3	2.70	2	144	1158.4	1158.4	1158.4	1158.4	1161.9	1161.9	1161.9
19	1	4	1.50	2	145	1161.9	1161.9	1161.9	1161.9	1164.1	1164.1	1164.1
19	1	5	0.75	2	146	1164.1	1164.1	1164.1	1164.1	1165.6	1165.6	1165.6
19	1	6	0.90	2	147	1165.6	1165.6	1165.6	1165.6	1167.3	1167.3	1167.3
19	1	7	4.27	2	148	1167.3	1167.3	1167.3	1167.3	1172.3	1172.3	1172.3
19	1	8	3.43	2	149	1172.3	1172.3	1172.3	1172.3	1176.5	1176.5	1176.5
19	1	9	0.50	2	150	1176.5	1176.5	1176.3	1176.5	1177.8	1177.8	1177.8

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
19	1	23	1.00	2	164	1233.5	1233.5	1233.5	1233.5	1235.3	1235.3	1235.3
19	1	24	0.50	2	165	1235.3	1235.3	1235.3	1235.3	1236.5	1236.5	1236.5
19	1	25	0.37	2	166	1236.5	1236.5	1236.5	1236.5	1237.7	1237.7	1237.7
19	1	26	0.55	2	167	1237.7	1237.7	1237.7	1237.7	1239.0	1239.0	1239.0
19	1	27	0.42	2	168	1239.0	1239.0	1239.0	1239.0	1240.2	1240.2	1240.2
19	1	28	0.58	2	169	1240.2	1240.2	1240.2	1240.2	1241.5	1241.5	1241.5
19	1	29	0.48	2	170	1241.5	1241.5	1241.5	1241.5	1242.7	1242.7	1242.7
19	1	30	0.50	2	171	1242.7	1242.7	1242.7	1242.7	1244.0	1244.0	1244.0
19	1	31	1.32	2	172	1244.0	1244.0	1244.0	1244.0	1246.1	1246.1	1246.1
19	1	32	1.93	2	173	1246.1	1246.1	1246.1	1246.1	1248.8	1248.8	1248.8
19	1	33	0.88	2	174	1248.8	1248.8	1248.8	1248.8	1250.4	1250.4	1250.4
19	1	34	0.85	2	175	1250.4	1250.4	1250.4	1250.4	1252.0	1252.0	1252.0
19	1	35	3.42	2	176	1252.0	1252.0	1252.2	1252.2	1256.4	1258.4	1258.4

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
20	1	1	4.20	2	177	1258.4	1256.4	1258.4	1258.4	1263.4	1263.4	1263.4
20	1	2	0.92	2	178	1263.4	1263.4	1263.4	1263.4	1265.0	1265.0	1265.0
20	1	3	1.42	2	179	1265.0	1265.0	1265.0	1265.0	1267.2	1267.2	1267.2
20	1	4	1.20	2	180	1267.2	1267.2	1267.2	1267.2	1269.2	1269.2	1269.2
20	1	5	3.42	2	181	1269.2	1269.2	1269.2	1269.2	1273.4	1273.4	1273.4
20	1	6	1.95	2	182	1273.4	1273.4	1273.4	1273.4	1276.1	1276.1	1276.1
20	1	7	2.23	2	183	1276.1	1276.1	1276.1	1276.1	1279.1	1279.1	1279.1
20	1	8	1.70	2	184	1279.1	1279.1	1279.1	1279.1	1281.5	1281.5	1281.5
20	1	9	14.53	2	185	1281.5	1281.5	1281.5	1281.5	1296.8	1296.8	1296.8
20	1	10	1.28	2	186	1296.8	1296.8	1296.8	1296.8	1298.9	1298.9	1298.9
20	1	11	1.00	2	187	1298.9	1298.9	1298.9	1298.9	1300.6	1300.6	1300.6
20	1	12	1.10	2	188	1300.6	1300.6	1300.8	1300.8	1302.7	1304.7	1304.7
21	1	1	15.40	2	189	1304.7	1302.7	1304.7	1304.7	1320.8	1320.8	1320.8

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
21	1	28	0.58	2	216	1409.1	1409.1	1409.1	1409.1	1410.5	1410.5	1410.5
21	1	29	0.48	2	217	1410.5	1410.5	1410.5	1410.5	1411.7	1411.7	1411.7
21	1	30	0.50	2	218	1411.7	1411.7	1411.7	1411.7	1413.0	1413.0	1413.0
21	1	31	1.32	2	219	1413.0	1413.0	1413.0	1413.0	1415.1	1415.1	1415.1
21	1	32	1.93	2	220	1415.1	1415.1	1415.1	1415.1	1417.8	1417.8	1417.8
21	1	33	0.88	2	221	1417.8	1417.8	1417.8	1417.8	1419.4	1419.4	1419.4
21	1	34	0.85	2	222	1419.4	1419.4	1419.4	1419.4	1421.0	1421.0	1421.0
21	1	35	3.42	2	223	1421.0	1421.0	1421.2	1421.2	1425.4	1427.4	1427.4
22	1	1	4.20	2	224	1427.4	1425.4	1427.4	1427.4	1432.3	1432.3	1432.3
22	1	2	0.92	2	225	1432.3	1432.3	1432.3	1432.3	1434.0	1434.0	1434.0
22	1	3	1.42	2	226	1434.0	1434.0	1434.0	1434.0	1436.2	1436.2	1436.2
22	1	4	1.20	2	227	1436.2	1436.2	1436.2	1436.2	1438.2	1438.2	1438.2
22	1	5	3.42	2	228	1438.2	1438.2	1438.2	1438.2	1442.3	1442.3	1442.3

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
22	1	6	1.95	2	229	1442.3	1442.3	1442.3	1442.3	1445.1	1445.1	1445.1
22	1	7	2.23	2	230	1445.1	1445.1	1445.1	1445.1	1448.0	1448.0	1448.0
22	1	8	1.70	2	231	1448.0	1448.0	1448.0	1448.0	1450.5	1450.5	1450.5
22	1	9	14.53	2	232	1450.5	1450.5	1450.5	1450.5	1465.8	1465.8	1465.8
22	1	10	1.28	2	233	1465.8	1465.8	1465.8	1465.8	1467.8	1467.8	1467.8
22	1	11	1.00	2	234	1467.8	1467.8	1467.8	1467.8	1469.6	1469.6	1469.6
22	1	12	1.10	2	235	1469.6	1469.6	1469.8	1469.8	1471.7	1473.7	1473.7
23	1	1	15.40	2	236	1473.7	1471.7	1473.7	1473.7	1489.8	1489.8	1489.8
23	1	2	5.80	2	237	1489.8	1489.8	1489.8	1489.8	1496.4	1496.4	1496.4
23	1	3	2.70	2	238	1496.4	1496.4	1496.4	1496.4	1499.8	1499.8	1499.8
23	1	4	1.50	2	239	1499.8	1499.8	1499.8	1499.8	1502.1	1502.1	1502.1
23	1	5	0.75	2	240	1502.1	1502.1	1502.1	1502.1	1503.6	1503.6	1503.6
23	1	6	0.90	2	241	1503.6	1503.6	1503.6	1503.6	1505.3	1505.3	1505.3

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
23	1	33	0.88	2	268	1586.7	1586.7	1586.7	1586.7	1588.4	1588.4	1588.4
23	1	34	0.85	2	269	1588.4	1588.4	1588.4	1588.4	1590.0	1590.0	1590.0
23	1	35	3.42	2	270	1590.0	1590.0	1590.2	1590.2	1594.4	1596.4	1596.4
24	1	1	4.20	2	271	1596.4	1594.4	1596.4	1596.4	1601.3	1601.3	1601.3
24	1	2	0.92	2	272	1601.3	1601.3	1601.3	1601.3	1603.0	1603.0	1603.0
24	1	3	1.42	2	273	1603.0	1603.0	1603.0	1603.0	1605.2	1605.2	1605.2
24	1	4	1.20	2	274	1605.2	1605.2	1605.2	1605.2	1607.1	1607.1	1607.1
24	1	5	3.42	2	275	1607.1	1607.1	1607.1	1607.1	1611.3	1611.3	1611.3
24	1	6	1.95	2	276	1611.3	1611.3	1611.3	1611.3	1614.0	1614.0	1614.0
24	1	7	2.23	2	277	1614.0	1614.0	1614.0	1614.0	1617.0	1617.0	1617.0
24	1	8	1.70	2	278	1617.0	1617.0	1617.0	1617.0	1619.5	1619.5	1619.5
24	1	9	14.53	2	279	1619.5	1619.5	1619.5	1619.5	1634.8	1634.8	1634.8
24	1	10	1.28	2	280	1634.8	1634.8	1634.8	1634.8	1636.8	1636.8	1636.8

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
24	1	11	1.00	2	281	1636.8	1636.8	1636.8	1636.8	1638.6	1638.6	1638.6
24	1	12	1.10	2	282	1638.6	1638.6	1638.8	1638.8	1640.6	1642.6	1642.6
25	1	1	15.40	2	283	1642.6	1640.6	1642.6	1642.6	1658.8	1658.8	1658.8
25	1	2	5.80	2	284	1658.8	1658.8	1658.8	1658.8	1665.4	1665.4	1665.4
25	1	3	2.70	2	285	1665.4	1665.4	1665.4	1665.4	1668.8	1668.8	1668.8
25	1	4	1.50	2	286	1668.8	1668.8	1668.8	1668.8	1671.1	1671.1	1671.1
25	1	5	0.75	2	287	1671.1	1671.1	1671.1	1671.1	1672.6	1672.6	1672.6
25	1	6	0.90	2	288	1672.6	1672.6	1672.6	1672.6	1674.2	1674.2	1674.2
25	1	7	4.27	2	289	1674.2	1674.2	1674.2	1674.2	1679.3	1679.3	1679.3
25	1	8	3.43	2	290	1679.3	1679.3	1679.3	1679.3	1683.5	1683.5	1683.5
25	1	9	0.50	2	291	1683.5	1683.5	1683.5	1683.5	1684.7	1684.7	1684.7
25	1	10	0.58	2	292	1684.7	1684.7	1684.7	1684.7	1686.1	1686.1	1686.1
25	1	11	13.15	2	293	1686.1	1686.1	1686.1	1686.1	1700.0	1700.0	1700.0

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
25	1	25	0.37	2	307	1743.5	1743.5	1743.5	1743.5	1744.6	1744.6	1744.6
25	1	26	0.55	2	308	1744.6	1744.6	1744.6	1744.6	1745.9	1745.9	1745.9
25	1	27	0.42	2	309	1745.9	1745.9	1745.9	1745.9	1747.1	1747.1	1747.1
25	1	28	0.58	2	310	1747.1	1747.1	1747.1	1747.1	1748.4	1748.4	1748.4
25	1	29	0.48	2	311	1748.4	1748.4	1748.4	1748.4	1749.7	1749.7	1749.7
25	1	30	0.50	2	312	1749.7	1749.7	1749.7	1749.7	1750.9	1750.9	1750.9
25	1	31	1.32	2	313	1750.9	1750.9	1750.9	1750.9	1753.0	1753.0	1753.0
25	1	32	1.93	2	314	1753.0	1753.0	1753.0	1753.0	1755.7	1755.7	1755.7
25	1	33	0.88	2	315	1755.7	1755.7	1755.7	1755.7	1757.4	1757.4	1757.4
25	1	34	0.85	2	316	1757.4	1757.4	1757.4	1757.4	1759.0	1759.0	1759.0
25	1	35	3.42	2	317	1759.0	1759.0	1759.2	1759.2	1763.3	1765.3	1765.3
26	1	1	4.20	2	318	1765.3	1763.3	1765.3	1765.3	1770.3	1770.3	1770.3
26	1	2	0.92	2	319	1770.3	1770.3	1770.3	1770.3	1772.0	1772.0	1772.0

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
26	1	3	1.42	2	320	1772.0	1772.0	1772.0	1772.0	1774.2	1774.2	1774.2
26	1	4	1.20	2	321	1774.2	1774.2	1774.2	1774.2	1776.1	1776.1	1776.1
26	1	5	3.42	2	322	1776.1	1776.1	1776.1	1776.1	1780.3	1780.3	1780.3
26	1	6	1.95	2	323	1780.3	1780.3	1780.3	1780.3	1783.0	1783.0	1783.0
26	1	7	2.23	2	324	1783.0	1783.0	1783.0	1783.0	1786.0	1786.0	1786.0
26	1	8	1.70	2	325	1786.0	1786.0	1786.0	1786.0	1788.5	1788.5	1788.5
26	1	9	14.53	2	326	1788.5	1788.5	1788.5	1788.5	1803.8	1803.8	1803.8
26	1	10	1.28	2	327	1803.8	1803.8	1803.8	1803.8	1805.8	1805.8	1805.8
26	1	11	1.00	2	328	1805.8	1805.8	1805.8	1805.8	1807.6	1807.6	1807.6
26	1	12	1.10	2	329	1807.6	1807.6	1807.8	1807.8	1809.6	1811.6	1811.6
27	1	1	15.40	2	330	1811.6	1809.6	1811.6	1811.6	1827.8	1827.8	1827.8
27	1	2	5.80	2	331	1827.8	1827.8	1827.8	1827.8	1834.3	1834.3	1834.3
27	1	3	2.70	2	332	1834.3	1834.3	1834.3	1834.3	1837.8	1837.8	1837.8

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
27	1	30	0.50	2	359	1918.7	1918.7	1918.7	1918.7	1919.9	1919.9	1919.9
27	1	31	1.32	2	360	1919.9	1919.9	1919.9	1919.9	1922.0	1922.0	1922.0
27	1	32	1.93	2	361	1922.0	1922.0	1922.0	1922.0	1924.7	1924.7	1924.7
27	1	33	0.88	2	362	1924.7	1924.7	1924.7	1924.7	1926.3	1926.3	1926.3
27	1	34	0.85	2	363	1926.3	1926.3	1926.3	1926.3	1927.9	1927.9	1927.9
27	1	35	3.42	2	364	1927.9	1927.9	1928.1	1928.1	1932.3	1934.3	1934.3
28	1	1	4.20	2	365	1934.3	1932.3	1934.3	1934.3	1939.3	1939.3	1939.3
28	1	2	0.92	2	366	1939.3	1939.3	1939.3	1939.3	1941.0	1941.0	1941.0
28	1	3	1.42	2	367	1941.0	1941.0	1941.0	1941.0	1943.1	1943.1	1943.1
28	1	4	1.20	2	368	1943.1	1943.1	1943.1	1943.1	1945.1	1945.1	1945.1
28	1	5	3.42	2	369	1945.1	1945.1	1945.1	1945.1	1949.3	1949.3	1949.3
28	1	6	1.95	2	370	1949.3	1949.3	1949.3	1949.3	1952.0	1952.0	1952.0
28	1	7	2.23	2	371	1952.0	1952.0	1952.0	1952.0	1955.0	1955.0	1955.0

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
28	1	8	1.70	2	372	1955.0	1955.0	1955.0	1955.0	1957.4	1957.4	1957.4
28	1	9	14.53	2	373	1957.4	1957.4	1957.4	1957.4	1972.7	1972.7	1972.7
28	1	10	1.28	2	374	1972.7	1972.7	1972.7	1972.7	1974.8	1974.8	1974.8
28	1	11	1.00	2	375	1974.8	1974.8	1974.8	1974.8	1976.5	1976.5	1976.5
28	1	12	1.10	2	376	1976.5	1976.5	1976.7	1976.7	1978.6	1980.6	1980.6
29	1	1	5.00	3	1	4.3	951.8	953.8	953.8	959.5	959.5	959.5
29	1	2	4.00	3	2	959.5	959.5	959.5	959.5	964.3	964.3	964.3
29	1	3	1.00	3	3	964.3	964.3	964.3	964.3	966.0	966.0	966.0
29	1	4	3.00	3	4	966.0	966.0	966.0	966.0	969.8	969.8	969.8
29	1	5	10.50	3	5	969.8	969.8	969.8	969.8	981.1	981.1	981.1
29	1	6	0.40	3	6	981.1	981.1	981.1	981.1	982.2	982.2	982.2
29	1	7	0.30	3	7	982.2	982.2	982.2	982.2	983.3	983.3	983.3
29	1	8	1.10	3	8	983.3	983.3	983.3	983.3	985.1	985.1	985.1

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
29	1	9	0.40	3	9	985.1	985.1	985.1	985.1	986.3	986.3	986.3
29	1	10	4.50	3	10	986.3	986.3	986.3	986.3	991.6	991.6	991.6
29	1	11	1.20	3	11	991.6	991.6	991.6	991.6	993.5	993.5	993.5
29	1	12	4.00	3	12	993.5	993.5	993.5	993.5	998.3	998.3	998.3
29	1	13	2.00	3	13	998.3	998.3	998.3	998.3	1001.0	1001.0	1001.0
29	1	14	0.50	3	14	1001.0	1001.0	1001.0	1001.0	1002.3	1002.3	1002.3
29	1	15	0.80	3	15	1002.3	1002.3	1002.3	1002.3	1003.9	1003.9	1003.9
29	1	16	0.45	3	16	1003.9	1003.9	1003.9	1003.9	1005.1	1005.1	1005.1
29	1	17	0.45	3	17	1005.1	1005.1	1005.1	1005.1	1006.3	1006.3	1006.3
29	1	18	1.00	3	18	1006.3	1006.3	1006.5	1006.5	1008.2	1010.2	1010.2
30	1	1	27.00	3	19	1010.2	1008.2	1010.2	1010.2	1038.0	1038.0	1038.0
30	1	2	5.00	3	20	1038.0	1038.0	1038.0	1038.0	1043.8	1043.8	1043.8
30	1	3	10.00	3	21	1043.8	1043.8	1043.8	1043.8	1054.5	1054.5	1054.5

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
30	1	17	4.00	3	35	1115.4	1115.4	1115.6	1115.6	1120.4	1122.4	1122.4
31	1	1	5.00	3	36	1122.4	1120.4	1122.4	1122.4	1128.1	1128.1	1128.1
31	1	2	4.00	3	37	1128.1	1128.1	1128.1	1128.1	1132.9	1132.9	1132.9
31	1	3	1.00	3	38	1132.9	1132.9	1132.9	1132.9	1134.6	1134.6	1134.6
31	1	4	3.00	3	39	1134.6	1134.6	1134.6	1134.6	1138.4	1138.4	1138.4
31	1	5	10.50	3	40	1138.4	1138.4	1138.4	1138.4	1149.7	1149.7	1149.7
31	1	6	0.40	3	41	1149.7	1149.7	1149.7	1149.7	1150.8	1150.8	1150.8
31	1	7	0.30	3	42	1150.8	1150.8	1150.8	1150.8	1151.9	1151.9	1151.9
31	1	8	1.10	3	43	1151.9	1151.9	1151.9	1151.9	1153.7	1153.7	1153.7
31	1	9	0.40	3	44	1153.7	1153.7	1153.7	1153.7	1154.9	1154.9	1154.9
31	1	10	4.50	3	45	1154.9	1154.9	1154.9	1154.9	1160.2	1160.2	1160.2
31	1	11	1.20	3	46	1160.2	1160.2	1160.2	1160.2	1162.1	1162.1	1162.1
31	1	12	4.00	3	47	1162.1	1162.1	1162.1	1162.1	1166.9	1166.9	1166.9

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
31	1	13	2.00	3	48	1166.9	1166.9	1166.9	1166.9	1169.6	1169.6	1169.6
31	1	14	0.50	3	49	1169.6	1169.6	1169.6	1169.6	1170.9	1170.9	1170.9
31	1	15	0.80	3	50	1170.9	1170.9	1170.9	1170.9	1172.5	1172.5	1172.5
31	1	16	0.45	3	51	1172.5	1172.5	1172.5	1172.5	1173.7	1173.7	1173.7
31	1	17	0.45	3	52	1173.7	1173.7	1173.7	1173.7	1174.9	1174.9	1174.9
31	1	18	1.00	3	53	1174.9	1174.9	1175.1	1175.1	1176.8	1178.8	1178.8
32	1	1	27.00	3	54	1178.8	1176.8	1178.8	1178.8	1206.6	1206.6	1206.6
32	1	2	5.00	3	55	1206.6	1206.6	1206.6	1206.6	1212.4	1212.4	1212.4
32	1	3	10.00	3	56	1212.4	1212.4	1212.4	1212.4	1223.1	1223.1	1223.1
32	1	4	10.00	3	57	1223.1	1223.1	1223.1	1223.1	1233.9	1233.9	1233.9
32	1	5	7.00	3	58	1233.9	1233.9	1233.9	1233.9	1241.6	1241.6	1241.6
32	1	6	3.00	3	59	1241.6	1241.6	1241.6	1241.6	1245.4	1245.4	1245.4
32	1	7	4.00	3	60	1245.4	1245.4	1245.4	1245.4	1250.2	1250.2	1250.2

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
32	1	8	1.00	3	61	1250.2	1250.2	1250.2	1250.2	1251.9	1251.9	1251.9
32	1	9	1.00	3	62	1251.9	1251.9	1251.9	1251.9	1253.7	1253.7	1253.7
32	1	10	2.00	3	63	1253.7	1253.7	1253.7	1253.7	1256.4	1256.4	1256.4
32	1	11	1.00	3	64	1256.4	1256.4	1256.4	1256.4	1258.2	1258.2	1258.2
32	1	12	6.00	3	65	1258.2	1258.2	1258.2	1258.2	1265.0	1265.0	1265.0
32	1	13	3.00	3	66	1265.0	1265.0	1265.0	1265.0	1268.7	1268.7	1268.7
32	1	14	2.00	3	67	1268.7	1268.7	1268.7	1268.7	1271.5	1271.5	1271.5
32	1	15	6.00	3	68	1271.5	1271.5	1271.5	1271.5	1278.2	1278.2	1278.2
32	1	16	5.00	3	69	1278.2	1278.2	1278.2	1278.2	1284.0	1284.0	1284.0
32	1	17	4.00	3	70	1284.0	1284.0	1284.2	1284.2	1289.0	1291.0	1291.0
33	1	1	5.00	3	71	1291.0	1289.0	1291.0	1291.0	1296.7	1296.7	1296.7
33	1	2	4.00	3	72	1296.7	1296.7	1296.7	1296.7	1301.5	1301.5	1301.5
33	1	3	1.00	3	73	1301.5	1301.5	1301.5	1301.5	1303.2	1303.2	1303.2

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
33	1	17	0.45	3	87	1342.3	1342.3	1342.3	1342.3	1343.5	1343.5	1343.5
33	1	18	1.00	3	88	1343.5	1343.5	1343.7	1343.7	1345.4	1347.4	1347.4
34	1	1	27.00	3	89	1347.4	1345.4	1347.4	1347.4	1375.2	1375.2	1375.2
34	1	2	5.00	3	90	1375.2	1375.2	1375.2	1375.2	1381.0	1381.0	1381.0
34	1	3	10.00	3	91	1381.0	1381.0	1381.0	1381.0	1391.7	1391.7	1391.7
34	1	4	10.00	3	92	1391.7	1391.7	1391.7	1391.7	1402.5	1402.5	1402.5
34	1	5	7.00	3	93	1402.5	1402.5	1402.5	1402.5	1410.2	1410.2	1410.2
34	1	6	3.00	3	94	1410.2	1410.2	1410.2	1410.2	1414.0	1414.0	1414.0
34	1	7	4.00	3	95	1414.0	1414.0	1414.0	1414.0	1418.8	1418.8	1418.8
34	1	8	1.00	3	96	1418.8	1418.8	1418.8	1418.8	1420.5	1420.5	1420.5
34	1	9	1.00	3	97	1420.5	1420.5	1420.5	1420.5	1422.3	1422.3	1422.3
34	1	10	2.00	3	98	1422.3	1422.3	1422.3	1422.3	1425.0	1425.0	1425.0
34	1	11	1.00	3	99	1425.0	1425.0	1425.0	1425.0	1426.8	1426.8	1426.8

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
34	1	12	6.00	3	100	1426.8	1426.8	1426.8	1426.8	1433.6	1433.6	1433.6
34	1	13	3.00	3	101	1433.6	1433.6	1433.6	1433.6	1437.3	1437.3	1437.3
34	1	14	2.00	3	102	1437.3	1437.3	1437.3	1437.3	1440.1	1440.1	1440.1
34	1	15	6.00	3	103	1440.1	1440.1	1440.1	1440.1	1446.8	1446.8	1446.8
34	1	16	5.00	3	104	1446.8	1446.8	1446.8	1446.8	1452.6	1452.6	1452.6
34	1	17	4.00	3	105	1452.6	1452.6	1452.8	1452.8	1457.6	1459.6	1459.6
35	1	1	5.00	3	106	1459.6	1457.6	1459.6	1459.6	1465.3	1465.3	1465.3
35	1	2	4.00	3	107	1465.3	1465.3	1465.3	1465.3	1470.1	1470.1	1470.1
35	1	3	1.00	3	108	1470.1	1470.1	1470.1	1470.1	1471.8	1471.8	1471.8
35	1	4	3.00	3	109	1471.8	1471.8	1471.8	1471.8	1475.6	1475.6	1475.6
35	1	5	10.50	3	110	1475.6	1475.6	1475.6	1475.6	1486.9	1486.9	1486.9
35	1	6	0.40	3	111	1486.9	1486.9	1486.9	1486.9	1488.0	1488.0	1488.0
35	1	7	0.30	3	112	1488.0	1488.0	1488.0	1488.0	1489.1	1489.1	1489.1

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
35	1	8	1.10	3	113	1489.1	1489.1	1489.1	1489.1	1490.9	1490.9	1490.9
35	1	9	0.40	3	114	1490.9	1490.9	1490.9	1490.9	1492.1	1492.1	1492.1
35	1	10	4.50	3	115	1492.1	1492.1	1492.1	1492.1	1497.4	1497.4	1497.4
35	1	11	1.20	3	116	1497.4	1497.4	1497.4	1497.4	1499.3	1499.3	1499.3
35	1	12	4.00	3	117	1499.3	1499.3	1499.3	1499.3	1504.1	1504.1	1504.1
35	1	13	2.00	3	118	1504.1	1504.1	1504.1	1504.1	1506.8	1506.8	1506.8
35	1	14	0.50	3	119	1506.8	1506.8	1506.8	1506.8	1508.1	1508.1	1508.1
35	1	15	0.80	3	120	1508.1	1508.1	1508.1	1508.1	1509.7	1509.7	1509.7
35	1	16	0.45	3	121	1509.7	1509.7	1509.7	1509.7	1510.9	1510.9	1510.9
35	1	17	0.45	3	122	1510.9	1510.9	1510.9	1510.9	1512.1	1512.1	1512.1
35	1	18	1.00	3	123	1512.1	1512.1	1512.3	1512.3	1514.0	1516.0	1516.0
36	1	1	27.00	3	124	1516.0	1514.0	1516.0	1516.0	1543.8	1543.8	1543.8
36	1	2	5.00	3	125	1543.8	1543.8	1543.8	1543.8	1549.6	1549.6	1549.6

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
36	1	16	5.00	3	139	1615.4	1615.4	1615.4	1615.4	1621.2	1621.2	1621.2
36	1	17	4.00	3	140	1621.2	1621.2	1621.4	1621.4	1626.2	1628.2	1628.2
37	1	1	5.00	3	141	1628.2	1626.2	1628.2	1628.2	1633.9	1633.9	1633.9
37	1	2	4.00	3	142	1633.9	1633.9	1633.9	1633.9	1638.7	1638.7	1638.7
37	1	3	1.00	3	143	1638.7	1638.7	1638.7	1638.7	1640.4	1640.4	1640.4
37	1	4	3.00	3	144	1640.4	1640.4	1640.4	1640.4	1644.2	1644.2	1644.2
37	1	5	10.50	3	145	1644.2	1644.2	1644.2	1644.2	1655.5	1655.5	1655.5
37	1	6	0.40	3	146	1655.5	1655.5	1655.5	1655.5	1656.6	1656.6	1656.6
37	1	7	0.30	3	147	1656.6	1656.6	1656.6	1656.6	1657.7	1657.7	1657.7
37	1	8	1.10	3	148	1657.7	1657.7	1657.7	1657.7	1659.5	1659.5	1659.5
37	1	9	0.40	3	149	1659.5	1659.5	1659.5	1659.5	1660.7	1660.7	1660.7
37	1	10	4.50	3	150	1660.7	1660.7	1660.7	1660.7	1666.0	1666.0	1666.0
37	1	11	1.20	3	151	1666.0	1666.0	1666.0	1666.0	1667.9	1667.9	1667.9

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
37	1	12	4.00	3	152	1667.9	1667.9	1667.9	1667.9	1672.7	1672.7	1672.7
37	1	13	2.00	3	153	1672.7	1672.7	1672.7	1672.7	1675.4	1675.4	1675.4
37	1	14	0.50	3	154	1675.4	1675.4	1675.4	1675.4	1676.7	1676.7	1676.7
37	1	15	0.80	3	155	1676.7	1676.7	1676.7	1676.7	1678.3	1678.3	1678.3
37	1	16	0.45	3	156	1678.3	1678.3	1678.3	1678.3	1679.5	1679.5	1679.5
37	1	17	0.45	3	157	1679.5	1679.5	1679.5	1679.5	1680.7	1680.7	1680.7
37	1	18	1.00	3	158	1680.7	1680.7	1680.7	1680.7	1682.4	1682.4	1682.4
37	1	19	1.00	3	159	1682.4	1682.4	1682.4	1682.4	1684.2	1684.2	1684.2
37	1	20	3.40	3	160	1684.2	1684.2	1684.2	1684.2	1688.4	1688.4	1688.4
37	1	21	0.90	3	161	1688.4	1688.4	1688.4	1688.4	1690.0	1690.0	1690.0
37	1	22	0.85	3	162	1690.0	1690.0	1690.2	1690.2	1691.8	1693.8	1693.8
38	1	1	5.00	3	163	1693.8	1691.8	1693.8	1693.8	1699.6	1699.6	1699.6
38	1	2	4.00	3	164	1699.6	1699.6	1699.6	1699.6	1704.3	1704.3	1704.3

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
38	1	16	0.45	3	178	1743.9	1743.9	1743.9	1743.9	1745.1	1745.1	1745.1
38	1	17	0.45	3	179	1745.1	1745.1	1745.1	1745.1	1746.3	1746.3	1746.3
38	1	18	1.00	3	180	1746.3	1746.3	1746.3	1746.3	1748.1	1748.1	1748.1
38	1	19	1.00	3	181	1748.1	1748.1	1748.1	1748.1	1749.9	1749.9	1749.9
38	1	20	3.40	3	182	1749.9	1749.9	1749.9	1749.9	1754.0	1754.0	1754.0
38	1	21	0.90	3	183	1754.0	1754.0	1754.0	1754.0	1755.7	1755.7	1755.7
38	1	22	0.85	3	184	1755.7	1755.7	1755.9	1755.9	1757.5	1759.5	1759.5
39	1	1	5.00	3	185	1759.5	1757.5	1759.5	1759.5	1765.3	1765.3	1765.3
39	1	2	4.00	3	186	1765.3	1765.3	1765.3	1765.3	1770.0	1770.0	1770.0
39	1	3	1.00	3	187	1770.0	1770.0	1770.0	1770.0	1771.8	1771.8	1771.8
39	1	4	3.00	3	188	1771.8	1771.8	1771.8	1771.8	1775.5	1775.5	1775.5
39	1	5	10.50	3	189	1775.5	1775.5	1775.5	1775.5	1786.8	1786.8	1786.8
39	1	6	0.40	3	190	1786.8	1786.8	1786.8	1786.8	1788.0	1738.0	1788.0

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Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
39	1	20	3.40	3	204	1815.5	1815.5	1815.5	1815.5	1819.7	1819.7	1819.7
39	1	21	0.90	3	205	1819.7	1819.7	1819.7	1819.7	1821.4	1821.4	1821.4
39	1	22	0.85	3	206	1821.4	1821.4	1821.6	1821.6	1823.2	1825.2	1825.2
40	1	1	5.00	3	207	1825.2	1823.2	1825.2	1825.2	1830.9	1830.9	1830.9
40	1	2	4.00	3	208	1830.9	1830.9	1830.9	1830.9	1835.7	1835.7	1835.7
40	1	3	1.00	3	209	1835.7	1835.7	1835.7	1835.7	1837.4	1837.4	1837.4
40	1	4	3.00	3	210	1837.4	1837.4	1837.4	1837.4	1841.2	1841.2	1841.2
40	1	5	10.50	3	211	1841.2	1841.2	1841.2	1841.2	1852.5	1852.5	1852.5
40	1	6	0.40	3	212	1852.5	1852.5	1852.5	1852.5	1853.6	1853.6	1853.6
40	1	7	0.30	3	213	1853.6	1853.6	1853.6	1853.6	1854.7	1854.7	1854.7
40	1	8	1.10	3	214	1854.7	1854.7	1854.7	1854.7	1856.5	1856.5	1856.5
40	1	9	0.40	3	215	1856.5	1856.5	1856.5	1856.5	1857.7	1857.7	1857.7
40	1	10	4.50	3	216	1857.7	1857.7	1857.7	1857.7	1863.0	1863.0	1863.0

Edit Screen Ctrl - 8	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt £	It	Op£	Op min	mc	Q	McAvtS	Act.St	Pt. Ld	Op. St	Op.End	PtUnld	McAvtF
40	1	11	1.20	3	217	1863.0	1863.0	1863.0	1863.0	1864.9	1864.9	1864.9
40	1	12	4.00	3	218	1864.9	1864.9	1864.9	1864.9	1869.7	1869.7	1869.7
40	1	13	2.00	3	219	1869.7	1869.7	1869.7	1869.7	1872.4	1872.4	1872.4
40	1	14	0.50	3	220	1872.4	1872.4	1872.4	1872.4	1873.7	1873.7	1873.7
40	1	15	0.80	3	221	1873.7	1873.7	1873.7	1873.7	1875.3	1875.3	1875.3
40	1	16	0.45	3	222	1875.3	1875.3	1875.3	1875.3	1876.5	1876.5	1876.5
40	1	17	0.45	3	223	1876.5	1876.5	1876.5	1876.5	1877.7	1877.7	1877.7
40	1	18	1.00	3	224	1877.7	1877.7	1877.7	1877.7	1879.4	1879.4	1879.4
40	1	19	1.00	3	225	1879.4	1879.4	1879.4	1879.4	1881.2	1881.2	1881.2
40	1	20	3.40	3	226	1881.2	1881.2	1881.2	1881.2	1885.4	1885.4	1885.4
40	1	21	0.90	3	227	1885.4	1885.4	1885.4	1885.4	1887.0	1887.0	1887.0
40	1	22	0.85	3	228	1887.0	1887.0	1887.2	1887.2	1888.8	1890.8	1890.8

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 5

Cell Tool Transportation

Cell	CtE	Mc	Q	UnldTlMc	SSAvtS	Ct Avt	Ld Kit	UnldKit	RtnKit	Ct Avt	SSAvtF
1	3	1	1	0.25	0.0	0.000	0.0	239.5	472.0	479.5	479.5
1	2	2	1	2.25	435.0	435.0	435.0	626.5	811.0	818.5	818.5
1	1	3	1	4.25	780.0	780.0	780.0	951.5	1116.0	1123.5	1123.5

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 6

Machine Information

Cell	MachineID	Mc	Sp	MorF	P	Capac.	Cell	MachineID	Mc	Sp	MorF	P	Capac.
1	MC1	1	1	F	1	123							
1	MC2	2	1	F	2	123							
1	MC3	3	1	F	3	123							

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 7

Part Information

Cell	Part ID	Ops.	Pt £	P	B.Size	Cell	Part ID	Ops.	Pt £	P	B.Size
1	3176302a	39	1	1	1	1	3177537a	12	14	1	1
1	3035844a	8	2	1	1	1	3177536b	35	15	1	1
1	3176302b	39	3	1	1	1	3177537b	12	16	1	1
1	3035844b	8	4	1	1	1	3177536c	35	17	1	1
1	3176302c	39	5	1	1	1	3177537c	12	18	1	1
1	3035844c	8	6	1	1	1	3177536d	35	19	1	1
1	3176302d	39	7	1	1	1	3177537d	12	20	1	1
1	3035844d	8	8	1	1	1	3177536e	35	21	1	1
1	3176302e	39	9	1	1	1	3177537e	12	22	1	1
1	3176398a	39	10	1	1	1	3177536f	35	23	1	1
1	3176398b	39	11	1	1	1	3177537f	12	24	1	1
1	3176398c	39	12	1	1	1	3177536g	35	25	1	1
1	3177536a	35	13	1	1	1	3177537g	12	26	1	1

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Part Information

Cell	Part ID	Ops.	Pt #	P	B.Size	Cell	Part ID	Ops.	Pt #	P	B.Size
1	3177536h	35	27	1	1	1	3176918d	22	40	1	1
1	3177537h	12	28	1	1						
1	3177545a	18	29	1	1						
1	3178276a	17	30	1	1						
1	3177545b	18	31	1	1						
1	3178276b	17	32	1	1						
1	3177545c	18	33	1	1						
1	3178276c	17	34	1	1						
1	3177545d	18	35	1	1						
1	3178276d	17	36	1	1						
1	3176918a	22	37	1	1						
1	3176918b	22	38	1	1						
1	3176918c	22	39	1	1						

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

SELECT OUTPUT REQUIRED BY NUMBER :

1) Final Primary Tool Store Contents.
2) Final Tooling Details + Status.
3) Machining History and Cell Performance Measures
4) Machine Activities for Schedule.
5) Cell Tool-Transfer Activities.
6) List of Machines in Each Cell.
7) List of Scheduled Parts for Each Cell.
8) Tool Transporter Contents and Schedule.
9) Cell Tool Summary and Tool Status Report.

0) Quit.

Select Desired Output and press <Enter>

Output Number Selected ? : 9

Cell Details

Cell E	:	1	Run E	:	1
Machines	:	3	Parts	:	40
Tools	:	145	Transporters	:	3

Tools on :	Mc E1: 58	Cap.: 123	Mc E2: 46	Cap.: 123	
	Mc E3: 41	Cap.: 123	Mc E4: 0	Cap.: 0	
Tools in STS :	0	Cap.: 3000	Spare cap.: 3000		

Next	Edit Screen	Hard Copy	Selection ?	Previous Screen
Enter	Ctrl - B	Shift - PrtSc		P

Cell Tool Status Report

Cell Tool Input	:	145
Tools in Cell	:	145
Worn Tools	:	1
Refurbished Tools	:	0
Added Tools	:	0

for scheduled period

Next Enter	Edit Screen Ctrl - 8	Hard Copy Shift - PrtSc	Selection ? ♥	Previous Screen P

Appendix 5A:
MODELLING A BLANKING CELL
- AN INDUSTRIAL CASE STUDY

5A.1 Introduction

The work reported here is the result of a case study carried out with data supplied by a Teaching Company programme. The purpose of the work was to illustrate a novel application of the tool flow modelling to metalforming as opposed to the traditional metalcutting environment.

5A.2 Scope of the Study

The primary objective of the study was to examine the suitability of the models for management of the blanking cell. The secondary objectives were to examine tool store capacities, tooling requirements under different operating strategies and to determine cost-effective work schedules.

5A.3 The Cell

The layout of the proposed blanking cell, and the necessary back-up tool stores, is shown in figure 5B.1 . The elements within the cell are as follows :
- a coil holder with coil change carriage.
- a set of feed/measurement rolls.
- a 250-ton CNC/DNC blanking press with a capability of 15-30 strokes per minute.
- an automated component and scrap removal and stacking system.
- a two-station tool change 'buggy' acting as the primary tool store.
- a set of tool racks adjacent to the blanking press acting as a secondary tool store (STS).
- a central tool store (CTS) and refurbishment facility with storage capacity for upto 100 tools.
- manually assisted transfer devices capable of transferring a single tool between the central tool store and the secondary tool store and between the latter and the blanking press's primary tool store (PTS).

5A.4 The Tools

A typical tooling layout is shown in figure 5B.2 . The tools are by far the most expensive resource costing in the range of £20-30K per tool. The number and type of tools has to be very carefully monitored and the usage has to be high to obtain a satisfactory return on investment. The duplication of tools has thus got to be maintained at relatively low levels. This leads to two decisions unique in press shops; firstly, the flow of coils has to be scheduled to utilise a tool as fully as possible and secondly, refurbishment of the tool has to be planned in such a manner so as to enable the same tool to be reused as quickly as possibled. Two methods of refurbishment are possible : the steelings can either be subjected to regrind or replaced when regrinding is no longer possible.

5A.5 Modelling of Component Production

A typical component is shown in two stages in figures 5B.3 and 5B.4. The manufacture of this type of component required the translation of the model from metalcutting to metalforming. Three areas challenged the modelling in its current format : operation time, batch size and tool life.

The approach adopted in considering tool life, traditionally measured in discrete time or production units in metalcutting and hits in press work, was to translate the number of hits into minutes. From historical data it was estimated that each tool was capable of 4000 hits, with one hit occuring every 4 seconds, giving an initial tool life of 267 minutes, after which refurbishment was to be considered.

The approach to considering the number of laminations and the time incurred in the production of these laminations was based on mean batch sizes for different types of components. Since the production of each batch only required a single tool and the laminations were produced consecutively, it was possible to consider the total number of laminations (mean batch size) produced as being similar to a batch of one where the single operation time in minutes was calculated as :

(time to produce one lamination x mean batch size) / 60

This calculation had to be adjusted in some cases to take into consideration the tool life. Thus adjustment of the batch size or batch splitting was possible and at the end of the tool life even desirable so that production of the next split batch of laminations could await return of the refurbished tool rather than call for a duplicate tool. At this point it was also considered necessary to increase the the tool life arbitarily to 300 to include a safety margin.

5A.6 The Workpiece - Oriented Model

The workpiece-oriented model was set-up to machine a total of seventy components, see part information table in appendix 5B, in batches of one over a period of 163 hours (estimated machining time). The blanking cell representation and parameters were specified as described below.

The machine was considered to have a primary tool store with a capacity for one tool. This meant that only one tool could be emloyed in the machine with its successor being assigned on a just-in-time basis. An STS was set-up with an initial capacity for 500 tools. This tool store is effectively a back-up tool store which supplies the PTS and accepts returned tools which are then assessed for their residual tool life. Tool which require refurbishment or are worn are dispatched to the CTS.

Journey times specified were 20 minutes from STS to PTS and 60 minutes from STS to CTS. Tools were transferred manually and assisted by truck between the STS and CTS.

A coil changeover time of 30 minutes was specified and an average refurbishment time of 4 hours. The tool search and load times at the stores averaged at 10 minutes.

5A.7 Results of Workpiece - Oriented Modelling

An initial set of results was obtained which provided a basis for assessment of the tool flow models' ability to model the blanking press cell and provided an insight into the working of the cell. The results are presented via tables in appendix 5B.

5A.7.1 Tool Requirements Analysis

For this initial run of seventy components, it was found that a maximum of 46 tools were required. No tools required refurbishment but as can be observed from the results, in the 'final tool details' table in appendix 5B, a large number of these tools could not be effectively reused as their residual life is insufficient to continue machining. This would imply that a number of tools would require refurbishment at the start of the next production period.

5A.7.2 Machining Analysis

The results obtained from the 'machining history' table in appendix 5B, when coupled with the tool requirements analysis, details the usage of these tools over the machining period and provides the history of gradual decline in residual tool life. An examination of this table together with the finish times of the activity for the particular machining stage, would effectively provide a schedule for refurbishment. This schedule could then effectively be used to reschedule the machining list or sequence of machining to achieve best utilisation of the tools. This iterative process will converge on a best solution in a finite number of steps.

5A.7.3 Cell Performance

The time required to carry out all the machining activities was determined as approximately 12500 minutes. This increase in expected time by approximately 28% appeared to be in the main due to the tool transfer times between the STS and the PTS. The utilisations are shown in the 'cell performance measures' table in appendix 5B. The machine activities are shown in the 'machine activities' table and indicate the machine activity times with the last activity in the schedule being completed at 12499.4 minutes.

5A.7.4 Cell Tool Transportation

The single tool transporter was found to be fairly heavily utilised. This is because of the need to transfer tools after every coil change or batch changeover. A total of sixty-three trips were required in order to satisfy the machining list with the first trip being undertaken after 20 minutes and the last trip after 12176 minutes. The number of trips undertaken implies that organisation of the work schedule provided continued usage of the same tool on a number of successive batches, see 'machining history' table in appendix 5B.

The schedule of tool transfer, i.e the actual times that the tool transfer was effected at and the contents of the transporter at this time are given in the 'tool transporter contents' table in appendix 5B. This table also provides insight into the particular transfer device used, useful when a number of machines and transporters are employed, and the origin of the transporter and its destination. It is thus possible using this table to ascertain the traffic density and capability of the tool transporter in meeting its assigned tasks. This table may be read in conjunction with the 'cell tool transportation' table in appendix 5B.

5A.7.5 Cell Tool Summary

The part routing / schedule of work is given in the 'part information' table in appendix 5B. This table indicates the sequence of machining which if changed would generate a different tooling requirement. This schedule is thus the determining factor not only in specifying a refurbishment schedule but also in the specification of the minimum and actual tooling requirements. These requirements per machine and major store and the overall requirements for the cell are shown in the 'cell details' and 'cell tool status' reports in appendix 5B. The latter providing global figures of tools requiring refurbishment, tools required to be input to overcome shortages and indicating the number of tools currently held within the cell. The tables indicate that the specified capacity of the STS is more than sufficient.

5A.8 Results of Computer Assisted Cluster Analysis (CACA)

A subset of 25 part types was created for the CACA module evaluation. This subset was drawn pseudo-randomly from the original set of 70 jobs used to evaluate the workpiece-oriented model. This subset of part types required 11 tool types and was used to constitute the initial clustering matrix shown in figure 5B.5.

A total of 4 iterations was necessary to achieve the fully ranked matrix shown in figure 5B.6. Examination of this matrix shows the formation of three tool cluster sets as shown in table 5A.1.

Table 5A.1 : Tool Cluster Sets		
Tool Cluster Set #	Basic Tools	Part Types
1	1	11
2	1	5
3	9	9

Since no further ranking was possible or necessary, substitution of the cell entries with the cumulative tool usage times was carried out according to the rank order clustering algorithm. This manual task was completed with the insertion of the order requirement for each part type, the same as that for the workpiece-oriented model, as shown in figure 5B.7.

The insertion of the tool usage times and order requirement completed, the next task was to specify the tool life and tool life limit for each tool which is again the same as that specified for the workpiece-oriented model. The latter values in conjunction with the order requirement and cumulated tool usage produce the minimum tool requirement for each tool cluster set, shown in table 5A.2 and in figure 5B.8.

Table 5A.2 : Minimum Tool Cluster Set Tool Requirements		
Tool Cluster Set #	Basic Tools	Total Tools
1	1	5
2	1	2
3	9	17

5A.9 Discussion of Results

Both models, operating under different tool management strategies have been found to be suitable for the modelling of the blanking press facility and to fulfil the secondary objectives of the study. Some limitations and restrictions are present in both models for the modelling of this facility as opposed to the metalcutting facility for which the models were primarily intended.

The workpiece-oriented model considers the problem in greater detail than the CACA module and offers solutions to the problems of tool requirements planning, tool flow deficiencies and the transient capacities required. These results have been offered within the output tables. The particular problem faced in the modelling of the blanking press was not in the actual representation of the press itself but in regard to the refurbishment of tools. The current model works to a static production schedule and thus a minimum tooling requirement is generated as a matter of routine, but the added complication in this situation is the cost of the tools involved i.e not only does it seem necessary to reuse a tool as often as possible but unlike in metalcutting where the cost of a single tool is low in comparison, the same tool must be refurbished and used without the creation or addition of another cutting tool. This implies that either the press remains idle for a period as will be the case in the workpiece-oriented model or the whole work schedule would have to be adjusted dynamically to respond to such situations.

Modification of the workpiece-oriented model to use a refurbished tool in the first instance is possible but is not considered a feasible option because the delays incurred in nearly all cases proved unacceptable and thus new tools would be created anyway. This meant that what was required was not only a minimum tooling requirement but this requirement without tool duplication. This situation is possible by setting a tolerance limit for worn tools in the STS as low as one which would force tools into refurbishment and thus enable their recycling into the system at the earliest oppurtunity. What is not possible is to dynamically reassign a work schedule. This latter facility, considered the most appropriate route to follow, is offered by the CACA module. This suitability of CACA does not however derate the value of the workpiece-oriented model which is in itself significant in that it provides an actual tooling requirement to satisfy a given machining list, the number of tools requiring refurbishment and the times at which the tools leave and re-enter the cell besides the whole host of detailed results presented above. These results if interpreted correctly will considerably enhance the tool management of the cell, particularly if accompanied by the CACA module.

The CACA module as discussed offers a more appropriate solution to the tooling and capacity problems as it is not only able to offer short term or revised work schedules but also to provide the appropriate number of tools required to satisfy the given order requirement.

The CACA module offers rapid configuration and reconfiguration of tool and part cluster sets. This implies that at the very least machining of any work within a tool cluster set may continue until exhaustion of tool life for a particular tool. At the end of tool life a decision may be taken as to whether to proceed with machining using a replacement tool or another tool, if any, within the tool cluster set or discontinue with this particular work configuration altogether and proceed to another work set till the tool for the former configuration is made available again after refurbishment. This hysteresis of work sets permits dynamic work-to lists to be established. An added facility which will considerable enhance this dynamic allocation of work is the 'cost' column.

This cost column will permit decisions to be made on tooling configurations to be based on a cost limit in which the end result will be enhanced decision making as to whether to refurbish or replace with a sister tool.

5A.10 Concluding Remarks

In conclusion it appears that either of the models may be used depending upon purpose and depth of analysis required. The CACA module has been found to be more appropriate for the type of management required of the blanking cell but if further analysis is required as to actual flow and scheduled times then the 'optimum' short range work schedule from the CACA module may be used as input to the workpiece-oriented model. This iterative process of scheduling and rescheduling will converge on a complete tool management solution. Finally, the generic model representations have proved their ability to model other facilities besides those for prismatic and cylindrical part metalcutting manufacture.

Appendix 5B:

RESULTS AND FIGURES

A BLANKING CELL INDUSTRIAL CASE STUDY

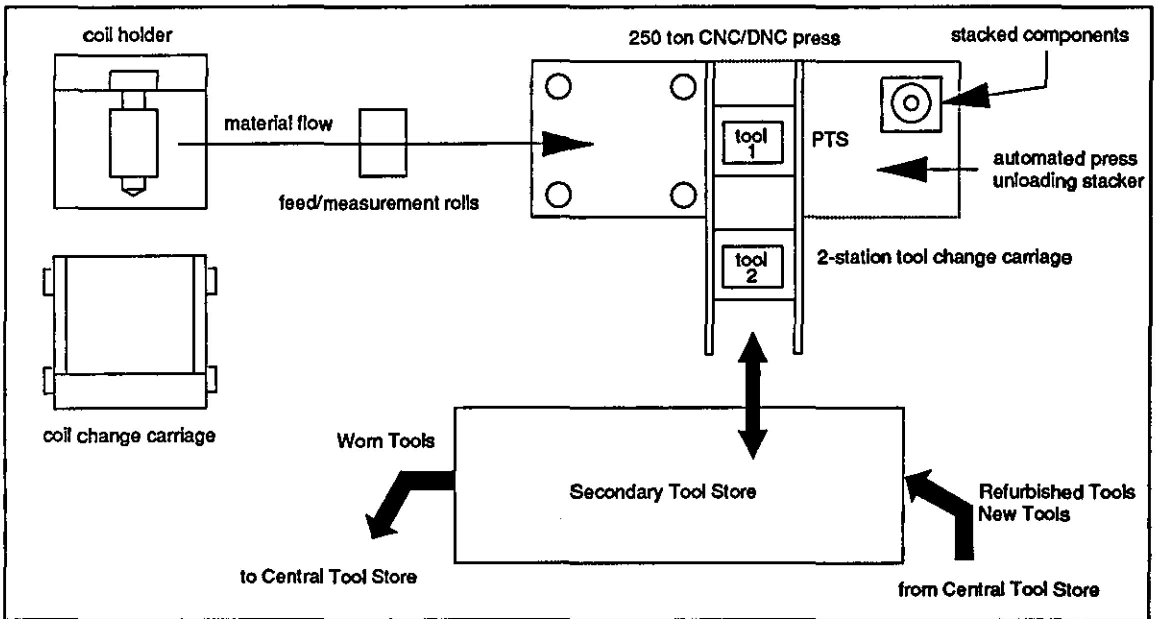

Figure 5B.1	BLANKING LINE	LUT - FMS Research Group

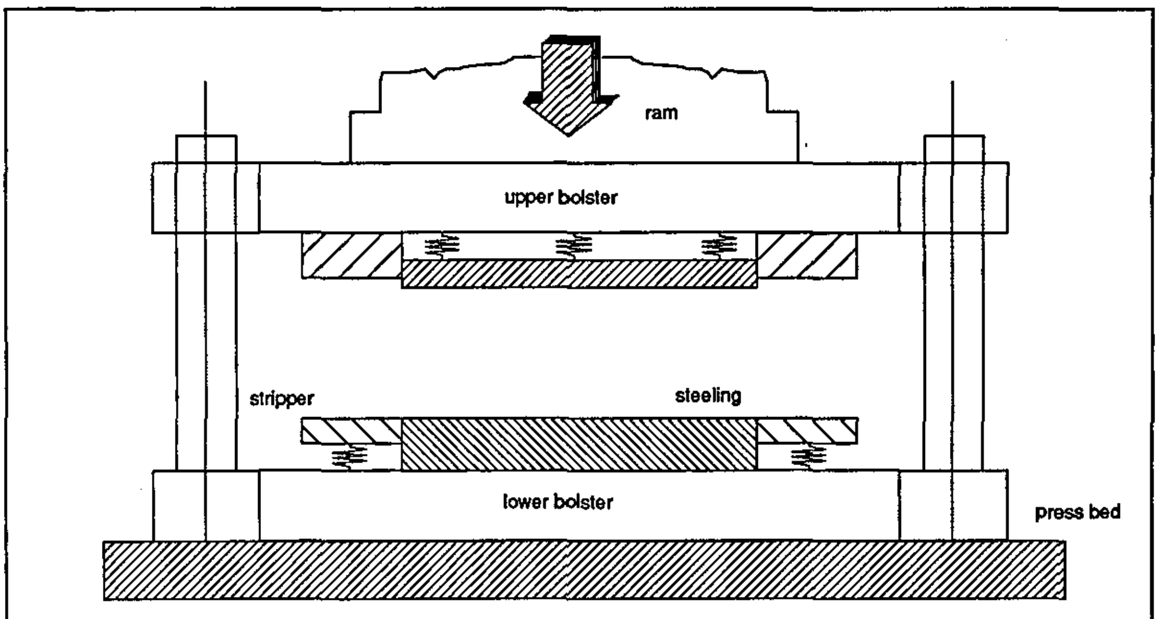

Figure 5B.2	SECTION THROUGH SIMPLE BLANKING TOOL	LUT - FMS Research Group

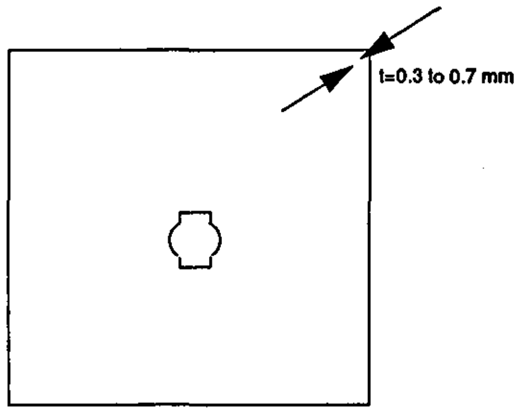

Figure 5B.3	BLANKED COMPONENT - MINIMUM LEVEL OF DETAIL	LUT - FMS Research Group

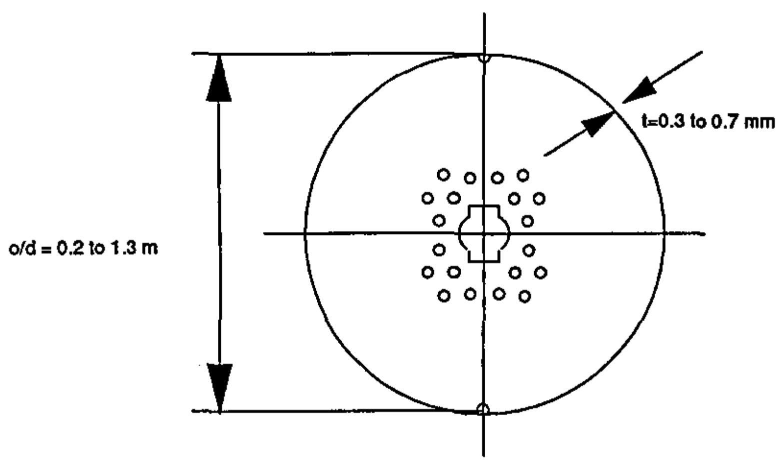

Figure 5B.4	BLANKED COMPONENT - MAXIMUM LEVEL OF DETAIL	LUT - FMS Research Group

COMPUTER ASSISTED CLUSTER ANALYSIS

parts →
tools ↓

tools \ parts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1	1	1	1				1	1	1						1					1			1	
2					1	1	1						1												1
3											1														
4												1													
5														1											
6															1										
7																	1								
8																			1						
9																				1					
10																						1			
11																							1		

Figure 5B.5	CACA MODULE - INITIAL ROC MATRIX	LUT - FMS Research Group

COMPUTER ASSISTED CLUSTER ANALYSIS

Total Iterations = 4 Row Iterations = 2 Col. Iterations = 2

parts →
tools ↓

tools \ parts	1	2	3	4	8	9	10	16	18	21	24	5	6	7	13	25	11	12	14	15	17	19	20	22	23
1	1	1	1	1	1	1	1	1	1	1	1														
2												1	1	1	1	1									
3																	1								
4																		1							
5																			1						
6																				1					
7																					1				
8																						1			
9																							1		
10																								1	
11																									1

tool cluster set #1

tool cluster set #2

tool cluster set #3

Figure 5B.6	CACA MODULE - RANKED ROC MATRIX	LUT - FMS Research Group

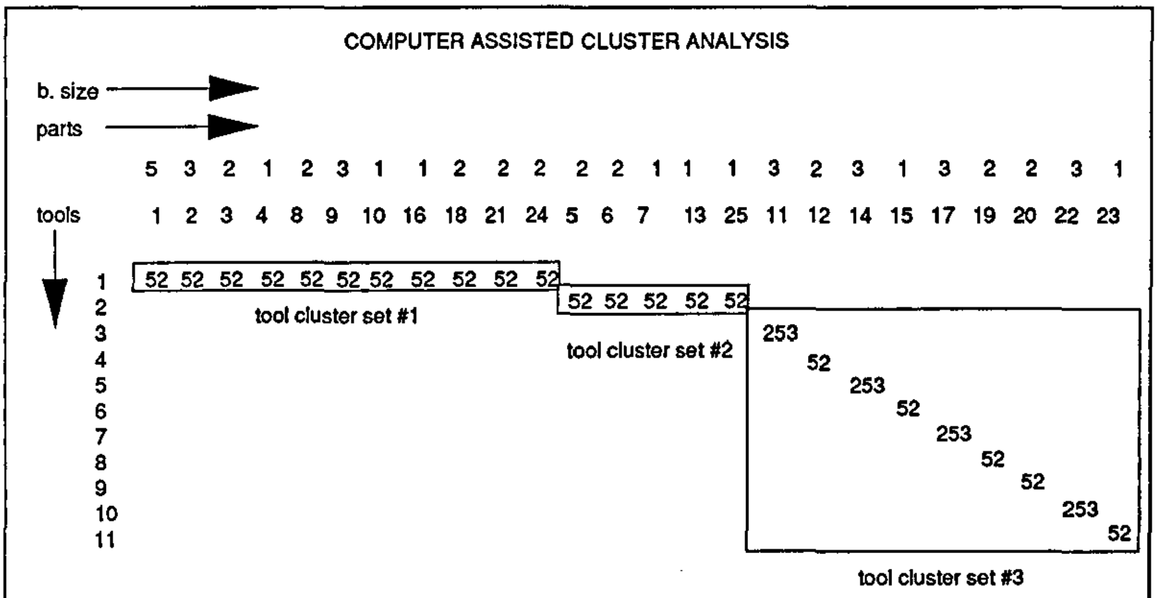

Figure 5B.7

CACA MODULE
TOOL TIMES AND ORDER REQUIREMENTS

LUT - FMS
Research Group

COMPUTER ASSISTED CLUSTER ANALYSIS

Tool Type	Max. % Tool Life	Tool Life	Cum. Tool Use Time	Min. Tools	Sis. Tools	Total
1	95	300	1248	4.37	4	5
2	95	300	364	1.27	1	2
3	95	300	759	2.66	2	3
4	95	300	104	0.36	0	1
5	95	300	759	2.66	2	3
6	95	300	52	0.18	0	1
7	95	300	759	2.66	2	3
8	95	300	104	0.36	0	1
9	95	300	104	0.36	0	1
10	95	300	759	2.66	2	3
11	95	300	52	0.18	0	1

Figure 5B.8

CACA MODULE
MINIMUM TOOL REQUIREMENT FOR CLUSTERS

LUT - FMS
Research Group

Machine Information

Cell	MachineID	Mc	Sp	MorF	P	Capac.	Cell	MachineID	Mc	Sp	MorF	P	Capac.
1	blankpress	1	1	F	1	1							

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Store Contents

Tool Store : blankpress Desc. : primary Status : final

Capacity : 1 Tools in Store : 1 Under [-] : 0

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
1	4	25.00	F								

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Part Information

Cell	Part ID	Ops.	Pt #	P	B.Size	Cell	Part ID	Ops.	Pt #	P	B.Size
1	1	1	1	1	1	1	9	1	14	1	1
1	41	1	2	1	1	1	8	1	15	1	1
1	21	1	3	1	1	1	44	1	16	1	1
1	23	1	4	1	1	1	45	1	17	1	1
1	32	1	5	1	1	1	10	1	18	1	1
1	4	1	6	1	1	1	48	1	19	1	1
1	42	1	7	1	1	1	38	1	20	1	1
1	3	1	8	1	1	1	46	1	21	1	1
1	12	1	9	1	1	1	6	1	22	1	1
1	29	1	10	1	1	1	47	1	23	1	1
1	43	1	11	1	1	1	31	1	24	1	1
1	30	1	12	1	1	1	36	1	25	1	1
1	13	1	13	1	1	1	49	1	26	1	1

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Part Information

Cell	Part ID	Ops.	Pt #	P	B.Size	Cell	Part ID	Ops.	Pt #	P	B.Size
1	7	1	27	1	1	1	55	1	40	1	1
1	50	1	28	1	1	1	28	1	41	1	1
1	53	1	29	1	1	1	58	1	42	1	1
1	56	1	30	1	1	1	37	1	43	1	1
1	5	1	31	1	1	1	59	1	44	1	1
1	51	1	32	1	1	1	22	1	45	1	1
1	35	1	33	1	1	1	62	1	46	1	1
1	54	1	34	1	1	1	27	1	47	1	1
1	26	1	35	1	1	1	65	1	48	1	1
1	57	1	36	1	1	1	18	1	49	1	1
1	24	1	37	1	1	1	60	1	50	1	1
1	52	1	38	1	1	1	20	1	51	1	1
1	17	1	39	1	1	1	63	1	52	1	1

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Part Information

Cell	Part ID	Ops.	Pt #	P	B.Size	Cell	Part ID	Ops.	Pt #	P	B.Size
1	25	1	53	1	1	1	40	1	66	1	1
1	66	1	54	1	1	1	15	1	67	1	1
1	39	1	55	1	1	1	16	1	68	1	1
1	61	1	56	1	1	1	70	1	69	1	1
1	33	1	57	1	1	1	19	1	70	1	1
1	64	1	58	1	1						
1	34	1	59	1	1						
1	67	1	60	1	1						
1	68	1	61	1	1						
1	2	1	62	1	1						
1	11	1	63	1	1						
1	14	1	64	1	1						
1	69	1	65	1	1						

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Tool Transporter Contents

Cart Dest. : 1 Cart Origin : -1 Cart # : 1

Cap. : 1 Start : 0.00 Tools in Cart : 1 Finish : 62.50

Pkt	Tl. No	Life	S	Pkt.	Tl. No	Life	S	Pkt.	Tl. No	Life	S
1	1	*	*								

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

#	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Req.	R.
1	T/RA	R	F	5	300.00	25.00	4	0	N
2	T/RA	R	F	5	300.00	25.00	4	0	N
3	T/RA	R	F	5	300.00	25.00	4	0	N
4	T/RA	R	F	5	300.00	25.00	4	0	N
5	T/SA	R	F	1	300.00	32.00	5	0	N
6	T/SA	R	F	1	300.00	32.00	5	0	N
7	T/SA	R	F	1	300.00	32.00	5	0	N
8	T/SA	R	F	1	300.00	32.00	5	0	N
9	T/SA	R	F	1	300.00	32.00	5	0	N
10	T/RB	R	F	5	300.00	25.00	3	0	N
11	T/RB	R	F	5	300.00	25.00	3	0	N
12	T/RB	R	F	1	300.00	233.00	3	0	N
13	T/SB	R	F	1	300.00	32.00	3	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

#	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Req.	R.
14	T/SB	R	F	1	300.00	32.00	3	0	N
15	T/SB	R	F	1	300.00	32.00	3	0	N
16	T/SC	R	F	1	300.00	32.00	3	0	N
17	T/SC	R	F	1	300.00	32.00	3	0	N
18	T/SC	R	F	1	300.00	32.00	3	0	N
19	T/RJ	R	F	1	300.00	233.00	1	0	N
20	T/RC	R	F	1	300.00	233.00	1	0	N
21	T/RH	R	F	1	300.00	233.00	1	0	N
22	T/SD	R	F	1	300.00	32.00	3	0	N
23	T/SD	R	F	1	300.00	32.00	3	0	N
24	T/SD	R	F	1	300.00	32.00	3	0	N
25	T/SE	R	F	1	300.00	32.00	3	0	N
26	T/SE	R	F	1	300.00	32.00	3	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

#	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
27	T/SE	R	F	1	300.00	32.00	3	0	N
28	T/SF	R	F	1	300.00	32.00	3	0	N
29	T/SF	R	F	1	300.00	32.00	3	0	N
30	T/SF	R	F	1	300.00	32.00	3	0	N
31	T/RG	R	F	1	300.00	233.00	1	0	N
32	T/RI	R	F	1	300.00	233.00	1	0	N
33	T/SG	R	F	1	300.00	32.00	2	0	N
34	T/SG	R	F	1	300.00	32.00	2	0	N
35	T/SH	R	F	1	300.00	32.00	2	0	N
36	T/SH	R	F	1	300.00	32.00	2	0	N
37	T/SI	R	F	1	300.00	32.00	3	0	N
38	T/SI	R	F	1	300.00	32.00	3	0	N
39	T/SI	R	F	1	300.00	32.00	3	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Final Tool Details

#	Tool id	S1	S2	Uses	Life St.	Life Fin.	Sis.	Reg.	R.
40	T/RK	R	F	1	300.00	233.00	1	0	N
41	T/RE	R	F	1	300.00	233.00	1	0	N
42	T/RF	R	F	1	300.00	233.00	1	0	N
43	T/SJ	R	F	1	300.00	32.00	3	0	N
44	T/SJ	R	F	1	300.00	32.00	3	0	N
45	T/SJ	R	F	1	300.00	32.00	3	0	N
46	T/RL	R	F	1	300.00	233.00	1	0	N

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machining History

Pt #	Mc. ID	Mc	It	Op #	Q	Op min	Tl#1	Life1S	Life1F	Tl#2	Life2S	Life2F
1	blankpress	1	1	1	1	52.00	1	285.0	233.0			
2	blankpress	1	1	1	2	253.00	5	285.0	32.0			
3	blankpress	1	1	1	3	52.00	10	285.0	233.0			
4	blankpress	1	1	1	4	52.00	10	233.0	181.0			
5	blankpress	1	1	1	5	52.00	1	233.0	181.0			
6	blankpress	1	1	1	6	52.00	1	181.0	129.0			
7	blankpress	1	1	1	7	253.00	6	285.0	32.0			
8	blankpress	1	1	1	8	52.00	1	129.0	77.0			
9	blankpress	1	1	1	9	52.00	1	77.0	25.0			
10	blankpress	1	1	1	10	52.00	10	181.0	129.0			
11	blankpress	1	1	1	11	253.00	7	285.0	32.0			
12	blankpress	1	1	1	12	52.00	10	129.0	77.0			
13	blankpress	1	1	1	13	52.00	2	285.0	233.0			

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Cell Performance Measures

Cell No. : 1 Planning Horizon : 9760.00

Cell Performance Time : 12499.20

Machine No. :	1	Used for :	12499.20	Utilisation :	128.07
Machine No. :	0	Used for :	0.00	Utilisation :	0.00
Machine No. :	0	Used for :	0.00	Utilisation :	0.00
Machine No. :	0	Used for :	0.00	Utilisation :	0.00
Tool Cart # :	1	Used for :	6615.00	Utilisation :	67.78
Tool Cart # :	0	Used for :	0.00	Utilisation :	0.00
Tool Cart # :	0	Used for :	0.00	Utilisation :	0.00
Tool Cart # :	0	Used for :	0.00	Utilisation :	0.00

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Machine Activities

Pt #	It	Op#	Op min.	Mc.No	Q.Pos.	Mc.Avail.St.	Activity St.	Mc.Avail.End
1	1	1	52.00	1	1	0.2	62.5	179.7
2	1	1	253.00	1	2	179.7	187.5	505.7
3	1	1	52.00	1	3	505.7	475.7	592.9
4	1	1	52.00	1	4	592.9	562.9	680.1
5	1	1	52.00	1	5	680.1	655.6	772.8
6	1	1	52.00	1	6	772.8	742.8	860.0
7	1	1	253.00	1	7	860.0	835.5	1153.7
8	1	1	52.00	1	8	1153.7	1123.7	1240.9
9	1	1	52.00	1	9	1240.9	1210.9	1328.1
10	1	1	52.00	1	10	1328.1	1303.6	1420.8
11	1	1	253.00	1	11	1420.8	1428.6	1746.8
12	1	1	52.00	1	12	1746.8	1716.8	1834.0
13	1	1	52.00	1	13	1834.0	1809.5	1926.7

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Machine Activities

Pt #	It	Op#	Op min.	Mc.No	Q.Pos.	Mc.Avail.St.	Activity St.	Mc.Avail.End
66	1	1	52.00	1	66	11851.4	11821.4	11938.6
67	1	1	52.00	1	67	11938.6	11914.1	12031.3
68	1	1	52.00	1	68	12031.3	12001.3	12118.5
69	1	1	253.00	1	69	12118.5	12094.0	12412.2
70	1	1	52.00	1	70	12412.2	12382.2	12499.4

Edit Screen	Next	Hard Copy	Selection ?	Previous Screen
Ctrl - B	Enter	Shift - PrtSc		P

Cell Tool Transportation

Cell	Trans.No.	Mc.	Q.Pos.	Trans.Av.	Load Tls	Unld.Tls	Rtn. STS	Trans.Av
1	1	1	1	0.000	20.0	60.0	105.0	125.0
1	1	1	2	125.0	145.0	185.0	230.0	250.0
1	1	1	3	250.0	270.0	310.0	355.0	375.0
1	1	1	5	593.1	613.1	653.1	698.1	718.1
1	1	1	7	773.0	793.0	833.0	878.0	898.0
1	1	1	8	898.0	918.0	958.0	1003.0	1023.0
1	1	1	10	1241.1	1261.1	1301.1	1346.1	1366.1
1	1	1	11	1366.1	1386.1	1426.1	1471.1	1491.1
1	1	1	12	1491.1	1511.1	1551.1	1596.1	1616.1
1	1	1	13	1747.0	1767.0	1807.0	1852.0	1872.0
1	1	1	16	2014.1	2034.1	2074.1	2119.1	2139.1
1	1	1	17	2139.1	2159.1	2199.1	2244.1	2264.1
1	1	1	18	2395.0	2415.0	2455.0	2500.0	2520.0

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Cell Tool Transportation

Cell	Trans.No.	Mc.	Q.Pos.	Trans.Av.	Load Tls	Unld.Tls	Rtn. STS	Trans.Av
1	1	1	58	10240.8	10260.8	10300.8	10345.8	10365.8
1	1	1	59	10365.8	10385.8	10425.8	10470.8	10490.8
1	1	1	60	10621.7	10641.7	10681.7	10726.7	10746.7
1	1	1	61	10746.7	10766.7	10806.7	10851.7	10871.7
1	1	1	62	11002.6	11022.6	11062.6	11107.6	11127.6
1	1	1	63	11290.8	11310.8	11350.8	11395.8	11415.8
1	1	1	65	11470.7	11490.7	11530.7	11575.7	11595.7
1	1	1	66	11595.7	11615.7	11655.7	11700.7	11720.7
1	1	1	67	11851.6	11871.6	11911.6	11956.6	11976.6
1	1	1	69	12031.5	12051.5	12091.5	12136.5	12156.5
1	1	1	70	12156.5	12176.5	12216.5	12261.5	12281.5

Edit Screen Ctrl - B	Next Enter	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Cell Details

Cell #	:	1	Run #	:	1
Machines	:	1	Parts	:	70
Tools	:	46	Transporters	:	1

Tools on :	Mc #1:	1	Cap.: 1	Mc #2:	0	Cap.:	0
	Mc #3:	0	Cap.: 0	Mc #4:	0	Cap.:	0

Tools in STS : 45 Cap.: 500 Spare cap.: 455

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Cell Tool Status Report

Cell Tool Input	:	46
Tools in Cell	:	46
Worn Tools	:	0
Refurbished Tools	:	0
Added Tools	:	0

for scheduled period

Next Enter	Edit Screen Ctrl - B	Hard Copy Shift - PrtSc	Selection ?	Previous Screen P

Appendix 6:

PUBLISHED PAPERS

PUBLISHED PAPERS NOT FILMED FOR COPYRIGHT REASONS

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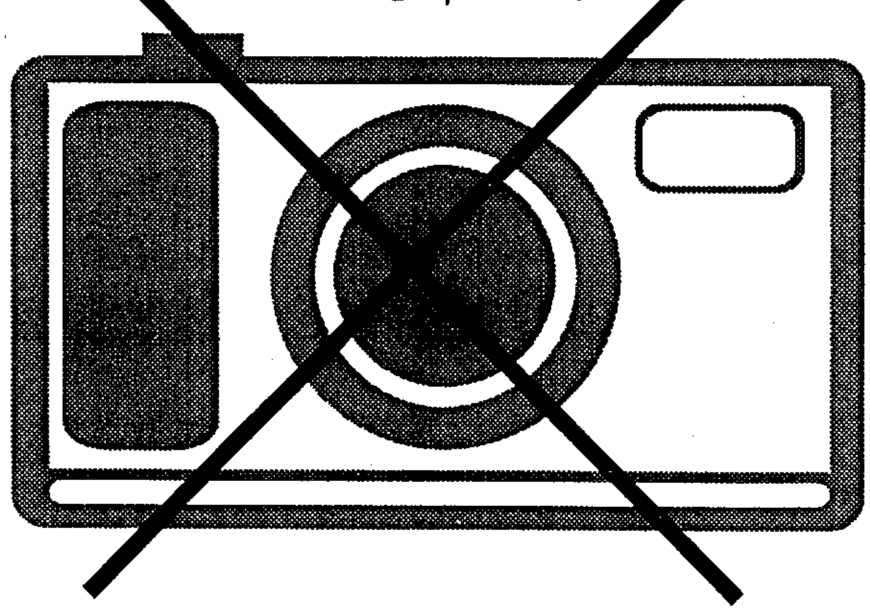

Published Papers

1.

'The management of tool flows in highly automated flexible machining installations', published at the 2nd Intl. Conf. on Comp. Aided Prodn. Engg., Edinburgh, April 1987.

2.

'Tool management in highly automated batch manufacturing', published at 1988 ACME Grant Holders Conf., Nottingham, 1988.