INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI[®]

Bell & Howell Information and Learning 300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA 800-521-0600

	,	

THE UNIVERSITY OF ALBERTA A MANUFACTURING RESOURCE PLANNING SYSTEM

Ву

BENG F. LIM



A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

DEPARTMENT OF MECHANICAL ENGINEERING

EDMONTON, ALBERTA SPRING, 1999



National Library of Canada

Acquisitions and Bibliographic Services

395 Wellington Street Ottawa ON K1A 0N4 Canada Bibliothèque nationale du Canada

Acquisitions et services bibliographiques

395, rue Wellington Ottawa ON K1A 0N4 Canada

Your file Votre référence

Our file Notre rélérence

The author has granted a nonexclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-40077-8



THE UNIVERSITY OF ALBERTA LIBRARY RELEASE FORM

NAME OF AUTHOR BENG F. LIM

TITLE OF THESIS A MANUFACTURING RESOURCE PLANNING SYSTEM

DEGREE FOR WHICH THESIS WAS PRESENTED MASTER OF SCIENCE
YEAR THIS DEGREE GRANTED SPRING, 1999

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(SIGNED)

PERMANENT ADDRESS:

30, JALAN ATHINAHAPAN 3

TAMAN TUN DR. ISMAIL

60000 KUALA LUMPUR

MALAYSIA

DATED Spail 29, 1999

THE UNIVERSITY OF ALBERTA FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "A MANUFACTURING RESOURCE PLANNING SYSTEM" submitted by BENG F. LIM in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

.C. Sprague

Supervisor

mille

B.M. Patichett

Freuer Altorer

Date October 4th 1982

ABSTRACT

The task involved in this thesis is concerned with designing some of the major elements (Forecasting, Master Production Schedule, Resource Requirements Planning and Capacity Requirements Planning sub-systems) of the Manufacturing Resource Planning system applicable to Argo Engineering Limited.

Basically, a Manufacturing Resource Planning system is a closed loop computerized production-inventory planning and control system. The work on the balance of the major sub-systems are undertaken by E.S. Kombe and D. Quek. E.S. Kombe is designing the major elements of Inventory Planning, Identification System (Bill of Materials) and Production Scheduling.

Each of the above mentioned major sub-systems undertaken in this thesis involved a substantial amount of computer programming. The computer programs are extensively documented.

It is anticipated that with minor modifications, the system may be implemented in other industrial plants.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation for the inspiration, guidance and supervision rendered by Dr. J.C. Sprague in the preparation of this thesis.

The author is much obliged to Mr. Loblick for his time and assistance during the visits to Argo Engineering Limited.

Thanks to Miss Kean Goh for typing this thesis.

Last but not least, the author is grateful to his parents for their encouragement.

Table of Contents

Ch	pter Pa	ıge
1.	INTRODUCTION	1
	1.1 Purpose	. 1
	1.2 Background Information	. 1
	1.3 Problem Statement	. 2
	1.4 Overview of Manufacturing Resource Planning	. 2
	1.5 Scope and Methodology	. ε
2.	INDEPENDENT DEMAND FORECASTS	1 1
	2.1 Forecasting	1 1
	2.2 Determination of Forecasted Demand	13
	2.3 The Forecasting Computer Program	15
	2.3.1 Model Algorithm	16
	2.4 Testing the Model	19
	2.4.1 Interactive Input Data Format	20
	2.4.2 Output Data Format	2 1
	2.4.3 Discussion of Results	3 1
3.	WASTER PRODUCTION SCHEDULE (MPS) MODEL	32
	3.1 Master Production Schedule	32
	3.2 Establishment of a Master Production Schedule	33
	3.3 The Master Production Schedule Computer Program	37
	3.3.1 Model Algorithm	37
	3.4 Testing the Model	41
	3.4.1 Interactive Input Data Format	42
	3.4.2 Output Data Format	45
	3.4.3 Explanation of Terminologies	53
	3.4.4 Discussion of Results	56
4.	RESOURCE REQUIREMENTS PLANNING (RRP) MODEL	58

	4.1	Resource Requirements Planning
		4.1.1 Establishment of a Resource Requirements Plan
		4.1.1.1 Suggested Solutions For Long Term Capacity Planning60
	4.2	The Resource Requirements Planning Computer Program61
		4.2.1 Model Algorithm62
		4.2.2 Input Data Format
		4.2.2.1 Production Quantity File65
		4.2.2.2 Capacity Available File66
		4.2.2.3 Capacity Required File68
		4.2.2.4 Resource Definition69
		4.2.2.5 Load Profile Definition71
	4.3	Editing of the Data Files
	4.4	Testing the Model72
		4.4.1 Batch Mode Input Data72
		4.4.2 Interactive Input Data Format
		4.4.3 Output Data Format
		4.4.4 Discussion of Results
		4.4.5 Sensitivity Analysis
5.	CAPA	CITY REQUIREMENTS PLANNING (CRP) MODEL83
	5.1	Capacity Requirements Planning83
		5.1.1 Establishment of a Capacity Requirements Plan
		5.1.1.1 Suggested Solutions For Short Term Capacity Planning
	5.2	The Capacity Requirements Planning Computer Program85
		5.2.1 Model Algorithm86

	5.2.2 Critical Path Analysis Technique91
	5.2.3 Input Data Format92
	5.2.3.1 Work File93
	5.2.3.2 Work Center File95
	5.2.3.3 Activity Definition97
	5.2.3.4 Production Calendar99
	5.3 Testing the Model100
	5.3.1 Batch Mode Input Data101
	5.3.2 Interactive Input Data Format
	5.3.3 Output Data Format
	5.3.4 Discussion of Results
	5.3.5 Sensitivity Analysis
6.	EVALUATION OF THE MODELS AND SYSTEM
	6.1 Advantages of the Models
	6.2 Evaluation of the IBM Personal Computer System118
	6.2.1 Computer Programs Capacity Requirements122
7.	IMPLEMENTATION127
	7.1 Implementation Guidelines
	7.1.1 Phase 1 - Study and Review
	7.1.2 Phase 2 - Development
	7.1.2.1 Time Study Procedure
	7.1.3 Phase 3 - Installation
8.	CONCLUSIONS AND RECOMMENDATIONS
	8.1 Benefits of Manufacturing Resource Planning136
	8.2 Strengths and Weaknesses of the System
	8.3 Recommendations for Future Study
BIE	BLIOGRAPHY140

APPENDIX	A	-	Glossary	of	Variables	(Computer	Programs)1	44
APPENDIX	В	-	The Compu	ıter	Programs		1	48

LIST OF TABLES

Table	Description	Page
2.1	DLM68 Long Term Forecast Report	23
2.2	DLM68 Long Term Forecast Graph	24
2.3	DLM68 Short Term Forecast Report	25
2.4	DLM68 Short Term Forecast Graph	26
2.5	DLM610 Long Term Forecast Report	27
2.6	DLM610 Long Term Forecast Graph	28
2.7	DLM610 Short Term Forecast Report	29
2.8	DLM610 Short Term Forecast Graph	30
3.1	DLM68 Long Term Master Production	35
	Schedule Report Sample	
3.2	DLM610 Short Term Master Production	36
	Schedule Report Sample	
3.3	DLM68 Long Term Master Production	47
	Schedule Report	
3.4	DLM68 Short Term Master Production	49
	Schedule Report	
3.5	DLM610 Long Term Master Production	50
	Schedule Report	
3.6	DLM610 Short Term Master Production	52
	Schedule Report	
4.1	Production Quantity File Format Example	66
4.2	Capacity Available File Format Example	67

LIST OF TABLES

Table	Description	Page
4.3	Capacity Required File Format Example	68
4.4	Department-Machine Group Code	70
4.5	Production Quantity File Input Data	73
4.6	Capacity Available File Input Data	73
4.7	Capacity Required File Input Data	74
4.8	Long Term Work Center Load Report 1	76
4.9	Overload Report 1	77
4.10	Edited Capacity Available File	79
4.11	Long Term Work Center Load Report 2	8 1
4.12	Overload Report 2	82
5.1	Work File Format	94
5.2	Work File Format Example	95
5.3	Work Center File Format	96
5.4	Work Center and Activity Code	98
5.5	Production Calendar	100
5.6	Work File Input Data	102
5.7	Work Center File Input Data	104
5.8	Work Center Load Report 1	108
5.9	Summary Overload Report 1	109
5.10	Component Part Scheduling Report 1	110
5.11	Edited Work Center File Input Data	112
5.12	Work Center Load Report 2	114
5.13	Summary Overload Report 2	115

LIST OF TABLES

Table	Description	Page
5.14	Component Part Scheduling Report 2	116
6.1	IBM Basic Unit	119
6.2	Expanded IBM Unit	121
6.3	Forecasting Model Files	123
6.4	Master Production Schedule Model Files	124
6.5	Resource Requirements Planning Model Files	125
6.6	Capacity Requirements Planning Model Files	126
7.1	Time Study Observation Form	133

LIST OF FIGURES

Figure	Description	Page
1.1	Manufacturing Resource Planning Process	3
1.2	Manufacturing Resource Planning System	10
	Project Division	
2.1	Forecasting Model Flow Chart	17
3.1	Master Production Schedule Model Flow Chart	38
4.1	Resource Requirements Planning Model	63
	Flow Chart	
5.1	Capacity Requirements Planning Model	87
	Flow Chart	
5.2	Activity Network	92
5.3	Arrow Diagram For Component DL3045	95
7.1	Closed Loop Implementation Plan	127

1. INTRODUCTION

1.1 Purpose

The purpose of this thesis is to design some of the major sub-systems of a Manufacturing Resource Planning system; namely the Master Production Schedule, the Resource Requirements (or Rough-Cut Capacity) Planning Simulation Model, the Capacity Requirements Planning Simulation Model and the Forecasting Model applicable to Argo Engineering Limited.

It is envisaged that with minor modifications, the system may be installed in other industrial plants.

1.2 Background Information

Argo Engineering Limited manufactures and markets materials handling equipment. Among the range of materials handling equipment are dock levellers, elevating docks, hand trucks, platform lifts, wheelchairs or handicapped lifts and shelving and racking equipment. Dock levellers, and elevating docks account for approximately 60% of the total dollar sales volume.

The company is based in Edmonton with a subsidiary manufacturing plant in Ajax, Ontario. The company also has manufacturing licensing arrangements with several companies around the world.

1.3 Problem Statement

At present, the company practices an informal form of production-inventory planning and control system. The method is based on a combination of experience, 'trial and error' and a reorder point system.

Although the existing manual system works reasonably well, the company is interested in further improving the performance of its production-inventory control and planning system. This interest and perhaps a need is necessary for an improved system in order to cope with rampant inflation, rapidly rising labour and material costs, high interest rates and increasing competition.

One effective answer to the problem is to design and implement a fully integrated Manufacturing Resource Planning system.

1.4 Overview of Manufacturing Resource Planning

The schematic layout of Manufacturing Resource Planning (referred to as MRP II by the American Production and Inventory Control Society) is depicted in Figure 1.1.

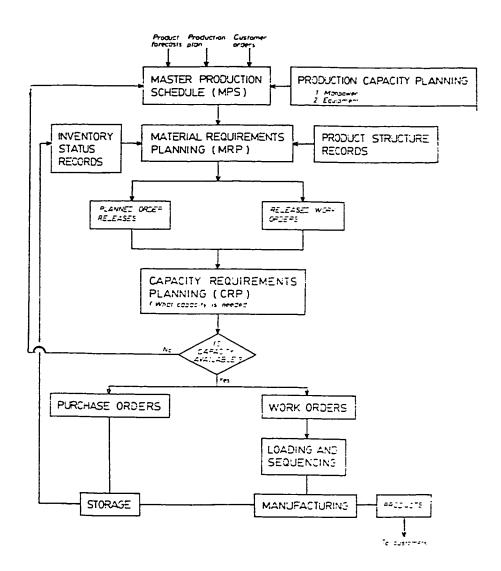


Figure 1.1 Manufacturing Resource Planning Process

The Forecasting sub-system is only used to determine the requirements of independent demand items. Dependent demand items need not be forecasted, but are calculated by the Material Requirements Planning sub-system from the Master Production Schedule.

The sales forecast must be uncoupled from the Material Requirements Planning sub-system. The sales forecast has a tendency to fluctuate. The production work load should be smoothed in order to have an efficient running plant. This is achieved by Master Production Scheduling. The Master Production Schedule is needed to control the fluctuations the demand can place on the factory. In fact, the backbone of a Manufacturing Resource Planning system is the Master Production Schedule. The Short Term Master Production Schedule "drives" the Manufacturing Resource Planning system by establishing the demand. The Master Production Schedule must be a realistic and realizable schedule. To insure capacity availability at a gross level, an initial check is made on the Long Term Master Production Schedule.

Resource Requirements Planning or long range capacity planning is the technique employed to check on the Long Term Master Production Schedule. In either an underload or overload case, appropriate action is taken to resolve the situation. The Long Term Master Production Schedule is revised until an acceptable schedule is agreed upon by production planning and control, manufacturing, marketing and finance.

The Bill of Materials (BOM) record, contains information on every item or assembly required to produce end items. Information on each item, such as part numbers, description, quantity per assembly, next higher assembly and quantity per end item are also available. It is vital that the information contained in the Bill of Materials be accurate. The success of a Manufacturing Resource Planning system depends on the integrity of the input information.

The Inventory Status Records contain the status of all items in inventory. All inventory items must be uniquely identified. These records must be kept up to date with each receipt, disbursement or withdrawal documented to maintain record integrity. They should also contain information on lead time, lot sizes or other item peculiarities.

These three sources. (Master Production Schedule, Bill of Materials and Inventory Status Records) are the data inputs for the Material Requirements Planning sub-system.

The Material Requirements Planning sub-system takes the Short Term Master Production Schedule for end items and determines the gross quantities of components required by exploding the end item Bill of Materials into its lower level requirements. The exploding process is simply a multiplication of the number of end items by the quantity of each component required to produce a single end item. The explosion identifies what components are required, as well as how many to produce a given quantity of end items. By referring to the inventory status records, the gross

quantities will be netted by subtracting the available inventory items. Just as important as "what" and "how many" is "when", which is determined by offsetting (setting back in time) the lead times for each component. Thus, the material requirements for each component are phased over time in a pattern determined by lead times and parent requirements.

The output of the Material Requirements Planning sub-system indicates what component items will have to be produced and when. This output is converted into the capacities required to produce these items. Capacity Requirements Planning is used to achieve this purpose. Through Capacity Requirements Planning, it is possible to determine what capacities by work center by period, in the short-to-medium range, are required to meet production goals.

1.5 Scope and Methodology

The entire project is to develop the major elements of the Manufacturing Resource Planning system. The major sub-systems covered by the entire project are listed as follows:

- Forecasting,
- Master Production Schedule,
- Resource Requirements Planning,
- Material Requirements Planning,

- Bill of Materials,
- Inventory Planning and Control, and
- Capacity Requirements Planning.

This thesis concentrates on the key functional components of:

- Forecasting,
- Master Production Schedule (MPS),
- Resource Requirements Planning (RRP), and
- Capacity Requirements Planning (CRP).

Computer models are developed for each of the sub-systems. These modular software packages are specifically designed to be used on the IBM personal computer.

Forecasting

The Exponential Weighted Moving Average Model was selected and developed as a computer program. The program designed has the capability of being able to select the appropriate sub-model to forecast situations where either "random", "trend", or "seasonal" patterns prevail. In other words, the forecasting program is adaptive in nature. The forecasts are derived by projecting and smoothing the actual demand pattern.

Master Production Schedule

The work in this area involved the development of a simulation program. A realistic and realizable Master Production Schedule is developed by running sets of raw schedules on a trial basis. The Master Production Schedule

program makes the necessary calculations to yield the trial Long and Short Term Master Production Schedules. The trial Long Term Master Production Schedules are simulated through the Resource Requirements Planning program to check for capacity availability. In addition, the Master Production Schedule Model generates two other reports, namely:

- 1. End Item File, and
- 2. Receipt List.

The trial Short Term Master Production Schedules are used to "drive" the Materials Requirements Planning sub-system.

Resource Requirements Planning

The resource requirements planning objective is achieved by developing a simulation program. The program processes the trial Long Term Master Production Schedules and outputs the resource requirements for each trial Long Term Master Production Schedule. The reports also highlight whether resources have been under or over-utilized. The reports generated are:

- 1. Long Term Work Center Report, and
- 2. Overload Report.

Capacity Requirements Planning

Similarly, this area involved the development of a simulation program. The program outputs the following reports which accommodate various purposes:

- 1. Work Centre Load Report,
- 2. Overload Report, and

3. Component Part Scheduling Report.

These reports may be used by management to plan and control shop floor scheduling in the most efficient manner.

The remaining major sub-systems of the Manufacturing Resource Planning system are covered by the thesis of E.S. Kombe and the engineering report of D.Quek. E.S. Kombe is undertaking the task of designing an identification system which is used for structuring the Bill of Materials in the future. In the process of setting up the Bill of Materials, the thesis involves the development of an inventory planning and control system. It extends to investigating the production scheduling problem in an attempt to devise scheduling rules and guidelines.

D. Quek is developing the Material Requirements

Planning program for the Manufacturing Resource Planning

system.

The computer programs are written in Fortran using the IBM personal computer.

Figure 1.2 shows the project division of the entire Manufacturing Resource Planning system.

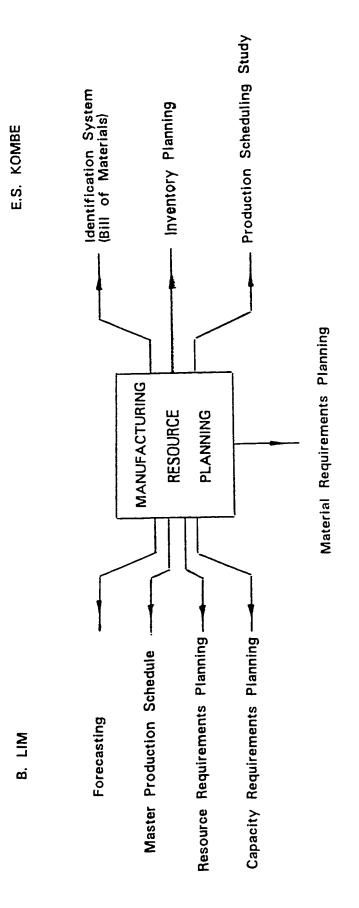


Figure 1.2 Manufacturing Resource Planning System Project Division

D. QUEK

2. INDEPENDENT DEMAND FORECASTS

2.1 Forecasting

Planning and control for production-inventory systems must neccessarily take place at several different levels. Therefore, it is unlikely that one kind of forecast can do the job. To be sure, the immediate problem is always the controlling of inventories, providing raw materials for current production programs, planning the use of workers and machines on a day-to-day basis, week-to-week, or month-to-month basis. However, it is important to look somewhat farther into the future to provide for new capacity or a different kind of capacity. The result is that forecasts are required for different time spans:

- plans for current operations and for the immediate future;
- 2. intermediate range plans to provide for the required capacities of workers, materials and equipment for the next one to two years; and

To cater for each individual requirement, forecasts are made at three different levels; namely:

- 1. short term forecasting.
- 2. intermediate term forecasting, and

3. long term forecasting.

J.A.Orlicky proposed the Dependent and Independent Demand Principle in which he stated that:

"When items are independent such as finished goods, items or service parts not used in current production, where the demand of certain items is unrelated to the demand of other items, it is necessary to forecast demand. In turn, where the demand is dependent, related to the demand for other items, it has to be calculated through the Bill of Materials explosion based on the demand for the finished good items [24]."

Several forecasting techniques are available for forecasting independent demand items.

There are three broad classifications of forecasting techniques:

- 1. qualitative techniques,
- 2. time series analysis and projection, and
- 3. causal models.

The first uses qualitative data (expert opinion for example) and information about special events of the kind already mentioned and may or may not take the past into consideration. The second, on the other hand, focuses entirely on patterns and pattern changes and thus relies entirely on historical data. The third uses highly refined and specific information about relationships between system elements and is powerful enough to take special events formally into account. As with time series analysis and projection techniques, the past is unimportant to causal models.

Time series analysis include a wide variety of techniques with varying degrees of sophistication, ranging from the very simple weighted average technique to adaptive forecasting. The Exponential Weighted Moving Average (EWMA) technique was selected for the following reasons:

- The only input data required is historical data. Such data is readily available at Argo Engineering Limited. There is no need to incur a substantial amount of expense in preparing and collecting the necessary input information.
- 2. A person can make use of the model with a minimum amount of training and supervision.
- 3. The model is capable of producing fairly accurate forecasts in the short and intermediate term.

2.2 Determination of Forecasted Demand

The forecasted demand is derived by following a set of procedures. These procedures are intended to produce forecasts of acceptable accuracy. The responsibility of forecasting is defined as part of the function of sales and marketing. Sales and marketing usually assign the job of running the Forecasting Model to the marketing analyst. A typical forecasting procedure is described in a step-by-step manner below:

 In the first instance, the marketing analyst produces a long term forecast by running historical sales data through the Forecasting Model. The historical sales data is in the form of semi-annual sales for the past six years. The Forecasting Model makes semi-annual projections for the next six years. The marketing analyst then inputs monthly sales for the past year into the Forecasting Model to generate the Short Term Forecast Report.

- 2. The marketing analyst comments upon the forecast outputs. Copies are then distributed to the senior managers of the respective departments. The senior manager of sales and marketing then organizes a meeting to discuss the forecast reports.
- 3. The senior managers each express their opinions regarding the forecasts. Following discussion and by consensus of opinion, the forecasts are adjusted to take into account the experience and expertise of the various managers. This is an important factor because the forecasts produced by the Forecasting Model do not incorporate sociological, psychological and economical factors in the computation. Adjustments may be necessary to account for these factors.
- 4. The finalized long and short term forecasts are passed to the Master Scheduler to serve as input into the Master Production Schedule Model.

2.3 The Forecasting Computer Program

The model design is based on the following rules:

- 1. The most recent data is allocated the heaviest weighting and vice-versa for the oldest data. The exact weighting allocated depends on the value of the smoothing constant. The higher the value of the smoothing constant, the heavier the weighting is allocated to the most recent data and vice-versa.
- 2. The total mean absolute deviation is the sole criterion for deciding which is the best sub-model (AVG or TREND or SEASON) to be used for forecasting.
- 3. The best smoothing constant is determined internally by the Forecasting Model. The total mean standard error and the total mean absolute deviation are the criteria used for determining the best smoothing constant.
- 4. The model generates forecasts for twelve periods by utilizing twelve historical demand data points. The latter consists of data immediately preceding the periods to be forecasted. For example, to forecast for the twelve months of 1983, twelve monthly historical demand data points for the year 1982 are utilized as input data.
- 5. Fourteen base series demand data points are also required as input data. With reference to the above example the base series demand data will consist of fourteen data points selected from the twelve months of 1982 and the last two months of 1981.

The first base series is derived by adding the first three historical data points and dividing the result by three. The second base series is arrived at by adding the second, third and fourth data points and dividing the result by three. The fourteen historical data points thus yield twelve base series data points. Each of the twelve historical demand data points is divided by the corresponding base series data points and the results are subsequently utilized for forecasting.

2.3.1 Model Algorithm

The algorithmic flow of the Exponential Weighted Moving Average Model is depicted in Figure 2.1.

The variables used in the flow diagram are defined in Appendix A.

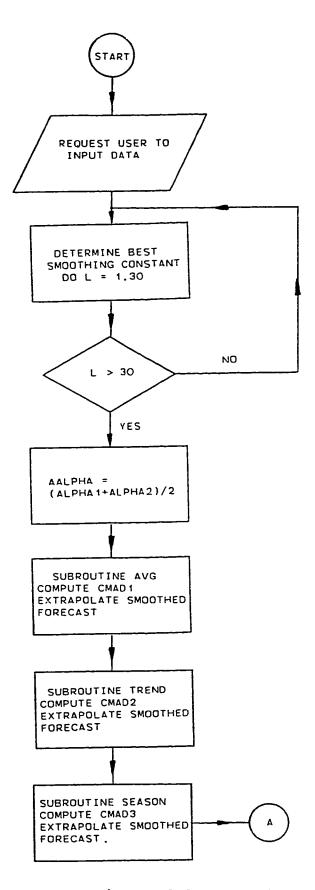


Figure 2.1 Forecasting Model Flow Chart

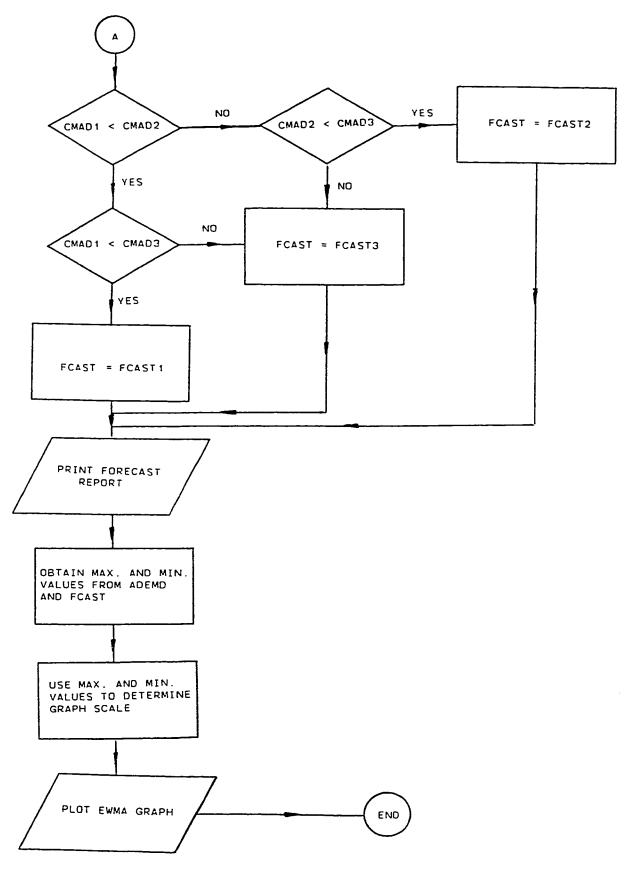


Figure 2.1 Continued

The description of the algorithmic flow is summarized as follows:

- The main program reads the historical sales and base series demand data.
- 2. The main program passes the input data to the AVG, TREND and SEASON subroutines. The subroutines compute the total mean absolute deviation individually. The main program selects the subroutine with the smallest total mean absolute deviation.
- 3. In addition to determining the total mean absolute deviation, the subroutine also computes the smoothed forecasted demand using the best smoothing constant.
- 4. The smoothed forecasted demand associated with the smallest total mean absolute deviation is passed to the main program. The main program transfers the results to the report and plot subroutines.
- 5. The results are printed on the line printer by the command of the report and plot subroutines.

2.4 Testing the Model

This model accepts any type of data irrespective of its source. The data tested are hypothetical because it is intended to show the dynamics and versatility of the model.

To run the model, the user is only required to load the executable file into the core memory by typing in the file name FM . The model is brought into conversational mode and

all the user has to do is to key in the data requested.

2.4.1 Interactive Input Data Format

The displays on the visual display unit are as follows:

```
********
* FORECASTING MODEL *
*******
Enter today's date (mm/dd/yy):
08/20/82
Enter forecast item (40 alpha-characters):
Dock Leveller Model M68
Enter forecast for month or year (semi-annual):
Press 1 for month
Press 2 for year (semi-annual)
2
Enter forecast period:
(Example: 1982 to 1987)
(40 alpha-characters)
1982 to 1987
Enter 14 historical data points in units for base series
demand on a single line (XXXXX.X real each):
00130.0 00128.0 00130.0 00125.0 00127.0 00132.0 00133.0
00130.0 00126.0 00128.0 00125.0 00129.0 00123.0 00128.0
Enter 12 historical data points in units for past historical
demand on a single line (XXXXX.X real each):
```

00130.0 00125.0 00127.0 00132.0 00133.0 00130.0 00126.0 00128.0 00125.0 00129.0 00123.0 00128.0

Once the user presses ENTER following the last entry of 00128.0, the next display is:

**** PROCESSING

2.4.2 Output Data Format

The output data is printed on the line printer. It consists of a Long Term Forecast Tabular Report and a Long Term Forecast Graphical Report. The results are shown in Tables 2.1 and 2.2.

On the other hand, the user may key in "1" following the prompt:

Enter forecast for month or year (semi-annual):

Press 1 for month

Press 2 for year (semi-annual)

1

The next few prompts which follow are listed below: Enter forecast period:

(Example: Jan 1982 to Dec 1982)

(40 alpha-character)

Aug 1982 to July 1983

Enter 14 historical data points in units for base series demand on a single line (XXXXX.X real each):

00020.0 00021.0 00020.0 00022.0 00021.0 00020.0 00021.0

00022.0 00020.0 00020.0 00022.0 00021.0 00020.0 00021.0

Enter 12 historical data points in units for past historical

demand on a single line (XXXXX.X real each):

00021.0 00020.0 00020.0 00021.0 00020.0 00021.0 00022.0

00020.0 00021.0 00021.0 00022.0 00020.0

The visual display unit will indicate to the user that the central processing unit is in progress by displaying:

**** PROCESSING

In this case, the output data will be a Short Term Forecast Tabular Report and a Short Term Forecast Graphical Report. The results are depicted in Tables 2.3 and 2.4.

The Forecasting Model is tested with the product, Dock Leveller Model M610 for the purpose of comparison with the previous two examples and showing the effectiveness of the model. The results are shown in Tables 2.5, 2.6, 2.7 and 2.8.

The graphical report complements the numerical results by displaying the latter graphically so that the pattern of demand is shown more clearly.

Table 2.1 DLM68 Long Term Forecast Report

DATE : 08/20/81

***** LONG TERM FORECAST REPORT *****

ITEM - DOCK LEVELLER MODEL M68 PERIOD - 1982 TO 1987

PERIOD NO.	ACTUAL (UNITS)	FORECAST	·UNITS
1	170.00	130.00	
2	125.00	128.50	
	127.00	128.05	
4	132.00	127.23	
5	153.00	130.38	
6	130.00	170.26	
7	126.00	128.98	
8	128.00	128.69	
9	125.00	127.55	
10	129.00	128,01	
1. 1.	123.00	126.50	
12	128.00	126.95	
13		127,55	
14		126.79	
15		126.85	
16		128.40	
17		129.78	
18		129.84	
19		128.69	
20		128.48	
21		127.44	
22		127.91	
23		126.43	
24		176.90	

Table 2.2 DLM68 Long Term Forecast Graph

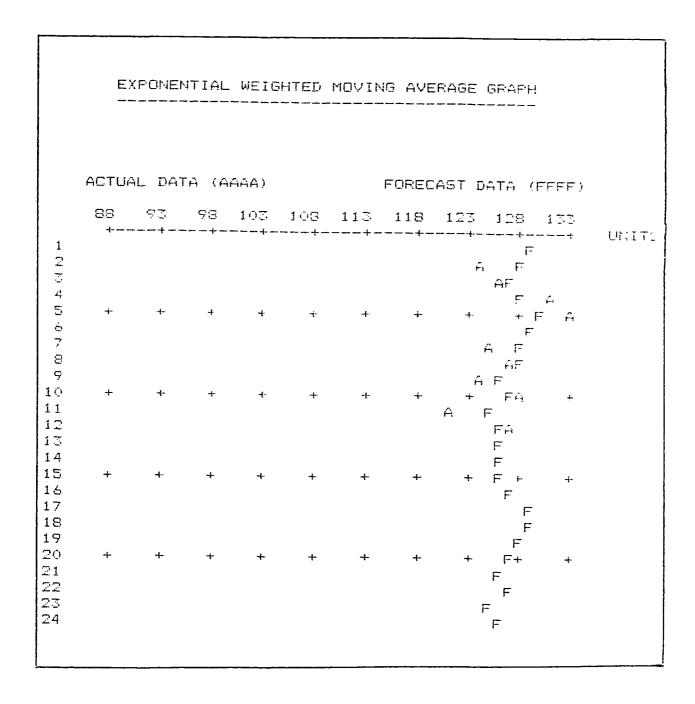


Table 2.3 DLM68 Short Term Forecast Report

DATE : 08/10/82

***** SHORT TERM FORECAST REPORT *****

ITEM - DOCK LEVELLER MODEL M68 PERIOD - AUG 1982 TO JULY 1983

MONTH NO.	ACTUAL (UNITS)	FORECAST (UNITS)
1	21.00	21.00
2 3	20.00	20.70
3	20.00	20.49
4	21.00	20.64
5	20.00	20.45
6	21.00	20.62
7	22.00	21.03
8	20.00	20.72
9	21.00	20.80
10	21.00	20.86
11	22.00	21.20
12	20.00	20.84
13		21.14
14		20.80
15		20.56
16		70.49
17		20.48
18		20.64
19		21.05
20		20.73
21		20.81
22		20.87
23		21.21
24		20.85
		alous Teef # New York

Table 2.4 DLM68 Short Term Forecast Graph

14	15	ΓΑ (ΑΑ 16	17	18	19	20	ST DATA (21 22	23	
+	+	+	+	+			+		Ł
							F F A		
+	+	+	₹-	+	+	+A	F+ + + + + + + + + + + + + + + + + + +	-1-	
						A	F	A	
+	+	- i-	+	+	-1-		FA + FA +	+	
						A	F	A	
						,,	, F		
+	+	+	+	+	+	+	F +	⊣ -	
							F F		
+	+	+	+	+	+	4-	, +F +	+	
							F		

Table 2.5 DLM610 Long Term Forecast Report

DATE : 08/20/82

***** LONG TERM FORECAST REPORT *****

ITEM - DOCK LEVELLER MODEL M610 PERIOD - 1982 TO 1988

PERIOD NO.	ACTUAL (UNITS)	FORECAST (UMITS)
1	87.00	87.00
2	95.00	87.40
2 3 4	104.00	94.JB
4	121.00	102.37
5	134.00	111.86
6 7	119.00	114.00
	107.00	111.50
8	98.00	107.73
9	71.00	96.71
10	89. 00	94.40
11	62.00	84.68
12	103.00	90.17
13		85.37
14		88.26
15		93.58
16		101.81
17		111.47
18		113.73
19		111.71
20		107.60
21		96.62
22		94.33
23		84.63
24		90.14

Table 2.6 DLM610 Long Term Forecast Graph

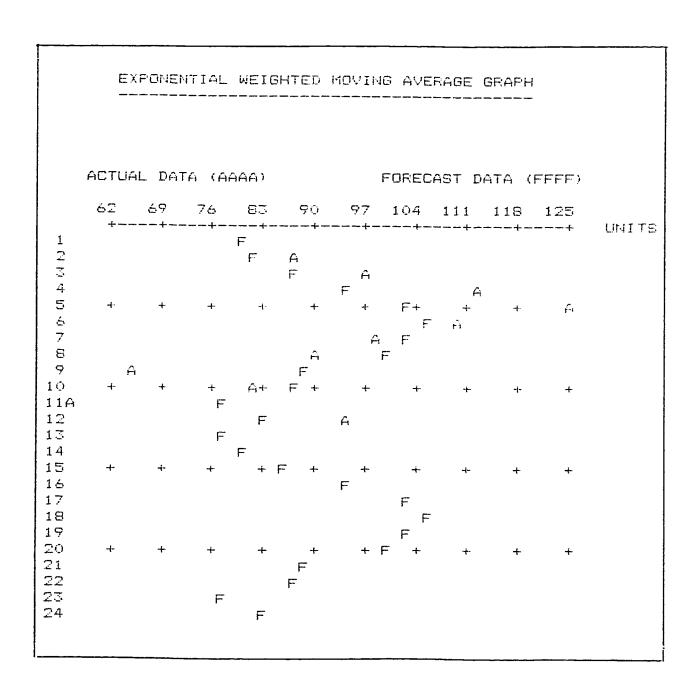


Table 2.7 DLM610 Short Term Forecast Report

DATE : 08/20/82

***** SHORT TERM FORECAST REPORT *****

ITEM - DOCK LEVELLER MODEL M610 PERIOD - AUG 1982 TO JULY 1983

MONTH NO.	ACTUAL (UNITS)	FORECAST (UNITS)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	9.00 10.00 9.00 10.00 12.00 15.00 18.00 20.00 23.00 25.00 7.00	9.00 9.30 9.21 9.45 10.21 11.65 13.55 15.49 17.74 19.92 16.04 13.33 13.93 12.75 11.63 11.14 11.40 12.48 14.13 15.89 18.03 20.12 16.18 13.43

Table 2.8 DLM610 Short Term Forecast Graph

	E:	XPONEI	NTIAL	WEIGH	HTED I	MOVIN(3 AVER	RAGE	GRAPH		
	ACTUA	AL DA	TA (AA	AAA)		F	FOREC <i>F</i>	اِم ۱۲۴	ATA (i	FFFF)	
	7 +	ç +	11	13	15	17	19	21	23	25	
1 2 3 4	F AF F	F A						+		 1 ·	UNITS
5 6 7 8 0	+	F+	F	F F		A	+	÷	-i -	- 1 -	
9 10 11A 12A 13	+	+	+	+ F F	+ F	F +	+F	+	Á +	A	
14 15 16 17 18	+	+ F F		-1 -	+	+	+	+	÷	+	
19 20 21 22 23 24	+	+	+	F + F	F	+ F	+ F	+	+	+	

2.4.3 Discussion of Results

With reference to Table 2.1, the data under the heading "Actual" shows the past historical demand data entered by the user. The first twelve data points under the heading "Forecast" is the "smoothed" past historical demand data. The next twelve data points under the same heading represents the forecasted data. This explanation holds true for Tables 2.3, 2.5 and 2.7.

The past demand for Dock Leveller Model M68 is fairly constant for both the short and long term. The forecasted demand in either case is shown to be fairly constant as observed in Tables 2.1 and 2.3. The demand patterns are depicted more clearly in Tables 2.2 and 2.4.

The demand data points which are used to represent the historical demand for Dock Leveller Model M610 is hypothetical and assumed to follow a cyclical pattern.

Tables 2.5 and 2.7 show the respective long and short term historical demand input data. The forecast is shown to follow a similar pattern. This is clearly depicted by Tables 2.6 and 2.8 respectively.

3. MASTER PRODUCTION SCHEDULE (MPS) MODEL

3.1 Master Production Schedule

The Master Production Schedule is defined by the American Production and Inventory Control Society (APICS) as a statement of what the company expects to manufacture [29].

The objectives of the Master Production Schedule are:

- 1. over the short horizon, to serve as a basis for the planning of material requirements, the production of components, the planning of order priorities and the planning of short term capacity requirements;
- 2. over the long horizon, to serve as the basis for estimating long term demands on the company's resources such as productive capacity (square footage, machine tools, manpower), warehousing capacity, engineering staff and cash;
- 3. to provide a mechanism to coordinate production planning and control, manufacturing, marketing, engineering and finance activities so that all can work together to achieve a common performance;
- 4. to provide a device to reconcile the needs of marketing with the capabilities of manufacturing;
- 5. to provide an overall measure of the ability of each major function in the business to execute a sound plan.

3.2 Establishment of a Master Production Schedule

The production planning and control department usually assigns the task of running the Master Production Schedule Model to the Master Scheduler. The step-by-step approach for developing a realistic Master Production Schedule is presented below:

- 1. For the first round, the long term forecast results for each end item is run through the Master Production Schedule Model. The Master Production Schedule Model produces reports for each end item, namely:
 - End Item File.
 - Long Term Master Production Schedule, and
 - Receipt List.
- 2. The next step is to check whether the company has the capacity to meet the Long Term Master Production Schedule. The output of the Long Term Master Production Schedule becomes the input into the Resource Requirements Planning Model.
- 3. The Master Production Schedule and Resource Requirements
 Planning reports are normally sent to the senior
 managers of the interfacing departments for approval.
- 4. Any revised Long Term Master Production Schedule will be resimulated through the Resource Requirements Planning Model to check for capacity availability. On agreement of the respective senior managers, the Long Term Master Production Schedule is fixed for a period of six months or for a period deemed appropriate by the senior

managers.

- 5. For the second round, the short term forecast results represent input into the Master Production Schedule Model. The Master Production Schedule Model outputs reports that serve as input data into the Material Requirements Planning Model and indirectly the Capacity Requirements Planning Model. The reports are:
 - End Item File,
 - Short Term Master Production Schedule, and
 - Receipt List.

These reports are circulated to the senior managers of the interfacing departments for approval. In the event of a revision, the revised Short Term Master Production Schedule is resimulated through the Material Requirements Planning and Capacity Requirements Planning Models. The process is repeated until a Short Term Master Production Schedule which is realistic and agreeable to all the senior managers, or at least the majority of the senior managers is achieved. Once the Short Term Master Production Schedule is set, it is frozen for one month or for a period deemed appropriate by the senior managers. The format of the Long and Short Term Master Production Schedules are depicted in Tables 3.1 and 3.2.

DLM68 Long Term Master Production Schedule Report Sample

ARGO ENGINEERING L	IMITED			DATE : 0	08/20/62
	****** Er	ND ITEM FILE	REPORT ***	***	
PART NUMBER DESCRIPTION		- DLI			
MAKE/BUY		- 600 - M	THE LEVELLER 1	10DEL M68	
CLASSIFICATION A/B	/C	- A			
LEAD TIME CODE		-	1		
MANUFACTURING LEAD					
JOE LOT SIZE (UNITS PURCHASE LEAD TIME		- :	100		
PURCHASE CEAD TIME PURCHASE ORDER QUAI	(DAYS) NTITY (HNITS)	-	0		
MINIMUM DUNTITY (U		_	0		
MAXIMUM DUANTITY (U		-	ò		
SCRAP (%)		-	10		
HORIZON (PERIODS)		-	12		
*****	LONG TERM MA	STER PRODUCT	TION COURNIES	FEEDDET ***	
******	CONG TERM TIP	SIEN PRODUCT	TON SCHEDOLE	KEFURI ***	****
EDC = 50 ROL = 10	PERIOD NO.	PERIOD NO.	PERIOD NO.	PERIOD NO.	PERIOD NO
GROSS FORECAST					
	120				
BOOK.INGS	101	160	179	128 50	170 89
NET FORFCAST	77	127 166 27	127 129 -2	50	
NET FORECAST NET REQUIREMENTS	27 128	27 127	-2 129	50 75 126	85 41 176
NET FORECAST NET REQUIREMENTS BACKLOG	27 128 1	27 127 0	-2 129 0	50 78 126	41 156
NET FORECAST NET REOUIREMENTS BACKLOG BROSS REOUIREMENTS	27 128 1 129	27 127 0 127	-2 129 0 129	50 75 125 0 125	41 136 0 136
NET FORECAST NET REOUIREMENTS BACKLOG BROSS REOUIREMENTS BTOCK ON HAND	27 128 1 129	27 127 0	-2 129 0	50 78 126	41 156
NET FORECAST NET REGUIREMENTS SACCYLOG SROSS REGUIREMENTS STOCK ON HAND HPS EDD = 50	27 128 1 1 129 0 150	27 127 0 127 21 150	-2 129 6 129 44 160	50 75 126 0 126 15	41 170 0 130 37 100
NET FORECAST NET REQUIREMENTS BACKLOG BROSS REQUIREMENTS BTOCK ON HAND MPS EOQ = 50 ROL = 10	27 128 1 129 0 150 PERIOD NO.	27 127 0 127 21 150 PERIOD NO.	-2 129 0 129 44 100 PERIOD NO.	50 75 126 0 126 15 150 PERIOD NO.	94 41 170 6 170 37 190 PERIOD NG.
NET FORECAST NET REQUIREMENTS BACKLOG BROSS REQUIREMENTS STOCK ON HAND HPS EQQ = 50 ROL = 10 EROSS FORECAST	27 128 1 129 0 150 PERIOD NO. 18	27 127 0 127 21 150 PERIOD NO.	-2 129 0 129 44 160 PERIOD NO. 20	50 75 126 0 126 15 150 PERIOD NO. 21	41 170 6 130 37 190 PERIOD NG. 22
NET FORECAST NET REDUIREMENTS SACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOKINGS	27 128 1 129 0 150 PERIOD NO. 18	27 127 0 127 21 150 PERIOD NO. 19	-2 129 0 129 44 160 PERIOD NO. 20	50 75 126 0 126 15 150 PERIOD NO. 21	95 41 179 6 179 77 100 PERIOD NG. 22 129 40
NET FORECAST NET REQUIREMENTS SACKLOG SROSS REQUIREMENTS STOCK ON HAND HPS EDD = 50 ROL = 10 SROSS FORECAST ROOKINGS NET FORECAST	27 128 1 129 0 150 PERIOD NO. 18	27 127 0 127 21 150 PERIOD NO. 19	-2 129 0 129 44 160 PERIOD NO. 20	50 75 126 0 126 15 150 PERIOD NO. 21	95 41 170 0 170 37 160 PERIOD NG. 22 129 40 68
NET FORECAST NET REQUIREMENTS SACKLOG	27 128 1 129 0 150 PERIOD NO, 18 130 98 32 130	27 127 0 127 21 150 PERIOD NO. 19	PERIOD NO. 20 128 105 23 128	50 75 125 0 125 150 150 PERIOD NO. 21 127 130 -3	95 41 170 0 170 37 100 PERIOD NO. 22 129 40 68 128
NET FORECAST NET REDUIREMENTS SACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EQU = 50 ROL = 10 SROSS FORECAST ROOKINGS NET FORECAST NET REDUIREMENTS SACKLOG SROSS REDUIREMENTS	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0	27 127 0 127 21 150 PERIOD NO. 19	PERIOD NO. 20 128 105 23 128	50 75 125 0 125 150 150 PERIOD NO. 21 127 130 -3 130	95 41 170 0 130 37 100 PERIOD NG. 22 128 40 68 128 6
NET FORECAST NET REQUIREMENTS SACCHLOG SACOS REQUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOHINGS NET FORECAST NET REQUIREMENTS SACCHLOG SROSS REQUIREMENTS STOCK ON HAND	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27	PERIOD NO. 20 128 105 23 128	50 75 125 0 125 150 150 PERIOD NO. 21 127 130 -3	95 41 170 0 170 37 100 PERIOD NG. 22 128 40 68 128 0 128
NET FORECAST NET REQUIREMENTS SACCHLOG SACOS REQUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOHINGS NET FORECAST NET REQUIREMENTS SACCHLOG SROSS REQUIREMENTS STOCK ON HAND	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0	PERIOD NO. 20 128 105 23 128 0 128	50 75 126 0 126 15 150 PERIOD NO. 21 127 130 -3 130	95 41 170 0 130 37 100 PERIOD NO. 22 129 40 68 128
NET FORECAST NET REQUIREMENTS BACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOKINGS NET FORECAST NET REQUIREMENTS SACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EQQ = 50	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150	PERIOD NO. 20 128 105 23 128 48 100	90 130 20	PERIOD NG. 22 129 40 68 128 40 100
NET FORECAST NET REQUIREMENTS PACKLOG PROSS REQUIREMENTS PROSS REQUIREMENTS PROSS FORECAST PROSS FORECAST PROCKLOG PROSS REQUIREMENTS PROCKLOG PROSS REQUIREMENTS PROSS	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150	PERIOD NO. 20 128 105 23 128 48 100	PERIOD NO. PERIOD NO. 21 127 120 -3 130 0 130 20 150	PERIOD NG. 22 129 40 68 128 40 100
NET FORECAST NET REQUIREMENTS SACKLOG SACS REQUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST ROCKINGS NET FORECAST NET REQUIREMENTS SACKLOG SROSS REDUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD NO. 20 128 105 22 128 105 22 128 0 128 48 100 PERIOD NO. 25	PERIOD NO. 21 127 130 -3 130 0 130 20 150 PERIOD NO. 22	PERIOD NO. PERIOD NO. 129 40 128 40 100
NET FORECAST NET REDUIREMENTS SACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOKINGS NET FORECAST NET REDUIREMENTS SACKLOG SROSS REDUIREMENTS STOCK ON HAND MPS EQQ = 50 ROL = 10 SROSS FORECAST ROOKINGS EQQ = 50 ROL = 10 SROSS FORECAST	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD NO. 20 128 105 23 128 0 128 105 23 128 0 128 48 100 PERIOD NO. 25	PERIOD NO. 21 127 120 127 127 120 20 130 20 150 PERIOD NO. 26	170 0 170 0 170 37 100 PERIOD NG. 22 128 40 68 128 0 128 40 100
NET FORECAST NET REQUIREMENTS PACKLOG PROSS REQUIREMENTS PROSS REQUIREMENTS PROSS FORECAST PROCEINGS NET FORECAST NET REQUIREMENTS PROSS FORECAST PROSS FORECAST PROSS FORECAST	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD ND, 20 128 105 128 105 128 100 128 0 128 0 128 0 128 0 128 0 0 0 0	PERIOD NO. 21 127 130 0 130 0 130 0 150 PERIOD NO. 20 150 0 150 PERIOD NO. 26	170 0 170 0 170 37 100 PERIOD NG. 22 128 40 68 128 0 128 40 100
NET FORECAST NET REQUIREMENTS REACYLOG GROSS REQUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 GROSS FORECAST REQUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS FORECAST REQUIREMENTS BACKLOG GROSS FORECAST REQUIREMENTS REQUIREMENTS REQUIREMENTS REACYLOG GROSS FORECAST REQUIREMENTS REACYLOG GROSS FORECAST RECUIREMENTS RACKLOG	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD NO. 20 128 105 23 128 0 128 105 23 128 0 128 48 100 PERIOD NO. 25	PERIOD NO. 21 127 120 127 127 120 20 130 20 150 PERIOD NO. 26	170 0 170 0 170 37 100 PERIOD NG. 22 128 40 68 128 0 128 40 100
NET FORECAST NET REQUIREMENTS RACKLOG SROSS REQUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST ROUKINGS NET FORECAST NET REQUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST REQUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST ROUKINGS REDUIREMENTS STOCK ON HAND MPS EDD = 50 ROL = 10 SROSS FORECAST ROUKINGS RET FORECAST REGUIREMENTS RACKLOG SROSS REDUIREMENTS RACKLOG SROSS REDUIREMENTS	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD ND, 20 128 105 128 105 128 100 128 0 128 0 128 0 128 0 128 0 0 0 0	PERIOD NO. 21 127 130 0 130 0 130 0 150 PERIOD NO. 20 150 0 150 PERIOD NO. 26	170 0 170 0 170 37 100 PERIOD NG. 22 128 40 68 128 0 128 40 100
BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND MPS EQU = 50 ROL = 10 GROSS FORECAST NET FORECAST NET REDUIREMENTS GACKLOG GROSS REDUIREMENTS GACKLOG GROSS FORECAST NET REDUIREMENTS GACKLOG GROSS REDUIREMENTS GROCK ON HAND	27 128 1 129 0 150 PERIOD NO. 18 130 98 32 130 0 130 7 150 PERIOD NO. 23	27 127 0 127 21 150 PERIOD NO. 19 129 104 25 129 0 129 27 150 PERIOD NO. 24	PERIOD ND, 20 128 105 128 105 128 100 128 0 128 0 128 0 128 0 128 0 0 0 0	PERIOD NO. 21 127 130 0 130 0 130 0 150 PERIOD NO. 20 150 0 150 PERIOD NO. 26	170 0 170 0 170 37 100 PERIOD NG. 22 129 40 68 128 0 128 40 100

Table 3.2

DLM610 Short Term Master Production Schedule Report Sample

PART NUMBER DESCRIPTION MAKE/BUY CLASSIFICATION A/B/C LEAD TIME CODE MANUFACTURING LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) PURCHASE DEAD TIME (DAYS) PURCHASE ORDER OUANTITY (UNITS) MINIMUM DUANTITY (UNITS) MAXIMUM DUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EDG = 100 WEEF NO ROL = 20 44	- DO - M - P	.M610 CE: LEVELLER ME 2 110 150 0 0 0 5 E	REPORT ***	
DESCRIPTION MAKE/BUY CLASSIFICATION A/B/C LEAD TIME CODE MANUFACTURING LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) MINIMUM QUANTITY (UNITS) MAXIMUM QUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EGG = 100 WEEF NO ROL = 20 44	- DO - M - P	CE LEVELLER MO 2 110 150 0 0 0 5 8 TION SCHEDULE	REPORT ***	
DESCRIPTION MAKE/BUY CLASSIFICATION A/B/C LEAD TIME CODE MANUFACTURING LEAD TIME (DAYS) JOB LOT SIZE (UNITS) PURCHASE LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) MINIMUM DUANTITY (UNITS) MAXIMUM DUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EOC = 100 WEEF NO ROL = 20 44	- DO - M - P	CE LEVELLER MO 2 110 150 0 0 0 5 8 TION SCHEDULE	REPORT ***	
CLASSIFICATION A/B/C LEAD TIME CODE MANUFACTURING LEAD TIME (DAYS) JOR LOT SIZE (UNITS) PURCHASE LEAD TIME (DAYS) PURCHASE ORDER OUANTITY (UNITS) MINIMUM OUANTITY (UNITS) MAXIMUM OUANTITY (UNITS) SCRAF (%) HORIZON (WEEKS) ***** SHORT TERM EDC = 100 WEEF NO ROL = 20 44	- P	2 110 150 0 0 0 5 E	WEEK NO.	
LEAD TIME CODE MANUFACTURING LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) PURCHASE ORDER OUANTITY (UNITS) MINIMUM DUANTITY (UNITS) MAXIMUM DUANTITY (UNITS) HORIZON (WEEKS) ###### SHORT TERM EDG = 100 WEEF NO ROL = 20 44	MASTER FRODUC	2 110 150 0 0 0 5 E	WEEK NO.	
MANUFACTURING LEAD TIME (DAYS) JOB LOT SIZE (UNITS) PURCHASE LEAD TIME (DAYS) PURCHASE ORDER QUANTITY (UNIT) MINIMUM QUANTITY (UNITS) MAXIMUM QUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EDG = 100 WEEF NO ROL = 20 44	MASTER FRODUC	110 150 0 0 0 5 6 TION SCHEDULE	WEEK NO.	
JOR LOT SIZE (UNITS) PURCHASE LEAD TIME (DAYS) PURCHASE LEAD TIME (DAYS) PURCHASE ORDER OUANTITY (UNITS) MAXIMUM OUANTITY (UNITS) SCRAF (%) HORIZON (WEEKS) ****** SHORT TERM EDG = 100 WEEF NO ROL = 20 44	MASTER FRODUC	TION SCHEDULE	WEEK NO.	
PURCHASE ORDER QUANTITY (UNITS) MINIMUM QUANTITY (UNITS) MAXIMUM QUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EDG = 100 WEEK NO	MASTER FRODUC	S E TION SCHEDULE WEEL NO.	WEEK NO.	
MINIMUM DUANTITY (UNITS) MAXIMUM DUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EDG = 100 WEEK NO	MASTER FRODUC	S E TION SCHEDULE WEEL NO.	WEEK NO.	
MAXIMUM DUANTITY (UNITS) SCRAP (%) HORIZON (WEEKS) ****** SHORT TERM EOC = 100 WEEK NO ROL = 20 44	MASTER FRODUC	S E TION SCHEDULE WEEL NO.	WEEK NO.	
SCRAP (%) HORIZON (WEEKS) ***** SHORT TERM EDG = 100 WEEK NO ROL = 20 44	MASTER FRODUC	S E TION SCHEDULE WEEL NO.	WEEK NO.	
##### SHORT TERM 	MASTER FRODUC D. WEEK NO. 45	ETION SCHEDULE	WEEK NO.	
EOC = 100 WEEF NO ROL = 20 44	D. WEEK NO. 45	WEEK NO.	WEEK NO.	
EOC = 100 WEEF NO ROL = 20 44	D. WEEK NO. 45	WEEK NO.	WEEK NO.	
GPOSS FORECAST 14		46	47	WEEF NO. 49
	13	12	11	11
GPOSS FORECAST 14 BOOKINGS 10 NET FORECAST 4	8 5	9	8	17
NET RECUIREMENTS 14		3 12		-6 17
BACKLOG O		-0	ō	o o
GROSS REQUIREMENTS 14	13	12 78	11	17
STOCK ON HAND 5 MPS 100	91		66	55
MPS 100	Ó	0	Q	O
	D. WEEK NO. 50	WEEL NO.	WEEK NO.	WEEL NO.
GROSS FORECAST 12 BOOKINGS 10	14 9	16 14	0 0	°
NET FORECAST 2	5 5	2	ő	/ \
NET REQUIREMENTS 12	14	16	· /	<i></i>
BACKLOG o	0	0	\sim	
GROSS REQUIREMENTS 12 STOCK ON HAND 38	14	16		
STOCK ON HAND 3B 1PS 0	26 100	<i>y</i> –	•	
•	/			

- 3.3 The Master Production Schedule Computer Program

 The model design is based on the following rules:
- The forecasted demand is accurate for the period when the Master Production Schedule is frozen. However, the discrepancies are adjusted once the "freeze" is over. This means that the Master Production Schedule frozen for the next period makes use of actual data for replanning.
- 2. Initially, the company may utilize the Economic Order Quantity formula as the most reasonable lot-sizing technique. Over time, based on experience the company may employ other techniques as deemed appropriate.
- 3. Backlog is permitted and if cancellation of orders occur during the "freeze" period, it is not reflected until the next replanning period.
- 4. The forecasted demand can be divided into equal lots per period of time. This implies that if the forecast is four units per month, it is equivalent to one unit per week per month.

3.3.1 Model Algorithm

The flow diagram of the Master Production Schedule Model is shown in Figure 3.1.

The variables used in the flow diagram are defined in Appendix A.

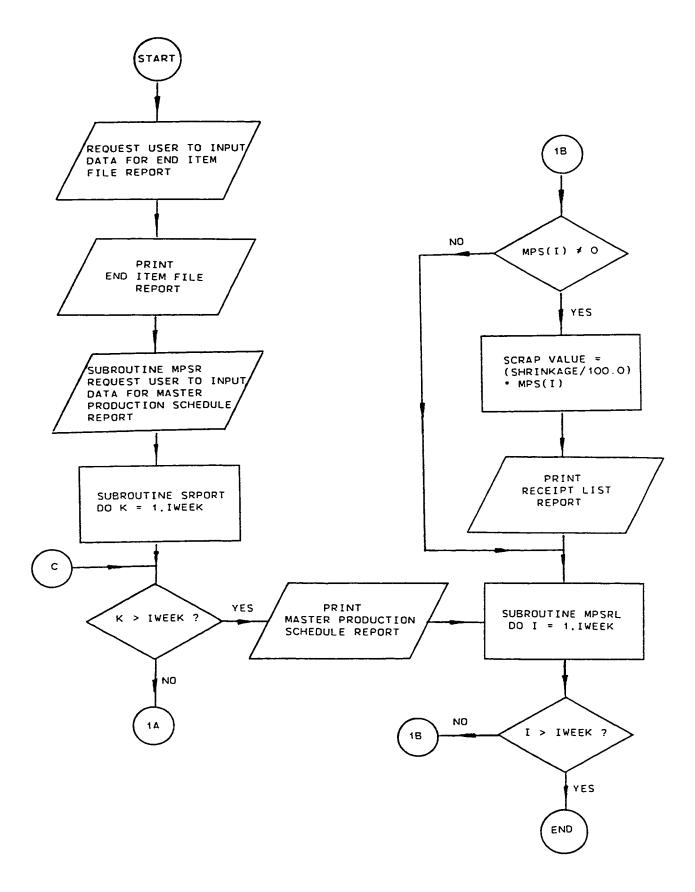


Figure 3.1 Master Production Schedule Model Flow Chart

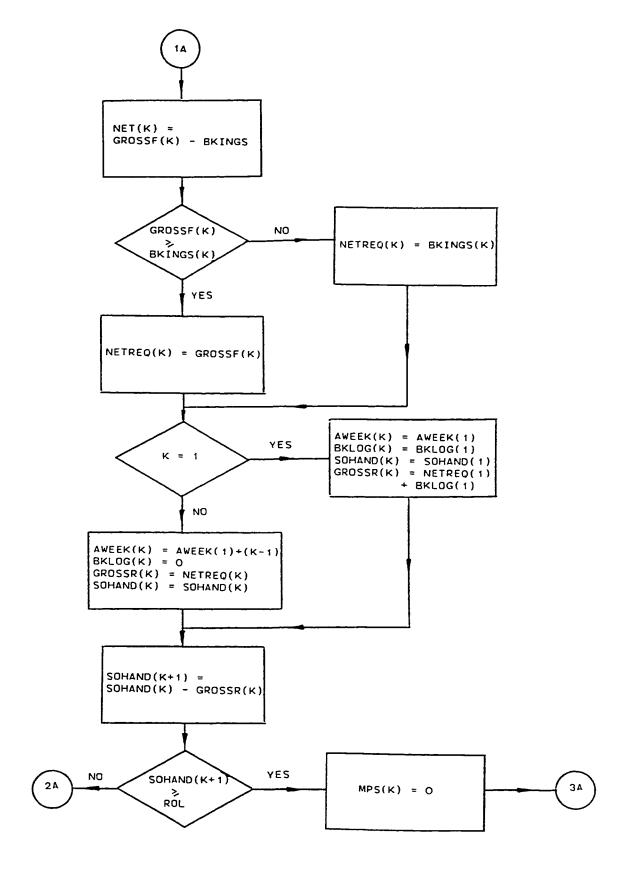


Figure 3.1 Continued

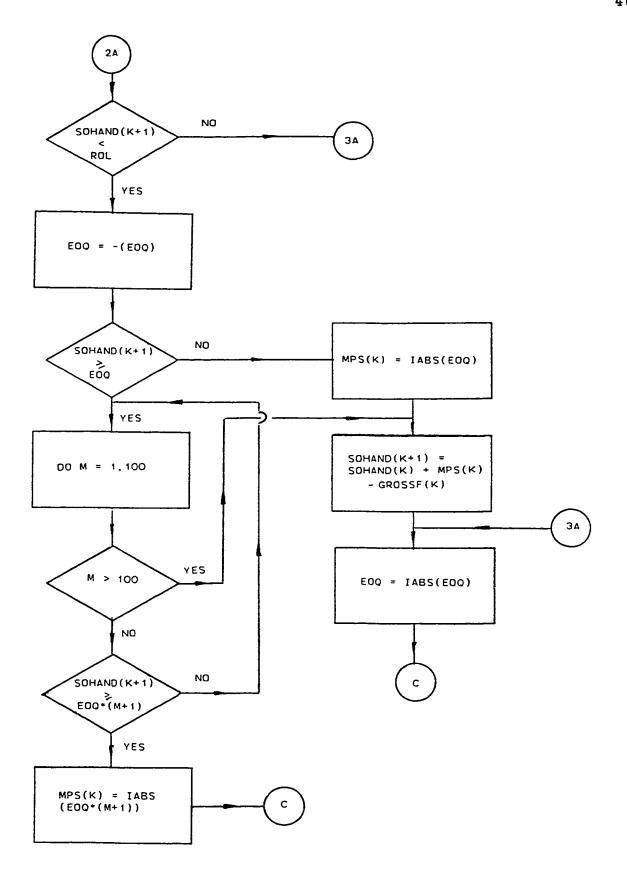


Figure 3.1 Continued

The algorithmic flow of the Master Production Schedule Model is explained below:

- 1. The user is required to input data for the formatting of the End Item File Report. The End Item File Report identifies and displays relevant information pertaining to the end item in question. The End Item File Report is printed on the line printer.
- 2. Next, the user is required to key in data for the compilation of the Master Production Schedule Report. The program manipulates the input data, calculates and formats the Master Production Schedule. The Master Production Schedule is printed on the line printer.
- 3. The program then reads the Master Production Schedule, picks out the necessary information and performs the required computations. The resultant output is printed on the line printer as the Receipt List Report.

3.4 Testing the Model

To produce the Long Term Master Production Schedule Report, the results of the Long Term Forecast Report for each product line for the next six years were input into the Master Production Schedule Model. The user gets the Master Production Schedule Model into interactive mode by typing in the file name MPSM. The user is required to key in the data requested.

3.4.1 Interactive Input Data Format The displays on the visual display unit are as follows: *********** * MASTER PRODUCTION SCHEDULE MODEL * *********** *Enter data for End Item File Report* Enter today's date (mm/dd/yy): 08/22/82 Enter part number (10 alphanumeric values): DLM68 Enter description (40 alphanumeric values): Dock Leveller Model M68 Enter make or buy (M/B): М Enter classification (A/B/C): Enter lead time code (1/2/3): 1 Enter manufacturing lead time in days (3 digits): 100 Enter job lot size in units (4 digits): 0100

Enter purchasing lead time in days (3 digits):

Enter purchase order quantity in units (digits):

000

```
00000
Enter minimum quantity in units (5 digits):
00000
Enter maximum quantity in units (5 digits):
00000
Enter scrap in % (4 digits):
0010
Enter horizon in weeks or periods (3 digits):
012
***** PRINTING .....
*Enter data for Master Production Schedule Report*
Enter long or short term:
Press 1 for long term
Press 2 for short term
Enter period or week:
Press 1 for period
Press 2 for week
1
Enter number of weeks or periods desired:
12
Enter beginning week or period no. (2 digits):
13
Enter economic order quantity in units (4 digits):
0050
Enter reorder level in units (4 digits):
```

```
0010
Enter backlog and stock on hand in units
(2 digits, a space, followed by 2 digits):
01 00
Enter gross forecast and bookings for those weeks or periods
desired in units
(5 digits, a space, followed by another 5 digits):
00128 00101
00127 00100
00127 00129
00128 00050
00130 00089
00130 00098
00129 00104
00128 00105
00127 00130
00128 00040
00126 00059
00127 00068
**** PRINTING .....
     The user may enter "2" following the prompts:
Enter long or short term:
Press 1 for long term
Press 2 for short term
Enter period or week:
Press 1 for period
```

Press 2 for week

2

The data requests which follow will appear in the same sequence as above, commencing from:

Enter number of weeks or periods desired:

The difference is in the output data format.

3.4.2 Output Data Format

In the first instance where "1" is entered for both "long term" and "period", the results are shown in Table 3.3. Table 3.4 shows the output as a result of entering "2" for both "short term" and "week".

The Master Production Schedule is tested with hypothetical data pertaining to a different product; Dock Leveller Model M610. The objective is to compare the different sets of results as a means of highlighting the effectiveness of the model. The results of the second test are shown in Tables 3.5 and 3.6.

The purpose of the End Item File Report is to identify the end item completely. The information is thus made readily available to management who can make use of it as reference notes for making decisions during meetings.

The Long and Short Term Master Production Schedules are the most important outputs of the Master Production Schedule Model. The Long Term Master Production Schedule becomes the input data into the Resource Requirements Planning Model. The results of the Resource Requirements Plan are used to

justify changes to the Long Term Master Production Schedule as may be required during meetings of senior managers. The Short Term Master Production Schedule is used to "drive" the Material Requirements Planning sub-system.

Table 3.3 DLM68 Long Term Master Production Schedule Report

ARGO ENGINEERING LI	MITED			DATE : 0	6/10/61
	****** EV	D ITEM FILE	REPORT ****	***	
PART NUMBER DESCRIPTION MAKE/EUY CLASSIFICATION A/B/ LEAD TIME CODE MANUFACTURING LEAD JOE LOT SIZE (UNITS PURCHASE LEAD TIMEN MINIMUM DUANTITY (UM MAXIMUM QUANTITY (UM SCRAP (%) HORIZON (PERIODS)	TIME (DAYS)) (DAYS) ITITY (UNITS) VITS)	- M - A - 1 - 1	1 00 00 00 0	ODEL M69	
	PERIOD NO.	PEFIOD NO.	PERIOD NO.	PERIOD NO.	PERIOD NO.
	126 101 27 128 1	127 100 27 127 0 127 21	127 129 -2 129 0 129 44 100	126 50 76 126 0 126 15	100 89 41 100 0 100 57
EDC = 50 ROL = 10	PERIOD NO.	17	PERIOD NO. 20	21	PERIOD NO. 32
GROSS FORECAST BOOKINGS NET FORECAST NET REQUIREMENTS EACKLOG GROSS REQUIREMENTS STOCK ON HAND MPS	130 96 32 130 0 130	129 104 25 129 0 129 27 150	126 105 23 128 0 128 46 100	127 130 -3 130 -0 130 20 150	128 40 58 128 0 128 40 100
E00 = 50 R0L = 10	PERIOD NO. 23	PERIOD NO 24	PERIOD NO. 25	PERIOD NO.	FERIOD NO. 27
GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG	126 59 67	127 68 59 127	0 0 0 0	0 0 0 0	0 0 0 0

Table 3.3 Continued

####### RE	ECEIFT LIST R	EPORT ******
PERIOD NO.	OUANTITY (ETINU)	SCRAP (UNITS)
13	150	15.00
14	150	15.00
15	100	10.00
16	150	15.00
17	100	10.00
16	150	15.00
19	150	15.00
20	100	10.00
21	150	15.00
22	100	10.00
23	150	15.00
24	100	10.00

Table 3.4

DLM68 Short Term Master Production Schedule Report

	MITED			DATE : 08	NI0181
	***** EN	D ITEM FILE F	REPORT \$888	\#\$	
PART NUMBER		- DLM	5 6		
DESCRIPTION			LEVELLER ME	ODEL Mo8	
MARE/BUY CLASSIFICATION A/R/	r	– M – A			
LEAD TIME CODE		-			
MANUFACTURING LEAD JOB LOT SIZE (UNITS)		- 10 - 10	00 56		
PURCHASE LEAD TIME	(DAYS)	_	o		
PURCHASE ORDER QUAN MINIMUM QUANTITY (U	TITY (UNITS)	- - -	0		
MAXIMUM QUANTITY (U		-	o o		
SCRAF (%) HORIZON (WEEKS)		-	10		
HONTZON (MEERO)		_	_		
****** 5	HORT TERM MA	STER PRODUCT	ION SCHEDULE	REPORT ****	124
EBC = 50 ROL = 10				WEEL NO. 20	
POOLINGS	15	10	7	,	_
NET FORFACT	- 1 6	• •			2
NET FORECAST NET REQUIREMENTS	-14 19	5 10 -5 10	- 2 7	1 5	5 4 5
EHL! LUG	5 19 -14 19 17	10 0	-2 7 0	1 5 0	÷
EHL! LUG	29	10	- 2 7	1 5	
GF055 REDUIREMENTS STOCK ON HAND	29	10 0 10	-2 7 0 7	1 5 6 5	÷ 5
GFOSS REDUIREMENTS STOCK ON HAND MPS EDD = 50	36 0 50 50 	10 0 10 14 50 WEEL NO	-2 7 0 7 54 0	1 5 6 5 47 6 WEE! NO.	0 5 40 6 WEEN NO.
GROSS REDUIREMENTS STOCK ON HAND MPS EDD = 50	36 0 50 50 WEEL NO. 22	10 0 10 14 50 WEEL NO	-2 7 0 7 54 0 WEEL NO.	1 5 6 5 47 6	0 41 41 WEEN NO.
GROSS FORECAST	#EEN NO.	10 0 10 14 50 WEEL NO 23	-2 7 0 7 54 0 WEEL NO. 24	1 5 6 47 6 WEE! NO. 25	0 5 40 6 WEEN NO. 26
GFOSS REDUIREMENTS STOCK ON HAND MFS EDO = 50 ROL = 10 GFOSS FORECAST BOOKINGS NET FORECAST	#EEL NO.	10 0 10 14 50 WEEL NO 23	-2 7 0 7 54 0 WEEL NO.	1 5 6 5 47 0 WEEL NO. 25	0 5 40 0 WEEN NO. 26
GROSS REDUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST ROOKINGS NET FORECAST NET REDUIREMENTS	#EEF NG. 22 8	10 0 10 14 50 WEEL NO 23 5 6 -1 6	-2 7 0 7 54 0 	1 5 6 5 47 6 WEEL NO. 25 0 0	0 5 40 6 WEEN NO. 26 0 0
GROSS REDUIREMENTS STOCK ON HAND MPS EOO = 50 ROL = 10 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG	WEEK NO. 22 5 6	10 0 10 14 50 WEE! NO 23 5 6	-2 7 0 7 54 0 WEEF NO. 24	1 5 6 5 47 6 WEE! NO. 25 0 0	0 5 42 0 week No 26 0
GROSS REQUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST BOOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	WEEK NO. 22 5 0 5 5 7	10 0 10 14 50 WEE! NO 23 5 6 -1 6 0 4	-2 7 0 7 54 0 WEEL NO. 24 5 2 5 0 5	1 5 6 5 47 6 WEE! NO. 25 0 0 0 0	0 5 40 6 0 0 0 0
GROSS FORECAST FORECAST NET FORECAST NET FORECAST NET FORECAST NET REOUIREMENTS GROSS REQUIREMENTS	WEEK NO. 25 50 5	16 0 16 14 50 WEEL NO 23 5 6 -1 6 0	-2 7 0 7 54 0 WEEF NO. 24 5 3	1 5 6 5 47 6 WEE! NO. 25 0 0 0	0 8 40 40 40 80 80 80 80 80 80 80 80 80 80 80 80 80
GROSS REQUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST ROOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	WEEK NO. 22 5 0 5 5 7	10 0 10 14 50 WEE! NO 23 5 6 -1 6 0 4	-2 7 0 7 54 0 WEEL NO. 24 5 2 5 0 5	1 5 6 5 47 6 WEE! NO. 25 0 0 0 0	0 5 40 6 0 0 0 0
GROSS REQUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST BOOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	#EEF NG. 22 50 50 52 50 50 50 50 50 50	10 0 10 14 50 WEEL NO 23 5 6 -1 6 0 6 32 0	-2 7 0 7 54 0 WEEL NO. 24 5 2 5 0 5	1 5 6 5 47 6 25 0 0 0 0 0 0	0 5 40 6 0 0 0 0
GROSS REQUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST ROOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	#EEF NG. 22 50 50 52 50 50 50 50 50 50	10 0 10 14 50 WEEL NO 23 5 6 -1 6 0 6 32 0	-2 7 0 7 54 0 WEEF NO. 24 5 3 2 5 0 5 26 0	1 5 6 5 47 6 25 0 0 0 0 0 0	0 5 40 6 0 0 0 0
GROSS REQUIREMENTS STOCK ON HAND MPS EOD = 50 ROL = 10 GROSS FORECAST ROOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	###### RE	10 0 10 14 50 WEEL NO 23 5 6 -1 6 0 6 32 0	-2 7 0 7 54 0 WEEF NO. 24 5 3 2 5 0 5 26 0	1 5 6 5 47 6 25 0 0 0 0 0 0	0 41 41 855 NO 0 0 0 0

Table 3.5

DLM610 Long Term Master Production Schedule Report

ARGO ENGINEERING L1	IMITED			DATE : 4	08/10/62
	****** 61	ND ITEM FILE	REPORT ***	1688	
D2DT					
PART NUMBER DESCRIPTION		- DL1 - DD0	1610 D LEVELLER M	100Ec Mato	
MAKEZBUY		- m			
CLASSIFICATION A/B/ LEAD TIME CODE	C .	- F -	2		
MANUFACTURING LEAD	TIME (DAYS)				
JOB LOT SIZE (UNITS PURCHASE LEAD TIME		<u> </u>			
PURCHASE ORDER QUAN			0 0		
MINIMUM QUANTITY (U			0		
MAXIMUM QUANTITY (U SCRAP (%)	141 121	_	0 5		
HORIZON (PERIODS)		-	12		
*****	LONG TERM M	VETER REARINGS			
******	CONG TERM MA	SIER PRODUCT	FION SCHEDULE	KEPURI **	
E00 = 100	PERIOD NO.	PERIOD NO.	EFETOR NO	EFETOR NO	EFETOT NO
55.		. 511100 1403	LEWIOD MO-	PERIOD NO.	1 E112 E2 140
ROL = 20	2	3	4	5	6
ROL = 20 GROSS FORECAST	2 85	86 86	74 	5 102	111
GROSS FORECAST BOOKINGS	2 85 43	3 8e 50	4 94 67	5 102 23	111 67
ROL = 20 GROSS FORECAST BOOW INGS NET FORECAST NET REDUIREMENTS	2 85 43 42	3 	4 	5 102	111
ROL = 20 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACHLOG	85 43 42 85 2	3 88 50 56 88 0	4 67 27 94 0	102 23 79 102 0	111 67 44 111 0
ROL = 20 GROSS FORECAST BOOW INGS NET FORECAST NET REDUIREMENTS	85 43 42 85 2	86 50 86 0 89	94 67 27 94 0 94	5 102 23 79 102 0 102	111 6.7 44 111 0
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REQUIREMENTS	85 43 42 85 2 87	3 88 50 56 88 0	4 67 27 94 0	102 23 79 102 0	111 67 44 111 0
ROL = 20 GROSS FORECAST BOO! INGS NET FORECAST NET REDUIREMENTS BACH.LOG GROSS REQUIREMENTS STOCH ON HAND MPS	85 43 42 85 2 87 0	5 50 56 88 0 89 13 100	4 67 27 94 0 94 25	5 102 23 79 102 0 102 31 100	111 67 44 111 0 111 29 100
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS RACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS EDD = 100	2 85 43 42 85 2 87 0 100	50 50 50 50 15 100	94 67 27 94 0 94 25 100	5 102 20 79 102 0 102 31 100	111 67 44 111 0 111 29 100
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS	2 85 43 42 85 2 87 0 100	88 50 38 88 13 100 FERIOD NO.	94 67 27 94 0 94 25 100 PERIOD NO.	5 102 23 79 102 0 102 31 100 PERIOF NO.	111 67 44 111 0 111 29 100
ROL = 20 GROSS FORECAST ROOF INGS NET FORECAST NET REDUIREMENTS RACELOG GROSS REDUIREMENTS STOCK ON HAND MPS EOO = 100 GROSS FORECAST	85 43 42 85 2 87 0 100 PERIOD NO.	88 50 38 88 13 100 FERIOD NO.	94 67 27 94 0 94 25 100 PERIOD NO.	5 102 23 79 102 0 102 31 100 PERIOF NO.	111 67 44 111 0 111 29 100
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS RACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS EOO = 100 ROL = 20 GROSS FORECAST BOOKINGS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7	50 50 50 68 88 13 100 FERIOD NO.	94 67 27 94 0 94 25 100 PERIOD NO. 9	5 102 20 79 102 31 100 FERIOR NO. 10	111 6.7 44 111 0 111 29 100 FEFIOD NO. 11
ROL = 20 GROSS FORECAST ROOF INGS NET FORECAST NET REDUIREMENTS RACHLOG GROSS REDUIREMENTS STOCK ON HAND MPS EOO = 100 ROL = 20 GROSS FORECAST BOOFINGS NET FORECAST	2 85 43 42 85 2 87 0 100 PERIOD NO. 7	5 86 50 56 88 13 100 FERIOD NO. 8	94 67 27 94 0 94 25 100 PERIOD NO. 9	5 102 23 79 102 0 102 31 100 FERIOF NO.	111 6.7 44 111 0 111 29 100 FEFIOD NG.
ROL = 20 GROSS FORECAST ROOF INGS NET FORECAST NET REDUIREMENTS RACELOG GROSS REQUIREMENTS STOCK ON HAND MPS EDD = 100 GROSS FORECAST BOOF INGS NET FORECAST NET REQUIREMENTS BACKLOG	2 85 43 42 85 2 87 0 100 PERIOD NO. 7	50 50 50 50 88 13 100 FERIOD NO. 8	94 67 27 94 0 94 25 100 PERIOD NO. 9	5 102 27 102 0 102 31 100 FERIOR NO. 10 97 32 45 97 0	FEFICE NG. 111 29 100 FEFICE NG. 11 94 57 37
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND MPS EDO = 100 ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS BACKLOG GROSS REQUIREMENTS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7	50 50 50 68 88 13 100 FERIOD NO. 8	94 67 27 94 0 94 25 100 PERIOD NO. 9	5 102 20 79 102 31 100 FERIOR NO. 10 97 32 45 97 0 97	PEFIOD NO. 111 94 57 37 94 94 95
ROL = 20 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACHLOG GROSS REDUIREMENTS STOCH ON HAND MPS EDD = 100 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACKLOG	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114	50 50 50 50 88 13 100 FERIOD NO. 8	94 67 27 94 0 94 25 100 PERIOD NO. 9	5 102 27 102 0 102 31 100 FERIOR NO. 10 97 32 45 97 0	FEFICE NG. 111 29 100 FEFICE NG. 11 94 57 37
ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND MPS EDO = 100 ROL = 20 GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18	50 50 50 50 68 88 13 100 FERIOD NO. 8 112 120 100 112 0 112 4	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0	5 102 25 79 102 31 100 FERIOR NO. 10 97 32 45 97 0 97 84	FEFIOE NG, 111 94 57 37 94 67
ROL = 20 GROSS FORECAST BOOHINGS NET FORECAST NET REDUIREMENTS RACHLOG GROSS REQUIREMENTS STOCK ON HAND MPS EDO = 100 ROL = 20 GROSS FORECAST BOOHINGS NET FORECAST NET REQUIREMENTS BACKLOG GROSS REQUIREMENTS STOCK ON HAND MPS EDO = 100	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18	50 50 50 56 88 13 100 FERIOD NO. 8 112 12 100 112 0 112 4 200	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 92 100	5 102 20 79 102 31 100 FERIOR NO. 10 97 32 45 97 0 97 84 100	FEFIOE NO. 111 94 57 37 94 67 100
ROL = 20 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACHLOG GROSS REDUIREMENTS STOCH ON HAND MPS EDO = 100 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18	50 50 50 56 88 13 100 FERIOD NO. 8 112 12 100 112 0 112 4 200	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0 108 92 100	5 102 20 79 102 31 100 PERIOF NO. 10 97 32 45 97 0 97 84 100 PERIOD NO. 15	FEFIOE NO. 111 94 57 37 94 67 100
ROL = 20 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACHLOG GROSS REDUIREMENTS STOCK ON HAND MPS EDO = 100 GROSS FORECAST BOOK INGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG BROSS PORECAST BOOK INC. BROSS PORECAST BROS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 18 100	5 86 50 56 88 0 89 13 100 PERIOD NO. 13	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0 108 92 100	5 102 27 79 102 0 102 31 100 FERIOR NO. 10 97 32 45 97 0 97 84 100 PERIOD NO. 15	FEFIOD NG. 111 94 57 94 67 100 PERIOD NG. 11
ROL = 20 GROSS FORECAST BOOH INGS NET FORECAST NET REDUIREMENTS BACHLOG GROSS REDUIREMENTS STOCH ON HAND MPS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18 100 PERIOD NO. 12	50 50 50 50 68 88 13 100 FERIOD NO. 8 112 100 112 4 200 PERIOD NO.	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0 108 92 100	5 102 20 79 102 31 100 PERIOF NO. 10 97 32 45 97 0 97 84 100 PERIOD NO. 15	PERIOD NG. PERIOD NG. PERIOD NG. PERIOD NG. PERIOD NG. PRIOD NG.
ROL = 20 GROSS FORECAST ROOF INGS NET FORECAST NET REDUIREMENTS RACHLOG GROSS REDUIREMENTS STOCK ON HAND MPS EOO = 100 ROL = 20 GROSS FORECAST BOOF INGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS REDUIREMENTS BACKLOG GROSS FORECAST BOOF INGS NET FORECAST BOOK INGS NET FORECAST BOOK INGS NET FORECAST	2 85 43 42 85 2 87 0 10G PERIOD NO. 7 114 76 38 114 0 114 18 100 PERIOD NO. 12	50 50 56 88 60 88 13 100 FERIOD NO. 8 112 12 100 112 4 200 PERIOD NO. 13	4 64 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0 108 92 100 PERIOD NO. 14	5 102 207 79 102 0 102 31 100 FERIOR NO. 10 97 32 45 97 0 97 84 100 PERIOD NO. 15	FEFIOD NO. 111 94 57 37 94 67 100 PERIOD NO. 16
ROL = 20 GROSS FORECAST ROO; INGS NET FORECAST NET REDUIREMENTS RAC:LOG GROSS REDUIREMENTS STOC: ON HAND MPS EOO = 100 GROSS FORECAST BOO! INGS NET FORECAST BOO! INGS NET FORECAST BAC:LOG GROSS REDUIREMENTS BAC:LOG GROSS REDUIREMENTS BAC:LOG GROSS REDUIREMENTS BAC:LOG GROSS REOUIREMENTS BAC:LOG GROSS FORECAST BOO: 0	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18 100 PERIOD NO. 12	50 50 50 50 68 88 13 100 FERIOD NO. 8 112 12 100 112 4 200 PERIOD NO. 13	4 64 67 27 94 0 94 25 100 PERIOD NO. 9 108 92 100 PERIOD NO. 14 0 0	5 102 207 79 102 31 100 102 31 100 FERIOR NO. 10 PERIOD NO. 15	PERIOD NO. PERIOD NO. 11 94 57 37 94 67 100 PERIOD NO. 16
ROL = 20 GROSS FORECAST BOO; INGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS EDO = 100 ROL = 20 GROSS FORECAST BOOK INGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS FORECAST NET REDUIREMENTS BACKLOG ROSS FORECAST BOOK INGS NET FORECAST NET REDUIREMENTS	2 85 43 42 85 2 87 0 100 PERIOD NO. 7 114 76 38 114 0 114 18 100 PERIOD NO. 12 85 45 40 85	50 50 50 50 68 88 13 100 FERIOD NO. 8 112 120 100 112 0 112 4 200 PERIOD NO. 13	94 67 27 94 0 94 25 100 PERIOD NO. 9 108 58 50 108 0 108 92 100 PERIOD NO.	5 102 27 79 102 31 100 31 100 FERIOR NO. 10 97 32 45 97 0 97 84 100 PERIOD NO. 15	FEFIOD NG. 11 94 57 74 111 29 100 FEFIOD NG. 11 94 57 37 94 67 100 PERIOD NG. 16

Table 3.5 Continued

\$\$\$\$\$\$ RE	CEIPT LIST R	EPORT ******
PERIOD NO.	QUANTITY (UNITS)	SCRAF (UNITS)
2	100	5.00
3 2	100	5.00
4	100	5.00
5	100	5.00
6	100	5.00
7	100	5.00
8	200	10.00
9	100	5.00
10	100	5.00
11	100	5.00
12	100	5.00
13	100	5.00

Table 3.6

DLM610 Short Term Master Production Schedule Report

ARGO ENGINEERING LIM	ITED		DATE : 06/20/82			
	****** ENI	O ITEM FILE R	EPORT *****	**		
PART NUMBER DESCRIPTION MAKE/BUY CLASSIFICATION A/E/C LEAD TIME CODE MANUFACTURING LEAD T JOR LOT SIZE (UNITS) PURCHASE LEAD TIME (PURCHASE DEADER QUANT MINIMUM QUANTITY (UN MAXIMUM QUANTITY (UN SCRAP (%) HORIZON (WEEKS)	IME (DAYS) DAYS) ITY (UNITS) ITS) ITS)	- M - B - 11 - 15 -	LEVELLER MO 2 0 0 0 0 0 0 5 8			
EOC = 100 ROL = 20	WEEK NO. 44	WEE! NO. 45	WEEK NO 46	WEEK NO. 47	WEEK 140.	
GROSS FORECAST BOOKINGS NET FORECAST NET REDUIREMENTS BACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS	14 10 4 14 0		12 9 3 12 0 12 78 0	11 8 7 11 0 11 66	11 17 -6 17 0 17 55	
E00 = 100 ROL = 20	WEEK NO.	WEEK NO.	WEEK NO.	WEEH NO.	WEEK NO, 53	
GROSS FORECAST ROOFINGS NET FORECAST NET REOUIREMENTS BACKLOG GROSS REDUIREMENTS STOCK ON HAND MPS	12 10 2 12 0 12 38 0	14 9 5 14 0 14 26 100	16 14 2 16 0 16 112	0 0 0 0 0 0 76	0 0 0 0	
	****** RE	CEIPT LIST R	EPORT ****	**		
		OUANTITY (UNITS)		**		

3.4.3 Explanation of Terminologies

The terminologies used in the reports are explained as follows:

Part Number

- A unique number or alphanumeric value which identifies the item.

Description

- Name of the end item.

Make/Buy

- Refers to whether the end item is manufactured in-house or purchased.

A/B/C

- The ABC classification is based on the Pareto curve. Class A items are the few items which account for 80% of the total inventory value. Class C items are 80% of the items which account for a few per cent of the total inventory value. Class B items are those items which fall in between the above two classes and account for the balance of the total inventory value.

Lead .Time Code

- Defined as the time between the receipt of an order to its issue onto the shop floor for manufacture. On the basis of duration, lead time is divided into three classifications; long denoted by 1, medium denoted by 2 and short denoted by 3. Management decides what duration is considered as long, medium and short based on subjective judgement and experience.

Manufacturing Lead Time

- Defined as the time between the issue of the manufacturing order onto the shop floor and its completion.

Job Lot Size

- A quantity to be produced on each replenishment cycle. The quantity is determined by balancing the operating expense of setting up and following the order against the capital investment in the working stock that results from ordering more than enough for the current consumption.

Purchase Lead Time

- Defined as the time between the issue of the purchase order and the receipt of the goods.

Economic Order Quantity

- A quantity to be ordered on each replenishment cycle. The lot quantity is determined by balancing the operating expense of raising the order and following the order against the capital investment in the working stock that results from ordering more than enough for the current consumption.

Reorder Level

- The stock level at which a replenishment is made. The replenishment is equal to the job lot size for manufactured items and equal to the economic order quantity for purchased items.

Minimum Quantity

- Defined as the minimum job lot size which can be produced economically or the minimum purchase order quantity as stipulated by the supplier.

Maximum Quantity

- There could be a constraint such as storage space which puts a limit to the production or order size.

Scrap

- A percentage factor applied to a job lot to account for scrap due to unsatisfactory product quality.

Horizon

- The number of periods through which requirements are planned or forecast.

Gross Forecast

- Forecasted demand results obtained from the Forecasting Model.

Book i nas

- Orders already confirmed by the customers.

Net Forecast

- Defined as the difference between the gross forecast and bookings.

Net Requirements

- If gross forecast is greater than bookings, net requirements are equal to gross forecast. On the contrary, net requirements are equal to bookings.

Backlog

- Orders confirmed and promised to customers but the

delivery date is missed. Priority is given to the backorder on completion of the next batch of end items.

Gross Requirements

- Equals the sum of the net requirements and backlog. Stock On Hand
 - The quantity of stock of a product that is available for sale, less any reservations or commitments for current shipment.

3.4.4 Discussion of Results

Table 3.3 shows the Long Term Master Production

Schedule for Dock Leveller Model M68 which has a planning horizon of twelve periods. The period here is defined as six months. The user may define any duration for "period" which suits the purpose of the situation. The economic order quantity is fifty units while the reorder level is ten units for this particular product.

In this case, the Master Production Schedule lots are created for each of the twelve periods because the stock on hand is less than the reorder level in each occasion. The Master Production Schedule lot is created in multiplications of the economic order quantity. For example, in the thirteenth period, the Master Production Schedule lot is three times the economic order quantity.

The twenty-fifth period is the first period outside the planning horizon period. The stock on hand carried forward is nine. The rest are indicated by zero because no

computation has occured beyond the planning horizon.

If the booking is greater than the gross forecast as indicated in the fifteenth period, the booking is used for computing the Master Production Schedule lot, instead of the gross forecast.

Table 3.6 shows the Short Term Master Production Schedule for Dock Leveller Model M610.

The planning horizon is eight weeks. The Master Production Schedule lot is created during the forty-fourth week. This Master Production Schedule lot is equal to the economic order quantity. The next Master Production Schedule lot is not created until week number fifty.

Tables 3.4 and 3.5 become self explanatory. These tests reveal the different structure of the reports and how the model handles different input information accurately and efficiently.

4. RESOURCE REQUIREMENTS PLANNING (RRP) MODEL

4.1 Resource Requirements Planning

Capacity planning and control is addressed to three different time horizons which correspond to three major decision areas for material management. These three time horizons for capacity planning and control are long range, medium range and short range. In the long range, capacity planning and control is concerned with decisions affecting resources that take long periods of time to acquire or dispose of and always require top management approval. These resources include land, facilities, machines, equipment and workforce as they relate to capacity to meet production objectives as dictated by the Long Term Master Production Schedule.

The term used in connection with long range planning of capacity at the Long Term Master Production Schedule level is Resource Requirements Planning or Rough-Cut Capacity Planning. The objective of Resource Requirements Planning is to assess any imbalance between the planned factors that affect capacity and the Long Term Master Production Schedule.

4.1.1 Establishment of a Resource Requirements Plan

The task of carrying out simulation experiments employing the Resource Requirements Planning Model is the responsibility of the Master Scheduler.

In the long term, it is only possible to approximate the capacity required from the plant work centers and vendors. It cannot be precise as the process relies on long term forecasts. The steps involved in organizing a Resource Requirements Plan are as follows:

- 1. The first round is conducted to produce results which are used to aid long term planning. The output of the Long Term Master Production Schedule forms one of the prime inputs into the Resource Requirements Planning Model. The other major input is the load profile of the end items concerned. The Resource Requirements Planning Model produces the Long Term Work Center Load Report and the Overload Report. The Long Term Work Center Load Report together with the Overload Report highlight whether the company has the available capacity to meet the Long Term Master Production Schedule.
- 2. The reports produced by the Master Production Schedule and Resource Requirements Planning Models are circulated to the interfacing departments for approval. Once approved, the Long Term Master Production Schedule is fixed for six months or for a period deemed appropriate by the senior managers. If the contrary happens, the revised Long Term Master Production Schedule is

resimulated through the Resource Requirements Planning Model. The process is repeated until a realistic Master Production Schedule is achieved.

3. The next step involves usage of the Capacity
Requirements Planning Model. Detail coverage of the
application of the Capacity Requirements Planning Model
is given in chapter 5.

The Master Scheduler should be aware that it is not necessary to include all the departments or machine groups or machines on the shop floor during the simulation experiment. If the Master Scheduler knows from past experience which is/are the bottleneck department(s) or machine group(s) or machines, it is reasonable to simulate only for these department(s) or machine group(s) or machine(s).

4.1.1.1 Suggested Solutions For Long Term Capacity Planning

In the event of insufficient capacity, there are a number of ways of overcoming the problem, such as:

- 1. adding additional facilities,
- 2. raising labour performance,
- working overtime,
- 4. adding additional shifts, and
- 5. subcontracting to suitable subcontractors.

These and other alternatives need to be explored and an effective solution implemented.

On the other hand, if the available capacity exceeds the required capacity, management may fill the "spare" capacity by one of the following methods:

- 1. increasing the Long Term Master Production Schedule,
- reducing the capacity available by selling redundant machines and trimming the labour force, and
- 3. subcontracting from suitable suppliers.

4.2 The Resource Requirements Planning Computer Program

The model design is developed on the basis of the following rules:

- 1. The capacity available from a department only includes the normal operating capacity of the department. It must not include overtime or any other abnormal operating conditions.
- 2. The company can only sub-divide its production facility up to a maximum of twenty departments. Each department can only accommodate a maximum of thirty machines. This limitation is necessary in order that the core memory capacity of the present basic IBM personal computer system is not exceeded. It can be increased when the core and external memory capacities of the machine are expanded to one and five megabytes respectively. (The machine limitations are thoroughly discussed in section 6.2.)

4.2.1 Model Algorithm

The flow diagram of the Resource Requirements Planning Model is shown in Figure 4.1.

The variables used in the flow diagram are defined in $\mbox{\sc Appendix A.}$

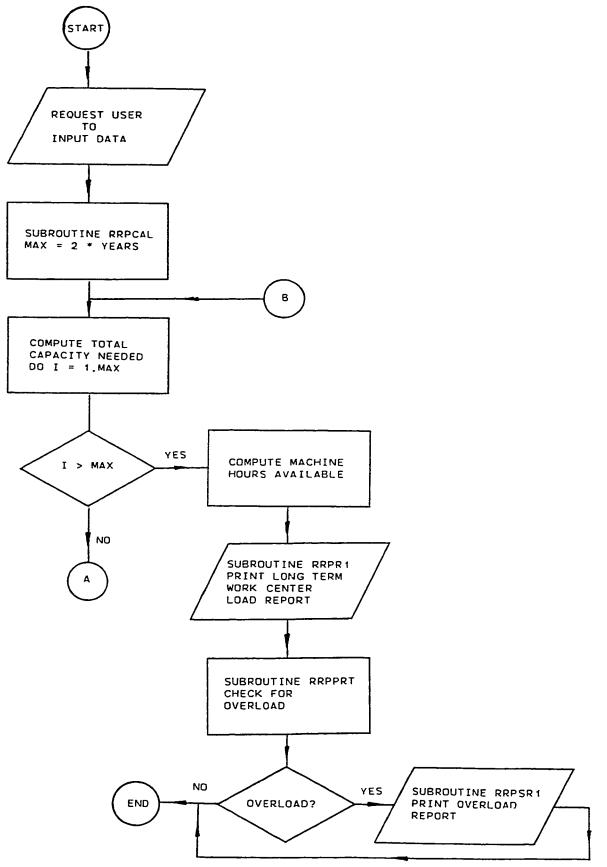


Figure 4.1 Resource Requirements Planning Model Flow Chart

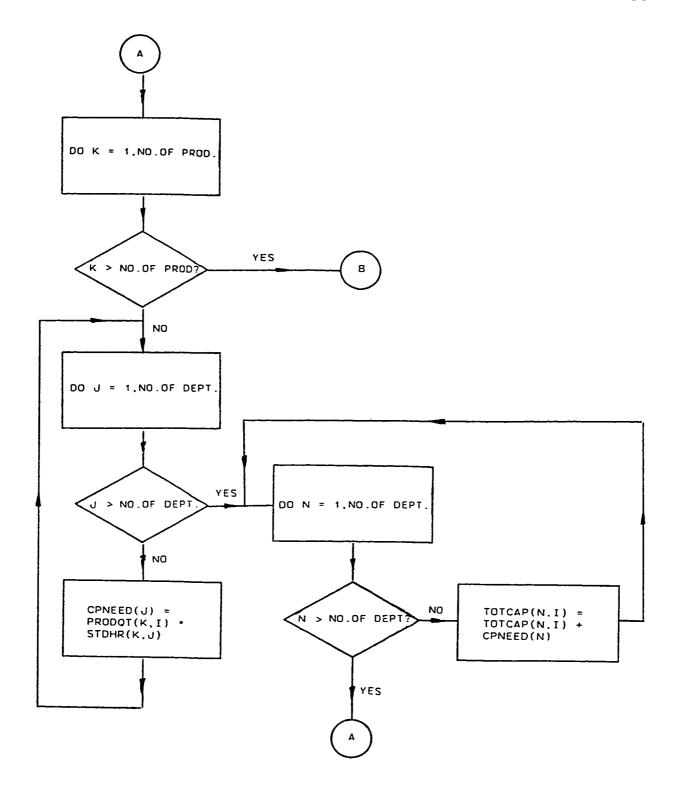


Figure 4.1 Continued

The algorithmic flow of the Resource Requirements Planning Model is explained below:

- 1. The user is required to key in data as requested by the "prompts". The types of data required are listed and explained in section 4.4.
- The main program calls the subroutine RRPCAL to manipulate the input data and make the necessary calculations.
- 3. The main program then transfers the calculated data to the subroutines RRPR1 and RRPSR1. These routines rearrange the data and formats the Long Term Work Center Load Report and the Overload Report respectively. The reports are then printed on the line printer.

4.2.2 Input Data Format

The Resource Requirements Planning Model is partly interactive and partly non-interactive.

The production quantity, capacity availability and capacity requirement data are input on a "batch" mode basis. It is more efficient to input a large amount of information using the "batch" mode of data entry.

4.2.2.1 Production Quantity File

Table 4.1 shows an example of a production quantity file.

Table 4.1

Production Quantity File Format Example

PRODCD (10 alpha-numeric characters)

Example: DLM68

PRODQT (5 digits)

Example:

00150 00150 00100 00150 00100 00150 00150 00100

The variables are defined as follows:

PRODCD - Product code.

PRODQT - Production quantity.

PRODCD is typed in on the first line. PRODQT is entered on the next line and each PRODQT is separated by a space. The above two variables are repeated for the number of products required for processing.

4.2.2.2 Capacity Available File

Table 4.2 shows an example of a capacity available file.

Table 4.2

Capacity Available File Format Example

NDMC (4 digits)

Example: 0009

DCODE (4 alpha) MCAP (6 digits) MORD (1 alpha)

Example: Example: Example:

DMS 000016 M

DMP 000024 M

DMPB 0000024 M

DP 000008 D

The variables are defined as follows:

NDMC - Total number of departments, machine groups and machines.

DCODE - Department or machine group or machine code.

DMP - Group of presses in the metal working department.

DMS - Group of shears in the metal working department.

DMPB - Group of press brakes in the metal working department.

DP - Painting department.

MCAP - Capacity available in standard hours per day.

MORD - Machine group or machine or department identification.

M - Machine.

D - Department.

NDMC is inserted on the first line. It is then followed by DCODE, MCAP and MORD, each separated by a space on the second line. DCODE, MCAP and MORD are repeated NDMC times.

4.2.2.3 Capacity Required File

Table 4.3 shows an example of a capacity required file.

Table 4.3

Capacity Required File Format Example

PRODCD (10 alpha-numeric characters)

Example: DLM68

DCODE (4 alpha) CREQ (4 digits)

Example: Example:

DMS 0012

DMP 0003

DMPB 0015

The variables are defined as follows:

PRODCD - Product code.

DCODE - Department or machine group or machine code.

DMS - Group of shears in the metal working department.

DMP - Group of presses in the metal working department.

DMPB - Group of press brakes in the metal working department.

CREQ - Capacity required for manufacturing the product
 in standard hours.

PRODCD is keyed in on the first line and indented one space to the right. It is then followed by DCODE and CREQ, each separated by a space on the second line. DCODE and CREQ are repeated NDMC times, after which all of the preceding information is repeated for all the products.

4.2.2.4 Resource Definition

The term resource in this context refers to physical resources such as machines and people. The shop floor of Argo Engineering Limited is classified into six departments. Each department has a variety of machines. However, within each variety of machines, there are a few machines which have common characteristics. These machines may be grouped together for the purpose of simulating through the Resource Requirements Planning Model. Machines which cannot be aggregated may be simulated individually. In cases where a department accommodates only one type of machine, the department may be used to represent a single physical resource.

To illustrate the above, a sample of the machines existing on the shop floor of Argo Engineering Limited are aggregated as depicted in Table 4.4.

Table 4.4

Department-Machine Group Code

No.	Machine	Dept. (Code Machine Group Code
1	Cheer - Birra Mal 1 40		
	Shear - Bisco Model 10		DMS
2.	Shear - Loblick Special	DM	DMS
3.	Punch - Brown Bogg	DM	DMP
4.	Punch - Brown Bogg	DM	DMP
5.	Punch - Loblick Special	DM	DMP
6.	Press Brake	DM	DMPB
7.	Press Brake	DM	DMPB
8.	Press Brake	DM	DMPB
9.	MIG Welder	DW	DWM
10.	MIG Welder	DW	DWM
11.	MIG Welder	DW	DWM
12.	Arc Welder	DW	DWA
13.	Arc Welder	DW	DWA
14.	Lathe - Grazlano	DS	DSL
15.	Lathe - Economatic	DS	DSL
16.	Drill - Modigs	DS	DSD
17.	Drill - Arboga	DS	DSD
18.	Grinder - Metabo	DS	DSG
19.	Grinder - Metabo	DS	DSG
20.	Painting System	DP	None

The Resource Requirements Planning Model is designed to accept departmental and machine group codes with a maximum of two and four characters respectively. The above coding system is proposed for the following reasons:

- it is simple and satisfies the prerequisite of the Resource Requirements Planning Model;
- an individual can understand the coding system almost immediately.

4.2.2.5 Load Profile Definition

The procedures for computing the load profile is described below:

- The Bill of Materials for the product whose load profile is to be computed is identified.
- 2. The production routing and the corresponding time study data are identified for each item which makes up the end product.
- 3. The standard time for all the raw materials, sub-assemblies and assemblies which utilize the facility of a particular department or machine group or machine as appropriate is added. This is done by referring to the production routes and cumulatively totalling the corresponding standard time by department or machine group or machine as appropriate.
- 4. The load profile of the end item concerned is thus defined for each department or machine group or machine.

Argo Engineering Limited at present does not keep time study data. It is recommended that the company launch a program for collecting and later updating time study records. A more elaborate discussion of record keeping and record integrity is presented in chapter 7.

4.3 Editing of the Data Files

The permanent files are edited by using the Disk Operating System (DOS). The Disk Operating System diskette is inserted into drive A and the data file into drive B.

To enter edit mode in order to edit the data file, the command A:EDLIN data file name is keyed in. When the editing is completed, the edited file is saved by keying in the command E. However, the old file is still retained as a back-up copy. Detailed instructions are given in the IBM personal computer manual - Disk Operating System.

4.4 Testing the Model

The department or machine groups indicated are "real life" data collected from Argo Engineering Limited. However, the capacity required by each end product is hypothetical.

4.4.1 Batch Mode Input Data

The input data for the production quantity, capacity available and capacity required data files are entered by utilizing the editing facility provided by the Disk

Operating System (DOS).

The respective input data are depicted in Tables 4.5, 4.6 and 4.7.

Table 4.5

Production Quantity File Input Data

0002
DLM68
00150 00150 00100 00150 00100 00150 00150 00100
DLM610
00100 00150 00100 00100 00150 00150 00100

Table 4.6
Capacity Available File Input Data

0009 DMS 000016 M DMP 000024 M DMPB 000024 M DWM 000024 M DWA 000016 M DSL 000016 M DSD 000016 M DSG 000016 M DP 000008 D

Table 4.7
Capacity Required File Input Data

DLM68 DMS 0012 0003 DMP **DMPB** 0015 DWM 8000 DWA 0007 DSL 0010 DSD 0004 DSG 0009 DP 8000 DLM610 0011 DMS DMP 0003 DMPB 0010 DWM 0009 0005 DWA DSL 0007 DSD 0006 DSG 0012 DP 0007

4.4.2 Interactive Input Data Format

The Resource Requirements Planning Model is called into interactive mode by keying in the file name RRPM.

The terminal session is illustrated as follows:

* RESOURCE REQUIREMENTS PLANNING MODEL *

Enter today's date:

08/21/82

Enter number of years to be processed (2 digits):

04

Enter beginning year (4 digits):

1982

**** PROCESSING

4.4.3 Output Data Format

The output data consists of a Long Term Work Center

Load Report and an Overload Report. The latter will not be

printed if there are no overloads.

The results of the above terminal session is illustrated in Tables 4.8 and 4.9. Table 4.8 shows the capacity available and capacity needed from each department for a four year projection. Each year is sub-divided into two halves as long term planning is reviewed every six months. The third row shows the balance of the capacity available. The negative sign implies an overload.

The prime purpose of the Long Term Work Center Load
Report is to aid management in making long range decisions
and to justify the decision taken. The decision may be the
alteration of the Long Term Master Production Schedule3 or
may result in purchase of additional machines and extending
the existing manufacturing facilities.

The purpose of the Overload report is to substantiate the Long Term Work Center Load Report. The Overload Report summarizes the situations which have inadequate capacity.

Table 4.8 Long Term Work Center Load Report 1

ARGO	GO ENGINEERING LIMITED				DATE :08/2	DATE :08/21/82	
		*****	* LONG TERM	WORK CENTER	LOAD REPORT	******	
				2		3 = 2 ~	1
DEPT.	m/E	PROJECT HRS. FOR	ED STD.	STD. HRS.AVAILABLE AT PRESENT CAPACITY		AVAILARLE STD.	
	DMS	2900	3450	2080	[2ND HALF]	[1ST HALF] -820	CIND HALFI
	DMF	750	900	3120			2220
		3250	900 3750	3120	7120	-130	-630
	DLIM	2100	2550	3120	3120 3120 3120 3080	1020	570
	DHIC	2100 1550	1800	2080	3120	530	280
	DSL	1330	2550	2080	2080 2080	-120	-470
	DSD		1500	2080	2080	890	560
	DSG	7550	3150	2080	2080	-470	-1070
DP.	מבע	1900	2250	1040	1040	-860	-1210
			2250				
		1		2		3 = 2 ~	1
DEPT	M/C	PROJECT	ED STD.	STD. HRS	AVAILABLE	AVAILAB	LE STD.
	PT M/C PROJECTED STD. HRS.FOR 1984		AT PRESENT CAPACITY		HOURS		
		[1ST HALF]				[IST HALF]	
	DMS	2200	2900	2680	2080		-610
	DMF	600	750	3120	3120 3120	2520	2370
	DMPR	2500	3250	3120	3120	620	-150
	DWM	1700	2100	3120	3120	1420	1020
	DWA	1200	1550	2080	2080	880	500
	DSL	1700	2200	2080	2080	780	-120
	DSD	1000	1200	2080	2080	1080	690
	DSD DSG	1700 1200 1700 1700 1000 2100	2550	2080	2080	-20	-470
DF.		1500	1900	1040	1040	-460	-640
		i		 2		= 2 -	1
DEPT.	M/C	PROJECT	ED STD.	STD. HFS.	AVAILABLE	AVAILAE	LE STD.
		HRS.FOR	: 1985 	AT PRESEN	IT CAFACITY	HOURS	
		[1ST HALF]	[2ND HALF]	[1ST HALF]	[2ND HALF]	[IST HALF]	COND HALFI
		2650	3450	2080	2080	-770	-1770
	DMF		900	3120	3120	2370	2220
	DMFB	2000	3750	3120	3120	120	-670
		2150	2550	3120	3120	970	570
	DWA		1800	2080	2080	630	290
	DSL	-	2550	2080	2080	30	-470
	DSD	1300	1500	2080	2080	780	580
	DSG	2700	3150	2080	2080	-620	-1676
P		1850	2250	1040	1640	-810	-1210
		1		2		3 = 2 -	1
DEPT.	M/C		ED STD.	STD. HRS.	AVAILABLE	AVAILAB	LE STD.
			1986	AT PRESEN	T CAPACITY	HOURS	**************************************
	Dw~			[1ST HALF]			
	DMS	2900	2300	2080	2080		-220 2520
	DME:	750	600	3120	3120	2370	2520
	DMPB		2500	3120	3120	-130	620
	DWM	2100	1700	3120	3120	1020	1420
	DWA	1550	1200	2080	2080	500	880
	DSL	2200	1700	2080	2080	-120	780
	DSD	1200	1000	2080	2080	880	1080
	DSG	2550	2100	2080	2080	-470	-20
)P		1900	1500	1040	1040	-860	-450

Table 4.9 Overload Report 1

DEPT.	M/C	YEAR	OVERLOAD	(STD.	HRS)
	DMS	1987 [1]	-620		
	DMS	1983 [2]	-1370		
	DMPB	1983 [1]	-130		
	DMPB	1983 [2]	-630		
	DSL	1983 [1]	-120 -470		
	DSL DSG	1983 [2] 1983 [1]	-470 -470		
	DSG	1963 [2]	-1070		
DF:	מבע	1983 [1]	-860		
DP DP		1987 [2]	-1210		
D 1	DMS	1984 [1]	-220		
	DMS	1984 [2]	-620		
	DMPE	1984 [2]	-130		
	DSL	1984 [2]	-120		
	DSG	1984 [1]	-20		
	DSG	1984 [2]	-470		
D₽		1984 [1]	-460		
DF.		1984 [2]	-840		
	DMS	1985 [1]	-770		
	DMS	1985 [2]	-1370		
	DMFB	1985 [2]	-630		
	DSL	1985 [2]	-470		
	DSG	1985 [1]	-620		
55	DSG	1985 [2] 1985 [1]	-1070 -610		
DP DP		1985 [2]	-1210		
DF-	DMS	1986 [1]	-620		
	DMS	1986 [2]	-220		
	DMPB	1986 [1]	-130		
	DSL	1966 [1]	-120		
	DSG	1986 [1]	-470		
	DSG	1985 [2]	-20		
DP		1986 [1]	-860		
DP		1986 [2]	-460		

4.4.4 Discussion of Results

Table 4.9 shows that the machine groups DMS (shear) and DSD (drill) and the department DP (painting) are overloaded for all the years projected. Machine groups DMP (press), DWM (MIG welder) and DWA (arc welder) are underloaded for all the years projected. Machine groups DMPB (press brake), DSL (lathe) and DSD (drill) have variations of overload and underload. The exact amount of overload and underload for each machine group or department for each period is given in Table 4.8.

The Overload Report shown in Table 4.9 indicates thirty-four overload situations. It also provides information as to "how much", "where" and "when" the overloads occured.

4.4.5 Sensitivity Analysis

The capacity availability was increased as an attempt to overcome the problem. The capacity available from each machine group or department were altered as follows:

- machine group DMS (shear) increased from sixteen to twenty-four standard hours,
- 2. machine group DMP (press) was unaltered,
- machine group DMPB (press brake) increased from twenty-four to thirty-two standard hours,
- 4. machine group DWM (MIG welder) was unaltered,
- 5. machine group DWA (arc welder) was unaltered,
- 6. machine group DSL (lathe) was unaltered,

- 7. machine group DSD (drill) was unaltered,
- 8. machine group DSG (grinder) was increased from sixteen to twenty-four standard hours, and
- department DP (painting) was increased from eight to sixteen standard hours.

The capacity available file was edited by utilizing the editing facility provided by the Disk Operating System (DOS). The edited data is depicted in Table 4.10.

Table 4.10
Edited Capacity Available File

0009		
DMS	000024	М
כויום		IA
DMP	000024	M
DMPB	000032	M
DWM	000024	М
DWA	000016	Μ
DSL	000016	M
DSD	000016	M
DSG	000024	М
DP	000016	D

The effect of this action is to reduce the overload situations to eleven ocassions. The overload situations which have been removed are:

No.	Dept.	Machine Group	Period
1.		DMS	1982[1],
2.		DMS	1982[2],
3.		DMS	1983[1],
4.		DMS	1983[2],
5.		DMS	1984[1],
6.		DMS	1984[2],
7.		DMS	1985[1],
8.		DMS	1986[1],
9.		DMS	1986[2].
10.		DSG	1984[1],
11.		DSG	1984[2],
12.	DP		1984[1],
13.	DP		1984[2],
14.		DMS	1985[1],
15.		DMPB	1985[2],
16.		DSG	1985[1],
17.	DP		1985[1],
18.		DMS	1986[1],
19.		DMS	1986[2],
20.		DSG	1986[1],
21.		DSG	1986[2],
22.	DP		1986[1], and
23.	DP		1986[2].

"[1]" represents the first half of the year while "[2]" represents the second half. The results are depicted in Tables 4.11 and 4.12.

Table 4.11 Long Term Work Center Load Report 2

ARGO I	RGO ENGINEERING LIMITED		DATE :08/21/8			/82	
		*****	LONG TERM	WORK CENTER	LOAD REPORT	******	
				 2		3 = 2 -	1
DEPT.	M/C	PROJECT HRS.FOR	ED STD. 1983	STD. HRS. AT PRESEN	T CAPACITY	AVAILABL HOURS	E STD.
		[1ST HALF]	[ZND HALF]	[1ST HALF]	[2ND HALF]	[1ST HALF] [2ND HALF
	DMS	2900	3450	3120	3120	220 2370	2220 -330
	DMF	750	900	3120	3120	910	410
		3250	3750	4160	4160 3120	1020	570
	DWM	2100	2550	5120 2080	2080	530	280
	DWA	1550	1800 2550	2080	2080	-120	-470
	DSL	2200	1500	2080	2080	880	560
	DSD DSG	1200 2550	1500 3150	3120	3120	570	-30
DP	טבע	1900	2250	2080	2080	180	-170
							 1
		1 					
DEFT,	M/C		ED STD. 1984	STD. HRS. AT PRESEN	AVAILABLE T CAPACITY	AVAILAR HOURS	LE STD.
		[1ST HALF]		[1ST HALF]		[1ST HALF]	COND HALF
	DMS		2900	3120	3120	820	
	DMF'	600	750	3120	3120	2520	2070
		2500	3250	4160	4160	1660	910
	DWM	1700	2100	2120	3120	1420	1020
	DWA	1200	1550	2080	2080	880	570 -170
	DSL	1700	2200	2080	2080	380	-120
	DSD	1000	1200	2080	2080	1080 1020	820 570
DF:	DSG	2100 1500	2550 1960	7120 2080	3126 2080	1020 580	180
		1		2		3 = 2 - 1	
DEFT.	M/C	HRS.FOR		STD. HRS. AT PRESE		AVAILAB HOURS	LE STD.
				[1ST HALF]	[2ND HALF]	[1ST HALF]	COND HALF
	DMS		3450	3120	3120	270	-220
	DMF.		900	3120	3120	2370	2220
	DMPB		3750	4160	4160	1160	410 570
	DMI	2150	2550	3120	3120	970 6 00	280
	DWA	1450	1800	2080	2080	20	-470
	DSL	2050	2550 1500	2080 2080	2080 2080	780	590
	DSD DSG	1300	1500 3150	3120	3120	420	-50
DP	טפע	2700 1850	2250	2080	2080	230	-170
				 2		- 2 = 2	· 1
							er ern
DEFT.	M/C	HRS.FOR 1986		STD. HRS.AVAILABLE AT PRESENT CAPACITY			
	B			[1ST HALF]	[2ND HALF] 3120	[1ST HALF] 220	IOND HALF
	DMS	2900	2300	3120 3120	3120 3120	2370	2520
	DMP	750 7350	600 3500	4160	4160	910	1660
	DMPR DWM		2500 1700	3120	3120	1020	1420
	DWA	2100 1550	1700 1200	2080	2080	570	880
	DSL	1550 2200	1700	2080	2080	-120	780
	DSD	1200	1000	2080	2080	880	1080
	DSG	2550	2100	3120	3120	570	1020
D₽	-50	1900	1500	2080	2080	180	580

Table 4.12 Overload Report 2

DEPT.	M/C	YEAR	OVERLOAD (ST	D. HRS)
	DMS	1983 [2]	-230	
	DSL	1983 [1]	-120	
	DSL	1983 [2]	-470	
	DSG	1983 [2]	-30	
DP		1983 [2]	-170	
٠.	DSL	1984 [2]	-120	
	DMS	1985 [2]	-220	
	DSL	1985 [2]	-470	
	DSG	1985 [2]	-20	
DF:		1985 [2]	-170	
	DSL	1986 [1]	-120	

5. CAPACITY REQUIREMENTS PLANNING (CRP) MODEL

5.1 Capacity Requirements Planning

In the medium and short term, a detailed study is made of available and required capacity. In the medium and short range, the information is more certain. The required capacity can be computed directly from released and planned orders rather than using the approximation techniques in long range planning. As in long range planning, the objectives of medium and short term planning are to adjust factors that determine capacity until the required capacity computed from released and planned orders is in balance with the available capacity of the plant, work centers and vendors.

This area of capacity planning relates to the detailed Material Requirements Planning sub-system. The technique associated with medium and short term planning is referred to as Capacity Requirements Planning.

5.1.1 Establishment of a Capacity Requirements Plan

This section is a continuation of the long range capacity planning exercise described in the preceding chapter. What follows is a step-by-step procedure for setting up the Capacity Requirements Plan.

1. The Short Term Master Production Schedule is used to "drive" the Material Requirements Planning Model. The

start date and production quantity information are output from the Material Requirements Planning Model.

These information, plus the production routing and time study data are input into the Capacity Requirements Planning Model.

- 2. The Capacity Requirements Planning Model produces the following reports:
 - Work Center Load Report,
 - Overload Report, and
 - Component Part Scheduling Report.

Production planning and control studies the reports and decides if it is capable of resolving any impending capacity shortage. If production planning and control is capable of handling the problem, it is not necessary to raise the problem during the regular scheduled meetings. If the contrary happens, the team of senior managers are required to seek an acceptable solution to the problem. This may mean altering the Short Term Master Production Schedule, resimulating it through the Material Requirements Planning Model and subsequently the Capacity Requirements Planning Model until a satisfactory short term plan is achieved.

3. Once the short term plan is finalized, the Master Scheduler issues the Component Part Scheduling Report to the shop floor. The machine operators are required to follow the schedule indicated by the Component Part Scheduling Report.

- 4. The cycle is repeated once for the period as determined by the rate of change of the Short Term Master Production Schedule.
- 5.1.1.1 Suggested Solutions For Short Term Capacity Planning

 If the required capacity is greater than the available capacity, management may take one or a combination of the following decisions:
- working overtime,
- 2. subcontracting to suitable subcontractors,
- transfer of operators to the bottleneck work centers,
- 4. altering the Short Term Master Production Schedule.

 On the other hand, if the capacity required is less than the available capacity, management has the option of taking one or a combination of the following actions:
- reducing working hours,
- 2. releasing some orders early, and
- laying off a portion of the workforce.
- 5.2 The Capacity Requirements Planning Computer Program

The model design is developed on the basis of the following rules:

- 1. Lead time and time study data are deterministic.
- 2. The maximum number of activities required to manufacture a component does not exceed fifty activities. This is done in order that the core memory capacity of the

present system is not exceeded. However, the number of activities can be increased when the core and external memory capacities are expanded to one and five megabytes respectively.

5.2.1 Model Algorithm

The algorithmic flow of the Capacity Requirements Planning Model is shown in Figure 5.1.

The variables used in the flow diagram are defined in Appendix $\mbox{A.}$

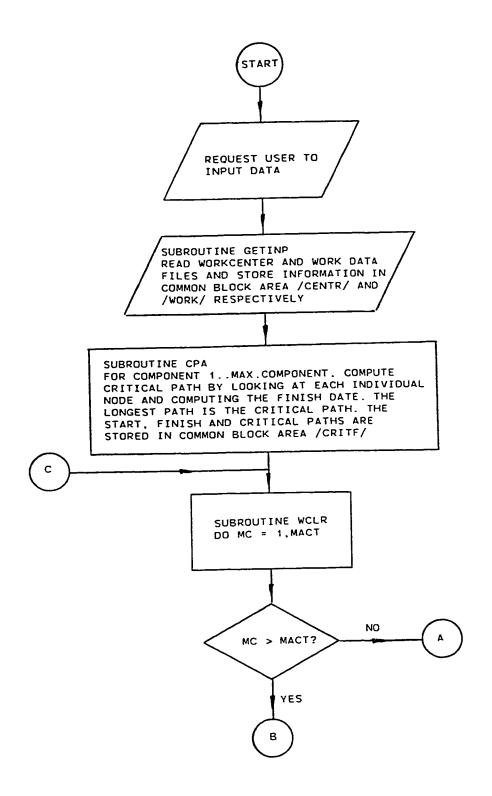
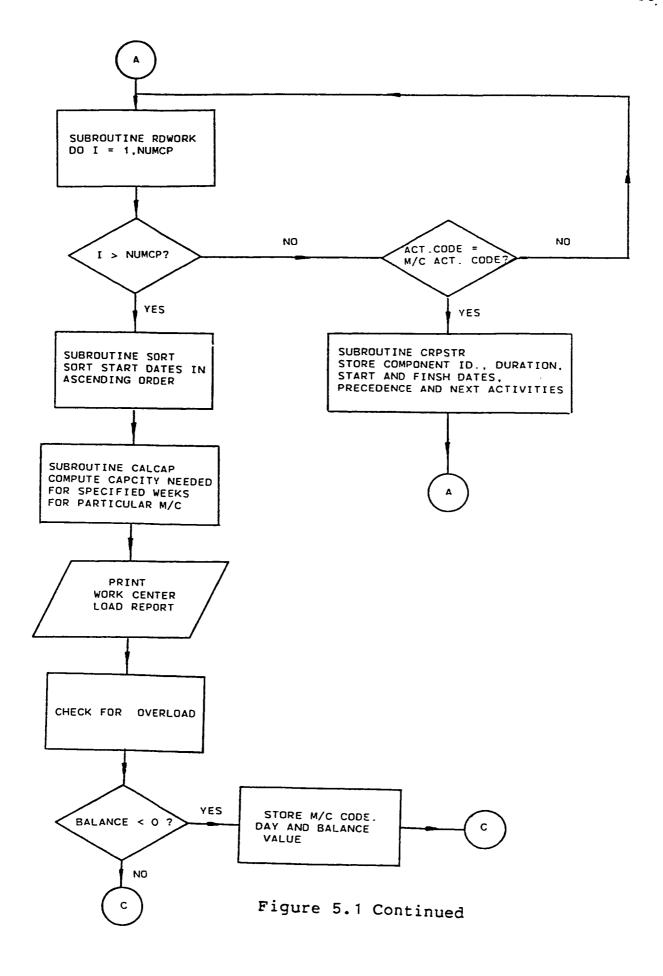


Figure 5.1 Capacity Requirements Planning Model Flow Chart



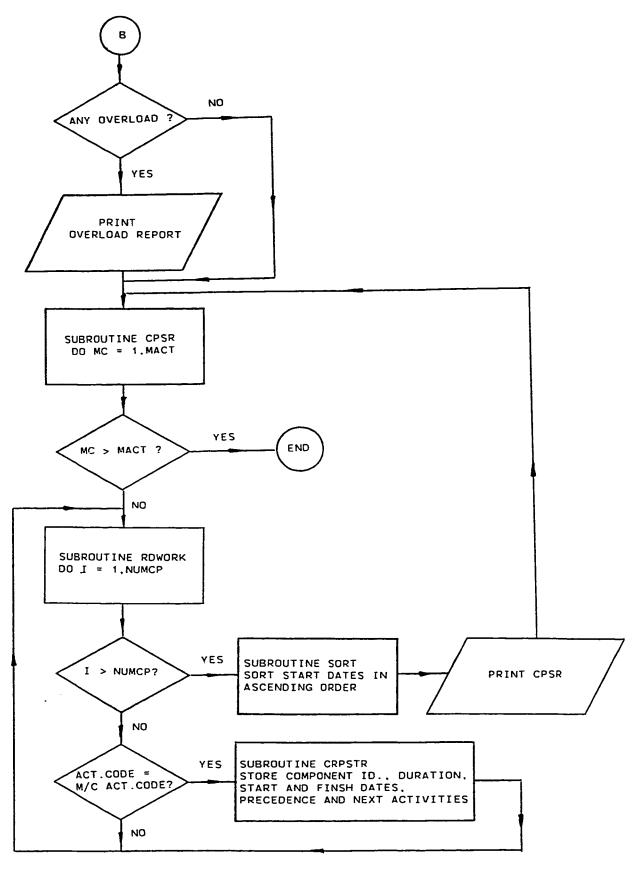


Figure 5.1 Continued

The algorithmic flow of the Capacity Requirements Planning Model is explained below:

- The user is required to key in data as requested by the "prompts". The types of data required are listed and explained in section 5.3.
- 2. The main program calls the subroutine GETINP to open and read the data files; WORKFL and CENTREFL. Subroutine GETINP reads and stores the information in the common block area /WORK/ and /CENTR/ respectively.
- 3. The main program then calls subroutine CPA to compute the critical paths for all the components. This is accomplished by 'looking' at each individual node along the path and computing the finish date. The longest path is the critical path. The start, finish and critical path are stored in the common block area /CRITF/.
- 4. The main program then transfers control to the subroutine WCLR. This routine calls subroutine SORT to sort out the start dates in ascending order before printing the Work Center Load Report on the line printer.
- 5. The main program then calls subroutine OVERLR if there is any overload in the balance capacity.
- 6. The main program calls the subroutine CPSR to produce the Component Part Scheduling Report. Again, the subroutine SORT is called to sort out the start dates in ascending order before printing the report on the line printer.

5.2.2 Critical Path Analysis Technique

The Capacity Requirements Planning Model is based on the principle of Critical Path Analysis.

The heart of the Critical Path Analysis Technique is a network portrayal of the plan for carrying out a job. Such a network shows the precedence relationships of the elements of the job leading to the job's completion and is called an arrow diagram.

The development of the arrow diagram occurs in the planning phase of the job. Resources and times are neglected at this point. With respect to each element of the job, the following three questions are asked:

- 1. What immediately precedes this element?
- 2. What can be done concurrently?
- 3. What immediately follows this job?

With the answers to these questions, the engineer can draw an arrow diagram to describe a job. In an arrow diagram, the arrow represents the activities of the job under consideration and the node or event represents the precedence relationships between activities.

Figure 5.2 shows a job which has four activities 01, 02, 03 and 04. The relationships between these activities are:

- activity 04 is started first;
- activities 01 and 02 can be started simultaneously as soon as activity 04 is completed;
- 3. both activities 01 and 02 must be completed before

activity 03 may be started.

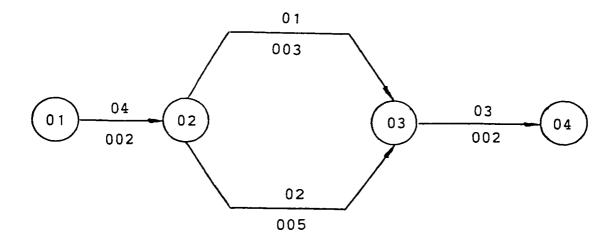


Figure 5.2 Activity Network

The next step is to allocate times and resources to each activity. The engineer then translates the information depicted by the arrow diagram into the format acceptable by the Capacity Requirements Planning Model. The format is explained in the section 5.2.3.1.

5.2.3 Input Data Format

The Capacity Requirements Planning Model is partly interactive and partly non-interactive. This is because it is required to process a large amount of information at frequent intervals. The time study, activity and work center

data are therefore stored permanently in back-up files. The back-up copies are transferred to temporary files which are edited during each interval to suit the particular alteration.

When there is a revision in the time standard or a change of routing for a certain component, the user simply has to edit that particular piece of information in the permanent file and make the necessary changes. The procedures for editing the files have been briefly outlined in section 4.3.

5.2.3.1 Work File

The work file contains the information as indicated in Table 5.1. The variable names are defined as follows:

ACTCD - Activity code.

CPID - Component identification.

DESTND - Destination node.

DURATN - Duration for that activity code.

JNXT1 - First next activity.

JNXT2 - Second next activity.

JNXT3 - Third next activity.

JPRE1 - First precedence activity.

JPRE2 - Second precedence activity.

JPRE3 - Third precedence activity.

MAXACT - Maximum number of activities.

MAXND - Maximum nodes.

SND - Source node.

Table 5.1
Work File Format

CPID MAXACT MAXND (10 alpha digits) (2 digits) (2 digits) ACTCD DURATN SND DESTND (2 digits) (3 digits) (2 digits) JPRE2 JPRE3 JPRE 1 (2 digits) (2 digits) (2 digits) JNXT2 JNXT1 JNXT3 (2 digits) (2 digits)

The above table shows the information required for the processing of a single component. The same format is repeated for the next component and thereafter.

The CPID, MAXACT and MAXND are on the same line, each separated by a space. The ACTCD is indented one space from the left hand margin and all the variables following are separated from each other by a space. The JPRE1, JPRE2, JPRE3 and JNXT1, JNXT2, JNXT3 are indented two spaces from the left margin.

The example which follows will illustrate the format.

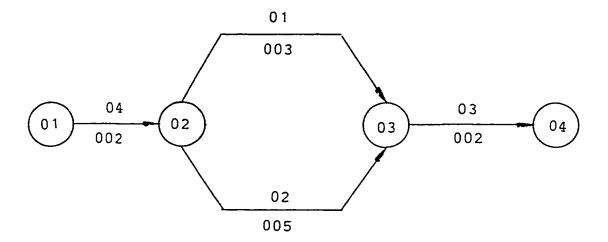


Figure 5.3 Arrow Diagram For Component DL3045

Table 5.2
Work File Format Example

DL3045	04 04
04 002	01 02
00 00	00
01 02	00
01 003	02 03
04 00	00
03 00	00
02 005	02 03
04 00	00
03 00	00
03 002	03 04
01 02	00
00 00	00

5.2.3.2 Work Center File

The work center file stores information with respect to the number of work centers, the work center code, the corresponding activity code and the corresponding capacity availability.

The user is required to follow exactly the format as illustrated in Table 5.3.

Table 5.3
Work Center File Format

MACT (3 digits)

Example: 003

MACTCD	MAXCAP	MCODE
(2 digits)	(3 digits)	(4 alpha-digits)
Example:	Example:	Example:
0 1	40	M520
02	35	C100
03	40	W330

The variables MACT, MACTCD, MAXCAP and MCODE are defined as follows:

MACT - Maximum number of machines in the file 'CENTREFL'.

MACTCD - Machine activity code.

MAXCAP - Maximum capacity.

MCODE - Machine code (Work center number).

MACT (which indicates the number of MACTCD or MAXCAP or MCODE to be entered) is typed in on the first line. MACTCD, MAXCAP and MCODE are entered MACT times. MACTCD is indented one space from the left hand margin and all the variables following are separated from each other by a space.

5.2.3.3 Activity Definition

In order for the computer to process the information contained in the work center and work files, the activity and work center must be coded so that they are meaningful to the computer.

The activity is coded by two digits. The two digit system for coding the activity allows efficient information processing and easy identification. Two digits are sufficient allowance for the addition of extra activities in the future. The maximum number of activities which can be coded by the two digit system is ninety-nine.

The corresponding work center for an activity is denoted by a character followed by three digits. The character identifies the location of the work center by department. The three digits give the exact location of the work center in a three dimensional space. The first digit represents the x-axis; the second digit represents the y-axis and the third digit represents the z-axis. The third digit is zero for the ground floor; one for the first floor; two for the second floor and so on.

To illustrate the coding system, it is necessary to code a number of the work centers existing on the shop floor of Argo Engineering Limited.

Table 5.4
Work Center and Activity Code

No.	Description	Workcenter Code	Activity
1	Shear-Bisco	Т330	07
	Cut Model		
	10		
2	Press Brake	Т380	02
	-70 tons		
3	Tig Welder	W550	03
4	Mig Welder	W590	08
5	Lathe-	• м760	05
	Economatic		
6	Milling	M7 10	06
	Machine		

5.2.3.4 Production Calendar

The production calendar is set up to facilitate the usage of the Capacity Requirements Planning sub-system and the Manufacturing Resource Planning system in general. The production calendar is needed not only in a Manufacturing Resource Planning environment but it is also useful for a manual production control and inventory system. People are more aware of time if a production calendar is used. It gives employees a clearer picture of the amount of time to completion date as consecutive numbering of the production calendar is much easier to visualize than the ordinary calendar.

The suggested system is to number the days consecutively only for the days where production is running. This implies the exclusion of weekends, public holidays and any other holidays declared by the company. The weeks are similarly numbered consecutively. The proposed production calendar system is shown in Table 5.5.

Table 5.5
Production Calendar

Ordi	nary	Day	Production	Calendar	Production	Calendar
Cale	ndar	of	Wee	k	Da	У
Da	Y	Week				
Jan.	1	Mon.	1		1	
**	2	Tue.	1		2	
##	3	Wed.	1		3	
**	4	Thr.	1		4	
Ħ	5	Fri.	1		5	
ŧī	6	Sat.				
Ħ	7	Sun.				
#	8	Mon.	2		6	
11	9	Tue.	2		7	

Each year, the production calendar is revised and a copy issued to each employee for reference. The receipt, scheduling and delivery of orders will be based on the production calendar. The system should be used company-wide as appropriate.

5.3 Testing the Model

The Capacity Requirements Planning Model was tested utilizing a mixture of Argo Engineering and hypothetical components. The dummy components were used as test data

because the production flow of these components were relatively more complicated than those of Argo Engineering Limited. This gave the model an opportunity to demonstrate its capability and versatility.

5.3.1 Batch Mode Input Data

The work file and the work center file are stored in permanent files. The data is input by utilizing the editing facility provided by the Disk Operating System (DOS). The contents of these files are illustrated in Tables 5.6 and 5.7.

Table 5.6
Work File Input Data

DL3048 01 002 00 00	0 1 00	.02 02	03
02 00 02 003 01 00	00 02 00	03	
00 00 DL3028 01 002	00	07 02	08
00 00 03 00 03 003	00 00 02	03	
01 00 02 00 02 001	00 00 03	04	
03 00 04 00 04 002	00 00 04	05	
02 00 05 00 05 003	00 00 05	06	
04 00 06 00 06 004	00 00 06	07	
05 00 05 00 06 00 06 001	00 00 07	08	
06 00 00 00 DL3047	00	07	08
01 002 00 00 02 00	0 1 0 0 0 0	02	00
02 001 01 00 07 00	02	03	
07 004 02 00 08 00	03 00 00	04	
08 001 07 00 05 00	04 00 00	05	
05 003 08 00 06 00	05 00 00	06	
06 002 05 00 09 00	06 00 00	07	
09 002	0.7	80	

Table 5.6 continued

Table 5.6 Continued

Table 5.7 Work Center File Input Data

004 01 002 A126 02 005 B345 03 010 C444 04 008 B666

5.3.2 Interactive Input Data Format

The user invokes the Capacity Requirements Planning

Model into "conversational" mode by typing in the file name

CRPM.

The displays on the visual display unit are as follows:

```
*************
* CAPACITY REQUIREMENTS PLANNING MODEL *
************
Enter today's date (mm/dd/yy):
08/25/82
Enter production calendar day number (3 digits):
200
Enter first day of the week (3 digits):
198
Enter number of components to be processed (3 digits):
008
Enter component part number, start date with reference to
the production calender and production quantity in units on
a single line
(10 alpha-numeric values, 3 digits and 3 digits):
Do it 8 times
DL3048
          210 010
DL3028
          204 020
DL3047
          211 010
DL3046
          230 030
```

DL3044 222 020

AAAAAAA123 215 010

BBBBBBBB180 214 030

CCCCCC155 235 040

***** PROCESSING

5.3.3 Output Data Format

The Capacity Requirements Planning Model outputs three reports, namely:

- 1. Work Center Load Report,
- 2. Overload Report, and
- 3. Component Part Scheduling Report.

These reports are depicted in Tables 5.8, 5.9 and 5.10.

The purpose of the Work Center Load Report is to highlight impending capacity problems in the short term before it actually occurs. Management can thus take appropriate action to deal with the situation.

The Overload Report acts as a complement to the Work Center Load Report. It gives a summary of the overload situation. This gives management a better picture of the capacity problem and saves managers the time required to look through each individual Work Center Load Report.

The Component Part Scheduling Report gives a detailed picture by work center of the components utilizing the particular resource. Operators make use of this schedule to determine the priority of processing a batch of components. Operators are made aware beforehand of the time to commence

production of a particular batch of components and the completion date.

Table 5.8 Work Center Load Report 1

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** WORK CENTER LOAD REPORT *****

WORK CENTER : A126

ACTIVITY : 1

*-----

FROM	AY TO	CAPACITY NEEDED (DAYS)	CAPACITY AVAILABLE (DAYS)					
198	202	0	2					
203	207	2	2	ō				
208	212	4	2	- 2				
213	217	7	2	-5				
218	222	3	2	-1				
223	227	0	2	2				
228	232	3	2	-1				
222	237	3	2	-1				
233	237	3	2	-1				

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** WORK CENTER LOAD REPORT *****

WORK CENTER : 8666

ACTIVITY: 4

D	AY	CAPACITY NEEDED	CAPACITY AVAILABLE	BALANCE
FROM	TO	(DAYS)	(DAYS)	(DAYS)
178	202	0	8	8.
203	207	. 1	8	7
208	212	2	8	6
213	217	0	8	8
218	222	2	8	6
223	227	o	8	8
228	232	o	8	8
233	237	0	8	8
238	242	2	8	6

Table 5.9 Summary Overload Report 1

ARGO ENGINEERING LIMITED DATE : 8/25/82

***** SUMMMARY OVERLOAD REPORT *****

WORK CENTER	DAY		OVERLOAD
	FROM	то	(DAYS)
 A126	208	212	-2
A126	213	217	-5
A126	218	222	-1
A126	228	232	-1
A126	233	237	-1
B345	218	222	-2

Table 5.10 Component Part Scheduling Report 1

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** COMPONENT PART SCHEDULING REPORT *****

WORK CENTER : A126

ACTIVITY : 1

PART NO	START DAY	FINISH DAY	DURATION (DAYS)	PRE ACT		ENCE	NEX ACT		TY	COMMENT
DL3028	204	205	· 2	0	0	0	3	Q	0	
DL3048	210	211	2	O	0	0	7	0	0	
DL3047	211	212	2	O	0	0	2	O	0	
BRBBBBBB180	214	218	5	2	O	0	3	4	0	
AAAAAA123	215	217	3	0	Q	0	2	3	0	
AAAAAAA123	221	221	1	2	3	0	3	2	O	
DL3046	230	232	3	0	0	0	2	O	Ç	
CCCCCCC155	235	237	3	0	0	0	11	0	O	

ARGO ENGINEERING LIMITED

DATE : 8/25/62

***** COMPONENT PART SCHEDULING REPORT *****

WORK CENTER : 8666

ACTIVITY : 4

PART NO	START DAY	FINISH DAY	DURATION (DAYS)	PRE ACT		ENCE	NEX ACT		ΤΥ	COMMENT
DL3028	207	208	2	2	0	0	 -		_ი	
BBBBBBB180	218	220	2	1	o	0	0	0	0	
CCCCCCC1SS	241	244	4	11	0	0	Q	O	0	

5.3.4 Discussion of Results

Table 5.8 shows that work center B666 is underloaded for all the days indicated.

Work Center A126 does not have sufficient capacity for five out of eight projected weeks.

The overload situations are summarized clearly in Table 5.9. It defines "how much", "when" and "where" the overload occurred. There are six overload situations in this particular case.

Table 5.10 indicates the components in the order of priority which work center B666 is required to process. Work center B666 is required to process part number DL3028 first, followed by BBBBBBB180 and finally CCCCCCC155. With respect to each component, the machine operator is informed which is the next activity and what activity precedes the present one. As for example, with reference to work center B666, the part number DL3028 was processed by activity number "2" before passing through this particular work center. When work center B666 which is associated with activity number "4" has completed processing this particular component, it will be passed on to activity number "5". Processing of part number DL3028 has to start on day number two hundred and seven and be completed by day number two hundred and eight. The machine operator is required to insert any relevant comments such as delay in the comment section after the completion of each activity.

5.3.5 Sensitivity Analysis

Similarly, the resolution taken to overcome the short term overload was by increasing the capacity available. The capacity available data in the work center file is edited utilizing the editing facility provided by the Disk Operating System (DOS). The capacity available in department A126 was increased by two days to four days. The capacity availability from the rest of the departments were unaltered. The new set of data is depicted in Table 5.11. The rest of the data was kept intact. The edited data was resimulated according to the procedures described in the previous section.

Table 5.11

Edited Work Center File Input Data

004 01 004 A126 02 005 B345 03 010 C444 04 008 B666

The results are presented in Tables 5.12, 5.13 and 5.14. The Summary Overload Report of Table 5.13 shows that the overload situations have been reduced from six ocassions to two. Work center A126 is overloaded by three days from day number two hundred and thirteen to day number two hundred and seventeen. This is a reduction from an overload of five days. Before increasing the capacity for work center

A126, it was overloaded from day number two hundred and eight to day number two hundred and thirty-seven.

Table 5.14 remains the same as before as there was no alteration to any of the other input parameters, as for example changing the production routing or start date. The increase in capacity does not affect the Component Part Scheduling Report.

This exercise shows that by altering any one of the parameters, the user is able to simulate a plan of action and obtain reasonably accurate results without actually needing to implement the action in practice.

Table 5.12 Work Center Load Report 2

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** WORK CENTER LOAD REPORT *****

WORL CENTER : A126

ACTIVITY : 1

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** WORK CENTER LOAD REPORT *****

WORK CENTER : B666

ACTIVITY : 4

DAY		CAPACITY NEEDED	CAPACITY AVAILABLE	BALANCE	
FROM	το	(DAYS)	(DAYS)	(DAYS)	
198	202	0	8	 8	
203	207	1	8	7	
208	212	2	8	6	
213	217	•	8	8	
218	222	2	8	6	
223	227	0	8	6	
228	232	0	8	e	
233	237	Q	8	ē	
238	242	2	8	6	

Table 5.13 Summary Overload Report 2

ARGO ENGINEERING LIMITED				DATE :	8/25/82
*****	SUMMMARY	OVERLOAD	REPORT	*****	
WORK CENTER	FROM)AY TO		OVERLOAI (DAYS))
A126 8345	213 218			-3 -2	

Table 5.14 Component Part Scheduling Report 2

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** COMPONENT PART SCHEDULING REPORT *****

WORK CENTER : A126

ACTIVITY: 1

PART NO	5TART DAY	FINISH DAY	DURATION (DAYS)	PRE ACT		ENCE	NEX ACT	T TIVI	TY	COMMENT
DL3028	204	205		0	0	0		0	·	
DL3048	210	211	2	ō	ō	ò	2	ò	ò	
DL3047	211	212	2	Ō	ō	ō	- 2	õ	ò	
3BBBBBBB180	214	218	5	2	Õ	ò	3	4	ŏ	
19999999	215	217	3	ō	ō	ò	2	3	õ	
AAAAAA123	221	221	1	2	3	ŏ	3	2	ò	
DL3046	230	232	3	- ō	ŏ	ŏ	2	ō	ŏ	
000000155	235	237	3	o	ō	ŏ	11	ŏ	ò	

ARGO ENGINEERING LIMITED

DATE : 8/25/82

***** COMPONENT PART SCHEDULING REPORT *****

WORK CENTER : B666

ACTIVITY : 4

PART NO	START DAY	FINISH DAY	DURATION (DAYS)	PRE ACT		ENCE	NEX ACT	-	TY	COMMENT
DL3028	207	208	2	- -						
BBBBBBB180	218	220	ž		ŏ	ö	Č	õ	ô	
CCCCCCC155	241	244	4	11	-	ŏ	ő	õ	ŏ	

6. EVALUATION OF THE MODELS AND SYSTEM

6.1 Advantages of the Models

The Forecasting, Master Production Schedule, Resource Requirements Planning and Capacity Requirements Planning programs developed have a number of common advantages.

- 1. The programs are interactive whenever they are suitable, for the convenience of the user. This means that the user is able to "communicate" with the programs. The basic advantage of an interactive program is that the user is provided with a step-by-step approach to data entry. The chance of making mistakes is less compared to non-interactive data entry because one is reminded of what to do with respect to data entry.
- 2. The source program is written in the IBM personal computer Fortran. Fortran is a very common high level language. Most programmers and those trained in the scientific and engineering disciplines are familiar with the language.
- 3. The models are well documented. For each model, there is a flow diagram to explain the flow of the algorithm, in addition to the description. The variables used in the main program and each sub-routine are defined clearly in Appendix A. If reports are generated as outputs, the terminologies used in these reports are defined to avoid misunderstanding.

- 4. The models are tailored to the specifications of Argo Engineering Limited.
- 5. The models are designed for running on an IBM personal computer. There is one main benefit of using the personal computer. The personal computer is a relatively economic system compared to its counterparts; the mini-computer and the mainframe. The present cost of the basic elements of most personal computer systems ranges from \$5000 to \$15000.
- 6. The modular build-up of the model permits ease of alteration and refinement to the model. It is possible for the system designer to change any one of the sub-routines or main programs and keep the remaining programs intact.
- 7. Each model is a separate entity on its own. The company can make use of any one of the models independently. For example, the company might eventually decide that it only wants to implement the Resource Requirements Planning sub-system.

6.2 Evaluation of the IBM Personal Computer System

The basic IBM unit employed to run the models designed in this thesis is illustrated in Table 6.1.

Table 6.1

IBM Basic Unit

- 1. IBM system unit
- 2. 64K RAM memory
- 3. Dual disk drive
- 4. IBM monochrome display
- 5. IBM printer
- 6. DOS extended Basic
- 7. Operator training manual
- 8. Programming seminar

•	110gramming bemine	• •	
			\$6395
9.	Fortran compiler		410
10.	192K RAM memory		1395
		Total	\$8200

The system unit has a maximum core memory capacity of two hundred and fifty-six kilobytes. It constitutes a one hundred and ninety-two kilobytes and a sixty-four kilobytes random access memory (RAM) boards.

The total cost of the basic IBM unit is \$8200.

The utilization of the basic IBM unit to implement a computerized Manufacturing Resource Planning system poses a few practical limitations.

The existing external memory, that is, the diskette limits the size of the programs which were written. A single

program must not exceed sixty-five kilobytes in order that it can be compiled. The program had to be split into many sub-programs which were then compiled individually. This is not a limiting factor to the user whose task is just to load the executable file into the core memory and then run the data. However, it is a limitation to the system designer/programmer who wants to expand the program to accommodate more components.

The user is limited to storing a maximum of one hundred and sixty kilobytes on each diskette. On the average, to portray one component using the Critical Path Analysis Technique requires one hundred bytes. Thus, the maximum number of components which can be processed is one thousand and sixty components, assuming that the diskette is a blank. This is sufficient for many small manufacturing companies.

The present Fortran compiler is not perfect in the sense that in certain occassions it is unable to give exact error messages which is certainly needed for efficient debugging of the program. This does not affect the user but is a limitation to the system designer who may need to modify the program as a result of changes in the environment. However, this is likely to improve in the near future as a result of modifications based partly on feedback reponses.

The core memory capacity limitation can be overcome by expanding it to one megabyte. This is achieved by inserting additional random access memory (RAM) boards. The basic unit

therefore requires an additional seven hundred and forty-four kilobytes of random access memory (RAM).

The external memory capacity limitations can be overcome by attaching a hard disk drive which has a storage capacity of five megabytes.

The total cost of the expanded system is illustrated in Table 6.2.

Table 6.2
Expanded IBM Unit

1. As	above	\$ 8200
2. Tw	o 512K RAM memory	1500
3. Ha	rd disk drive	2900
	Total	\$12600

The IBM Personal Computer-Manufacturing Resource
Planning system is suitable for small manufacturing
companies provided the data base does not exceed the five
megabytes of external storage capacity and one megabyte of
core memory capacity. In any case, the hard disk drive is
recommended as an "add-on" to make the system more efficient
for both the user and system designer. It is possible that
the system may also be suitable for medium to large
companies provided the data base does not exceed the
aforementioned core memory and external storage capacities
limit.

6.2.1 Computer Programs Capacity Requirements

The source, object and executable files of the individual models occupy the storage capacity as indicated in Tables 6.3, 6.4, 6.5 and 6.6.

The source file is the file which contains the source codes of the program. The object file is the file which contains the object codes (binary codes) of the program. The object codes are the translated source codes by the IBM Fortran compiler; FOR1 and FOR2. When the object file(s) is/are linked utilizing the SYSTEM LIBRARY, a file called the executable file is created. This is the "run" file. The instructions (codes) of the "run" file will be retrieved, decoded and executed by the central processing unit when the model is invoked by the user.

It is evident from the tables that the largest source file, that is, the Master Production Schedule Report (MPSR) file only occupies 5520 bytes. The main program of the individual models are split into many smaller sub-programs for two reasons:

- 1. a single program cannot exceed sixty-five kilobytes in order for it to be compiled; and
- 2. it is intended to create ample storage capacity for expansion of the individual models in the future.

Table 6.3
Forecasting Model Files

File Name	Туре	of File	Number of Bytes
FM		FOR	2738
AVG		FOR	3446
TREND		FOR	4248
SEASON		FOR	4797
REPORT		FOR	2072
PLOT		FOR	3116
FM		OBJ	4713
AVG		OBJ	9179
TREND		OBJ	13427
SEASON		OBJ	16185
REPORT		OBJ	4024
PLOT		OBJ	8634
FM		EXE	82048

Table 6.4

Master Production Schedule Model Files

File Name	Type of File	Number of Bytes
MPSM	FOR	4344
MPSR	FOR	5520
MPSRL	FOR	1498
MPSINIT	FOR	779
SRPORT	FOR	2159
MPSM	OBJ	7906
MPSR	OBJ	13925
MPSRL	OBJ	2099
MPSINIT	OBJ	1739
SRPORT	OBJ	5244 ·
MPSM	EXE	57856

Table 6.5

Resource Requirements Planning Model Files

File Name	Type of File	Number of Bytes
RRPM	FOR	2840
RRPCAL	FOR	1587
RRPR1	FOR	2218
RRPSR1	- FOR	811
RRPPRT	FOR	2067
RRPM	OBJ	5529
RRPCAL	OBJ	4716
RRPR1	OBJ	3694
RRPSR1	OBJ	1650
RRPPRT	OBJ	6990
RRPM	EXE	50944

Table 6.6

Capacity Requirements Planning Model Files

	-	•		
File Name	Type of	File Num	mber of	Bytes
CRPM	FOR		210	7
GETINP	FOR		173	3
СРА	FOR		220	0
WCLR	FOR		242	3
OVERLR	FOR		119	8
CPSR	FOR		252	3
CRPINIT	FOR		71	6
RDWORK	FOR		111	3
CRPSTR	FOR		189	3
SORT	FOR		108	8
CALCAP	FOR		299	1
CRPM	OBJ		339	5
GETINP	OBJ		408	2
CPA	OBJ		445	7
WCLR	OBJ		397	0
OVERLR	OBJ		192	1
CPSR	OBJ		400	2
CRPINIT	OBJ		190	6
RDWORK	OBJ		129	3
CRPSTR	OBJ		369	7
SORT	OBJ		2058	В
CALCAP	OBJ		675	2
CRPM	EXE		6118	4

7. IMPLEMENTATION

7.1 Implementation Guidelines

The best results can be achieved when implementing a Manufacturing Resource Planning system by following the Manufacturing Resource Planning closed-loop philosophy. The basic outline of the implementation steps applicable to Argo Engineering Limited is depicted in Figure 7.1.

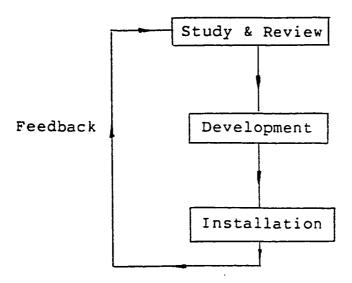


Figure 7.1 Closed-Loop Implementation Plan

7.1.1 Phase 1 - Study and Review

Key people in the company should investigate the workings of Manufacturing Resource Planning, and why the company should be committed to it. These key people should be top managers from engineering, finance, marketing and production planning. Since each of these areas will be

directly involved, the managers shold have an understanding of what will be necessary to get Manufacturing Resource Planning working in their company.

There are a number of alternatives open to a company to receive training in Manufacturing Resource Planning. These include:

- employing consultants to conduct in-house appreciation courses;
- sending managers for courses offered externally by the consultants;
- 3. sending managers for courses offered by the Canadian American Production and Inventory Control Society (CAPICS).

After there is a formal commitment to the project, the "key people" group has two important tasks: the first is to establish the project team; the second is to assign accountability. The project team should consist of the top managers in each of the manufacturing and support functions (marketing and finance) which is absolutely necessary to show top management's dedication and support. The team should also contain members of lower level management (first line supervisors) who will provide feedback on day-to-day operations. This is a first step towards achieving a critical mass of talent that is necessary for Manufacturing Resource Planning to work.

The second task of the key group is to assign accountability. It should be established from the start who

is going to be responsible for what, and what timetable will be set up for implementation of the system. If individuals are made responsible for specified jobs, there is a tendency that a higher quality job will be done. The general responsibilities of the three functions that will be continously involved may be specified as follows:

Marketing

- 1. responsible for forecasts of consumer demand, which "drive" the Master Production Schedule; and
- distribution and model mix should also be the responsibility of marketing.

Finance

- responsible for financing and control of finished goods inventory in terms of total investment, credit and receivables; and
- responsible for the financing of the Manufacturing Resource Planning project.

Production Planning and Control

- responsible for development and performance of the Master Production Schedule within the contraints developed by marketing;
- 2. controls engineering changes Bill of Materials; and
- establishes and maintains inventory accuracy.

Detailed education and training is the next major task that the project team should address. The objective of this part of the project is to give the people who will be operating the system an understanding of the system, and the

means to use it effectively. Education and training must translate the general principles of Manufacturing Resource Planning into the specifics of operations within the company. The project team can design a program to train their own staff; beginning with those who are going to be affected the earliest.

The education and training process will exact a great amount of time and effort from management, especially in the first 18-24 months.

Even after the system is up and running, "maintenance training" in the form of refresher courses will be necessary. This will keep people from developing bad habits and helps to stimulate fresh thinking and analysis.

Refresher courses will help to maintain that "critical mass" of trained, experienced personnel to keep Manufacturing Resource Planning operating effectively.

7.1.2 Phase 2 - Development

After completion of phase 1, there should be a commitment of people and top management to accomplish a successful Manufacturing Resource Planning implementation. Everyone should have a clear idea of what is required to be done to achieve the desired results.

The first step is to ensure that the inventory record is 95% accurate [24]. The procedure for achieving this is covered in E.S. Kombe's thesis. The second step is to implement the procedures for setting up an identification

system (Bill of Materials) as detailed in E.S. Kombe's thesis.

7.1.2.1 Time Study Procedure

The next step is to establish time study records for the production of each component.

There are two categories of work measurement procedure; direct and indirect.

The direct work measurement procedure includes:

- 1. time study, and
- 2. activity sampling.

The indirect work measurement procedure includes:

- 1. synthetic timing,
- 2. predetermined motion time systems, and
- 3. analytical estimating.

Time study accounts for the majority of the exercises conducted. Therefore, the time study procedure will be elaborated.

- The engineer studies the component drawing to be time studied.
- 2. The total job is broken down into smaller bits called elements. Each element is chosen to have a definite beginning and end (break point which is visible or audible).
- 3. Each element is timed by a stop watch many times until reasonable consistency is achieved. At the same time each element is rated on a suitable scale of pace and

recorded.

4. At the end of the study, each element is multiplied by the rating factor. This is called the elemental normal time. The equation for deriving the elemental normal time is:

Normal time = Observed time * Rating factor %

- 5. The elemental standard time is derived by taking into account contingency allowances. The equation for deriving the elemental standard time is:
 Standard time = Normal time * 1/(1 Allowance %)
- 6. The elemental shop planning time is derived by taking into account the efficiency of the shop or department or machine as appropriate. The equation for deriving the elemental shop planning time is:

Shop planning time = Standard time / Efficiency %

7. The sum of these elemental shop planning times is the total time to produce the component.

The time study may be recorded in the observation sheet as depicted in Table 7.1.

Table 7.1 Time Study Observation Form

Argo Engineering Limited Time Study Observation Form

Part	Number:	Dat	:e:
Sarr	Number:	Dat	:e

Part Description: Study Commenced:

Study End:

	Ī .		<u> </u>	ī		1	<u> </u>	
No.	Elem't	Freq'cy	Obser'd	Rat'g	Relaxat'n	Normal	Std.	Shop
			Time		Allow'ces	Time	Time	Plan
			(sec)			(sec)	(sec)	Time
								(sec)
						1		1

Total

7.1.3 Phase 3 - Installation

The system should by now be ready for a trial run. There are three methods of implementation. The team may select: pilot program, total system implementation or parallel system implementation.

The complete switch-over approach drops all past procedures and implements the new complete method company-wide.

The parallel approach is when both systems are being used at the same time.

The third method is the pilot approach which takes a sample, which may be one or two, of the product lines to be tested on a trial basis. This is a safer method as the users are given the opportunity to get used to the system before it is implemented company-wide. It is possible to study the possible causes of failure, learn from it and rerun the system again after resolving the problems.

The pilot approach is highly recommended for installation in Argo Engineering Limited, if and when the company decides to implement a Manufacturing Resource Planning system in the near future.

The pilot program is a trial run of the system on one or a group of product lines. The Manufacturing Resource Planning system is implemented on a stage by stage basis. Initially, a group of product lines, as for example dock levellers is selected for testing the system. The first step is to test the Material Requirements Planning sub-system.

The Bill of Materials of the chosen product line, assumed to be dock levellers in this case, are loaded into the system. The Master Production Schedule is set up following the procedures outlined in the Master Production Schedule chapter. The Material Requirements Planning sub-system takes the Master Production Schedule for end items and explodes the end item Bill of Materials into its lower level requirements. Details of how to utilize the Material Requirements Planning sub-system is given in D. Quek's engineering report.

After the Material Requirements Planning sub-system has been implemented and has settled down, the project team can begin training and implementation of the Capacity Requirements Planning sub-system. The procedures for utilizing the Capacity Requirements Planning sub-system is discussed in this thesis.

Once the system is verified and the desired results are achieved, the pilot run can be systematically expanded until all product lines are on line. After implementation has successfully been completed, the project team should again review its progress with top management. It should be top management's responsibility to provide continued encouragement and support to ensure that people do not slip back into the old system.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Benefits of Manufacturing Resource Planning

Once the entire system is running successfully, Argo Engineering Limited can expect to gain the benefits which are summarized by Fuchs [36] as follows:

Master Planning and Scheduling

- 1. orders tracked and repromised in a timely manner;
- 2. forecast maintained current:
- 3. continuous monitoring of performance to schedule;
- 4. planned and controlled production;
- fewer emergencies (less expediting).

Inventory and Material Planning

- 1. proper participation in what-to-stock decisions;
- 2. inventory record accuracy;
- 3. a master plan for complete material management;
- 4. tool inventory control.

Capacity Planning and Control

- 1. resource planning;
- shop load forecast;
- 3. priorities maintained by material availability;
- 4. fewer setups;
- 5. reduced and correct lead times.

Manufacturing Resource Planning does not discriminate size, nature and location of a company. It is very difficult to draw the line as to what size of company should consider

implementing a Manufacturing Resource Planning system. It is suggested that if a company shows symptoms of high inventory costs, low productivity and frequent missed delivery promises, the company should consider installing a Manufacturing Resource Planning system [21].

However, the author believes that a company should consider implementing a Manufacturing Resource Planning system when it is still "small". It is normally easier to manage and control the transformation to Manufacturing Resource Planning in a small company.

8.2 Strengths and Weaknesses of the System

The strengths of the various simulation models have been discussed in chapter 6. A recapitulation of the advantages discussed are listed as follows:

- 1. interactive mode of operation;
- 2. written in Fortran;
- proper documentation;
- 4. tailored to the specifications of Argo Engineering Limited;
- 5. designed for running on an IBM personal computer;
- 6. modular design permits ease of alteration and refinement;
- 7. independent application of the models is permissible.

The weaknesses of the individual models are outlined below:

- The Forecasting Model does not incorporate economical, sociological and psychological factors in computing the forecast. The individual must be made aware of this limitation. Adjustments may be necessary to account for these factors.
- 2. The Master Production Schedule Model at present utilizes the Economic Order Quantity formula in computing the Master Production Schedule job lot size. The above formula may or may not provide the "best" results for Argo Engineering Limited. Over time, based on experience the company may employ other lot sizing techniques as deemed appropriate.
- 3. The Master Production Schedule and Capacity Planning Models do not have the capability of producing material and labour costs reports respectively.

8.3 Recommendations for Future Study

The major sub-systems discussed in this thesis can be expanded to include the following extensions in order to make the system more sophisticated and versatile.

1. The Forecasting Model can be extended to incorporate economical, sociological and psychological factors in its computation. This will probably help to reduce the forecast error.

- 2. The Master Production Schedule Model can be extended to provide material cost output data in the long and short term. This will be useful for financial planning and control. In addition, the next logical extension is to include a sub-routine for processing and displaying statistical quality control information.
- 3. The extension in the Capacity Planning Models concerns the inclusion of the facility for providing labour cost output data. Again, this will serve as useful information for financial planning and control.

BIBLIOGRAPHY

- 1. Aley, P.N. and Zimmer, G.H. Capacity Planning, Industrial Engineering, April 1974, pp.16-19.
- 2. Aley, P.N. Priority Scheduling Reduces Inventory, Industrial Engineering, January 1976, pp. 14-18.
- 3. Berry, W.L., Mohnmon, R.A. and Callarman Master Scheduling and Capacity Planning: - A Case Study.
- 4. Blumberg, D.F. Factors Affecting the Design of a Successful MRP System, Production and Inventory Management, Fourth Quarter 1980.
- Boyer, C.H. Production Control: MRP Ends Guessing at Southwire, Industrial Engineering, March 1977, pp.26-31.
- 6. Buffa, E.S. and Miller, J.G. Production-Inventory Systems: Planning and Control, Third Edition, 1979.
- 7. Chambers, J.C., Mullick, S.K. and Smith, D.D How to Choose the Right Forecasting Technique, Harward Business Review, July-Aug. 1971, pp.45-74.
- 8. Chopra, V. Productivity Improvement Through Closed Loop MRP, Production and Inventory Management Review and APICS News, April 1982.
- 9. Compton, H.K. Supplies and Materials Management: A Textbook for Purchasing and Supply, Second Edition, 1972.
- 10. Fisher, K.R How to Implement MRP Successfully, Production and Inventory Management, Fourth Quarter 1981, pp.36-54.

- 11. Friedman, F.L and Koffman, E.B Problem Solving and Structured Programming in Fortran, Addison-Wesley Publishing Company 1981.
- 12. Greene, J.H. Production and Inventory Control: Systems and Decisions, The Irwin Series in Management & Behavioural Sciences, 1974.
- 13. Howey, C.F. Factors to Consider when Implementing Material Requirements Planning: Prepared for CAPIC 19th Annual Seminar, June 9-11, 1981.
- 14. IBM IBM Manufacturing Monitoring System, 1973.
- 15. IBM Capacity Planning and Sequencing System, 1971.
- 16. IBM The Personal Computer Language Series Disk Operating System, 1982.
- 17. Jelley, B.B. Computer-Aided Shopfloor Scheduling for Batch Production IBM CLASS (Capacity Loading and Scheduling System), Machinery and Production Engineering, October 1970.
- 18. Loveridge, J. and Sawyer, J.H.F. Computer Scheduling for Batch Production Machine Shops, The Production Engineer, June 1968.
- 19. Microsoft IBM The Personal Computer Language Series Fortran Compiler, 1982.
- 20. Moore, F.G. and Hendrick, T.E. Production/Operations Management, Richard D. Irwin Inc., Eighth Edition, 1980.
- 21. New. C Requirements Planning, Gower Press 1973.
- 22. Niland. P Production Planning, Scheduling and Inventory Control: A Text and Cases, The Macmillan Company, Collier-Macmillan Limited (London).

- 23. O'Brien, J.J. Scheduling Handbook, McGraw-Hill Book Company.
- 24. Orlicky. J Material Requirements Planning, McGraw-Hill Book Company, 1975.
- 25. Pennente, E. and Levy, T. MRP on Micro-Computers,
 Production and Inventory Management Review and
 APICS News, May 1982.
- 26. Peltu, M. Using Computers: A Manager's Guide, NCC Publications, The National Computing Center Limited, 1981.
- 27. Plossl, G.W. Material Requirements Planning and Inventory Record Accuracy.
- 28. Plossl, G.W. Manufacturing Control: The Last Frontier For Profits, Reston Publishing Company, 1973.
- 29. Proud, J.F. Controlling The Master Schedule,
 Production and Inventory Management, Second
 Quarter 1981.
- 30. Plummell, D.R. Programmed Workshop Control, The Production Engineer, March 1969, pp.108-114.
- 31. Riggs, R.L. Production Systems: Planning, Analysis and Control, Third Edition, John Wiley and Sons.
- 32. Steff, W., Buer, W.J. and Schultz, L.H. Inventory
 Controls for the Small & Medium Sized Firm:
 Computer-Aided Inventory Control and Manual
 Inventory Control Method, Industrial Development
 Division, Institute of Science and Technology,
 The University of Michigan, 1970.
- 33. Trusler, J.D.C. Production Control by the Computer with Particular Reference to Jobbing and Small Batch Production, The Machinery Publishing Company, First Published 1968.

- 34. Winters, P.R. Forecasting Sales by Exponentially Weighted Moving Averages, Management Science, Vol.6, No.3, April 1970, pp.324-42.
- 35. Zeigler, B.P. Theory of Modelling and Simulation, John Wiley & Sons, 1976.
- 36. Fuchs, J.H. Computerized Inventory Control Systems, Prentice-Hall, 1978.

APPENDIX A

GLOSSARY OF VARIABLES USED IN THE COMPUTER PROGRAMS

FORECASTING MODEL

ADEMD	Actual historical sales data						
AERR	Actual historical sales data Average error based on specified range						
	of smoothing constants						
ALFA	Best smoothing constant						
ALPHA	Smoothing constants						
BSDMD	d as the						
	base series for the SEASON sub-re	outine					
CAERR	Total average error based on bes	t smoothing					
CECACE	constant						
CFCAST	Current smoothed demand data						
CMAD 1	Total mean absolute deviation from AVG sub-routine	m					
CMAD2	Total mean absolute deviation from	om					
	TREND sub-routine						
CMAD3	Total mean absolute deviation from	om					
	SEASON sub-routine						
CMSE	Total mean standard error based of	on best					
77.7.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	smoothing constant						
EWMA	Exponential Weighted Moving Avera	age					
FCAST	Forecast output data which can be either FCAST1 or FCAST2 or FCAST3						
FCAST1	Forecast output data derived from						
FCAST2	Forecast output data derived from						
	sub-routine						
FCAST3	Forecast output data derived from	n SEASON					
	sub-routine -						
LFCAST	Smoothed demand data of previous						
MAD	Mean absolute deviation based on	specified					
	range of smoothing constant						
MSE	Mean standard error based on spec	cified					
	range of smoothing constants						
TAERR	Total average error based on spec	cified					
TMAD	range of smoothing constants Total mean absolute deviation bas	sod on					
TIMD	specified range of smoothing cons						
TMSE	Total mean standard error based of						
	specified range of smoothing cont						
		- u u u					

MASTER PRODUCTION SCHEDULE MODEL

APRWK An array of week numbers (MPSRL routine)

AWEEK - An array of week numbers

BKINGS - Bookings BKLOG - Backlog

CLASS - Classification A/B/C

DESCRP - Description

EOQ - Economic Order Quantity

GROSSF - Gross Forecast GROSSR - Gross Requirements

HORZON - Horizon

IWEEK - Number of weeks (MPSR routine) - Number of weeks (MPSRL routine) IWK

ISHRNK - Shrinkage (MPSRL routine)

JLSIZE - Job lot size LTCODE - Lead time code MAXOTY - Maximum quantity MINQTY - Minimum quantity

MLT - Manufacturing lead time

MORB - Make or Buy

- Master Production Schedule MPS

- Master Production Schedule (MPSRL routine) MPSCH MPSR - Subroutine name: Master Production Schedule

Report

MPSRL - Subroutine name: Master Production Schedule Receipt List Report

- Net forecast

NETF NETREQ - Net requirement

NWEEK - Number of weeks desired by the user to be processed and compiled for the Master Production Schedule Report

ORDQTY - Order quantity PARTNO - Part number

- Purchase lead time PLT

ROL - Reorder level SOHAND - Stock on hand

SRPORT - Subroutine name: it computes the output data for the Master Production Schedule Report

RESOURCE REQUIREMENTS PLANNING MODEL

CPAVAL - Capacity available array CPNEED - Capacity needed array DEPTCD - Department code array HRAVAL - Machine hours available - Type of output ITYPE - Beginning year I YEAR - Department code array for the Overload Report JDEPT - Year array for the Overload Report JYEAR JYHALF - 1st half or 2nd half of the year JVALUE - Negative value of HRAVAL - Machine capacity array MCAP NDEPT - Number of departments array NEG - Subscript used to identify the negative value in HRAVAL array NOPROD - Number of products NYRS - Number of years PRODCD - Product code array PRODQT - Production quantity RRPCAL - Subroutine name: it calculates the output data for the Long Term Work Center Report RRPPRT - Subroutine name: it prints the output data for the Long Term Work Center Report - Subroutine name: it prints the Long Term Work RRPR1 Center Report headings - Subroutine name: it prints the Overload Report RRPSR1 - Standard hour array STDHR TOTCAP - Total capacity array

CAPACITY REQUIREMENTS PLANNING MODEL

- Activity code ACTCD CALCAP - Subroutine name: it calculates the capacity needed - Subroutine name: Critical Path Analysis CPA CPAMT - Production amount for the component - Component identification CPID - Subroutine name: Component Part Scheduling Report CPSR CRIPTS - "Critical Points". It indicates the start/finish date of that particular activity CRPINIT - Subroutine name: it initializes the variables in the common block area /STRF/ - Subroutine name: it stores information in CRPSTR common block /STRF/ - Destination node (TO) DESTND DURATN - Duration for that activity code - Subroutine name: it reads from the data files; GETINP WORKFL and CENTREFL and stores the information in common block /WORK/ and /CENTR/ respectively ICP - Component identification IDEST - Destination node IDUR - Duration of the activity - Finish date IFIN - Next activity INEXT IPRE - Precedence activity IPTR - Pointer to the next vacant space in array ICP, ISTART, IFIN, IDUR, ISORCE, IDEST, IPRE, INEXT ISTART - Start date ISORCE - Source node IWORK - Information in IWORK is a duplicate of ISTART. Array IWORK is used for the purpose of sorting out the start dates in ascending order MACT Maximum number of machines in the file 'CENTREFL' MACTCD - Machine activity code - Maximum number of activities for that component MAXACT MAXCAP - Maximum capacity MAXND - Maximum nodes for that component - Machine code (Work center number) MCODE NACT - Activity number NCOMP - Component number NUMCP - Number of components NDUR - Duration of activity NEXT - Next activity NFIN - Finish date OVERLR - Subroutine name: Overload Report RDWORK - Subroutine name: it reads information from the common block /WORK/ SORT - Subroutine name: it sorts the start dates in ascending order WCLR - Subroutine name: Work Center Load Report

APPENDIX B - The Computer Programs

```
$TITLE: 'MSc. THESIS PROGRAM - 1'
$SUBTITLE: 'FORECASTING MODEL'
      PROGRAM FM
C
С
  ******************
  * THIS IS THE MAIN PROGRAM.
С
  * THIS PROGRAM SELECTS THE BEST EXPONENTIAL
C
  * WEIGHTED MOVING AVERAGE (EWMA) MODEL BY
C
  * COMPARING THE RESULTS OF EACH INDIVIDUAL MODEL *
С
  * BASED ON THE CRITERION OF TMAD.
C
  *******************
C
C
     COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
                    FCAST1(25), FCAST2(25), FCAST3(25)
C
     REAL ADEMD, FCAST, BSDMD, FCAST1, FCAST2, FCAST3
C
     REAL CMAD1, CMAD2, CMAD3
С
     CHARACTER*8 DATE
     CHARACTER*40 FITEM, PERIOD
C READ INPUT VARIABLES
     WRITE(*,888)
 888 FORMAT(' ',23('*'),/,
    &' ','* FORECASTING MODEL *',/,
&' ',23('*'),/,' ')
C
     WRITE(*,1)
     FORMAT(' ','ENTER TODAY"S DATE (MM/DD/YY):')
     READ(*,2) DATE
     FORMAT(BN, A8)
 2
     WRITE(*,3)
     FORMAT(' ', 'ENTER FORECAST ITEM ',
    &'(40 ALPHA-CHARACTERS:')
     READ(*,4) FITEM
4
     FORMAT(BN, A40)
C
     WRITE(*,55)
     FORMAT(' ', 'ENTER FORECAST FOR MONTH/',
    &'1 YEAR [HALF]',/,
    &' ','PRESS 1 FOR MONTH',/,
    &' ','PRESS 2 FOR 1 YEAR [HALF]')
     READ(*,12) MORY
     FORMAT(BN, I1)
12
     IF (MORY .EQ. 1) THEN
        WRITE(*,13)
       FORMAT(' ','ENTER FORECAST PERIOD',/,
 13
    & '','(EXAMPLE: JAN 1982 TO DEC 1982)',/,
```

```
& ' ','(40 ALPHA-CHARACTERS):')
         READ(*,14) PERIOD
         FORMAT(BN, A40)
 14
      ELSE
         WRITE(*,15)
         FORMAT(' ','ENTER FORECAST PERIOD',/,
 15
     & '','(EXAMPLE:1982 TO 1987)',/,
& '','(40 ALPHA-CHARACTERS):')
         READ(*,16) PERIOD
         FORMAT(BN, A40)
 16
      ENDIF
C ENTER DATA FOR BSDMD & ADEMD
      WRITE(*,17)
     FORMAT(' ', 'ENTER 14 DATA FOR BASE SERIES', &' DEMAND', /, ' ', 'ON A SINGLE LINE.',
     &' (XXXXX.X REALS EACH):')
      READ(*, 18) (BSDMD(I), I=1, 14)
      FORMAT(BN, F7.1, 13F8.1)
 18
      WRITE(*,19)
      FORMAT(' ','ENTER 12 DATA FOR PAST HISTORICAL',
 19
     &' DEMAND',/,' ','ON A SINGLE LINE.',
     &' (XXXXX.X REALS EACH):')
      REAL(*,20) (ADEMD(I), I=1,12)
      FORMAT(BN, F7.1, 11F8.1)
 20
      WRITE(*,21)
      FORMAT(' ','**** PROCESSING .....')
 21
C
C OPEN OUTPUT FILE
      OPEN (6,FILE='PRN')
C
C
C INITIALISATION
C
      SMALL = 9999.9
C
      CALL AVG(CMAD1)
      CALL TREND(CMAD2)
      CALL SEASON (CMAD3)
C
      SMALL = CMAD1
      IPRT = 1
      IF ( CMAD2 .LT. SMALL) GOTO 10
      GOTO 11
 10
          SMALL = CMAD2
          IPRT = 2
          IF ( CMAD3 .LT. SMALL) GOTO 15
 11
          GOTO 25
 15
                SMALL = CMAD3
                IPRT = 3
```

```
GOTO (100,120,130), IPRT
 25
 100
       CALL REPORT(1)
       GOTO 140
       CALL REPORT(2)
 120
       GOTO 140
      CALL REPORT(3)
 130
 140
       CALL PLOT
C
C
     STOP
     END
C
C
C
     SUBROUTINE AVG (CMAD1)
C
C
     *****************
C
         THIS SUBROUTINE CALCULATES THE FORECAST
BASED ON THE BEST ALPHA, DERIVED BY AVERAGING
         THE RESULTS OF TWO DIFFERENT CRITERIA.
     *
         THIS SUBROUTINE WOULD BE SELECTED IF THE
     *
         COMPONENTS OF DEMAND EXHIBIT 'RANDOMNESS'.
     *****************
     INPUT PARAMETER
                      : NONE
     OUTPUT PARAMETER: CMAD1
     DIMENSION LFCAST(13), CFCAST(12),
               AERR(12), TAERR(30), MAD(12), TMAD(30),
               MSE(12), TMSE(30), ALPHA(30)
C
     COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
                    FCAST1(25), FCAST2(25), FCAST3(25)
C
C
     REAL CFCAST, LFCAST, ADEMD, AERR, TAERR, MAD, TMAD,
          MSE, TMSE, SMALL, ALPHA, LNUM, AALPHA, ALFA,
          CAERR, CMAD1, CMSE, PFCAST, LADEMD, FCAST,
    &
          FCAST1
C
Č
 INITIALIZATION
     DO 5 I=1,25
        CFCAST(I)=0.0
        LFCAST(I)=0.0
        FCAST(I)=0.0
5
     CONTINUE
C
     DO 10 J=1,12
```

```
AERR(J)=0.0
          MAD(J)=0.0
          MSE(J)=0.0
 10
      CONTINUE
C
      DO 15 K=1,30
          TAERR(K)=0.0
          TMAD(K)=0.0
          TMSE(K)=0.0
          ALPHA(K)=0.0
 15
      CONTINUE
      SMALL=9999.9
      LNUM=0.0
      AALPHA=0.0
С
      THIS LOOP COMPUTES THE BEST VALUE OF ALPHA BY
С
      COMPARING THE TOTAL MEAN ABSOLUTE DEVIATION (TMAD)
С
      AND THE TOTAL MEAN SQUARED DEVIATION (TMSE)
C
      ASSOCIATED WITH EACH ALPHA VALUE. THE BEST ALPHA
С
      CORRESPONDS TO THE LOWEST TMAD AND TMSE. THE 2
C
      ALPHAS ARE AVERAGED TO YIELD THE BEST ALPHA.
Č
      DO 100 L=1.30
         LNUM=L
         ALPHA(L)=LNUM/100
C
C
      THIS LOOP COMPUTES THE TMAD AND TMSE.
         J=1
         LFCAST(1)=ADEMD(1)
         DO 50 I = 1.12
             CFCAST(I) = ALPHA(L) * ADEMD(I) + (1 - ALPHA(L))
     &
                       *LFCAST(J)
             J=I+1
             LFCAST(J)=CFCAST(I)
             AERR(I) = ADEMD(I) - CFCAST(I)
             TAERR(L) = TAERR(L) + AERR(I)
             MAD(I)=ABS(AERR)
             TMAD(L) = TMAD(L) + MAD(I)
             MSE(I) = ABS(AERR(I)) **2
             TMSE(L)=TMSE(L)+MSE(I)
 50
        CONTINUE
             IF (TMAD(L).LT.SMALL) SMALL=TMAD(L)
             ALPHA1=ALPHA(L)
             IF (TMSE(L).LT.SMALL) SMALL=TMSE(L)
             ALPHA2=ALPHA(L)
 100
      CONTINUE
             AALPHA=(ALPHA1+ALPHA2)/2
C
С
      THIS LOOP COMPUTES THE SMOOTHED DEMAND (FORECASTS)
C
      USING THE BEST ALPHA.
С
```

```
ALFA=AALPHA
          J=1
          LFCAST(1)=ADEMD(1)
C
       DO 150 I = 1, 12
          FCAST1(I)=ALFA*ADEMD(I)+(1-ALFA)*LFCAST(J)
          J=I+1
          LFCAST(J)=FCAST1(I)
          AERR(I)=ADEMD(I)-CFCAST(I)
          CAERR=CAERR+AERR(I)
          MAD(I)=ABS(AERR(I))
          CMAD1=CMAD1+MAD(I)
          MSE(I) = ABS(AERR(I)) **2
          CMSE=CMSE+MSE(I)
 150
       CONTINUE
C
C
C
      THIS LOOP EXTRAPOLATES THE SMOOTHED FORECASTS.
       J = 1
       K = 12
       DO 200 I = 13,25
         FCAST1(I) = ALFA*ADEMD(J)+(1-ALFA)*LFCAST(K)
          J = J+1
         K = K-1
         LFCAST(K) = FAST1(I)
200
       CONTINUE
       RETURN
       END
C
C
C
C
       SUBROUTINE TREND (CMAD2)
C
      ****************
С
      * THIS ROUTINE CALCULATES THE FORECAST BASED ON
С
      * THE BEST COMPUTED ALPHA, DERIVED BY AVERAGING
      * THE RESULTS OF TWO DIFFERENT CRITERIA. THIS
      * ROUTINE WOULD BE SELECTED IF THE COMPONENTS
C
      * OF DEMAND EXHIBIT 'TREND'.
C
      ****************
C
C
C
     INPUT PARAMETER : NONE
     OUTPUT PARAMETER: CMAD2
C
С
     DIMENSION CFCAST(13), TAERR(30),
     &
               TMAD(30), TMSE(30), ALPHA(30), CATRD(12),
               CATA(12), LFCAST(13), MAD(12), MSE(12),
     &
     &
               AERR(12)
C
     COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
```

```
&
                       FCAST1(25), FCAST2(25), FCAST3(25)
 C
       REAL CFCAST, LFCAST, ADEMD, TAERR, TMAD,
            TMSE, SMALL, ALPHA, AALPHA, FCAST, FCAST2,
            CATRD, CATA, CAERR, CMAD2, CMSE, ALFA, MAD, MSE
 C
C
č
       INITIALISATION
C
C
       DO 1 I = 1,25
          CFCAST(I) = 0.0
          LFCAST(I) = 0.0
 1
       CONTINUE
       DO 2 J=1,12
           CATRD(J)=0.0
           CATA(J)=0.0
           MSE(J)=0.0
           AERR(J)=0.0
 2
      CONTINUE
      SMALL = 9999.9
      DO 10 L = 1,30
         TAERR(L) = 0.0
         TMAD(L) = 0.0
         TMSE(L) = 0.0
         ALPHA(L) = 0.0
 10
      CONTINUE
C
C THIS LOOP COMPUTES THE BEST VALUE OF ALPHA BY COMPARING
C THE TMSE AND TMAD ASSOCIATED WITH EACH INDIVIDUAL ALPHA.
C THE BEST ALPHA CORRESPONDS TO THE LOWEST TMSE AND TMAD.
C THE TWO ALPHAS ARE AVERAGED TO YIELD THE BEST ALPHA.
C
C
      DO 300 L = 1.30
         LNUM = L
         ALPHA(L) = LNUM/100.0
C THIS LOOP COMPUTES THE TMSE AND TMAD.
         LFCAST(1) = ADEMD(1)
         DO 50 I = 1,12
            CFCAST(I) = ALPHA(L) * ADEMD(I) +
     &
                        (1 - ALPHA(L)) * LFCAST(J)
            J = I + 1
            LFCAST(J) = CFCAST(I)
 50
         CONTINUE
C
         DO 100 I = 1,12
            CATRD(I) = CFCAST(I) - LFCAST(I)
100
         CONTINUE
```

```
PATA = 0.0
C
         DO 150 I = 1,12
            CATA(I) = ALPHA(L) * CATRD(I) +
      &
                       ((1 - ALPHA(L)) * PATA)
            PATA = CATA(I)
 150
         CONTINUE
         DO 200 I = 1,12
            K = I + 1
            FCAST(K) = CFCAST(I) + (1/ALPHA(L)) * CATA(I)
 200
         CONTINUE
         DO 250 \text{ K} = 2,12
            AERR(K) = ADEMD(K) - FCAST(K)
            TAERR(L) = TAERR(L) + AERR(K)
            MAD(K) = ABS(AERR(K))
            TMAD(L) = TMAD(L) + MAD(K)
            MSE(K) = ABS(AERR(K)) ** 2
            TMSE(L) = TMSE(L) + MSE(K)
            IF (TMAD(L) .LT. SMALL) SMALL = TMAD(L)
            ALPHA1 = ALPHA(L)
            IF (TMSE(L) \cdot .LT. SMALL) SMALL = TMSE(L)
            ALPHA2 = ALPHA(L)
 250
         CONTINUE
            AALPHA = (ALPHA1 + ALPHA2) / 2
 300
      CONTINUE
            ALFA = AALPHA
C THIS LOOP COMPUTES THE SMOOTHED DEMAND (FORECASTS)
C USING THE BEST ALPHA.
C
      J=1
      LFCAST(1)=ADEMD(1)
      DO 350 I = 1,12
         CFCAST(I) = ALFA * ADEMD(I) + (1 - ALFA) *
     &
                      LFCAST(J)
         J = I + 1
         LFCAST(J) = CFCAST(I)
 350
      CONTINUE
C
      DO 400 I = 1,12
         J = I
         CATRD(I) = CFCAST(I) - LFCAST(J)
 400
      CONTINUE
      PATA = 0.0
C
      DO 450 I = 1,12
         CATA(I) = ALFA * CATRD(I) + (1 - ALFA) * PATA
         PATA = CATA(I)
 450
      CONTINUE
C
      DO 500 I = 1,12
```

```
K = I + 1
        FCAST2(K) = CFCAST(I) + (1/ALFA) * CATA(I)
 500
     CONTINUE
C
С
     THIS LOOP EXTRAPOLATES THE SMOOTHED FORECASTS.
C
     N = 2
     DO 550 K = 14,25
        I = 13
        FCAST2(K) = CFCAST(I) + (1/ALFA + N-1) * CATA(I)
        N = N+1
 550
     CONTINUE
C
     DO 600 K = 2,12
        I = K
        AERR(I) = ADEMD(I) - FCAST(K)
        CAERR = CAERR + AERR(I)
        MAD(I) = ABS(AERR(I))
        CMAD2 = CMAD2 + MAD(I)
        MSE(I) = ABS(AERR(I) ** 2)
        CMSE = CMSE + MSE(I)
 600
     CONTINUE
C
     RETURN
     END
C
С
Č
C
     SUBROUTINE SEASON (CMAD3)
C
C
     *****************
        THIS SUBROUTINE CALCULATES THE FORECAST BASED
C
     * ON THE BEST COMPUTED ALPHA, DERIVED BY
č
       AVERAGING THE RESULTS OF TWO DIFFERENT CRITERIA.*
       THIS SUBROUTINE WOULD BE SELECTED IF THE
        COMPONENTS OF DEMAND EXHIBIT 'SEASON'.
С
     *****************
CCCC
     INPUT PARAMETER :
                         NONE
     OUTPUT PARAMETER:
                         CMAD3
С
     DIMENSION BS(12), DRATIO(12),
               SAR(12), ASAR(12), TREN(12), ERATIO(12),
    &
               CFCAST(12), AERR(12), TAERR(30), MAD(12),
    &
               TMAD(30), MSE(12), TMSE(30), ALPHA(30)
C
     COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
                    FCAST1(25), FCAST2(25), FCAST3(25)
C
```

```
C
      REAL BS, DRATIO, ADEMD, BSDMD, SAR, ASAR, TREN,
            ERATIO, CFCAST, AERR, TAERR, MAD, TMAD, MSE,
            TMSE, ALPHA, ISAR, ITREND, AALPHA, ALFA,
            FCAST, CAERR, CMAD3, CMSE, FCAST3
     &
C
C
Ċ
      INITIALIZATION
C
C
      SMALL=9999.9
      DO 5 I=1,12
        BS(I)=0.0
        DRATIO(I)=0.0
        SAR(I)=0.0
        ASAR(I)=0.0
        TREN(I)=0.0
        ERATIO(I)=0.0
        AERR(I)=0.0
        MAD(I)=0.0
        MSE(I)=0.0
 5
      CONTINUE
C
      DO 7 J=1,30
        TAERR(J)=0.0
        TMAD(J)=0.0
        TMSE(J)=0.0
 7
      CONTINUE
C
С
      THIS LOOP COMPUTES THE BEST VALUE OF ALPHA BY
C
C
      COMPARING THE TMAD AND TMSE ASSOCIATED WITH EACH
      INDIVIDUAL ALPHA. THE BEST ALPHA CORRESPONDS TO
C
      THE LOWEST TMSE AND TMAD. THE 2 ALPHAS ARE
С
      AVERAGED TO YIELD THE BEST ALPHA.
Ċ
        DO 10 I = 1, 12
          J=I+1
          K=I+2
          BS(I) = (BSDMD(I) + BSDMD(J) + BSDMD(K))/3
 10
        CONTINUE
C
        DO 20 I = 1, 12
           DRATIO(I) = ADEMD(I) / BS(I)
 20
        CONTINUE
C
      DO 150 L=1,30
          LNUM=L
          ALPHA(L)=LNUM/100.0
          ISAR=1.0
          DO 30 I=1,12
              SAR(I) = ALPHA(L) *DRATIO(I) + (1-ALPHA(L)) *ISAR
              ISAR=SAR(I)
 30
          CONTINUE
          I = 1
```

```
ASAR(I)=SAR(I)-0.0
           DO 40 I=2,12
              J=I-1
              ASAR(I) = SAR(I) - SAR(J)
 40
          CONTINUE
C
           ITREND=0.0
           DO 50 I=1,12
              TREN(I) = (ALPHA(L) * ASAR(I)) + (1-ALPHA(L)) *
     &
                       ITREND
              ITREND=TREN(I)
 50
        CONTINUE
C
        DO 60 I = 1, 12
            ERATIO(I) = SAR(I) + ((1-ALPHA(L))/ALPHA(L))*
     &
                       TREN(I)
 60
         CONTINUE
C
        DO 70 I = 1, 12
           K=I+1
           FCAST(K) = (ERATIO(I) + TREN(I)) *BS(K)
70
        CONTINUE
C
        DO 100 I = 2, 12
           AERR(I)=ADEMD(I)-FCAST(I)
           TAERR(L)=TAERR(L)+AERR(I)
           MAD(I)=ABS(AERR(I))
           TMAD(L) = TMAD(L) + MAD(I)
           MSE(I) = ABS(AERR(I)) **2
           TMSE(L) = TMSE(L) + MSE(I)
           IF (TMAD(L).LT.SMALL) SMALL=TMAD(L)
           ALPHA1=ALPHA(L)
           IF (TMSE(L).LT.SMALL) SMALL=TMSE(L)
           ALPHA2=ALPHA(L)
 100
         CONTINUE
           AALPHA=(ALPHA1+ALPHA2)/2
 150
      CONTINUE
           ALFA=AALPHA
C
C
č
      THIS LOOP COMPUTES THE SMOOTHED DEMAND (FORECASTS)
С
      USING THE BEST ALPHA.
C
      DO 160 I = 1, 12
         J=I+1
         K=I+2
         BS(I) = (BSDMD(I) + BSDMD(J) + BSDMD(K))/3
 160
      CONTINUE
C
      DO 170 I=1,12
        DRATIO(I) = ADEMD(I) / BS(I)
 170
      CONTINUE
         ISAR=1.0
```

```
DO 180 I = 1, 12
         SAR(I)=ALFA*DRATIO(I)+(1-ALFA)*ISAR
         ISAR=SAR(I)
 180
      CONTINUE
C
      DO 190 I=1,12
        IF (I.EQ.1) ASAR(I)=SAR(I)-0.0
        J=I-1
        ASAR(I)=SAR(I)-SAR(J)
 190
      CONTINUE
C
        ITREND=0.0
      DO 200 I = 1, 12
        TREN(I)=ALFA*ASAR(I)+(1-ALFA)*ITREND
        ITREND=TREN(I)
 200
      CONTINUE
C
      DO 210 I=1.12
        ERATIO(I)=SAR(I)+((1-ALFA)/ALFA)*TREN(I)
 210
      CONTINUE
      DO 220 I=1,12
        K = I + 1
        FCAST3(K) = (ERATIO(I) + TREN(I)) *BS(K)
        AERR(I)=ADEMD(I)-FCAST(I)
        CAERR=CAERR+AERR(I)
        MAD(I)=ABS(AERR(I))
        CMAD3=CMAD3+MAD(I)
        MSE(I) = ABS(AERR(I)) **2
        CMSE=CMSE+MSE(I)
 220
      CONTINUE
C
С
      THIS LOOP EXTRAPOLATES THE SMOOTHED FORECASTS.
C
      DO 230 I = 13,24
        K = I + 1
        N=2
        FCAST3(K) = (SAR(12) + ((1/ALFA) + N - 1) *TREN(12)) *BS(12)
 230
      CONTINUE
C
C
      RETURN
      END
C
C
C
C
      SUBROUTINE REPORT (ITYPE, DATE, FITEM, PERIOD, MORY)
C
C
      ****************
C
         THIS ROUTINE OUTPUTS THE REPORT ACCORDINGLY.
С
      ****************
C
```

```
C
C
C
      INPUT PARAMETER : ITYPE, DATE, FITEM, PERIOD, MORY
C
      OUTPUT PARAMETER: NONE
C
C
C
C
      ITYPE - TYPE OF REPORT
C
      COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
                      FCAST1(25), FCAST2(25), FCAST3(25)
C
      REAL ADEMD, FCAST, BSDMD, FCAST1, FCAST2, FCAST3
C
      CHARACTER*8 DATE
      CHARACTER*40 FITEM, PERIOD
C
C TRANSFER FORECASTED DATA TO FCAST ARRAY FOR
C REPORT PRINTING AND GRAPH PLOTTING BY ROUTINE PLOT.
       GOTO (1,2,3) ITYPE
C
       DO 175 IBACK = 1,25
 1
          FCAST(IBACK) = FCAST1(IBACK)
 175
      CONTINUE
      GOTO 555
C
      DO 275 IBACK = 1,25
         FCAST(IBACK) = FCAST2(IBACK)
 275
      CONTINUE
      GCTO 555
C
 3
      DO 375 IBACK = 1,25
         FCAST9IBACK) = FCAST3(IBACK)
 375
      CONTINUE
C PRINT REPORT HEADING
C
 555
     WRITE(6,105) DATE
     FORMAT('0','ARGO ENGINEERING LIMITED', 18X,
     &'DATE : ', A8, /, '0', /, '0')
C
      IF (MORY .EQ. 1) THEN
         WRITE(6,10)
 10
         FORMAT('0',8X,'****** SHORT TERM FORECAST',
         'REPORT ******')
         WRITE(6,12) FITEM, PERIOD
         FORMAT('0','ITEM - ',A40,/,
'PERIOD - ',A40)
 12
         WRITE(6,13)
         FORMAT('0',70('-'),/,
 13
         ' ','MONTH NO.',11X,'ACTUAL',18X,'FORECAST',/,
         ' ',20x,'(UNITS)',17x,'(UNITS)'/,' ',70('-'))
      ELSE
```

```
WRITE(6,11)
 11
          FORMAT('0',8X'****** LONG TERM FORECAST',
          'REPORT ******')
          WRITE(6,14) FITEM, PERIOD
          FORMAT('0','ITEM - ',A40,'PERIOD - ',A40)
 14
          WRITE(6, 15)
          FORMAT('0',70('-'),/,
'','PERIOD NO.',10X,'ACTUAL',18X,'FORECAST',/,
'',20X,'(UNITS)',17X,'(UNITS)',/,'',70('-'))
 15
      ENDIF
C
C PRINT FCAST DATA FOR FORECASTING REPORT
      DO 20 J = 1,12
          WRITE(6,21) J,ADEMD(J),FCAST(J)
 21
          FORMAT(' ',I2,15X,F10.2,15X,F10.2)
 20
      CONTINUE
C
      DO 30 J = 13,24
          IF (FCAST(J) .EQ. 0.0) GOTO 99
         WRITE(6,31) J,FCAST(J)
FORMAT(' ',12,25X,15X,F10.2)
 31
 30
      CONTINUE
C
C
 99
      RETURN
      END
C
C
C
C
      SUBROUTINE PLOT
С
C
      ******************
C
      * THIS ROUTINE PLOTS THE EXPONENTIAL WEIGHTED
C
      * MOVING AVERAGE GRAPH ON THE LINE PRINTER.
C
      *********************************
С
C
      COMMON /DATA1/ ADEMD(12), FCAST(25), BSDMD(14),
                      FCAST1(25), FCAST2(25), FCAST3(25)
C
      REAL ADEMD, FCAST, BSDMD, FCAST1, FCAST2, FCAST3
C
      CHARACTER*1 CHAR(60), JBLANK, JPLUS, JSTAR, JEQUAL
C
C INITIALISE PRINT CONSTANTS
      JBLANK = ''
      JSTAR = 'A'
      JPLUS = '+'
      JEOUAL = 'F'
C INITIALISE PRINT LINE WITH BLANKS
```

```
C
     DO 400 I = 1,60
 400
        CHAR(I) = JBLANK
C GET THE SMALLEST AND BIGGEST VALUE OF ACTUAL AND
C FORECASTED DATA.
      ASMALL = 999999.9
      FSMALL = 999999.9
      ABIG = 0.0
      FBIG = 0.0
C
      DO 10 I = 1, 12
         IF (ADEMD(I) .LT. ASMALL) ASMALL = ADEMD(I)
         IF (ADEMD(I) .GT. ABIG) ABIG = ADEMD(I)
      CONTINUE
10
      DO 20 I = 1,25
         IF (FCAST(I) .LT. FSMALL) FSMALL = FCAST(I)
         IF (FCAST(I) .GT. FBIG) FBIG = FCAST(I)
20
      CONTINUE
C
      SMALL = FSMALL
      BIG = FBIG
      IF (ASMALL .LT. FSMALL) SMALL = ASMALL
      IF (ABIG .GT. FBIG) BIG = ABIG
C
C FIND THE VALUE FOR THE X-AXIS DIVISIONS
      RANGE = (BIG - SMALL) + 1.0
      IDIV = (RANGE/10.0) + 0.5
C PRINT GRAPH HEADING
     WRITE (6,601)
     FORMAT ('1', 10X,/,
     &' EXPONENTIAL WEIGHTED MOVING AVERAGE GRAPH',/,10X,
     &' -----',/,10X
     &' ACTUAL DATA (AAAA)
                                FORECAST DATA (FFFF)')
C
C
      ID1 = SMALL
      ID2 = SMALL + IDIV
      ID3 = SMALL + IDIV * 2
      ID4 = SMALL + IDIV * 3
      ID5 = SMALL + IDIV * 4
      ID6 = SMALL + IDIV * 5
      ID7 = SMALL + IDIV * 6
      ID8 = SMALL + IDIV * 7
      ID9 = SMALL + IDIV * 8
      ID10 = SMALL + IDIV * 9
C
```

```
WRITE (6,602) ID1 , ID2, ID3, ID4,
     *ID5, ID6, ID7, ID8, ID9, ID10
 602
     FORMAT (1X, 5X, 10(15))
      WRITE (6,603)
                        +', 9('---+'))
 603
      FORMAT (1X, '
       MIN = 1.0
      MAX = 50.0
      DIFFMM = ((MAX - MIN)/(BIG - SMALL))
C
      DO 500 J = 1,12
         DO 22 I=1,60
            CHAR(I)=JBLANK
 22
         CONTINUE
         IAVAL = (DIFFMM * (ADEMD(J) - SMALL)) + 1.0
         IFVAL = (DIFFMM * (FCAST(J) - SMALL)) + 1.0
         CHAR(IAVAL) = JSTAR
         CHAR(IFVAL) = JEQUAL
         IF (MOD(J,5)) 100,501,100
             DO 530 K = 5,50,5
 501
                CHAR(K) = JPLUS
 530
 100
             WRITE(6,604) J, CHAR
 604
             FORMAT(1X, I5, 60A1)
 500
     CONTINUE
C
     DO 550 JCOUNT = 1,12
         J = JCOUNT + 12
         DO 23 I = 1,60
            CHAR(I) = JBLANK
 23
         CONTINUE
         IFVAL = (DIFFMM * (FCAST(J) - SMALL)) + 1.0
         CHAR(IFVAL) = JEQUAL
         IF (MOD(J,5)) 201,502,201
             DO 531 K = 5,50,5
 502
                CHAR(K) = JPLUS
 531
             WRITE(6,605) J, CHAR
 201
             FORMAT(1X, I5, 60A1)
 605
 550
      CONTINUE
C
С
      RETURN
      END
```

```
$TITLE: 'MSc. THESIS PROGRAM - 2'
$SUBTITLE: 'MASTER PRODUCTION SCHEDULE MODEL'
      PROGRAM MPSM
C
С
      ******************
C
      * THIS IS THE MAIN PROGRAM OF THE MPS MODEL.
С
      * THIS PROGRAM PRODUCES THREE TYPES OF REPORTS. *
С
      ***************
C
      COMMON /DAT/ GROSSF(20), BKINGS(20), NETF(20),
                   NETREQ(20), BKLOG(20), GROSSR(20),
                   SOHAND(20), MPS(20), AWEEK(20), EQQ, ROL
     &
C
      CHARACTER*1 PARTNO(10), DESCRP(40), MORB, CLASS, DATES*8
C
      INTEGER LTCODE, MLT, JLSIZE, PLT, ORDQTY, MINQTY, MAXQTY,
              SHRINK, HORZON, NWEEK
      INTEGER GROSSF, BKINGS, NETF, NETREQ, BKLOG, GROSSR,
              SOHAND, MPS, AWEEK, EQQ, ROL
C OPEN OUTPUT FILE
      OPEN (6,FILE='PRN')
C REQUEST USER TO INPUT DATA FOR END ITEM FILE REPORT
      WRITE(*,388)
      FORMAT(' ',38('*'),/,
 388
     &' ','* MASTER PRODUCTION SCHEDULE MODEL *',/,
     &' ',38('*'),/,' ')
C
      WRITE(*,399)
      FORMAT(' ', 'ENTER TODAY"S DATE (MM/DD/YY):')
 399
      READ(*,499) DATE
      FORMAT(BN, A8)
 499
C
      WRITE(*,501)
      FORMAT(' ', 'ENTER PART NUMBER',
 501
          ' (10 ALPHANUMERIC VALUE):')
      READ(*,502) (PARTNO(I), I=1,10)
 502
      FORMAT(10A1)
C
      WRITE(*,503)
      FORMAT(' ', 'ENTER DESCRIPTION'
 503
     4 (40 ALPHANUMERIC VALUE):')
      READ(*,504) (DESCRP(I), I=1,40)
      FORMAT (40A1)
 504
      WRITE(*,505)
      FORMAT(' ','ENTER MAKE/BUY (M/B):')
 505
      READ(*,506) MORB
      FORMAT(A1)
 506
C
      WRITE(*,507)
```

```
FORMAT(' ', 'ENTER CLASSIFICATION (A/B/C):')
 507
      READ(*,508) CLASS
 508
      FORMAT(A1)
C
      WRITE(*,509)
      FORMAT(' ','ENTER LEAD TIME CODE (1 DIGIT):')
 509
      READ(*,510) LTCODE
 510
      FORMAT(I1)
      WRITE(*,511)
 511
      FORMAT(' ', 'ENTER MANUFACTURING LEAD TIME (1 DIGIT):')
      READ(*,512) MLT
 512
      FORMAT(I3)
C
      WRITE(*,513)
      FORMAT(' ', 'ENTER JOB LOT SIZE (4 DIGITS):')
 513
      READ(*,514) JLSIZE
      FORMAT(I4)
 514
C
     WRITE(*,515)
FORMAT(' ','ENTER PURCHASE LEAD TIME (3 DIGITS):')
 515
      READ(*,516) PLT
 516
      FORMAT(I3)
C
      WRITE(*,517)
 517 FORMAT(' ','ENTER PURCHASE ORDER QUANTITY',
     &'(5 DIGITS):')
      READ(*,518) ORDQTY
 518
     FORMAT(I5)
     WRITE(*,519)
     FORMAT(' ', 'ENTER MINIMUM QUANTITY',
     &'(5 DIGITS):')
      READ(*,520) MINQTY
 520
     FORMAT(I5)
      WRITE(*,521)
      FORMAT(' ', 'ENTER MAXIMUM QUANTITY',
 521
     &'(5 DIGITS):')
      READ(*,522) MAXQTY
      FORMAT(I5)
 522
      WRITE(*,523)
      FORMAT(' ', 'ENTER SCRAP (4 DIGITS):')
 523
      READ(*,524) SHRINK
      FORMAT(I4)
 524
C
      WRITE(*,525)
FORMAT(' ','ENTER HORIZON (3 DIGITS):')
 525
      READ(*,526) HORIZON
      FORMAT(I3)
 526
C
C ********* END OF 1ST DATA INPUT ************
```

```
WRITE(*,333)
 333
       FORMAT(' ','**** PRINTING .....')
C
C PRINT END ITEM FILE REPORT
       WRITE(6,301) DATE
       FORMAT('1', 'ARGO ENGINEERING LIMITED', 35%,
     &'DATE :',A8,/,'0',/,'0')
WRITE(6,401)
     FORMAT(' ',20X,'***** END ITEM FILE REPORT', &' *****',/,'0',/,'')
      WRITE(6,402) (PARTNO(I), I=1,10)
FORMAT('', 'PART NUMBER', 26X, '-', 10A1)
      WRITE(6,403) (DESCRP(I), I=1,40)
      FORMAT(' ', 'DESCRIPTION', 26X, '-', 40A1)
 403
      WRITE(6,404) MORB
      FORMAT(' ','MAKE/BUY (M/B)',23X,'-',A1)
      WRITE(6,405) CLASS
      FORMAT(' ','CLASSIFICATION (A/B/C)',15X,'-',A1)
 405
      WRITE(6,406) LTCODE
 406
      FORMAT(' ','LEAD TIME CODE (1/2/3)',15X,' - ',I1)
      WRITE(6,677) MLT
      FORMAT(' ', 'MANUFACTURING LEAD TIME (DAYS)', 7X,
 677
     &' - ',I5)
      WRITE(6,407) JLSIZE
      FORMAT(' ','JOB LOT SIZE (UNITS)',17X,' - ',15)
 407
      WRITE(6,408) PLT
      FORMAT(' ', 'PURCHASE LEAD TIME (DAYS)', 12X, ' - ', 15)
 408
      WRITE(6,409) ORDOTY
     FORMAT(' ', 'PURCHASE ORDER QUANTITY (UNITS)', 6X,
 409
     &' - ',I5)
      WRITE(6,410) MINOTY
      FORMAT(' ', 'MINIMUM QUANTITY (UNITS)', 13X,' - ', 15)
 410
      WRITE(6,411) MAXQTY
      FORMAT('', 'MAXIMUM QUANTITY (UNITS)', 13X,' - ',15)
WRITE(6,412) SHRINK
 411
     FORMAT(' ', 'SCRAP (%)', 28X, '-', I4)
 412
C CALL SUBROUTINE INIT, MPSR, MPSRL
      CALL INIT
      CALL MPSR (NWEEK, IPW)
      CALL MPSRL (NWEEK, SHRINK, IPW)
C
      END
С
С
С
С
      SUBROUTINE MPSR (NWEEK.IPW)
С
C
      ***********
С
      * THIS IS A SUBROUTINE OF MPSM.
С
      * THIS ROUTINE PRODUCES THE MASTER *
```

```
C
       * PRODUCTION SCHEDULE REPORT.
С
       ***********
С
С
      INPUT PARAMETER : NWEEK, IPW
С
      OUTPUT PARAMTER : NONE
С
C
      COMMON /DAT/ GROSSF(20), BKINGS(20), NETF(20),
     &
                     NETREQ(20), BKLOG(20), GROSSR(20)
     &
                     SOHAND(20), MPS(20), AWEEK(20), EQQ, ROL
C
      INTEGER GROSSF, BKINGS, NETF, NETREQ, BKLOG, GROSSR,
               SOHAND, MPS, AWEEK, EOO, ROL
C
      CHARACTER*1 CHAR
C REQUEST USER TO INPUT DATA FOR MASTER PRODUCTION
C SCHEDULE REPORT.
      WRITE(*,1)
      FORMAT('0', '**** ENTER DATA FOR MASTER
     &' PRODUCTION SCHEDULE REPORT ****')
      WRITE(*,341)
      FORMAT('0','ENTER LONG/SHORT TERM',/,
     &' ','PRESS 1 FOR LONG TERM',/,
&' ','PRESS 2 FOR SHORT TERM')
      READ(*,341) LS
 341
      FORMAT(I1)
C
      WRITE(*,330)
     FORMAT(' ','ENTER PERIOD/WEEK'/, &' ','PRESS 1 FOR PERIOD',/,
     &' ', 'PRESS 2 FOR WEEK')
      READ(*340) IPW
 340
     FORMAT(I1)
C PRINT HORIZON IN END ITEM REPORT
      IF (IPW .EQ. 1) THEN
          WRITE(6,413) HORZON
          FORMAT(' ','HORIZON (PERIODS)',10X,' - ',15)
 413
      ELSE
          WRITE(6,414) HORZON
          FORMAT(' ','HORIZON (MONTHS)',11X,' - ',15)
 414
      ENDIF
C
C
      WRITE(*,2)
      FORMAT(' ', 'ENTER NUMBER OF WEEKS/PERIOD DESIRED',
 2
     &'(2 DIGITS) :')
      READ(*,3) IWEEK
 3
      FORMAT(I2)
      WRITE(*,4)
```

```
FORMAT(' ', 'ENTER BEGINNING WEEK NO. / PERIOD NO.',
     &'(2 DIGITS):')
      READ(*,5) AWEEK(1)
 5
      FORMAT(I2)
C
      WRITE(*,10)
FORMAT(' ','ENTER ECONOMIC ORDER QUANTITY',
 10
     &'(4 DIGITS):')
      READ(*, 11) EOQ
 11
      FORMAT(I4)
C
      WRITE(*, 12)
      FORMAT(' ', 'ENTER REORDER LEVEL (4 DIGITS):')
 12
      READ(*,13) ROL
 13
      FORMAT(I4)
C
      WRITE(*,90)
      FORMAT(' ', 'ENTER BACKLOG AND STOCK ON HAND',
 90
     &' FOR THE 1ST WEEK',
     &'(2 DIGITS FOLLOWED BY 2 DIGITS):')
      READ(*, 102) BKLOG(1), CHAR, SOHAND(1)
 102
     FORMAT(I2, A1, I2)
      WRITE(*, 103)
 103 FORMAT(' ', 'ENTER GROSS FORECAST AND BOOKINGS',
     &' FOR THOSE WEEKS/PERIODS DESIRED',
     &'(5 DIGITS FOLLOWED BY 5 DIGITS):')
C
      DO 105 J = 1, IWEEK
         READ(*, 106) GROSSF(J), CHAR, BKINGS(J)
 106
         FORMAT(I5, A1, I5)
 105
      CONTINUE
      WRITE(*,88)
      FORMAT(' ','**** PRINTING.....')
C CALL SUBROUTINE SRPORT
      CALL SRPORT (IWEEK)
C
      IF (LS .EQ. 1) THEN
         WRITE(6,600)
         FORMAT('0',/,'0',/,' ',10X,'**** LONG TERM'
 600
     &' MASTER PRODUCTION SCHEDULE REPORT ****',/,'0')
      ELSE
         WRITE(6,602)
         FORMAT('0',/,'0',/,' ',10X,'**** SHORT TERM'
     &' MASTER PRODUCTION SCHEDULE REPORT ****',/,'0')
     ENDIF
C
      N = 0
C
      WRITE(6,501)
 501 FORMAT(' ',80('-'))
```

```
C
      IF (IPW .EQ. 1) THEN
          WRITE(6,410) EOQ
 410
          FORMAT('0', 'EOQ = ', I4, 10X, 5('PERIOD NO. '))
      ELSE
          WRITE(6,601) EQQ
          FORMAT('0', EOQ = ', I4, 10X, 5(' WEEK NO. '))
 601
      ENDIF
C
      WRITE(6,580) ROL, (AWEEK(I), I=1,5)
      FORMAT('', 'ROL = ', 14, 13X, 4(14, 8X), 14)
 508
      WRITE(6,502)
      FORMAT(' ',80('-'))
 502
C
      WRITE(6,603) (GROSSF(I), I=1,5)
FORMAT('', 'GROSS FORECAST',6X,5(17,5X))
 603
      WRITE(6,604) (BKINGS(I), I=1,5)
      FORMAT(' ','BOOKINGS', 12X, 5(17, 5X))
 604
      WRITE(6,605) (NETF(I), I=1,5)
      FORMAT(' ','NET FORECAST',8x,5(17,5x))
 605
      WRITE(6,606) (BKLOG(I), I=1,5)
      FORMAT(' ','BACKLOG',13X,5(17,5X))
 606
      WRITE(6,300) (NETREQ(I), I=1,5)
      FORMAT(' ','NET REQUIREMENTS',4X,5(17,5X))
 300
      WRITE(6,607) (GROSSR(I), I=1,5)
      FORMAT(' ','GROSS REQUIREMENTS',2X,5(17,5X))
 607
      WRITE(6,608) (SOHAND(I), I=1,5)
      FORMAT(' ','STOCK ON HAND',7X,5(17,5X))
 608
      WRITE(6,609) (MPS(I), I=1,5)
      FORMAT(' ','MPS',17X,5(I7,5X))
 609
      NUMWK = IWEEK
      M = 4 + AWEEK(I)
      N = 5
C
 400
      NUMWK = NUMWK - 5
      IF (NUMWK .GT. 0) THEN
         M = M + 1
         N = N + 1
         IF (IPW .EQ. 1) THEN
             WRITE(6,420) EOQ
             FORMAT('0',80('-'),/,' ','EOQ = ',14,10X,
.5('PERIOD NO. '))
 420
     &
         ELSE
             WRITE(6,610) EOO
             FORMAT('0',80('-'),/,' ',EOQ = ',14,10X, 5(' WEEK NO. '))
 610
     &
         ENDIF
C
         DO 611 I = N,N+4
             WRITE(6,612) ROL,M,M+1,M+2,M+3,M+4
             FORMAT(' ', 'ROL = ', 14, 13X, 4(14, 8X), 14)
 612
             WRITE(6,550)
 550
             FORMAT(' ',80('-'))
```

```
WRITE(6,613) (GROSSF(I), I=N,N+4)
  613
             FORMAT(' ', 'GROSS FORECAST', 6X, 5(17, 5X))
             WRITE(6,614) (BKINGS(I),I=N,N+4)
             FORMAT(' ','BOOKINGS',12X,5(17,5X))
  614
             WRITE (6,615) (NETF (I), I=1, N, N+4)
             FORMAT(' ','NET FORECAST',8X,5(17,5X))
  615
             WRITE(6,616) (BKLOG(I), I=N,N+4)
             FORMAT(' ', 'BACKLOG', 13X, 5(17, 5X))
  616
             WRITE(6,310) (NETREQ(I), I=N,N+4
             FORMAT(' ','NET REQUIREMENTS',4X,5(17,5X))
  310
             WRITE(6,617) (GROSSR(I), I=N,N+4)
            FORMAT(' ', 'GROSS REQUIREMENTS', 2X, 5(17, 5X))
  617
             WRITE(6,618) (SOHAND(I), I=N,N+4)
            FORMAT(' ', 'STOCK ON HAND', 7x, 5(17, 5x))
 618
             WRITE(6,619) (MPS(I), I=N,N+4)
 619
             FORMAT(' ','MPS',17X,5(17.5X))
C
 611
         CONTINUE
       M = M + 4
       N = N + 4
       GOTO 400
       ENDIF
C
       RETURN
       END
C
C
C
C
      SUBROUTINE MPSRL(IWK, ISHRNK, IPW)
C
C
      ****************
C
      * THIS IS A SUBROUTINE OF MPSM.
C
      * THIS ROUTINE PRODUCES THE RECEIPT LIST REPORT.*
C
      ****************
С
C
С
      INPUT PARAMETER
                       : IWK, ISHRNK, IPW
C
      OUTPUT PARAMETER : NONE
С
      COMMON /DAT/ GROSSF(20), BKINGS(20), NETF(20),
     &
                   NETREQ(20), BKLOG(20), GROSSR(20),
     &
                   SOHAND(20), MPS(20), AWEEK(20), EOQ, ROL
C
      INTEGER IWK, SHRNK, IPW
      INTEGER GROSSF, BKINGS, NETF, NETREQ, BKLOG, GROSSR,
              SOHAND, MPS, AWEEK, EOQ, ROL
C
      REAL SCRAP
С
C PRINT RECEIPT LIST REPORT HEADING
      WRITE(6,10)
```

```
FORMAT('0',/,'0',/,'0',20X,'**** RECEIPT LIST',
  10
      &' REPORT ****',/,'0')
       WRITE(6,11)
  11
       FORMAT(' ',20x,31('-'))
 C
       IF (IPQ .EQ. 1) THEN
            WRITE(6,222)
FORMAT(' ',20X,'PERIOD NO',3X,'QUANTITY',5X,
'SCRAP',/,' ',33X,'(UNITS)',5X,'(UNITS)',/,
21X,31('-'))
  222
       ELSE
            WRITE(6,12)
            FORMAT(' ',20X,'WEEK NO',5X,'QUANTITY',5X,'SCRAP',/,33X,'(UNITS)',5X,'(UNITS)',/,
  12
            21X,31('-'))
       ENDIF
C CALCULATE SCRAP VALUE
C
       DO 100 I = 1,IWK
          IF (MPS(I) .NE. 0) THEN
               SCRAP = (ISHRNK/100.0) * MPS(I)
               WRITE(6,601) AWEEK(I), MPS(I), SCRAP
 601
               FORMAT(' ',20X,16,4X,16,3X,F10.2)
          ENDIF
 100
       CONTINUE
C
       RETURN
       END
C
С
С
С
       SUBROUTINE SRPORT (IWEEK)
C
       ***************
С
       * THIS IS A SUBROUTINE OF MPSM.
С
      * THIS ROUTINE DOES THE NECESSARY CALCULATIONS *
C
       * FOR PRODUCING THE MASTER PRODUCTION SCHEDULE
C
       * REPORT.
С
       ****************
Ċ
Ċ
C
      INPUT PARAMETER : IWEEK
Č
     OUTPUT PARAMETER : NONE
C
C
      COMMON /DAT/ GROSSF(20), BKINGS(20), NETF(20),
     &
                     NETREQ(20), BKLOG(20), GROSSR(20),
                     SOHAND(20), MPS(20), AWEEK(20), EOQ, ROL
C
      INTEGER GROSSF, BKINGS, NETF, NETREQ, BKLOG, GROSSR,
               SOHAND, MPS, AWEEK, EQQ, ROL
C
```

```
C CALCULATIONS FOR MASTER PRODUCTION SCHEDULE REPORT.
C
      DO 200 K = 1, IWEEK
         NETF(K) = GROSS(K) - BKINGS(K)
         IF (GROSSF(K) .GE. BKINGS(K)) THEN
             NETREQ(K) = GROSSF(K)
         ELSE
             NETREQ(K) = BKINGS(K)
         ENDIF
C
         IF (K .EQ. 1) THEN
            AWEEK(K) = AWEEK(1)
            BKLOG(K) = BKLOG(1)
            SOHAND(K) = SOHAND(1)
            GROSSR(K) = NETREQ(1) + BKLOG(1)
         ELSE
            AWEEK(K) = AWEEK(1)+(K-1)
            BKLOG(K) = 0
            GROSSR(K) = NETREQ(K)
            SOHAND(K) = SOHAND(K)
         ENDIF
С
         SOHAND(K+1) = SOHAND(K) - GROSSR(K)
        . IF (SOHAND(K+1) .GE. ROL) THEN
            MPS(K) = 0
         ELSE
            IF (SOHAND(K+1) .LT. ROL) THEN
               EOQ = 0 - EOQ
               IF (SOHAND(K+1) .GE. EOQ) THEN
                  MPS(K) = IABS(EOQ)
               ELSE
                  IF (SOHAND(K+1) .LT. EOQ) THEN
                     DO 210 M = 1,100
                         IF (SOHAND(K+1) .GE. EOQ*(M+1))
      &
                         THEN
                             MPS(K) = IABS(EOQ*(M+1))
                             GOTO 220
                         ENDIF
 210
                      CONTINUE
                  ENDIF
               ENDIF
 220
               SOHAND(K+1) = SOHAND(K) + MPS(K) - GROSSR(K)
            ENDIF
         ENDIF
         EOQ = IABS(EOQ)
 200
      CONTINUE
С
      RETURN
      END
C
C
C
C
       SUBROUTINE INIT
```

```
С
CCCC
     *************
     * THIS ROUTINE INITIALISES DATA FOR THE
                                               *
                                               *
     * MPSM.
     ************
C
     COMMON /DAT/ GROSSF(20), BKINGS(20), NETF(20),
    &
                  NETREQ(20), BKLOG(20), GROSSR(20),
                  SOHAND(20), MPS(20), AWEEK(20), EQQ, ROL
    &
C
     INTEGER GROSSF, BKINGS, NETF, NETREQ, BKLOG, GROSSR,
             SOHAND, MPS, AWEEK, EQQ, ROL
C INITIALISATION
     DO 100 I = 1,20
        GROSSF(I) = 0
        BKINGS(I) = 0
        NETF(I) = 0
        NETREQ(I) = 0
        BKLOG(I) = 0
        SOHAND(I) = 0
        MPS(I) = 0
        AWEEK(I) = 0
     CONTINUE
 100
C
     RETURN
     END
```

```
$TITLE:'MSc. THESIS PROGRAM - 3'
$SUBTITLE: RESOURCE REQUIREMENTS PLANNING MODEL'
      PROGRAM RRPM
C
      **************
С
      * THIS IS THE MAIN PROGRAM OF THE
C
      * RESOURCE REQUIREMENTS PLANNING MODEL.
C
      **************
С
      COMMON /INP/ NYRS, IYEAR
C
      COMMON /PQTY1/ PRODCD(100)
      COMMON /PQTY2/ PRODQT(100,10), NOPROD
C
      COMMON /CA1/ DEPTCD(600), MORD(600)
      COMMON /CA2/ NDEPT, MCAP(600)
C
      COMMON /CREQ1/ PCODE(100), DCODE(100,600)
      COMMON /CREQ2/ STDHR(100,600)
C
      INTEGER PRODQT, STDHR
C
     CHARACTER*1 PRODCD*10, PCODE*10, DEPTCD*4, DCODE*4,
                 MORD(600), DATE*8
C
C OPEN OUTPUT FILE
      OPEN (6,FILE='PRN')
C REQUEST USER TO INPUT DATA
     WRITE(*,888)
    FORMAT(' ',42('*'),/,
     &' ','* RESOURCE REQUIREMENTS PLANNING MODEL *', &/,' ',42('*'),/,' ')
C
      WRITE(*,1)
      FORMAT(' ', 'ENTER TODAY"S DATE (MM/DD/YY):')
      READ(*,2) DATE
 2
     FORMAT(BN, A8)
     WRITE(*,10)
FORMAT(' ','ENTER NUMBER OF YEARS TO BE',
     &' PROCESSED (2 DIGITS):')
      READ(*,11) NYRS
      FORMAT(BN, I2)
      WRITE(*,13) IYEAR
     FORMAT (BN, I4)
13
C
     N = NYRS*2
C OPEN INPUT FILES
      OPEN (1,FILE='PQTYFL')
```

```
OPEN (2,FILE='CAVAILFL')
      OPEN (3,FILE='CREQFL')
C
C READ INPUT FILES AND STORE INFORMATION IN
C COMMON BLOCK AREA; /PQTY/, /CA/ AND /CREQ/
C RESPECTIVELY.
C READ FILE POTYFL
      READ(1,14) NOPROD
      FORMAT(I4)
 14
C
      DO 100 I = 1, NOPROD
         READ(1,15) PRODCD(I)
         FORMAT(A10)
         READ(1,16) (PRODQT(I,K),K=1,N)
 16
         FORMAT(15,916)
 100
      CONTINUE
C READ FILE CAVAILFL
      READ(2,20) NDEPT
 20
      FORMAT(I4)
      DO 200 I = 1,NDEPT
         READ(2,21) DEPTCD(I),MCAP(I),MORD(I)
 21
         FORMAT(A4, 17, A2)
 200
      CONTINUE
C READ FILE CREQFL
      DO 300 I = 1,NOPROD
         READ(3,30) PCODE(I)
         FORMAT(A10)
 30
         DO 350 J = 1,NDEPT
            READ(3,31) DCODE(I,J),STDHR(I,J)
 31
            FORMAT(A5, I5)
 350
         CONTINUE
 300
     CONTINUE
C CALL SUBROUTINES RRPCAL, RRPR1 & RRPSR1
      CALL RRPCAL
      CALL RRPR1 (DATE, INEG)
      IF (INEG .GT. 0) THEN
         CALL RRPSR1
      ENDIF
C
      END
C
C
Č
С
      SUBROUTINE RRPCAL
C
```

```
C
      *****************
C
      * THIS ROUTINE DOES THE NECCESSARY CALCULATIONS
C
      * FOR PRODUCING THE LONG TERM WORK CENTER
                                                       *
С
      * LOAD REPORT.
                                                       *
C
      *******************
C
C
C
      INPUT PARAMETER
                       : NONE
C
      OUTPUT PARAMTER
                       : NONE
C
C
C
      COMMON /INP/ NYRS, IYEAR
C
      COMMON /PQTY1/ PRODCD(100)
      COMMON /PQTY2/ PRODQT(100,10), NOPROD
C
      COMMON /CA2/ NDEPT, MCAP(600)
C
      COMMON /CREQ2/ STDHR(100,600)
C
      COMMON /CNEED1/ CPNEED(600), CPAVAL(600),
                      HRAVAL(4000), TOTCAP(600, 10)
C
      INTEGER PRODQT, STDHR, CPNEED, CPAVAL, HRAVAL, TOTCAP
C
      CHARACTER*1 PRODCD*10
C INITIALISATION
      DO 10 I = 1,20
        DO 20 J = 1.10
            TOTCAP(I,J) = 0
 20
         CONTINUE
 10
      CONTINUE
C COMPUTATION FOR TOTAL CAPACITY
     MAX = 2*NYRS
     DO 100 I = 1, MAX
        DO 150 K = 1,NOPROD
           DO 200 J = 1.NDEPT
C
C
              CHECK STDHR OF RIGHT PRODUCT CODE
C
              DO 201 L = 1, NOPROD
                 IF (PRODCD(K) .EQ. PCODE(L)) THEN
                    GOTO 202
                 ENDIF
 201
              CONTINUE
 202
              CPNEED(J) = PRODQT(K,I)*STDHR(K,J)
 200
           CONTINUE
           DO 220 N = 1, NDEPT
              TOPTCAP(N,I) = TOTCAP(N,I) + CPNEED(N)
```

```
220
            CONTINUE
  150
         CONTINUE
C
  100
      CONTINUE
C
C
  COMPUTATION FOR MACHINE HOURS AVAILABLE
C
      DO 310 J = 1, NDEPT
         CPAVAL(J) = MCAP(J)*130
 310
      CONTINUE
C
      JSUB = 1
      IHALF = 1
      DO 400 I = 1, NYRS
         DO 410 J = 1,NDEPT
            HRAVAL(JSUB) = CPAVAL(J) - TOTCAP(J, IHALF)
            HRAVAL(JSUB+1) = CPAVAL(J)-TOTCAP(J,IHALF+1)
            JSUB = JSUB + 2
 410
         CONTINUE
      IHALF = IHALF + 2
 400
      CONTINUE
C
      RETURN
      END
C
C
C
C
      SUBROUTINE RRPR1 (DATE, INEG)
C
С
      ***************
C
      * THIS ROUTINE PRODUCES THE REPORT FOR THE
C
      * LONG TERM WORK CENTER LOAD REPORT.
C
      ****************
C
C
С
      INPUT PARAMETER : DATE
C
      OUTPUT PARAMETER: INEG
C
C
      COMMON /INP/ NYRS, IYEAR
C
      COMMON /CA2/ NDEPT, MCAP(600)
C
      COMMON /CNEED1/ CPNEED(600), CPAVAL(600),
                     HRAVAL(4000), TOTCAP(600, 10)
C
     COMMON /OVER1/ JYEAR(99), JYHALF(99), JVALUE(99)
C
     CHARACTER*8 DATE
C
     INTEGER CPNEED, CPAVAL, HRAVAL, TOTCAP
C
```

```
C PRINT REPORT HEADING
      NYEAR = IYEAR - 1
      ITOT = 1
      NEG = 0
      N = 1
C
      WRITE(6.90) DATE
     FORMAT('0','ARGO ENGINEERING LIMITED',35X,
&' DATE :',A8,/,'0',/,'0')
 90
      WRITE(6,101)
      FORMAT('0', 15X, '**** LONG TERM WORK CENTER LOAD',
 101
     &' REPORT ****',/,' ')
C
      DO 200 I = 1,NYRS
         WRITE(6, 102)
         FORMAT('0',80('-'),/,' ',6%,11%,'1',23%,'2',
 102
     &12X,8X,'3 = 2 - 1',7X,/,80('-'))
         WRITE(6,103) NYEAR+I
         FORMAT(' ',1X,'DEPT ',1X,'M/C',3X,
 103
         'PROJECTED STD.', 4X, 4X,
         'STD. HRS AVAILABLE', 2X, 6X, 'AVAILABLE STD.',
     &2X,/,' ',6X,5X,'HRS FOR ',4X,5X,4X,
     &' AT PRESENT CAPACITY', 15X, 'HOURS')
         WRITE(6, 104)
         FORMAT(' ',80('-'),/,' ',10X,
 104
         2('[1ST HALF] [2ND HALF] '),
         '[1ST HALF] [2ND HALF]')
C
         DO 300 J = 1,NDEPT
             IF (HRAVAL(N) .LT. 0) THEN
                IF (HRAVAL(N+1) .LT. 0) THEN
                   CALL RRPPRT(I,J,ITOT,NYEAR+I)
                   CALL RRPPRT(2,J,ITOT,NYEAR+I)
                ENDIF
             ELSE
                IF (HRAVAL(N+1) .LT. 0) THEN
                   CALL RRPPRT(3,J,ITOT,NYEAR+I)
                   CALL RRPPRT(4,J,ITOT,NYEAR+I)
                ENDIF
            ENDIF
         N = N + 4
 300
      CONTINUE
      ITOT = ITOT + 2
 200
      CONTINUE
C
      INEG = NEG
      RETURN
      END
C
```

```
C
       SUBROUTINE RRPSR1
C
C
       ***************
C
C
       * THIS ROUTINE PRODUCES THE OVERLOAD REPORT. *
       ****************
C
C
      COMMON /OVER1/ JYEAR(99), JHALF(99), JVALUE(99),
                    NEG
      COMMON /OVER2/ JDEPT(99)
C
      CHARACTER*1 JDEPT*4
C
C PRINT OVERLOAD REPORT
     WRITE(6,201)
3
     FORMAT('0',/,'0',20%.'**** OVERLOAD REPORT ',
 201
     &'****',/,'0',80('-'),/,' ',15X,'DEPT
&3X,'YEAR ',6X,'OVERLOAD (STD.HRS)',/,
     &80('-'))
C
     DO 202 I = 1,NEG
         WRITE(6,203) JDEPT(I), JYEAR(I), JHALF(I),
                     JVALUE(I)
 203
        FORMAT(' ',15X,A3,9X,I4,' (',I1,')',10X,I8)
 202
      CONTINUE
 99
     RETURN
     END
C
C
C
      SUBROUTINE RRPRPT (ITYPE, J, I, N, IYRVAL)
C
C
      ****************
C
      * THIS ROUTINE PRODUCES THE REPORT FOR THE
C
      * LONG TERM WORK CENTER LOAD REPORT.
C
      *******************
C
C
      INPUT PARAMETER : ITYPE, J, I, N, IYRVAL
     OUTPUT PARAMETER: NONE
C
C
C
     ITYPE
            - TYPE OF OUTPUT
C
             - DEPT.CODE
     J
C
     Ι
             - YEAR NUMBER
C
            - 1ST HALF/2ND HALF
C
     IYRVAL - YEAR
C
     COMMON /CNEED1/ CPNEED(600), CPAVAL(600),
                   HRAVAL(4000), TOTCAP(600, 10)
C
```

```
COMMON /OVER1/ JYEAR(99), JYHALF(99), JVALUE(99),
                       NEG
       COMMON /OVER2/ JDEPT(99)
 C
       COMMON /CA1/ DEPTCD(600), MORD(600)
 C
       INTEGER CPNEED, CPAVAL, HRAVAL, TOTCAP
 C
       CHARACTER*1 DEPTCD*4, JDEPT*4, MORD
 C
       IF (MORD(J) .EQ. 'D') THEN
          WRITE(6,105) DEPTCD(J), TOTCAP(J,I), TOTCAP(J,I+1),
          CPAVAL(J),CPAVAL(J),HRAVAL(N),HRAVAL(N+1)
          FORMAT(' ',A4,5%,6(2%,18,2%))
  105
       ELSE
          IF (MORD(J) .EQ. 'M') THEN
              WRITE(6,106) DEPTCD(J), TOTCAP(J,I),
      &
              TOTCAP(J, I+1), CPAVAL(J), CPAVAL(J),
      &
              HRAVAL(N), HRAVAL(N+1)
 106
              FORMAT(' ',5X,A4,6(2X,I8,2X))
          ENDIF
       ENDIF
С
      GOTO (1,2,3,99) ITYPE
С
 1
      NEG = NEG + 1
      JDEPT(NEG) = DEPTCD(J)
      JYEAR(NEG) = IYRVAL
      JHALF(NEG) = 1
      JVALUE(NEG) = HRAVAL(N)
      NEG = NEG + 1
      JDEPT(NEG) = DEPTCD(J)
      JYEAR(NEG) = IYRVAL
      JHALF(NEG) = 2
      JVALUE(NEG) = HRAVAL(N+1)
      GOTO 99
С
 2
      NEG = NEG + 1
      JDEPT(NEG) = DEPTCD(J)
      JYEAR(NEG) = IYRVAL
      JHALF(NEG) = 1
      JVALUE(NEG) = HRAVAL(N)
      GOTO 99
C
      NEG = NEG + 1
      JDEPT(NEG) = DEPTCD(J)
      JYEAR(NEG) = IYRVAL
      JHALF(NEG) = 2
      JVALUE(NEG) = HRAVAL(N)
      GOTO 99
С
С
 99
      RETURN
      END
```

```
$TITLE: 'MSc. THESIS PROGRAM - 4'
$SUBTITLE: 'CAPACITY REQUIREMENTS PLANNING MODEL'
      PROGRAM CRPM
С
      **************
С
      * THIS IS THE MAIN PROGRAM OF THE CRP MODEL *
      * I.E. CAPACITY REQUIREMENTS PLANNING MODEL. *
      ***************
      COMMON /USER1/ NUMCP, STDATE(50), CPAMT(50)
      COMMON /USER2/ CPNENT(50)
C
      INTEGER DAY, MONTH, YEAR, MONDAY, PCDAYN, STDATE, CPAMT
C
      CHARACTER*1 A, B, CPNENT*10
C
C REQUEST USER TO INPUT TODAY'S DATE
      WRITE(*,1)
      FORMAT(' ',42('*'),/,
     &' ','* CAPACITY REQUIREMENTS PLANNING MODEL *',/, &' ',42('*'))
C
      WRITE(*,10)
      FORMAT(' ', 'ENTER TODAY'S DATE (MM/DD/YY):')
 10
      READ(*,11) MONTH, A, DAY, B, YEAR
      FORMAT(I2, A1, I2, A1, I2)
 11
C
      WRITE(*,20)
     FORMAT(' ', 'ENTER PRODUCTION CALENDER DAY NUMBER',
 20
     &' (3 DIGITS):')
     READ(*,21) PCDAYN
     FORMAT(BN, I3)
 21
      WRITE(*,22)
     FORMAT(' ', 'ENTER 1ST DAY OF WEEK NUMBER',
 22
     &' (3 DIGITS):')
     READ(*,23) MONDAY
 23
     FORMAT(BN.13)
C
C READ INPUT DATA
      WRITE(*,25)
     FORMAT(' ', 'ENTER #COMPONENTS TO BE PROCESSED',
     &' (3 DIGITS):')
     READ(*,26) NUMCP
 26
     FORMAT(BN, I3)
     WRITE(*,27) NUMCP
     FORMAT(' ', 'ENTER *COMPONENT* *START DATE*',
 27
     &' *PRODUCTION AMOUNT*',/,' ',
     &' ON A SINGLE LINE. (10 ALPHA, 3 DIGITS, 3 DIGITS):',
     &/,' ','DO IT', I4,' TIMES')
C
     DO 100 I = 1.NUMCP
```

```
READ(*,102) CPNENT(I), STDATE(I), CPAMT(I)
  102
          FORMAT(BN, A10, 214)
  100
      CONTINUE
C
      WRITE(*,103)
      FORMAT(' ','**** PROCESSING ....')
 103
C CALL SUBROUTINE GETINP TO OPEN AND READ FILES
      CALL GETINP
C
C OPEN OUTPUT FILES
      OPEN (6, FILE='PRN')
  CALL SUB-PROGRAM CAP TO CALCULATE THE CRITICAL PATHS
      CALL CPA
  CALL SUB-PROGRAMS FOR PRODUCING REPORTS
      CALL WCLR (DAY, MONTH, YEAR, PCDAYN, MONDAY, NEG)
      IF (NEG .NE. 0) THEN
         CALL OVERLR (DAY, MONTH, YEAR, NEG)
      ENDIF
C
      CALL CPSR (DAY, MONTH, YEAR)
С
      END
С
C
С
      SUBROUTINE GETINP
C
C
      ***************
C
      * THIS ROUTINE OPEN FILES 'WORKFL' & 'CENTREFL'
Č
      * IT READS THE DATA FROM THESE FILES AND STORE
C
      * THE INFORMATION IN COMMON BLOCK AREA /WORK/
C
      * AND /CENTR/ RESPECTIVELY.
Ċ
      ***************
C
      COMMON /USER1/ NUMCP, STDATE(50), CPAMT(50)
C
      COMMON /WORK1/ ACTCD(50,20), DURATN(50,20),
     &
                     SND(50,20), DESTND(50,20),
                     MAXACT(50), MAXND(50)
      COMMON /WORK2/ CPID(50)
COMMON /WORK3/ JPRE1(50,20), JPRE2(50,20),
     &
                     JPRE3(50,20),JNXT1(50,20),
     &
                     JNXT2(50,20),JNXY3(50,20)
C
      COMMON /CENTR1/ MACTCD(50), MAXCAP(50), MACT
      COMMON /CENTR2/ MCODE(50)
```

```
C
      CHARACTER*1 A, MCODE*4, CPID*10
C
      INTEGER ACTCD, DURATN, SND, DESTND, STDATE, CPAMT
C OPEN INPUT FILES
      OPEN (1,FILE='WORKFL')
      OPEN (2,FILE='CENTREFL')
C READ WORK CENTER FILE AND STORE INFORMATION
C IN COMMON /CENTR/
      READ(2, 100) MACT
 100
      FORMAT(I3)
      DO 200 I = 1,MACT
         READ(2,220) MACTCD(I), MAXCAP(I), A, MCODE(I)
 220
         FORMAT(I3,I4,A1,A4)
 200
     CONTINUE
C READ WORK FILE AND STORE INFORMATION IN COMMON /WORK/
     DO 800 I = 1, NUMCP
         READ (1,300) CPID(I), MAXCAP(I), MAXND(I)
 300
         FORMAT(A10,213)
        DO 700 J = 1, MAXACT(I)
            READ(1,301) ACTCD(I,J), DURATN(I,J), SND(I,J),
                        DESTND(I,J)
 301
            FORMAT(13,14,213)
            READ(1,305) JPRE1(I,J), JPRE2(I,J), JPRE3(I,J)
 305
            FORMAT(14,213)
            READ(1,307) JNXT1(I,J), JNXT2(I,J), JNXT3(I,J)
 307
            FORMAT(I4,2I3)
 700
         CONTINUE
 800
     CONTINUE
     RETURN
     END
C
C
С
C
       SUBROUTINE CPA
C
C
       ****************
С
       * THIS ROUTINE CALCULATES THE CRITICAL PATH *
C
       * FOR ALL COMPONENTS (ICOMP), AND ALL THE
С
       * "CRITICAL POINTS" IN THE PATH.
C
       ***************
C
       INPUT PARAMETER
                        : NONE
       OUTPUT PARAMETER: NONE
C
```

```
C
      COMMON /USER1/ NUMCP, STDATE(50), CPAMT(50)
C
      COMMON /WORK1/ ACTCD(50,20), DURATN(50,20),
                      SND(50,20), DESTND(50,20),
     &
                      MAXACT(50), MAXND(50)
     &
     &
                      JPRE3(50,20),JNXT1(50,20),
                      JNXT2(50,20),JNXY3(50,20)
     &
C
      COMMON /CRITF/ CRIPTS(15,50)
C
      INTEGER NFIN(100)
      INTEGER ACTCD, DURATN, SND, DESTND, STDATE, CPAMT
               CRIPTS, NFIN(100), NDUR
C INITIALISE WORKING ARRAY
      DO 5 I = 1,10
         DO 7 J = 1,10
             CRIPTS(I,J) = 0
 7
         CONTINUE
 5
      CONTINUE
C
      DO 10 I = 1,100
         NFIN(I) = 0
 100
      CONTINUE
C COMPUTE CRITICAL PATHS FOR ALL COMPONENTS
C
      DO 800 ICOMP = 1, NUMCP
C FIRST TIME IE. NODE 1
      DO 111 ID = 1, NUMCP
         IF (CPID(ICOMP) .EQ. CPNENT(ID)) THEN
            CRIPTS(1,ICOMP) = STDATE(ID)
            GOTO 222
         ENDIF
      CONTINUE
 111
C
 222
      LOOK = 1
      NODE = 2
      LONGST = 0
C
C LOOP FOR ALL DESTINATION NODE FROM 2 TO MAXND
      DO 500 M = 2,MAXND(ICOMP)
         NODE = M
         DO 100 I = 1, MAXACT(ICOMP)
C
C
C
         LOOP FOR THAT NODE;
         IF MATCHES, STORE THE FINISH DAY
            IF (DESTND(ICOPM, I) .EQ. NODE) THEN
```

```
NDUR = DURATN(ICOMP, I)
               NFIN(LOOK) = CRIPTS(NODE-1,ICOMP)
     &
                            + NDUR - 1
               LOOK = LOOK + 1
            ENDIF
  100
         CONTINUE
C
C COMPARE ALL ACTIVITIES WITH THE SAME DESTINATION
C NODE THAT HAS BEEN LOOKED AT; AND TAKE THE LONGEST
C VALUE.
C
          L = LOOK - 1
          DO 200 K = 1,L
             IF (NFIN(K) .GT. LONGST) THEN
                 LONGST = NFIN(K)
             ENDIF
 200
          CONTINUE
C
C
          STORE THE LONGEST VALUE
C
          CRIPTS(NODE, ICOMP) = LONGST
C
C
          REINITIALISE LOCAL WORKING ARRAYS AND VARIABLES
          DO 300 K = 1,L
             NFIN(K) = 0
 300
          CONTINUE
          LOOK = 1
          LONGST = 0
C
 500
       CONTINUE
 800
       CONTINUE
C
       RETURN
       END
C
C
C
C
      SUBROUTINE WCLR (DAY, MONTH, YEAR, PCDAYN, MONDAY, NEG)
C
C
      ***************
C
      * THIS ROUTINE PRODUCES THE WORK CENTER LOAD
                                                      *
C
      * REPORT FOR EACH WORK CENTER.
C
      ***************
      INPUT PARAMETER: DAY, MONTH, YEAR, PCDAYN, NEG
     OUTPUT PARAMETER : NONE
C
С
     COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
    &
                    ISORCE(100), IDEST(100),
    &
                    IPRE(100,3), INEXT(100,3), IPTR
```

```
COMMON /STRF2/ ICP(100)
C
       COMMON /EARLF/ IEARL(100)
C
       COMMON /CALF/ AWEEK(50,2), CPNEED(50), MAXWK
C
       COMMON /OVER1/ IFROM(80), ITO(80), IVALUE(80)
       COMMON /OVER2/ ICENTR(80)
C
       COMMON /CENTR1/ MACTCD(50), MAXCAP(50), MACT
       COMMON /CENTR2/ MCODE(50)
C
       INTEGER AWEEK, CPNEED, DAY, MONTH, YEAR, PCDAYN
C
       CHARACTER*1 ICP*10, MCODE*4, ICENTR*4
C READ WORK CENTER FILE UNTIL END-OF-FILE
       NEG = 0
C
       DO 300 \text{ MC} = 1, \text{MACT}
          CALL INIT
C
C FOR EACH MCODE, PRINT THE WORK CENTER LOAD REPORT.
C HENCE, SEARCH WORK FILE FOR COMPONENTS WITH
C MATCHING MACTCD.
C
      MCAC = MATCD(MC)
       CALL RDWORK (MCAC)
       CALL SORT
      CALL CALCAP
C
C PRINT WCL REPORT HEADING
      WRITE(6,303) MONTH, DAY, YEAR
      FORMAT('1', 'ARGO ENGINEERING LIMITED', 30X,
     &' DATE :',I2,'/',I2,'/',I2)
WRITE(6,304) MCODE(MC),MACTCD(MC)
       FORMAT('0',/,'0',/,' ',20X,'**** WORK CENTER'
     &' LOAD REPORT ****',/,'0','0','WORK CENTER :', &A4,45%,'ACTIVITY :',I3)
      WRITE(6,305)
     FORMAT('0',/,' ',80('-'),/,
     &' ','FROM
                    TO', 4X, 'CAPACITY NEEDED', 4X,
     &'CAPACITY AVAILABLE',4X,' BALANCE',/,' ',80('-'))
C PRINT REPORT INFORMATION
      DO 700 \text{ IWK} = 1, \text{MAXWK}
          IBAL = MAXCAP(MC) - CPNEED(IWK)
         WRITE(6,306) AWEEK(IWK,1), AWEEK(IWK,2),
     &
                        CPNEED(IWK), MAXCAP(MC), IBAL
306
         FORMAT(' ', I4, 1X, I4, 4X, I10, 4X, I10, 11X, I10)
```

```
C CHECK FOR OVERLOAD
          IF (IBAL .LT. 0) THEN
             NEG = NEG + 1
             ICENTR(NEG) = MCODE(MC)
             IFROM(NEG) = AWEEK(IWK, 1)
             ITO(NEG) = AWEEK(IWK, 2)
             IVALUE(NEG) = IBAL
          ENDIF
 700
      CONTINUE
C
 300
      CONTINUE
C
      RETURN
      END
C
C
C
C
      SUBROUTINE CPSR (DAY, MONTH, YEAR)
C
      *****************
C
      * THIS ROUTINE PRODUCES THE COMPONENT PART
Č
      * SCHEDULING REPORT FOR EACH ACTIVITY CODE.
C
C
      *******************
C
      INPUT PARAMETER
                       : DAY, MONTH, YEAR
С
      OUTPUT PARAMETER : NONE
C
      COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
                     ISORCE(100), IDEST(100),
     &
                     IPRE(100,3), INEXT(100,3), IPTR
      COMMON /STRF2/ ICP(100)
C
      COMMON /EARLF/ IEARL(100)
C
      COMMON /CENTR1/ MACTCD(50), MAXCAP(50), MACT
      COMMON /CENTR2/ MCODE(50)
C
      INTEGER DAY, MONTH, YEAR
С
      CHARACTER*1 ICP*10, A, MCODE*4
С
C READ & PROCESS WORK CENTER FILE UNTIL EOF
      DO 300 \text{ MC} = 1, \text{MACT}
C INITIALISE DATA IN COMMON BLOCK /STRF/
         CALL INIT
C
C FOR EACH MACTCD, PRINT THE COMPONENT PART SCHEDULING
C REPORT. HENCE, SEARCH WORK FILE FOR COMPONENTS WITH
```

```
C MATCHING MACTCD, AND STORE INFORMATION IN COMMON
C BLOCK /STRF/
          MCAC = MACTCD(MC)
          CALL RDWORK (MCAC)
C SORT DATES IN ASCENDING ORDER
          CALL SORT
C PRINT CPS REPORT WITH THE EARLIEST START-DATE
C PRINT REPORT HEADING
          WRITE(6,303) MONTH, DAY, YEAR
 303
          FORMAT('1', 'ARGO ENGINEERING LIMITED', 30X,
      &
          'DATE :',I2,'/',I2,'/',I2)
WRITE(6,304) MCODE(MC),MACTCD(MC)
          FORMAT('0',/,'0',/,' ',10X,
 304
     &'**** COMPONENT PART SCHEDULING REPORT ****',/,
     &'0',/,'0',/,' ','WORK CENTER :',A4,45%,
&'ACTIVITY :',I3)
          WRITE(6,305)
          FORMAT('0',/,' ',80('-'),/,
RT NO START FINISH
 305
     &'PART NO
                                          DURATION
                                        ACTIVITY',/,'',
     &'PRECEDENCE ',46X,'ACTIVITY
     &80('-'))
C READ # IN ARRAY IEARL AND PRINT THE INFORMATION
C FROM COMMON BLOCK /STRF/ IN THE ORDER OF THE
C NUMBER IN IEARL.
C
      IF (IPTR .NE. 1) THEN
          NPTR = IPTR - 1
          DO 400 K = 1, NPTR
             DO 450 J = 1, NPTR
                IF (IEARL(J) .EQ. K) THEN
                   WRITE(6,306) ICP(J), ISTART(J),
                   IFIN(J), IDUR(J), (IPRE(J,N), N=1,3),
                    (INEXT(J,N),N=1,3)
                   FORMAT(' ',A10,2X,14,7X,14,8X,5X,
 306
                    3I3,3X,3I3)
                   GOTO 400
                ENDIF
 450
             CONTINUE
 400
          CONTINUE
      ENDIF
 300
      CONTINUE
C
      RETURN
      END
С
C
С
```

```
SUBROUTINE OVERLR (DAY, MONTH, YEAR, INEG)
 C
 С
       ****************
 С
       * THIS ROUTINE PRODUCES THE OVERLOAD REPORT
 C
       * (IF ANY).
 C
       ***************
C
C
C
       INPUT PARAMETER : DAY, MONTH, YEAR, INEG
C
       OUTPUT PARAMETER: NONE
C
C
       COMMON /OVER1/ IFROM(80), ITO(80), IVALUE(80)
      COMMON /OVER2/ ICENTR(80)
C
      INTEGER DAY, MONTH, YEAR
C
      CHARACTER*4 ICENTR
C
C CHECK IF THERE IS ANY OVERLOAD REPORT TO BE PRINTED.
      IF (INEG .NE. 0) THEN
         WRITE(6,100) MONTH, DAY, YEAR
         FORMAT('1', 'ARGO ENGINEERING LIMITED', 30X, 'DATE: ', 12, '/', 12, '/', 12)
 100
         WRITE(6,102)
     FORMAT('0',20X,'**** SUMMARY OVERLOAD REPORT', &' ****',/,'0',/,'0',80('-'),/,' ',15X, &'WORK CENTER DAY',15X,'OVERLOAD'./.
 102
                         DAY',15x,'OVERLOAD',/,
               TO',/,' ',80('-'))
     &33X'FROM
C
         DO 300 I = 1, INEG
            WRITE(6,104) ICENTR(I), IFROM(I), ITO(I),
                          IVALUE(I)
 104
            FORMAT(' ',20X,A4,8X,I4,1X,8X,I10)
 300
         CONTINUE
      ENDIF
C
      RETURN
      END
C
C
С
C
      SUBROUTINE RDWORK (MCAC)
C
C
      ***************
C
      * THIS ROUTINE READS THE WORK FILE AND SEARCH
C
      * FOR COMPONENTS WITH MATCHING ACTIVITY CODE.
C
      * (MCAC). IT RECORDS ALL THE MATCHING
C
      * ACTIVITES AND ITS ASSOCIATED DATA INTO
С
      * COMMON BLOCK /STRF/
C
      ****************
```

```
C
C
      INPUT PARAMETER
                       : MCAC
      OUTPUT PARAMETER: NONE
C
C
C MCAC
         - CURRENT MACHINE ACTIVITY CODE TO BE PROCESSED
      COMMON /USER1/ NUMCP, STDATE(50), CPAMT(50)
C
      COMMON /WORK1/ ACTCD(50,20), DURATN(50,20),
     &
                     SND(50,20), DESTND(50,20),
     &
                     MAXACT(50), MAXND(50)
C
      INTEGER ACTCD, DURATN, SND, DESTND, STDATE, CPAMT
C FOR EACH COMPONENT, CHECK ALL ITS ACTIVITIES
C FOR MATCHING MACTCD.
C
     DO 300 I = 1, NUMCP
        DO 208 N = 1,MAXACT(I)
           IF (MCAC .EQ. ACTCD(I,N)) THEN
              CALL CRPSTR(I,N)
           ENDIF
 208
        CONTINUE
 300
      CONTINUE
C
      RETURN
      END
C
C
C
C
       SUBROUTINE CRPSTR (NCOMP, NACT)
C
C
       *******************
C
       * THIS ROUTINE STORES THE INFORMATION
C
       * REGARDING THE "FOUND" MATCHING ACTIVITIES *
С
       * IN COMMON BLCOK /STRF/.
C
       ***************
С
       INPUT PARAMETER
                        : NCOMP, NACT
       OUTPUT PARAMETER: NONE
C
С
С
       NCOMP
              - COMPONENT NUMBER
C
       NACT
              - ACTIVITY CODE NUMBER
      COMMON /WORK1/ ACTCD(50,20), DURATN(50,20),
                     SND(50,20), DESTND(50,20),
                     MAXACT(50), MAXND(50)
      COMMON /WORK2/ CPID(50)
     COMMON /WORK3/ JPRE1(50,20), JPRE2(50,20),
```

```
&
                      JPRE3(50,20),JNXT1(50,20),
      &
                      JNXT2(50,20),JNXY3(50,20)
C
       COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
      &
                      ISORCE(100), IDEST(100),
                      IPRE(100,3), INEXT(100,3), IPTR
      COMMON /STRF2/ ICP(100)
C
      COMMON /CRITF/ CRIPTS(15,50)
C
      INTEGER ACTCD, DURATN, SND, DESTND, STDATE, CPAMT
      CHARACTER*1 ICP*10, CPID*10
C FILL INFORMATION IN COMMON BLOCK /STRF/
C
C
      IPTR POINTS TO THE FREE LOCATION IN /STRF/
С
      IT IS RESET TO 1 EACH TIME IT STARTS
C
      PROCESSING A NEW COMPONENT.
      ICP(IPTR) = CPID(NCOMP)
      IDUR(IPTR) = DURATN(NCOMP, NACT)
      ISORCE(IPTR) = SND(NCOMP, NACT)
      IDEST(IPTR) = DESTND(NCOMP, NACT)
      IPRE(IPTR, 1) = JPRE1(NCOMP, NACT)
      IPRE(IPTR, 2) = JPRE2(NCOMP, NACT)
      IPRE(IPTR,3) = JPRE3(NCOMP,NACT)
      INEXT(IPTR, 1) = INXT1(NCOMP, NACT)
      INEXT(IPTR, 2) = INXT2(NCOMP, NACT)
      INEXT(IPTR, 3) = INXT3(NCOMP, NACT)
C LOOK UP FOR THE START AND FINISH DAY
      ISTART(IPTR) = CRIPTS(ISORCE(IPTR),NCOMP)
      IFIN(IPTR) = CRIPTS(IDEST(IPTR),NCOMP)
      IPTR= IPTR + 1
C
      RETURN
      END
C
C
C
      SUBROUTINE INIT
C
CCCC
      ************
      * THIS ROUTINE INITIALISES DATA IN THE *
      * COMMON BLOCK AREA /STRF/.
      *************
C
      COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
     &
                     ISORCE(100), IDEST(100),
     &
                     IPRE(100,3), INEXT(100,3), IPTR
      COMMON /STRF2/ ICP(100)
```

```
C INITIALISATION
C
     IPTR = 1
C
      DO 100 I = 1,100
         ISTART(I) = 99999
         IFIN(I) = 0
         IDUR(I) = 0
         ISORCE(I) = 0
         IDEST(I) = 0
        DO 110 J = 1,3
           JPRE(I,J) = 0
           INEXT(I,J) = 0
 110
         CONTINUE
 100
     CONTINUE
C
     RETURN
     END
C
C
C
     SUBROUTINE SORT
C
C
     *************
C
     * THIS ROUTINE SORTS THE START DATES IN
     * ASCENDING ORDER.
C
     **************
     COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
    &
                    ISORCE(100), IDEST(100),
    &
                    IPRE(100,3), INEXT(100,3), IPTR
C
     COMMON /EARLF/ IEARL(100)
C
     INTEGER IWORK (100)
С
C DUPLICATE INFORMATION IN ISTART TO IWORK FOR THE
C PURPOSE OF SORTING OUT THE EARLIEST START DATE
C AND PUT THE EARLIEST NUMBER IN ARRAY IEARL.
C DUPLICATE INFORMATION
     IF (IPTR .NE. 1) THEN
         NPTR = IPTR - 1
         DO 220 I = 1.NPTR
            IWORK(I) = ISTART(I)
 220
         CONTINUE
C
C SORT
C
     DO 120 J = 1,IPTR
        IELST = 99999
```

```
DO 110 N = 1,NPTR
            IF (IWORK(N) .LT. IELST) THEN
               IELST = IWORK(N)
               IE = N
            ENDIF
 110
         CONTINUE
         IEARL(IE) = J
         IWORK(IE) = 99999
 120
      CONTINUE
      ENDIF
C
      RETURN
      END
C
C
C
C
       SUBROUTINE CALCAP (MONDAY)
С
С
       *****************
C
       * THIS SUBROUTINE CALCULATES THE CAPACITY *
č
       * NEEDED FOR EACH ACTIVITY CODE, STARTING *
CCCC
       * FROM THE EARLIEST START DATE.
       **************************
       INPUT PARAMETER: MONDAY
Č
       OUTPUT PARAMETER: NONE
C
       COMMON /STRF1/ ISTART(100), IFIN(100), IDUR(100),
                      ISORCE(100), IDEST(100), IP(100),
      &
      &
                      IN(100), IPRE(100,3), INEXT(100,3),
      &
                      I PTR
C
       COMMON /EARLF/ IEARL(100)
       COMMON /CALF/ AWEEK(50,2), CPNEED(50), MAXWK
C
       INTEGER AWEEK, CPNEED, MON, FRI, CWEEK
       INTEGER BAL(50), NSTART(100), NDUR(100)
C
C INITIALIZATION
       KCOUNT = 1
       DO 50 I = 1,50
         CPNEED(I) = 0
         BAL(I) = 0
         DO 70 J = 1.2
            AWEEK(I,J) = 0
 70
         CONTINUE
 50
       CONTINUE
C SORT ISTART & IDUR ACCORDING TO THE ORDER IN THE NUMBER
C IN IEARL
C
      NPTR = IPTR - -1
```

```
DO 400 \text{ K} = 1, \text{NPTR}
           DO 450 J = 1,NPTR
              IF (IEARL(J) .EQ. K) THEN
                 NSTART(K) = ISTART(J)
                 NDUR(K) = IDUR(J)
                 GOTO 400
              ENDIF
  450
          CONTINUE
 400
        CONTINUE
C
C
       MIN = MONDAY
       MAX = NSTART(NPTR)
       MON = MIN
       FRI = MON + 4
C
C DETERMINE MAXIMUM NUMBER OF WEEKS TO PUT INTO ARRAY
C WEEK
С
       NUM = (MAX - MIN) + 1
       MAWWK = NUM/5
       IF (MOD(NUM, 5) .NE. 0) THEN
          MAXWK =MAXWK + 1
       ENDIF
C
C CREATE PRODUCTION CALENDER FOR MAXWK
       DO 100 I = 1, MAXWK
          AWEEK(I,1) = MON
          AWEEK(I,2) = FRI
          MON = FRI + 1
          FRI = MON + 4
C COMPUTE CAPACITY NEEDED STARTING WITH THE EARLIEST
C START DATE AND PUT IT INTO ARRAY CPNEED.
      DO 900 IWK = 1, MAXWK
         DO 800 I = KCOUNT, NPTR
              IDIFF = AWEEK(IWK, 2) - NSTART(I) + 1
              IF (IDIFF .GT. 0) THEN
                 IF (NDUR(I) .LE. IDIFF) THEN
                     CPNEED(IWK) = CPNEED(IWK) + NDUR(I)
                 ELSE
                     CPNEED(IWK) = CPNEED(IWK) + IDIFF
                     IREM = NDUR(I) - IDIFF
                     BAL(IWK) = IREM + 1
                ENDIF
             ELSE
C
C
          DO THE BALANCES
C
             KCOUNT = I
             CWEEK = IWK
             NWK = IWK + 1
             DO 150 K = 1,CWEEK
```

```
IF (BAL(K) .NE, 0) THEN
                    IF (BAL(K) .LE. 5) THEN
                       CPNEED(NWK) = CPNEED(NWK) + BAL(K)
                      BAL(K) = 0
                    ELSE
                       NREM = BAL(K) - 5
                      BAL(K) = NREM
                       CPNEED(NWK) = CPNEED(NWK) + 5
                   ENDIF
                ENDIF
 150
             CONTINUE
             GOTO 900
             ENDIF
 800
          CONTINUE
 900
     CONTINUE
С
      RETURN
      END
```