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OPERATIONS RESEARCH CENTER

GUIDE TO SIMULATION SCHEDULING

by
Robert C. Leachman*
Sooyoung Kim*
Shrane Koung Chou*

ORC-86-1

January 1986

UNIVERSITY OF CALIFORNIA



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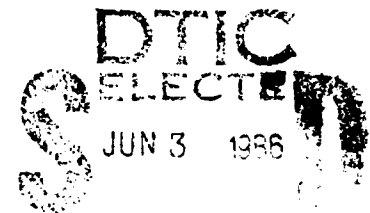
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ABSTRACT

Simulation Scheduling is a comprehensive software package for project scheduling and analysis developed at the Operations Research Center of the University of California at Berkeley. It is designed for use in project-oriented production systems which have inflexible resource capacities limiting the execution of multiple projects with uncertain work requirements. The package operates on an IBM mainframe utilizing the VM/SP operating system to compile CMS Fortran interactive commands and batch processing code. As described in this manual, the user may interactively edit data, perform simulations and statistical analysis, create schedules and obtain tabular or graphical output.

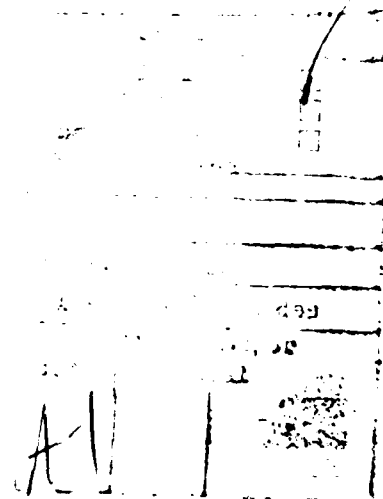


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1. Introduction

Simulation Scheduling is a comprehensive software package for project scheduling and analysis developed at the Operations Research Center of the University of California at Berkeley. It is designed for use in project-oriented production systems which have inflexible resource capacities limiting the execution of multiple projects with uncertain work requirements. Both tabular and graphical output for project schedules and risk analysis are provided.

The software is a result of 10 years of research at U.C. Berkeley concerning the development of mathematical models and techniques for production management, sponsored by the Office of Naval Research and the Puget Sound Naval Shipyard. A bibliography of research reports and articles describing the various aspects of this research is provided in section 6.

The simulation scheduling package operates on an IBM mainframe utilizing the VM/SP operating system to compile CMS Fortran interactive commands and batch processing code. With appropriate modification, the Fortran code could be adapted to run on other systems.

Section 2 of this report discusses management use of Simulation Scheduling. In section 3, data requirements are summarized. In section 4, important aspects of the mathematical models of production incorporated into Simulation Scheduling are described.

The on-line User's Manual for Simulation Scheduling is presented in section 5. In this User's Manual, some familiarity with basic CMS commands and Fortran formats is assumed. For a discussion of basic CMS commands, the reader is referred to the manual "Getting Started with CMS", Computing Services, 218 Evans Hall, University of California, Berkeley, CA 94720.

Sample output reports, graphics, and listings of all programs and execution files are provided in the Appendices.

2. Management Use

Simulation Scheduling is intended to be used to manage individual projects in conjunction with aggregate planning techniques for inter-project analysis. It is a powerful tool for scheduling project activities and for allocating scarce resources among project activities, and for risk analysis of project budgets and due dates. However, in the management of a project-oriented production system, major decisions must be made involving aggregate-level planning issues which are not considered in the Simulation Scheduling Package. These decisions include the planned allocations of available resource time among projects, and the establishment of major milestone target dates for each project. (For an advanced analytical methodology for aggregate planning, the reader is referred to Leachman and Boysen [1985], Boysen [1983] and Leachman and Boysen [1982].)

Simulation Scheduling requires as input data the allocations of resources to a project and its target milestone dates. Resource allocations to a project are treated by Simulation Scheduling as inviolable capacities for the project, on the grounds that exceeding such allocations would impact other projects. The scheduling algorithms within the Simulation Scheduling package derive schedules meeting the target milestone dates (if feasible) without exceeding the allocated resource levels.

The Simulation Scheduling package may be used to perform two different types of analyses which are termed *deterministic* and *probabilistic*. In deterministic analysis, a project schedule is derived assuming work requirements for the activities of the project are known. In addition to the schedule, resource load profiles corresponding to the schedule are provided as output. In probabilistic analysis, scheduling of the project is simulated many times with activity work requirements randomized according to probability distributions. The

user must specify distributions defining probabilities of unplanned rework activities. In addition, the software incorporates uniform distributions which randomize the work content of planned activities over a 80-120% range of given estimates.

Simulation Scheduling provides confidence curves for the realization date of each milestone and confidence curves for the total hours required of each resource. Resource load profiles reflecting a user-specified confidence level also may be obtained. Reviewing the results of such simulations, the user can assess the risks that trial project milestones and resource budgets can not be met.

3. Summary of Data Requirements

The data requirements of Simulation Scheduling are briefly summarized below. A thorough discussion of input procedures and formats is provided in the on-line users manual reproduced in section 5. Some of the data items are novel compared to other project scheduling software; for this reason, a brief discussion is provided in section 4 of the mathematical models of production incorporated in Simulation Scheduling.

CPM Activity Network -- An activity-on-arc network of all planned activities is specified using (I,J) notation. The "normal" duration for each activity is specified.

Resource Hours -- For each activity, estimated total hours of each scarce resource to be applied to the activity are specified. Resources are identified by a designated "shop" number. Subcategories of each resource (for reporting purposes only) are designated by a "work center" number. Activities whose resource utilization levels are not adjustable are so designated with a flag in the "activity type" field.

Target Project Completion Date -- A target due date for completion of all activities is specified.

Target Milestone Dates -- Target due dates for any other events also may be specified. If feasible, schedules will be developed meeting the target dates. Activities following such an event will not be scheduled to start earlier than the target date, unless all predecessors are complete and it is necessary to do so in order to meet other due dates.

Shop Capacities -- Time varying levels are specified for each resource allocated to the project. The user specifies the hours/day of each shop available to the project and an effectivity date such levels apply. Multiple levels and effectivity dates are allowed.

Flow Transfers -- Dependent activities which overlap instead of being separated by strict precedence have a flow transfer percentage specified to define the required lag in the progress of the two activities.

Rework Subnetworks -- For probabilistic analysis, subnetworks describing potential rework are defined. Each rework subnetwork consists of alternative paths of rework activities which may be required following a particular activity in the CPM network.

Calendar Data -- The starting date of the project to be scheduled/simulated and a list of non-working days is provided.

Reporting Dates -- A list of dates for reporting shop and work center loading statistics is provided.

Miscellaneous Parameters -- To initiate Simulation Scheduling, various parameters must be specified. These include the number of simulations to be performed, the number of work days simulated, upper and lower bounds for activity intensity, and the intensity assignment policy.

4. *Mathematical Models of Production*

Simulation Scheduling utilizes the network logic of Critical Path Methods (CPM). However, restrictive assumptions of CPM have been relaxed so that the scheduling model more realistically simulates work in a project-oriented production system such as a naval shipyard. For example, when using CPM, one schedules a project assuming the activities have pre-specified durations, or, in probabilistic analyses, assuming activity durations have pre-specified probability distributions. In reality, the durations for many activities are adjustable according to the intensity of resource applications to the activity. In Simulation Scheduling, the duration for each activity evolves according to the simulated application of resources to the activity. Simulation Scheduling determines efficient activity durations and schedules by efficiently allocating project resources among the activities of the project.

The mathematical details of the model of production and of the scheduling algorithms which are incorporated into Simulation Scheduling are presented in Dincerler [1985] and in Leachman and Dincerler [1986]. We briefly review the concepts of the model of production here so that the reader may better comprehend the use of data in Simulation Scheduling. The review is broken into sections discussing Resource Utilization, Activity Dependencies, and Probabilistic Networks.

4.1. *Resource Utilization*

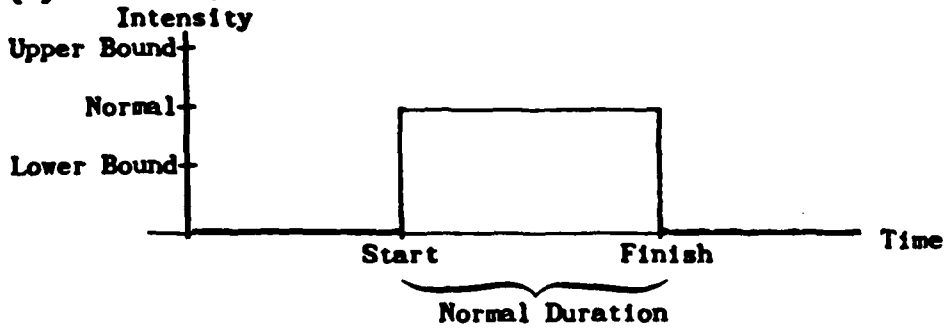
In Simulation Scheduling, it is assumed that all scarce resources utilized by an activity are applied proportionally. Under this assumption, the fraction of the total requirement of a resource that is applied to an activity on a particular day is the same for all resources utilized by the activity. This common fraction is termed the *intensity* of the activity on the particular day. For example, an intensity of 0.05 on day t would mean 5% of the activity is performed on day t .

i.e., 5% of each of the resource requirements of the activity are consumed on day t .

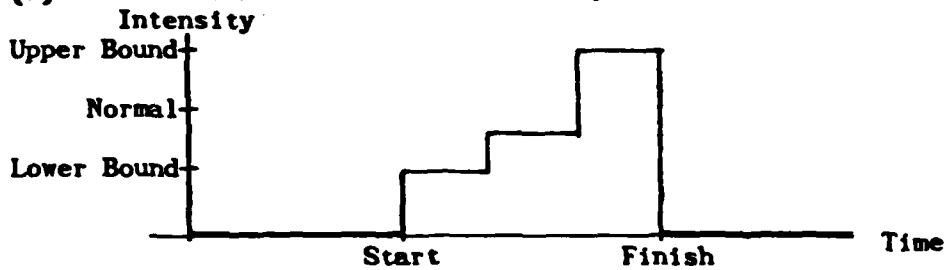
In CPM techniques, it is assumed that activity intensity is constant from start until completion. The value of this constant is the reciprocal of the pre-specified activity duration. However, in Simulation Scheduling, activity intensity is allowed to vary between upper and lower limits defined by the user. The user defines a normal duration for each activity which corresponds to a normal intensity, i.e., to normal rates of application of resources to the activity. The user also defines upper and lower bounds on activity intensity, expressed as percentages of normal intensity. For example, an intensity upper bound of 150% would mean the rates of resource applications could be up to 150% ($3/2$) of the rates corresponding to normal duration. If the intensity of the activity were maintained at upper bound from start to finish of the activity, the resulting duration would be only 67% ($2/3$) of the normal duration. In Simulation Scheduling, the user may identify fixed intensity activities. Fixed intensity activities are ones whose intensity must be held constant at the level corresponding to normal duration. Such activities would include, for example, test activities whose manning levels are not adjustable. All other activities are assumed to have intensities which are adjustable between the upper and lower percentage limits.

Figure 1 displays example intensity patterns. The graphs of activity loading of each resource utilized by the activity would be proportional to the activity's intensity pattern. Graph (a) displays the case in which activity intensity is constant at a level corresponding to normal duration. This is the only case allowed by most CPM techniques. A fixed intensity activity would have such a graph. Graph (b) displays a case in which activity intensity starts at a low level, but is upgraded enough as time goes on so that the activity is still

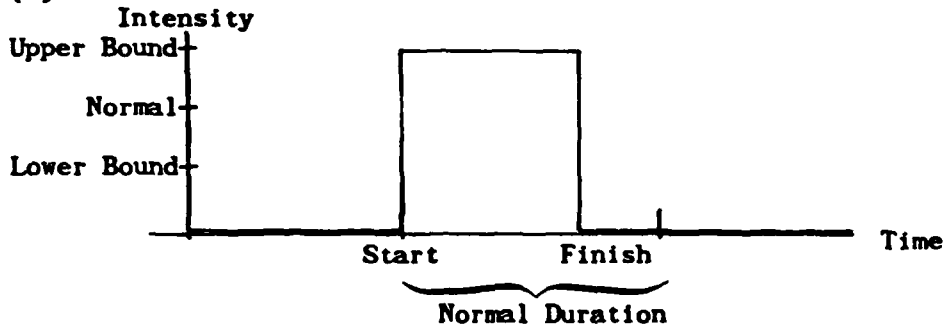
(a) CONSTANT, NORMAL INTENSITY



(b) INTENSITY AT LOWER BOUND AT FIRST, UPGRADED LATER



(c) INTENSITY CONSTANT AT UPPER BOUND



(d) INTENSITY UPGRADED AND DOWNGRADED

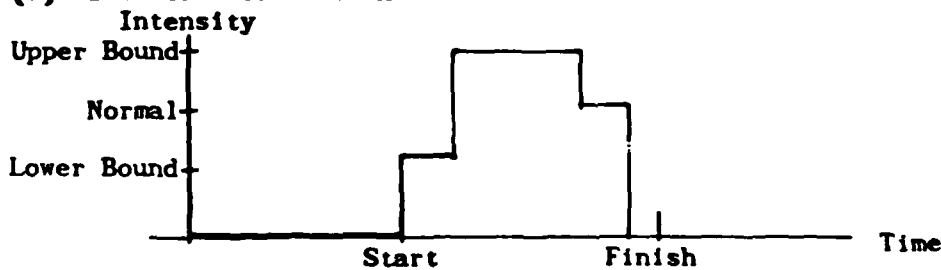


FIGURE 1
EXAMPLE INTENSITY PATTERNS

completed in the normal duration. Such a case might arise in a situation where a number of activities are completed while the activity in question is in progress, and the freed up resources are redirected to the activity in question. Graph (c) displays a case in which activity intensity is constant at the upper bound, as might arise when resources are plentiful. Graph (d) displays the most general case, in which activity intensity is both upgraded and downgraded.

In Simulation Scheduling, the user must select one of two alternative intensity assignment policies, known as Upgrading Only and Upgrading and Downgrading. In the Upgrading Only policy, resources can not be withdrawn from an activity in progress. Graph (a), (b) and (c) represent cases allowed by the Upgrading Only policy; graph (d) represents a case not allowed by the Upgrading Only policy. On the other hand, all cases are admitted under the Upgrading and Downgrading policy. In general, more efficient resource utilization and shorter project durations are feasible when activities can be downgraded as well as upgraded.

4.2. Activity Dependencies

In CPM, work flow is represented with strict precedence relationships between activities. In Simulation Scheduling, a more general workflow relationship may be specified, known as a *flow transfer*, which may possibly reduce network size. As an example, suppose 5 pumps are to be fabricated and then installed. As fabrication of each pump is completed, the pump may be installed. Using CPM, it would be inaccurate to have one activity representing the fabrication 5 pumps preceding one activity representing the installation of 5 pumps. To be completely accurate, there would need to be 5 separate pump fabrication activities and 5 separate pump installation activities.

Using Simulation Scheduling, one can define one activity representing the fabrication of 5 pumps and one activity representing the installation of 5

pumps, with a *20%-flow transfer* specified between them. The 20%-flow transfer insures that the fabrication activity is always 20% ahead of the installation activity. For example, installation can not start until fabrication is at least 20% done, installation can not be 50% done unless fabrication is at least 70% done, etc. In this way, the application of resources to install each pump will not be simulated until after the application of resources to fabricate the pump has been simulated, even though only two activities are used.

We remark that a 100%-flow transfer corresponds to familiar strict precedence. In Simulation Scheduling, the default activity network relationship is strict precedence.

4.3. *Probabilistic Networks*

In CPM, a given network of activities is scheduled. In probabilistic analysis using Simulation Scheduling, an overall network is scheduled which consists of the given network appended with randomly generated *rework subnetworks*. Many different overall networks are scheduled in the course of probabilistic analysis. The user of Simulation Scheduling must provide input data defining the probabilities and structure of the rework subnetworks, briefly described as follows.

For each rework subnetwork, the user identifies the activity of the given network which immediately precedes the potential rework. For purposes of discussion, we term this activity in the given network as a "test activity". The rework subnetwork following the test activity is defined in terms of alternative paths of rework activities. Each path is termed a "branch". The user defines the probability that each branch will arise following the test activity. The branch probabilities may sum to less than 1.0 to represent the case in which there is a chance that no rework is required.

A graph of an example rework subnetwork is presented in Figure 2. Activities are represented as arcs identified with (I,J) numbers. Activity (702,336) is the test activity in given network. There are three rework branches following this test activity with probabilities 0.35, 0.20 and 0.05, respectively. The first branch consists of the sequence of activities (R110,R111), (R111,R112), (R112,336). The second branch consists of the sequence of activities (R113,R114), (R114,R115), (R115,336). The third branch consists of a single activity (R116,336).

For each rework activity on each branch, the user specifies a normal resource mix (e.g., normal crew requirement). The user also specifies a probability distribution for the duration of the rework activity that would be realized if the normal resource mix were applied. This distribution is expressed in discrete form. For example, the duration distribution for rework activity (R110,R111) might be 1 day with probability 0.25 and 2 days with probability 0.75. Up to 5 alternative durations for each rework activity may be specified.

TEST ACTIVITY IN
THE GIVEN
NETWORK:



REWORK
SUBNETWORK:

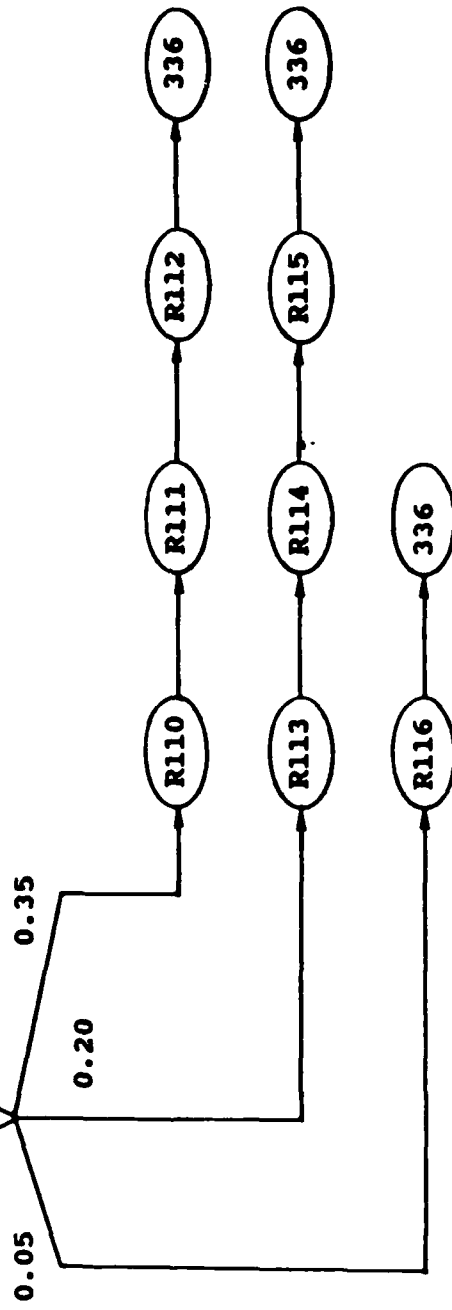


FIGURE 2

EXAMPLE OF REWORK SUBNETWORK

5. *On-Line User's Reference Manual*

The User's Reference Manual is contained in the file "USERS MANUAL" included in the software package. This file may be viewed on-line. Hard-copy may be obtained by printing out the file. A listing of the file follows.

*
* ON-LINE USER'S REFERENCE MANUAL *
* *
* FUR *
* *
* SIMULATION SCHEDULING *
* *

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SEPTEMBER, 1985

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INTRODUCTION

SIMULATION SCHEDULING IS A COMPREHENSIVE SOFTWARE PACKAGE FOR PROJECT SCHEDULING AND ANALYSIS. THE PACKAGE REQUIRES BOTH USER-PREPARED INPUT FILES AND INTERACTIVE INPUT TO GENERATE PROJECT SCHEDULES. BOTH TABULAR AND GRAPHIC OUTPUT ARE OBTAINABLE.

THE PACKAGE CONSISTS OF A SERIES OF CMS FORTRAN EXECS (TERMED "COMMANDS" IN THIS MANUAL) FOR DATA ENTRY, DATA PREPARATION, SCHEDULING SIMULATION, GENERATION OF OUTPUT REPORTS/GRAPHS, AND STORAGE/RETRIEVAL DATA AND RESULTS. THIS MANUAL DISCUSSES THE USE OF THESE COMMANDS AND THE FORMATS OF INPUT FILES WHICH MUST BE PREPARED BY THE USER. IN ADDITION, AN ABBREVIATED GUIDE FOR REMOTE LOG-ON TO THE U. C. BERKELEY COMPUTER NETWORK IS PROVIDED.

FOR A GENERAL DISCUSSION OF THE USE, CAPABILITIES AND MODELING ASSUMPTIONS OF SIMULATION SCHEDULING, THE USER IS REFERRED TO "GUIDE TO SIMULATION SCHEDULING", BY R. C. LEACHMAN ET AL., REPORT 86-1, OPERATIONS RESEARCH CENTER, UNIVERSITY OF CALIFORNIA, BERKELEY.


```
III III    *****  
I    I    *    SUMMARY OF STEPS FOR DATA PREPARATION,    *  
I    I    *    SIMULATION SCHEDULING , OUTPUT REPORTS,    *  
I    I    *    AND STORAGE/RETRIEVAL OF DATA & RESULTS    *  
III III *    *****
```

A LISTING OF THE STEPS REQUIRED TO OPERATE THE SYSTEM IS PROVIDED IN THIS SECTION. A DETAILED DESCRIPTION OF EACH STEP IS PROVIDED IN FOLLOWING SECTIONS.

A. SUMMARY OF STEPS FOR DETERMINISTIC DATA PREPARATION

1. PREPARE INPUT FILE NAMED "SHIP DATA"
2. EXECUTE COMMAND "STARTDAY" (INTERACTIVE INPUT OF PROJECT START DATE)
3. EXECUTE COMMAND "CALENDAR" (INTERACTIVE INPUT OF CALENDAR DATA)
4. EXECUTE COMMAND "MILES" (INTERACTIVE INPUT OF MILESTONE DATES)
- * 5. EXECUTE COMMAND "GEN" (COMPILATION OF NETWORK AND CALENDAR DATA)
- * 6. EXECUTE COMMAND "FTRAN" (INTERACTIVE INPUT OF FLOW TRANSFERS AND COMPILATION OF NETWORK DATA)
7. EXECUTE COMMAND "CAPDATE" (INTERACTIVE INPUT OF CAPACITY EFFECTIVITY DATES)
8. EXECUTE COMMAND "SHOPCAP" (INTERACTIVE INPUT OF SHOP CAPACITIES AND COMPILATION OF CAPACITY DATA)
9. EXECUTE COMMAND "REPDATE" (INTERACTIVE INPUT OF REPORTING DATES)

B. SUMMARY OF STEPS FOR PROBABILISTIC DATA PREPARATION

1. PREPARE INPUT FILE NAMED "REWORK DATA"
2. PREPARE INPUT FILE NAMED "RRES DATA"
- * 3. EXECUTE COMMAND "SINGEN" (COMPILATION OF PROBABILISTIC DATA)

* NOTE: THESE STEPS MUST BE PERFORMED EVEN WHEN DATA IS RETRIEVED. SEE PART E. BELOW.

C. SUMMARY OF STEPS FOR OPERATION OF SIMULATION SCHEDULING

1. PREPARE INPUT FILE NAMED "BPARAMR DATA" (OPTIONAL)
2. EXECUTE COMMAND "SIMSCHED" (INTERACTIVE INPUT OF OPTIONS AND PARAMETERS AND EXECUTION OF SCHEDULING)

D. SUMMARY OF STEPS FOR OUTPUT REPORTS AND GRAPHICS

1. TO GET REPORTS, EXECUTE COMMAND "CUTREP" (INTERACTIVE INPUT OF OPTIONS).
2. TO GET GRAPHS, EXECUTE COMMAND "GRAPH" (INTERACTIVE INPUT OF OPTIONS).

E. SUMMARY OF STEPS FOR SAVING AND RETRIEVING DATA/RESULTS

1. TO SAVE, EXECUTE COMMAND "KEEP" (INTERACTIVE INPUT OF PROJECT NAME).
2. TO RETRIEVE, EXECUTE COMMAND "RETRIEVE" (INTERACTIVE INPUT OF PROJECT NAME). AFTER RETRIEVING DATA, STEPS 5 & 6 OF PART A AND STEP 3 OF PART B MUST BE PERFORMED. OTHER STEPS OF DATA PREPARATION NEED TO BE PERFORMED ONLY IF DATA IS TO BE CHANGED.

```

III III III      *****
 1   1   1      *            OPERATING INSTRUCTIONS      *
 1   1   1      *            FLR                              *
 1   1   1      *            DETERMINISTIC DATA PREPARATION      *
III III III *      *****
    
```

1. PREPARE ORIGINAL NETWORK FILE

=====

1. PREPARE THE ORIGINAL NETWORK DATA FILE NAMED "SHIP DATA". THE FORMAT AND DESCRIPTION OF THIS FILE ARE AS FOLLOWS:

DATA ITEM	TYPE	FIELD
I NODE	I4	16-19
J NODE	I4	22-25
SHOP NUMBER	I3	27-29
WORK CENTER	I2	30-31
HOURS	I5	34-38
NORMAL DURATION	I3	41-43
ACTIVITY TYPE	I1	62

NOTE:
 IN ACTIVITY TYPE, IF THE INTENSITY OF THE ACTIVITY IS FIXED PLEASE INPUT 1, IF THE INTENSITY OF THE ACTIVITY IS VARIABLE LEAVE IT BLANK.

EXAMPLE:

	ACT. NO. I	SH/WC J	MAN HOUR	NORMAL DUR.			ACT. TYPE
3902599311843	0303	0342	0262	720	100	102683	041985 1
3902599311867	0315	0342	0262	720	015	070284	041985
1602599711365	0303	0306	0280	134	003	102683	102883 1
3902599311843	0303	0318	0280	8784	180	102683	072084
1602585311400	0303	0342	0280	56	100	102683	041985
1602599321643	0303	0342	0280	792	100	102683	041985
1602599221820	0309	0853	0280	40	100	103183	011885

11. IF THE ORIGINAL NETWORK FILE IS STORED ON A TAPE, USE THE FOLLOWING PROCEDURE TO READ IT:

- A. LABEL THE TAPE NAME WITH THE NAME "SHIP" AND DELIVER TO U.C. COMPUTER CENTER.
- B. USE COMMAND "DIFM MDPW" TO FIND THE DISK WRITE PASSWORD OF YOUR ACCOUNT. HERE, WE ASSUME IT IS "SHIPYARD".

C. USE COMMAND "TAPDSK" TO READ THE DATA FROM TAPE, THEN
TYPE IN THE FOLLOWING COMMAND TO SUBMIT JOB.

"SUBMIT TAPDSK CLASS B"

THE TAPE WILL BE LOADED AT THE U.C. COMPUTER CENTER AND
THE CONTENTS READ INTO YOUR ACCOUNT.

2. ENTER PROJECT STARTING DATE
=====

USE COMMAND "STARTDAY" TO RUN THE PROGRAM. THE PROGRAM WILL
ASK YOU TO INPUT THE PROJECT (OR REMAINING PROJECT) STARTING DATE.
EVENTS WHICH HAVE NO PREDECESSORS AND WHICH ARE NOT MILESTONES
WILL BE ASSIGNED THIS DATE.

EXAMPLE : (INPUT THE UNDERLINED PORTION)

STARTDAY

PLEASE INPUT THE STARTING DATE OF THE PROJECT (MM,DD,YY)

9,3,63

3. ENTER CALENDAR DATA
=====

USE COMMAND "CALENDAR" TO RUN THE PROGRAM. THE PROGRAM
WILL ASK YOU TO INPUT WORKING DAY OPTIONS FOR SATURDAY AND
SUNDAY. THE PROGRAM WILL GENERATE A WORKING DAY TABLE FOR
TEN YEARS USE. PLEASE FOLLOW THE INSTRUCTIONS DISPLAYED
ON THE SCREEN.

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

CALENDAR

IN YOUR FACILITY, IS SATURDAY A WORKING DAY?
IF YES PLEASE INPUT 1, IF NOT PLEASE INPUT 0.

0

IN YOUR FACILITY, IS SUNDAY A WORKING DAY?
IF YES PLEASE INPUT 1, IF NOT PLEASE INPUT 0.

0
-

ENTER THE YEAR WHICH YOU WANT AS THE STARTING YEAR. THE PROGRAM WILL GENERATE THE WORKING DAY TABLE FOR 10 YEAR'S USE STARTING FROM THE YEAR YOU HAVE INPUT

1983

ENTER ANY DATE OF A SUNDAY BETWEEN YEAR 1983 AND YEAR 1992 (MM,DD,YY)

2,9,86

YOU HAVE INPUT DATE: 2 9 1986, IT IS A SUNDAY BETWEEN YEAR 1983 AND YEAR 1992

INPUT ALL HOLIDAYS (OTHER THAN SUNDAYS & SATURDAYS):MM,DD,YY

AT END OF DATA, PLEASE PRESS RETURN TWICE.
IF THE HOLIDAY DATE IS THE SAME EVERY YEAR, THEN
INPUT : MONTH, DAY, 0

1,1,0

1,20,86

7,4,0

■ ■ ■
■ ■ ■

IF YOU WANT TO CHECK THE HOLIDAYS YOU HAVE INPUT, PLEASE LOOK AT THE FILE "HOLIDAY DATE".

IF YOU WANT TO CHECK THE WORKING DAY TABLE, YOU CAN LOOK AT THE FILE "WORKING DAY".

4. INPUT TARGET DATES FOR MILESTONES

=====

USE "MILES" COMMAND TO RUN FORTRAN PROGRAM. THE PROGRAM WILL ASK YOU TO INPUT THE TARGET FINISH DATE FOR EACH MILESTONE.

----- 6 -----

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

MILES

ENTER NUMBER OF MILESTONES TO BE ADDED

5

-

ENTER EVENT NUMBER OF MILESTONE 1
AND TARGET MILESTONE DATE. (MMDDYY OR 0 IF NONE, E.G. 303,
122585 OR 303,0)

102,0

ENTER EVENT NUMBER OF MILESTONE 2
AND TARGET MILESTONE DATE. (MMDDYY OR 0 IF NONE, E.G. 303,
122585 OR 303,0)

303,122585

" " "
" " "

5. CREATE FILES USED BY THE SYSTEM

=====

USE COMMAND "GEN" TO RUN THE PROGRAM. THE PROGRAM WILL GENERATE
MANY FILES FOR INTERNAL USE.

NOTE :

- A. THE SYSTEM WILL ONLY ACCEPT RESOURCE CAPACITIES AT THE SHOP
LEVEL. IF YOU WANT TO SPECIFY A WORK CENTER CAPACITY, PLEASE
INPUT "1" IN FRONT OF THE SHOP NUMBER, EG. 13108 INSTEAD OF
3108 IN THE ORIGINAL NETWORK FILE. IN CASE OF TWO OR MORE
CAPACITATED WORK CENTERS IN ONE SHOP YOU CAN ADD "2", "3",...
IN FRONT OF THE SHLP NUMBER, EG. 23109, 33112.... IT MEANS
IN SHOP 31 WE WANT TO CONTROL THE RESOURCES USED IN WORK CENTERS
8,9,12,....
- B. IF THERE ARE ANY CYCLES IN THE NETWORK, THE SCREEN WILL DISPLAY
A MESSAGE. PLEASE CHECK FILE "BBRANK1 OUT" TO SEE WHERE CYCLES
EXIST. CORRECT ORIGINAL DATA FILE, AND REPEAT THIS STEP.

6. INPUT FLOW TRANSFER COEFFICIENTS
=====

USE COMMAND "FTRAN" TO RUN THE PROGRAM AND THE PROGRAM WILL ASK YOU TO INPUT THE FLOW TRANSFER COEFFICIENT. EVEN IF YOU ALREADY HAVE ENTERED THE FLOW TRANSFERS, YOU MUST EXECUTE THIS PROGRAM IF ANY CHANGES TO THE NETWORK HAVE BEEN MADE.

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

FTRAN

IS THE FILE "BBTRC DATA" OF FLOW-TRANSFER INPUTS ALREADY COMPLETE?
IF YES, EXEC WILL COMPILE THE NETWORK
Y IF YES, N IF YOU WANT TO ENTER NEW DATA FOR FLOW-TRANSFERS.

N
-

ENTER NODE AND COEFFICIENT OF FLOW TRANSFER
(E.G. 303,0.5 FOR NODE 303 AND COEFFICIENT 0.5)
END OF DATA; TYPE RETURN ONLY

704, 0.80

1816, 0.90

" "

NOTE : THIS PROGRAM PREPARES THE FILE OF TRANSFER COEFFICIENTS BETWEEN EACH PREDECESSOR AND ITS FOLLOWERS AS WELL AS BETWEEN EACH FOLLOWER AND ITS PREDECESSORS.

7. PREFARE CAPACITY FILE
=====

1. USE COMMAND "CAPDATE" TO RUN FORTRAN PROGRAM AND THE PROGRAM WILL ASK YOU TO INPUT CAPACITY EFFECTIVITY DATES INTERACTIVELY.

EXAMPLE :

CAPDATE

ENTER DATES WHEN SHOP CAPACITIES CHANGE. STARTING DATE OF

----- 8 -----

PROJECT IS 9 3 1983, PLEASE ENTER ALL DATES AFTER THIS
TIME WHEN SHOP CAPACITIES CHANGES.
IF END OF DATA PLEASE PRESS RETURN TWICE.

1,5,86

3,20,86

• • •

• • •

- II. USE COMMAND "SHOPCAP" TO RUN THE PROGRAM & THE PROGRAM WILL ASK YOU IF YOU WISH TO INPUT THE SHOP CAPACITIES CORRESPONDING TO EACH EFFECTIVITY DATE. IF YOU ALREADY HAVE THE FILE "BBBCAP DATA" YOU CAN ASK THE PROGRAM TO COMPILE THE DATA DIRECTLY.

EXAMPLE : (INPUT THE UNDERLINED PORTIONS)

SHOPCAP

DO YOU ALREADY HAVE THE FILE BBBCAP DATA FOR SHOP CAPACITY INPUT ? IF YES, EXEC WILL COMPILE THE CAPACITY DATA
Y IF YES, N IF YOU WANT TO ENTER NEW DATA FOR SHOP CAPACITY.

N

ENTER SHOP, NUMBER OF EFFECTIVITY DATE, AND CAPACITY EXPRESSED IN HOURS/DAY. (E.G. 31,4,100 FOR SHOP 31, 4TH EFFECTIVITY DATE, 100 MANHOURS/DAY)
(IF NO CAP BOUND FOR ALL SHOPS, ENTER 0,0,9999)
FIRST EFFECTIVITY DATE IS STARTING DATE OF PROJECT, SECOND EFFECTIVITY DATE IS THE FIRST DATE ENTERED IN "CAPDATE", ETC.
AT END OF DATA, TYPE RETURN ONLY

0,0,9999

END OF DATA, THANK YOU

AFTER ENTERING ALL DATA, EXEC WILL COMPILE THE CAPACITY DATA.

8. DEFINE REPORTING DATES FOR STATISTICS ON RESOURCE USE
=====

USE COMMAND "REDATE" TO RUN THE PROGRAM, FOLLOW THE INSTRUCTIONS ON THE SCREEN AND INPUT THE REPORTING CALENDAR DATES WHICH WILL DEFINE PERIODS OF TIME OVER WHICH AVERAGE RESOURCE USAGE WILL BE REPORTED. THE PROGRAM WILL AUTOMATICALLY INCLUDE THE CAPACITY CHANGE DATES IN THE REPORTING DATES, SO, YOU JUST INPUT THE REPORTING DATES OTHER THAN CAPACITY CHANGE DATES.

EXAMPLE : SAME AS THE EXAMPLE IN SECTION 7.1.

9. RUN DETERMINISTIC NETWORK PROBLEM
=====

AT THIS POINT, ALL THE DATA FOR DETERMINISTIC ANALYSIS ARE READY. IF YOU WANT TO RUN THE DETERMINISTIC ANALYSIS, YOU MAY SKIP THE NEXT STAGE (PREPARATION OF THE PROBABILITISTIC DATA), AND GO DIRECTLY TO SECTION V. USE COMMAND "SIMSCHED" FOR SIMULATION SCHEDULING. FOR DETAILS PLEASE SEE SECTION V, OPERATING INSTRUCTIONS FOR SIMULATION SCHEDULING.

* END OF DETERMINISTIC DATA PREPARATION *

```

111 111      111      *****
  I  I      I      *          OPERATING INSTRUCTIONS          *
  I  I      I      *          FOR                          *
  I  I      I      *          PROBABILISTIC DATA PREPARATION  *
111      1  *      *****
    
```

THE FOLLOWING PROCEDURES CREATE DATA FOR TEST REWORK LOOPS.

1. CRLATE FILE OF REWORK ACTIVITIES

=====

DESCRIBE REWORK SUBNETWORKS IN TERMS OF AN INPUT FILE FOR REWORK ACTIVITIES LABELED BY THE (I,J) PAIR IDENTIFYING THE TEST WHICH THE POTENTIAL REWORK FOLLOWS. THIS FILE IS CALLED "REWORK DATA" IN FORMAT(A4,1X,A4,1X,F4.2,1X,A4,1X,A4,1X,11,5(1X,I3,1X,F4.2)). A SMALL EXAMPLE FOLLOWS :

TEST	ACT.	BRNC	REWORK	ACT.	DISTRIBUTION OF REWORK DURATION												
					I	J	TYPE	D1	P1	D2	P2	D3	P3	D4	P4	D5	P5
9095	903	.22	R111	903	1		1	.99	2	.01							
9095	903	.22	R112	903			1	.99	2	.01							
8897	903	.22	R113	903	1		1	.99	0	.01							
8939	903	.45	R114	903			1	.99	2	.01							
8939	903	.05	R115	R116			1	1.00									
8539	903		R116	R117			2	1.00									
6939	903		R117	R118			1	1.00									
6939	903		R118	903			1	.40	0	.60							
303	860	.80	R928	860			4	.30	6	.20	7	.30	13	.20			
8066	8349	.43	R126	8349			2	.18	3	.21	4	.26	5	.24	7	.11	
8066	8349	.06	R127	8349			2	.12	4	.14	5	.10	5	.03	0	.61	
805	810	.50	R126	810			1	.72	2	.26	3	.02					

II. THE FIRST TWO ROWS, POTENTIAL REWORK FOLLOWING THE TEST (9095, 903) IS DESCRIBED. WITH PROBABILITY 0.22, REWORK ACTIVITY (R111,903) WILL BE REQUIRED AFTER (9095,903) IS EXECUTED, BUT BEFORE ACTIVITIES WITH I=903 CAN BE INITIATED. WITH PROBABILITY 0.22, REWORK ACTIVITY (R112,903) WILL BE REQUIRED INSTEAD. WITH PROBABILITY 1.00-(0.22+0.22)=0.56, NO REWORK FOLLOWING THE TEST (9095,903) IS REQUIRED. BOTH ACTIVITIES (R111,903) AND (R112,903) HAVE A NORMAL DURATION OF 1 DAY WITH PROBABILITY 0.99 AND A NORMAL DURATION OF 2 DAYS WITH PROBABILITY 0.01.

THE ACTIVITY (R111,903) IS A FIXED INTENSITY ACTIVITY (TYPE 1), WHILE (R112,903) IS A VARIABLE INTENSITY ACTIVITY (BLANK TYPE).

NOTE THAT A REWORK BRANCH MAY INCLUDE MORE THAN ONE ACTIVITY IN ORDER TO MODEL MAJOR REWORK INVOLVING SEQUENTIAL STEPS WITH DIFFERENT RESOURCE.

MIXES. FOR EXAMPLE, THE TEST (8939,903) HAS TWO POSSIBLE REWORK BRANCHES FOLLOWING THE TEST. NO REWORK IS REQUIRED WITH PROBABILITY $1.00 - (0.45 + 0.05) = 0.50$. BRANCH (R114,903) IS REQUIRED WITH PROBABILITY 0.45. BRANCH (R115,R116)-(R116,R117)-(R117,R118)-(R118,903) IS REQUIRED WITH PROBABILITY 0.05.

2. CREATE FILE OF REWORK RESOURCES REQUIREMENT

CREATE THE FILE "RRES.DAT" EXPRESSING SHOP/WORK CENTER AND CREW REQUIREMENTS FOR REWORK IN THE FORMAT(14X,A5,A5,1X,I5,2X,I1). A SMALL EXAMPLE FOLLOWS :

TEST I	ACT. J	BRNCH PRDE	REWORK I	ACT. J	SH/WC	NO OF HOURS/DAY
9095	903	.22	R111	903	7204	8
9095	903	.22	R111	903	5602	8
9095	903	.22	R111	903	3802	8
9095	903	.22	R112	903	7204	8
9095	903	.22	R112	903	5602	8
9095	903	.22	R112	903	3805	8
8897	903	.22	R113	903	7204	8

NOTE THAT RESOURCE RATES (EG. 8 MAN-HOURS/DAY) ARE SPECIFIED INSTEAD OF TOTAL RESOURCE HOURS. TOTAL RESOURCE HOURS ARE COMPUTED AS THE RATE PER DAY TIMES THE PROBABILISTIC NORMAL DURATION SPECIFIED IN "REWORK DATA".

3. CREATE SIMULATION INPUT FILES

I. DEFINE STORAGE 4 MEGABYTES

DEFINE STORAGE 4M

II. USE "SIMGEN" COMMAND TO EXECUTE THE PROGRAM CREATING SIMULATION INPUT.

```
*****
* END OF PROBABILISTIC DATA PREPARATION *
*****
```

```

III   III   *****
I     I     *
      I     *   OPERATING INSTRUCTIONS   *
      I I    *   FOR                       *
      I I    *   SIMULATION SCHEDULING   *
      I *    *****
    
```

I. IF YOU PLAN TO RUN THE PROGRAM IN BATCH MODE YOU SHOULD PREPARE THE PARAMETERS' FILE "BPARAMR DATA" FORMAT(50X,15). IF YOU RUN THE PROGRAM INTERACTIVELY, THE PROGRAM WILL ASK YOU TO INPUT THE PARAMETERS ON THE SCREEN. AN EXAMPLE OF THIS FILE FOLLOWS :

EXAMPLE : FILE "BPARAMR DATA"

```

PROJECT NAME STARTING IN COLUMN 1 (E.G., BAINBRIDGE)
SIMULATION PRMTRS ASSIGNMENT POLICY           1
                   INTENSITY LOWER BOUND      50
                   INTENSITY UPPER BOUND     100
                   REWORK LOOPS?              1
                   NUM OF WORK DAYS SIMULATED 1500
                   NUMBER OF SIMULATIONS       1
                   TARGET FINISH TIME          121085
                   RLPORT STYLE                1
    
```

- NOTE: A. IN ASSIGNMENT POLICY INPUT "1" FOR UPGRADING INTENSITY ONLY, OR "2" FOR UP & DOWN GRADING.
- B. IF THERE ARE REWORK LOOPS PLEASE INPUT "1", IF NOT PLEASE INPUT "0".
- C. THE TARGET FINISH TIME IS THE DESIRED FINISH TIME FOR THE PROJECT. IF YOU ENTER "0" THE PROGRAM WILL USE THE EARLY FINISH TIME CALCULATED FROM CPM AS THE TARGET FINISH TIME.
- D. IN REPORT STYLE, IF YOU WANT THE REPORTING TIMES EXPRESSED IN TERMS OF CALENDAR DATES PLEASE INPUT "1". IF YOU WANT TIMES EXPRESSED IN TERMS OF WORKING DAYS SINCE START OF PROJECT, PLEASE INPUT "0".

II. USE COMMAND "SIMSCHED" TO RUN THE PROGRAM. THE PROGRAM WILL ASK YOU TO CHOOSE BATCH OR INTERACTIVE OPERATION. PLEASE REFER TO THE FOLLOWING EXAMPLE.

EXAMPLE :

```

DEFINE STORAGE 4M
-----
    
```

I CMS

SIMSCHED

* S I M S C H E C *

SELECT ONE OF THE FOLLOWING OPTION CODES :

- 1 : INTERACTIVE RUN WITHOUT TEST-REWORK LOOPS (DETERMINISTIC RUN)
- 2 : INTERACTIVE RUN WITH TEST-REWORK LOOPS (STOCHASTIC RUN)
- 3 : BATCH RUN WITHOUT TEST-REWORK LOOPS (DETERMINISTIC RUN)
- 4 : BATCH RUN WITH TEST-REWORK LOOPS (STOCHASTIC RUN)

- BATCH RUN WILL BE SUBMITTED AFTER 20:00

1
-

IF YOU RUN BATCH THE PROGRAM WILL ASK YOU :

ENTER THE LIMIT OF CPU SECONDS FOR YOUR BATCH RUN (0 IF NONE)

600

(IN A LARGE NETWORK, ALLOW ABOUT 20 SECONDS FOR EACH SIMULATION)

ENTER OPTION 0 = READ PARAMETERS FROM INPUT FILE
1 = INTERACTIVE INPUT

1
-

ENTER PROJECT NAME (MAX. 50 CHARACTERS)

BAINBRIDGE

ENTER ASSIGNMENT POLICY :

1 = UPGRADING ONLY, 2 = UP & DOWNGRADING

1
-

ENTER LOWER & UPPER BOUNDS OF INTENSITY :
(USE PERCENTAGE VALUES EG. 100 FOR 100%)

50,150

ARE THERE ANY REWORK LOOPS ? (Y OR N)

N
-

ENTER NUMBER OF SIMULATIONS :
1 = SINGLE RUN WITH DETERMINISTIC RESOURCE REQUIREMENTS
N = N SIMULATIONS WITH RANDOM RESOURCE REQUIREMENTS

20
--

ENTER MAXIMUM NUMBER OF WORKING DAYS TO BE SIMULATED

9999

ENTER NUMBER OF REPORTING DATES WHICH YOU WANT

20
--

ENTER PROJECT TARGET FINISH TIME (MMDDYY, 0 IF NONE)

121085

CHOOSE ONE OPTION FOR REPORT DATES :
0 = REPORT IN WORKING DATES
1 = REPORT IN CALENDAR DATES

1
-

THANK YOU. IN PROCESSING.....
READING FOLL & PRED
READING ACTIVITY-RESOURCE DATA
READING TRANSFER COEFFICIENTS
READING ACTIVITIES DATA
READING REWORK-ACTIVITIES DATA
READING CAPACITY(TIME, RESOURCE)
READING RANK OF ACTIVITIES
END LF DATA . INITIALIZE VALUES FOR SIMULATION
** START SIMULATION
** RUN CYCLE = 1
REPORTING EVENT. TIME IS 14.00000
REPORTING EVENT. TIME IS 35.00000
REPORTING EVENT. TIME IS 57.00000
" " "
" " "
" " "

SCHEDULER TABLE IS EMPTY.
END OF SIMULATION. TIME IS 706.000000

```
*****  
*                                     *  
*    END OF SIMULATION SCHEDULING    *  
*    OPERATING INSTRUCTIONS        *  
*                                     *  
*****
```

```
III    III III    *****
  1    1    1    *
    1   1    1    *    OUTPUT REPORTS AND GRAPHICS    *
      1 1    1    *
        1    III *    *****
```

- A. IF YOU WANT TO SEE THE PROJECT SCHEDULE, PLEASE LOOK AT THE FILE "SCHEDULE OUT". IN A PROBABILISTIC RUN, ONLY THE SCHEDULE OF THE FIRST SIMULATION IS KEPT IN THIS FILE.
- B. IN ORDER TO OBTAIN REPORTS OF THE SIMULATION RESULTS, A STATISTICAL PROGRAM CALCULATES THE AVERAGE RESOURCES USED AT EACH CONFIDENCE LEVEL FOR EACH SHOP OR WORK CENTER IN EACH PERIOD DEFINED BY THE REPORTING DATES. CONFIDENCE LEVELS FOR THE DATES EACH MILESTONE IS REALIZED AND FOR THE TOTAL AMOUNT EACH RESOURCE IS USED ARE ALSO CALCULATED.

USE COMMAND "OUTREP" TO RUN FORTRAN PROGRAM. THE PROGRAM WILL ASK FOR INTERACTIVE INPUT AS FOLLOWS.

EXAMPLE : (INPUT UNDERLINED PORTIONS)

OUTREP

SELECT ONE OF THE FOLLOWING OPTION CODES FOR OUTPUT (REPORT OUT):

- 0 : PRINT
- 1 : WRITE TO DISK IN A FILE NAMED 'REPORT OUT'

1
-

ENTER REPORTING OPTION CODE :

- 1 = SHOPS ONLY
- 2 = WORKCENTERS ONLY
- 3 = SHOPS & WORKCENTERS

3
-

ENTER CALENDAR OPTION CODE :

- 0 = REPORT IN WORKING DAYS
- 1 = REPORT IN CALENDAR DATES

1
-

- C. FOR EXAMPLES OF THE OUTPUT, PLEASE REFER TO APPENDIX A OF
----- 17 -----

"GUIDE TO SIMULATION SCHEDULING".

D. IN ORDER TO OBTAIN GRAPHICAL OUTPUT, YOU SHOULD LOGON TO THE SYSTEM USING A TERMINAL WITH GRAPHICS CAPABILITY, SUCH AS A TEKTRONIX 4015. USE COMMAND "GRAPH" TO RUN FORTRAN PROGRAM. THE PROGRAM WILL ASK YOU TO SELECT WHICH RESULTS YOU WANT TO BE GRAPHED.

EXAMPLE : (INPUT UNDERLINED PORTIONS)

GRAPH

```
*****  
*   G R A P H S   *  
*****
```

SELECT GRAPH TYPE YOU WANT :

- 1 = MILESTONE
- 2 = LOAD PROFILE
- 3 = TOTAL RESOURCE USAGE
- 4 = TERMINATE EXECUTION

2
-

***** LOAD PROFILE *****

CHOOSE OPTION : 0 = WORKCENTER LEVEL
1 = SHOP LEVEL

1
-

CHOOSE OPTION : 0 = IN WORKING DAYS
1 = IN CALENDAR DATE

1
-

ENTER SHOP NUMBER AND CONFIDENCE LEVEL (IN %)

31,90

NEED MORE? Y IF YES, N IF NO

Y
-

SELECT GRAPH TYPE YOU WANT :

- 1 = MILESTONE
- 2 = LOAD PROFILE

FILE: USERS MANUAL A1 VM/SP CMS RELEASE 3.1.E 851112, CFC - U.C. BERKELEY

3 = TOTAL RESOURCE USAGE
4 = TERMINATE EXECUTION

1
-

***** MILESTONE GRAPH *****

ENTER MILESTONE NODE YOU WANT

303

NEED MORE? Y IF YES, N IF NO

Y
-

SELECT GRAPH TYPE YOU WANT :

1 = MILESTONE
2 = LOAD PROFILE
3 = TOTAL RESOURCE USAGE
4 = TERMINATE EXECUTION

3
-

***** TOTAL RESOURCE USAGE *****

ENTER SHOP NUMBER, OR 9999 FOR GRAND TOTAL

9999

NEED MORE ? Y IF YES, N IF NO

N
-

* END OF OUTPUT REPORTS AND GRAPHICS *

```
III    III III III    *****  
I    I    I    I    *  
  I    I    I    I    *    SAVING AND RETRIEVING DATA AND RESULTS    *  
  I I    I    I    I    *  
  I    III III *    *****
```

I. IF YOU WANT TO SAVE THE DATA AND RESULTS FOR A PARTICULAR PROJECT PLEASE USE COMMAND "KEEP". THE PROGRAM WILL ASK YOU TO INPUT THE PROJECT NAME AS THE FILE NAME. THE PROGRAM WILL SAVE THE INPUT DATA & RESULTS, SO YOU CAN USE THE SAME PROCEDURE TO RUN OTHER PROJECTS WITHOUT LOSING DATA FOR THE PROJECT

EXAMPLE : (INPUT THE UNDERLINED PORTION)

KEEP

***** KEEP *****

THIS EXEC COPIES THE INPUT FILES AND RESULTS AND LABELS THEM WITH THE PROJECT I.D. TO KEEP THEM ENTER THE PROJECT I.D. (UP TO 8 CHARACTERS)

BAINBRID

II. IF YOU WANT TO RETRIEVE OLD DATA TO MAKE NEW ANALYSIS, PLEASE USE COMMAND "RETRIEVE". THE PROGRAM WILL ASK YOU TO INPUT THE PROJECT I.D. AND THE PROGRAM WILL RETRIEVE THE FILES AND GIVEN THEM ACTIVE FILENAMES AND FILEMODES.

EXAMPLE : (INPUT UNDERLINED PORTION)

RETRIEVE

***** RETRIEVE *****

THIS EXEC RETRIEVES THE FILES TO THEIR ORIGINAL NAMES AND MODES. ENTER THE PROJECT I.D. (UP TO 8 CHARACTERS)

BAINBRID

```
*****  
*    END OF SAVING AND RETRIEVING    *  
*    DATA AND RESULTS    *  
*****
```

6. Bibliography of Research Reports and Articles

- [1] Dincerler, A., "Project Scheduling in Project-Oriented Production Systems," ORC 85-11, Operations Research Center, University of California, Berkeley, (Sept. 1985).
- [2] Hackman, S. T., "A General Model of Production: Theory and Application," ISYE Report Series C-84-1, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, (1984).
- [3] Hackman, S. T. and R. C. Leachman, "An Aggregate Model of Project-Oriented Production. I: Construction of a Dynamic Production Function Based on a General Framework," Report J-85-8, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, (1985).
- [4] Hackman, S. T. and R. C. Leachman, "An Aggregate Model of Project-Oriented Production. II: Replications and Aggregations of the Primitive Network Structure," Report J-85-9, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, (1985).
- [5] Leachman, R. C., "Aspects of Dynamic Production Planning," ORC 79-8, Operations Research Center, University of California, Berkeley, (July 1979).
- [6] Leachman, R. C. and J. Boysen, "Multiple Resource Smoothing in Shipyard Planning," ORC 81-15, Operations Research Center, University of California, Berkeley, (June 1981).
- [7] Leachman, R. C., "Production Planning for Multi-Resource Network Systems," ORC 80-18, Operations Research Center, University of California, Berkeley, (August 1980); appeared in Naval Research Logistics Quarterly, Vol. 29, No. 1, pp.47-54, (March 1982).

- [8] Leachman, R. C. and J. Boysen, "An Aggregate Network Model of Ship Overhaul," ORC 82-2, Operations Research Center, University of California, Berkeley, (March 1982).
- [9] Leachman, R. C., "Multiple Resource Leveling in Construction Systems Through Variation of Activity Intensities," ORC 80-17, Operations Research Center, University of California, Berkeley, (August 1980); appeared in Naval Research Logistics Quarterly, Vol. 30, No.2, pp. 187-198, (August 1983).
- [10] Leachman, R. C. and J. Boysen, "An Aggregate Model for Multi-Project Research Allocation," in PROJECT MANAGEMENT: METHODS AND STUDIES, edited by B. V. Dean, North Holland, Amsterdam, (1985).
- [11] Mizarch, M., "Dynamic Models of Detailed and Aggregate Production Networks," ORC 85-10, Operations Research Center, University of California, Berkeley (Sept. 1985).
- [12] Shephard, R. W., Al-Ayat, R. A. and Leachman, R. C., "Shipbuilding Production Function: An Example of a Dynamic Production Function,"; ORC 78-25, Operation Research Center, University of California, Berkeley, (August 1978); appeared in QUANTITATIVE WIRTSCHAFTSFORSCHUNG FESTSCHRIFT VOLUMN, edited by Horst Albach et. al., J. C. Mohr, Tubingen, Germany, 1977.
- [13] Shephard, R. W., "Dynamic Production Functions," ORC 78-8, Operations Research Center, University of California, Berkeley, (May 1978); appeared in Proceedings of the Third Symposium on Operations Research, University Mannheim (Sept. 1978).
- [14] Shephard, R. W. and R. Fare, "Dynamic Theory of Production Correspondences, Verlag Anton Hain, Cambridge, Mass., (1979).

- [15] Shephard, R. W., "Dynamic Production Networks," ORC 81-7, Operations Research Center, University of California, Berkeley, (April 1981).
- [16] Shephard, R. W. and K. T. Mak, "Simulation of a Ship Overhaul Project Network," ORC 82-3, Operations Research Center, University of California, Berkeley (March 1982).
- [17] Shephard, R. W. and S. T. Hackman, "Production Networks: A Dynamic Model of Production," ORC 83-4, Operations Research Center, University of California, Berkeley, (June 1983).

Appendix A. Sample Output Reports and Graphics

1

PROJECT NAME : BAINBRIDGE 20 RUN(S) USING UPGRADING ONLY INTENSITY RANGE 60 - 120

.....

PROJECT START DATE : 9 1 1983

ACTIVITY INTERNAL #	I	J	SCHEDULE START DATE	FINISH DATE
1	1	303	9 1 83	10 5 83
2	1	309	9 1 63	12 26 83
3	1	312	1 17 64	1 19 64
4	1	336	9 1 83	12 26 83
5	1	342	2 20 64	3 16 84
6	1	805	9 1 83	1 3 84
7	1	807	9 20 83	2 14 84
8	1	810	9 1 83	1 12 84
9	1	812	9 2 83	1 27 84
10	1	815	9 2 83	2 16 84
11	1	820	9 2 83	2 10 84
12	1	825	9 2 83	7 20 84
13	1	828	9 1 83	9 6 84
14	1	830	9 1 83	9 14 84
15	1	835	9 1 83	8 6 84
16	1	836	11 29 83	11 30 84
17	1	838	9 16 83	10 10 84
18	1	840	9 1 83	10 2 84
19	1	843	9 1 83	11 6 84
20	1	850	9 28 83	1 1 85
21	1	860	9 20 83	1 3 85
22	1	863	9 2 83	12 25 84
23	1	903	9 1 83	1 30 84
24	1	2306	9 1 83	9 12 83
25	1	2513	9 1 83	11 9 83
26	1	2569	9 1 83	10 5 83
27	1	2592	9 1 83	11 9 83
28	1	3202	9 1 83	11 9 83
29	1	4312	9 1 83	9 12 83
30	1	4402	10 6 83	1 6 84
31	1	4422	9 1 83	12 2 83
32	1	4502	9 1 83	10 5 83
33	1	4714	9 2 83	11 16 83
34	1	4820	9 23 83	10 16 83
35	1	5002	9 1 83	10 5 83
36	1	5136	11 10 83	12 2 83
37	1	5156	9 2 83	9 15 83
38	1	5198	12 27 83	1 13 84
39	1	5811	9 1 83	10 11 83
40	1	6302	9 1 83	11 9 83
41	1	6310	9 1 83	2 22 84
42	1	6312	9 1 83	9 12 83
43	1	7112	9 1 83	11 15 83
44	1	7206	9 1 83	9 2 83
45	1	8007	9 1 83	1 17 84

PROJECT NAME : BAINBRIDGE 20 KM(S) USING UPGRADING ONLY INTENSITY RANGE BC - 120

PROJECT START DATE : 9 1 1963

RESOURCE USE (AVE. MAN-HOURS PER DAY) BY SHOP

PERIOD ENDED	C O M F I D E N C E L E V E L										MEAN	SIC DEL
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
112183	0	0	0	C	0	0	0	0	0	0	0.0	0.0
121983	0	0	0	0	0	0	0	0	0	0	0.0	0.0
11684	0	0	0	0	0	0	0	0	0	0	0.0	0.0
21484	50	52	54	56	59	63	64	66	68	70	59.3	6.6
31484	49	52	52	56	63	66	69	70	75	76	62.4	9.4
41184	59	63	64	69	70	74	76	79	80	93	71.3	9.7
51184	70	71	71	73	76	80	82	86	90	93	76.4	7.8
61184	66	70	71	71	75	80	82	85	90	93	76.8	9.9
71184	45	50	50	50	56	61	61	65	70	91	72.2	13.1
80984	50	56	61	63	66	73	74	75	80	86	67.4	10.4
90784	36	40	45	46	49	52	56	62	65	78	51.6	11.2
101184	0	34	49	45	59	55	63	65	68	69	50.2	20.3
110684	47	49	49	59	62	63	65	67	66	64	58.8	8.4
120584	47	49	49	59	63	63	65	67	68	69	59.1	8.3
10385	47	49	49	59	63	63	65	67	68	69	59.1	8.3
13185	47	49	49	59	63	63	65	67	68	69	59.1	8.3
30485	47	49	49	59	63	63	65	67	68	69	54.1	8.3
32985	45	47	47	45	51	59	63	65	68	69	55.5	8.6
42985	0	0	0	1	7	9	10	21	47	65	14.2	20.1
100985	0	0	0	C	0	0	0	C	0	1	0.1	0.3

PROJECT NAME : BAINBRIDGE 20 RUN(S) USING UPGRADING ONLY INTENSITY RANGE 60 - 120

PROJECT START DATE : 9 1 1983

TOTAL MAN-HOURS BY SHOP

SHOPS	C O M F I D E N C E										L E V E L			MEAN	STC DLY
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	70%	80%	90%		
2	17670	18098	19065	19405	20369	20539	20904	21291	22151	22151	23389	20237.3	1000.5		
3	1327	1337	1390	1412	1437	1460	1514	1535	1556	1556	1653	1451.0	95.9		
5	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		
6	11986	12403	12702	12936	13191	13431	13564	13686	13765	13765	13840	13081.0	602.2		
7	128	134	141	151	154	157	161	161	162	162	172	150.5	13.6		
9	1996	2034	2083	2119	2147	2194	2209	2235	2296	2296	2311	2153.5	101.1		
10	321	336	354	355	358	364	370	390	400	400	420	364.0	27.3		
11	93553	94235	94407	95388	95893	96037	96145	96210	96274	96274	96647	95362.1	1007.9		
12	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		
13	1161	1249	1279	1291	1305	1311	1320	1375	1395	1395	1475	1310.9	60.2		
14	32	34	37	38	39	40	41	43	45	45	47	39.3	4.4		
16	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		
17	68052	68189	68600	68872	69402	69619	69721	69869	70324	70324	70644	69241.9	812.1		
19	19280	20411	21007	21124	21921	22070	22873	24283	24905	24905	26075	22153.1	1962.9		
20	417	417	427	430	470	475	486	488	497	497	513	459.2	33.8		
22	1206	1260	1286	1314	1414	1439	1518	1565	1640	1640	1667	1418.5	153.1		
23	1922	1943	1947	1962	1969	1973	1984	1988	2002	2002	2033	1970.0	30.5		
24	3747	4216	4369	4550	4844	4721	4830	4983	5154	5154	5229	4615.7	449.1		
26	97818	98126	98715	98852	99185	99511	99545	99954	100118	100118	101239	99126.7	1076.8		
30	11422	12242	12477	12806	12879	13072	13711	13769	14024	14024	14370	12996.0	494.4		
31	108505	108588	109083	109354	110211	110354	110657	111368	111947	111947	113408	110205.0	1394.8		
32	8387	9260	9961	10416	10494	10671	11143	11370	11841	11841	12044	10467.7	1102.9		
33	2441	2605	2682	2800	2811	2831	2939	2948	2973	2973	3041	2818.4	150.6		
34	19426	20298	20663	20934	21182	21554	22369	22554	23664	23664	24594	21584.4	1532.9		
35	10503	10591	11042	11173	11546	11785	11929	12068	12515	12515	13021	11563.2	767.8		
36	19	19	20	23	23	24	25	25	26	26	27	22.5	2.8		
37	19	20	22	22	23	24	25	26	27	27	28	23.3	2.9		
38	169368	191120	191247	192397	192862	193030	193778	194261	194479	194479	198207	192640.8	2490.5		
39	15269	16124	16655	16797	17205	18090	18585	18719	20491	20491	21328	17731.7	1786.1		
40	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		
41	47150	47857	48814	49279	49356	49917	50794	50865	51852	51852	52605	49695.6	1021.9		
42	128	129	140	146	156	166	172	179	188	188	191	157.4	11.8		
47	7	8	6	8	9	9	9	10	10	10	11	8.8	1.2		
50	4	5	6	7	7	7	7	8	9	9	9	6.8	1.4		
51	152164	153039	154233	154596	155247	155275	156275	157096	157942	157942	159781	155255.2	2235.4		
56	298709	300974	301520	302234	304515	309185	310457	312413	313486	313486	315595	306325.4	5678.4		
57	90175	96056	98763	99323	100371	101796	102870	104705	105954	105954	108524	100470.0	4615.3		
62	1058	1080	1107	1124	1149	1187	1212	1250	1255	1255	1343	1164.2	51.6		
64	30205	32485	30703	30992	31261	32075	32395	32516	33009	33009	34627	31727.2	1457.0		
67	92862	93286	93442	93857	94858	95305	95873	96066	96427	96427	101300	94923.5	2014.8		
70	227	233	248	253	262	276	278	291	302	302	306	265.0	27.5		
71	96072	97594	98746	99404	100242	102479	102479	102512	102858	102858	105966	100574.0	2910.4		
72	122863	123799	125873	129376	130534	132441	131737	139774	140920	140920	147431	132214.2	7569.8		
81	2490	2499	2516	2519	2577	2590	2609	2637	2655	2655	2721	2572.1	73.5		
94	745	758	764	771	779	781	786	792	808	808	810	776.1	44.2		
99	35407	36414	38113	38940	39255	39656	40252	40862	41419	41419	42352	39142.4	2041.4		

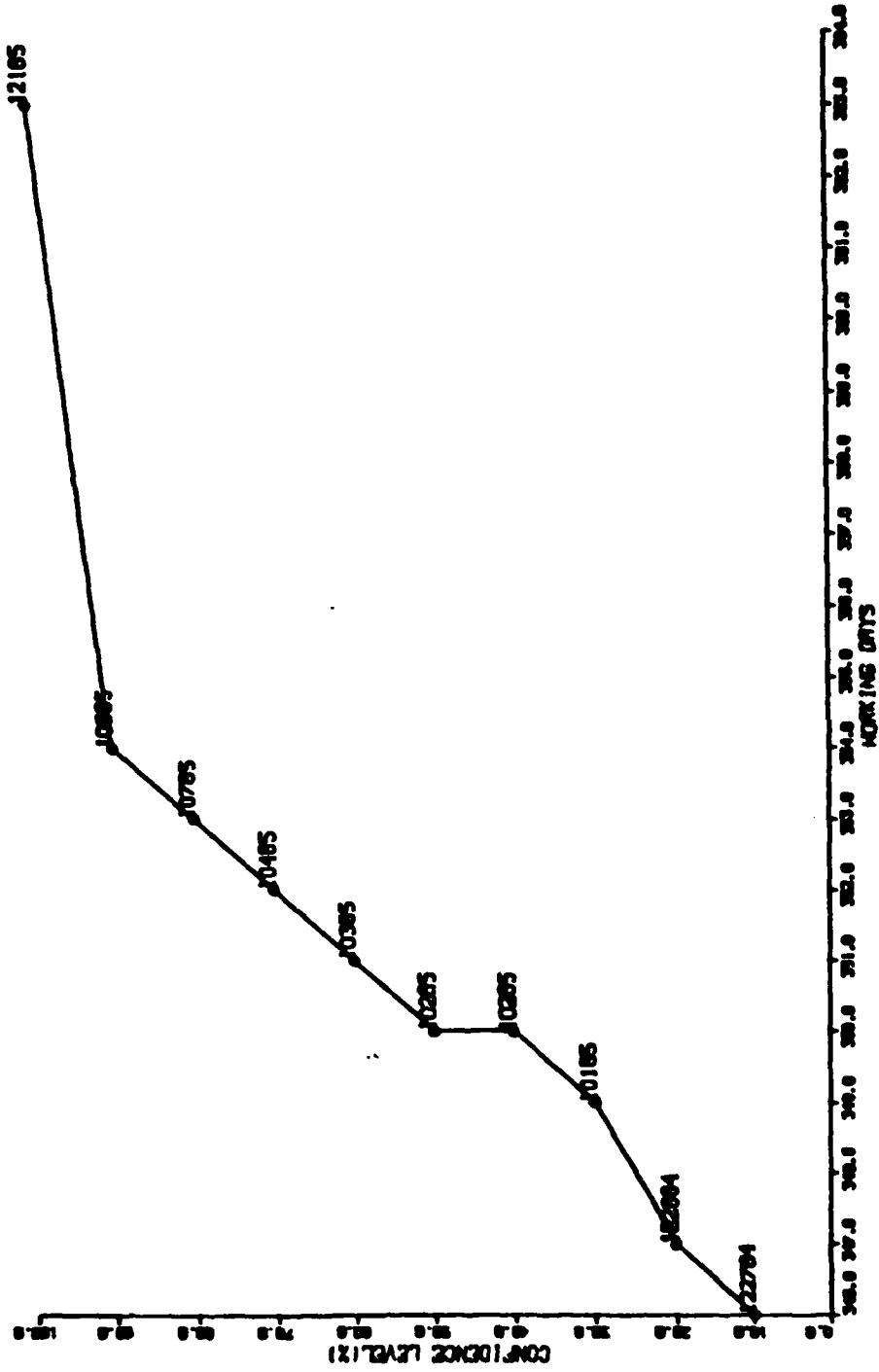
PROJECT NAME : HAINSBIDGE 20 RUN(S) USING UPGRADING ONLY INTENSITY RANGE 80 - 120

PROJECT START DATE : 9 1 1983

DATES OF MILE-STONES

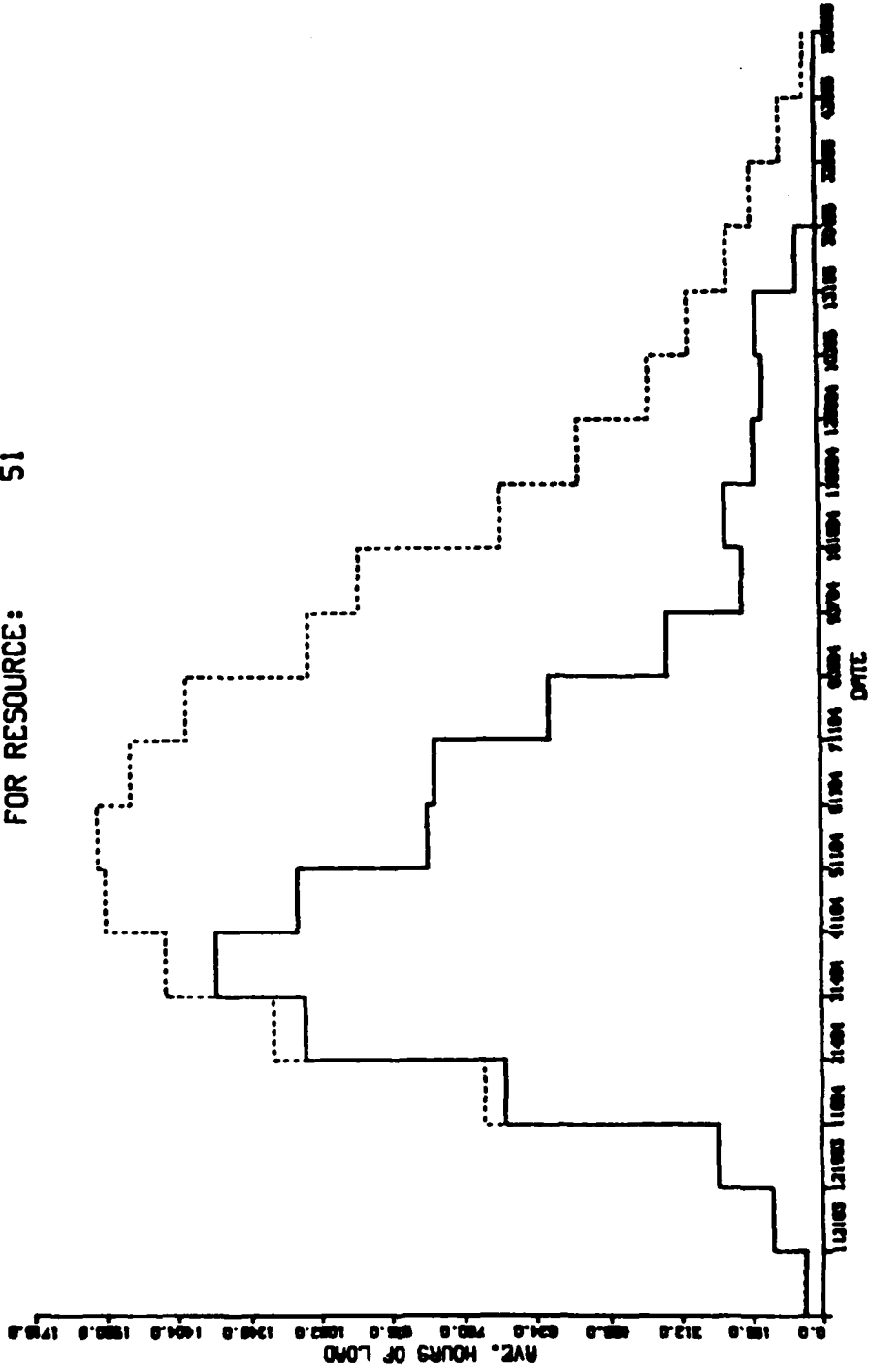
MILESTONE	10X	20X	30X	40X	50X	60X	70X	80X	90X	100X	MEAN	STL	ULV
503	831005	831005	831005	831005	831005	831005	831005	831005	831005	831005	831005.C		0.0
392	860512	860512	860512	860512	860512	860512	860512	860512	860512	860512	860511.2		557.9
850	850101	850101	850101	850101	850101	850101	850101	850101	850101	850101	850101.6		3605.7

SIMULATED REALIZATION
OF MILESTONE # 850

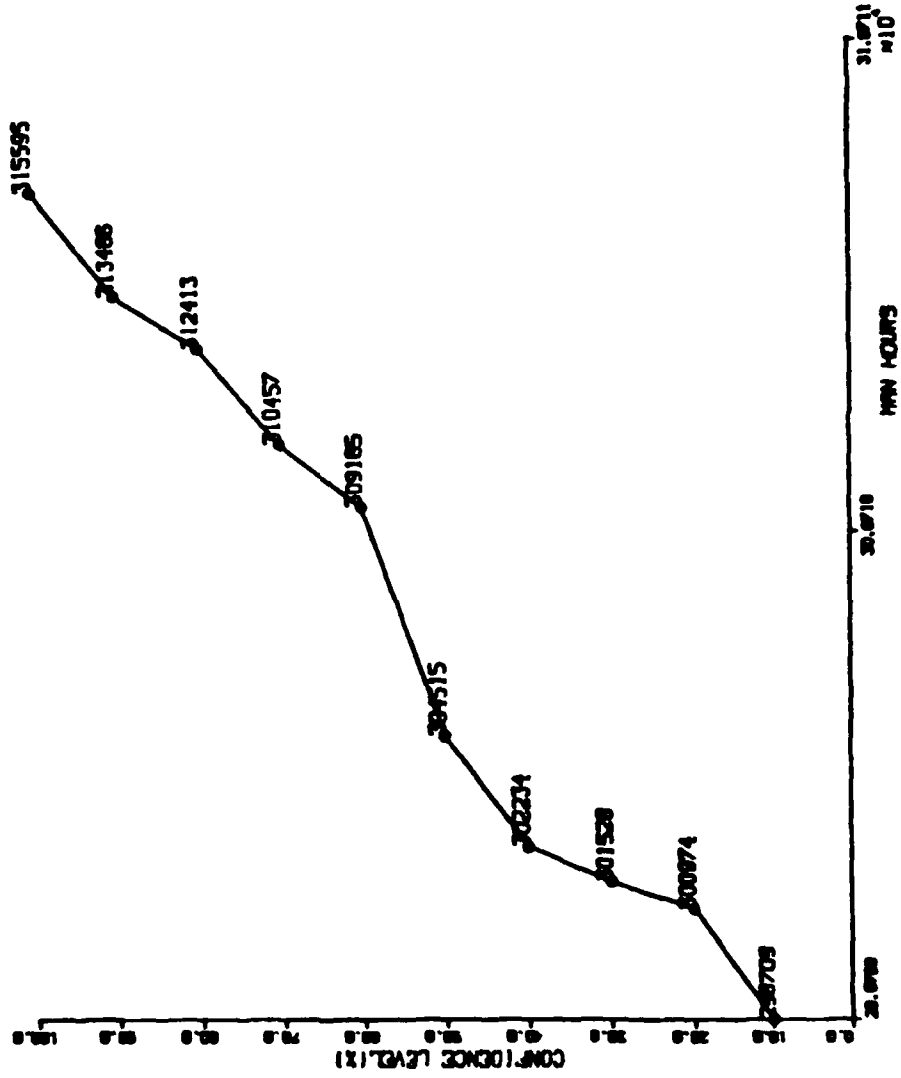


SIMULATED LOAD PROFILE

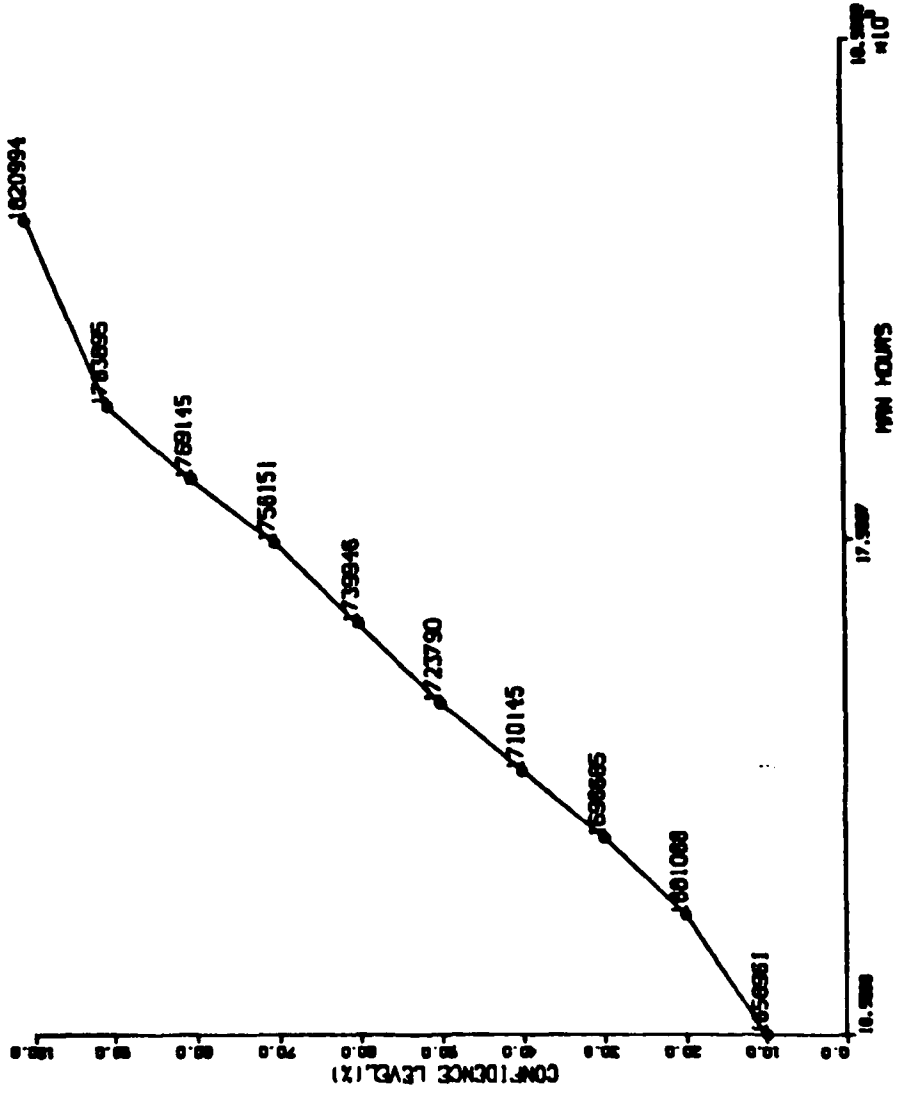
CONFIDENCE LEVEL: 100
FOR RESOURCE: 51



SIMULATED TOTAL REQUIREMENT
FOR RESOURCE # 56



SIMULATED TOTAL REQUIREMENT
FOR RESOURCE # ALL



END
DITIC

7-86