COMPUTER TECHNOLOGY

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A1

1620 PERT

Program Evaluation and Review Technique

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Modifications or revisions to this program, as they occur, will be announced in the appropriate Catalog of Programs for IBM Data Processing Systems. When such an announcement occurs, users should order a complete new program from the Program Information Department.

A2

DECK KEY

Deck 1	PERT - Part 2 SPS
Deck 2	PERT - Part 1 SPS
Deck 3	PERT - Part 2 Condensed
Deck 4	PERT - Part 1 Condensed
Deck 5	Sample Problem

A3

1620 PERT (Program Evaluation and Review Technique)

A. Purpose/Description: To allow 1620 users to utilize project planning and scheduling concepts. The 1620 PERT program combines least cost estimating and scheduling with the determination of the risk involved in attempting to complete a total project (or any part thereof) within assigned completion times. The program allows negative slack times to be produced for the determination of other existing critical paths. Projects may be planned, scheduled, monitored and changed with this program.

B. Method: Iteration

C. Restrictions and Range: No node may be numbered 000 or may be above 999. For a 20K machine, the sum of the number of the highest numbered node and the number of jobs must be 1672 or less. To work in conjunction with Part II, the sum of twice the number of jobs plus the highest numbered node must be 3100 or less in addition to the previous requirement. Node numbering is completely random.

D. Accuracy: N/A

E. Machine Configuration: 1622 with a memory of 20K

F. Program Requirements: 20K for the above requirements. 40K for 3672 & 7100 respect. 60K for 5672 & 11000 respect.

G. Source Language: Written in SPS.

H. Program Execution Time: Running time depends upon node numbering and the total number of jobs.

I. Check Out Status: Run successfully ten times. This program and its documentation were written by an IBM employee. It was developed for a specific purpose and submitted for general distribution to interested parties in the hope that it might prove helpful to other members of the data processing community. The program and its documentation are essentially in the author's original form. IBM serves as the distribution agency in supplying this program. Questions concerning the use of the program should be directed to the author's attention.

A7

January 14, 1963

Comm/Wash

1620 PERT 10.3.006 - Addendum to: (this Addendum supersedes all previous addendum which should be destroyed)

1620 Library
Program Distribution Center
Post Office Box 790
White Plains, New York

The following changes are to be incorporated into the 1620 PERT program (10.3.006) card decks and write-up.

1. Page 19, D, Error 2 - Delete: "To find the first "last" node type out locations 3247-49". Add .. 2925-27.

2. Page 19, D, Error 3 - Delete: "To find the first "first" node type out locations 3244-46." Add ....2922-24.

3. Some models of the 1620 will give a write check when punching a pass II output card that is on the critical path with zero slack. This is because a job on the critical path has been indicated by an asterisk in cc.75 which is a special character (11-4-8) in the numeric mode. These models will not write the asterisk in the numeric mode without a write check although earlier models will. A remedy to this discrepancy is as follows:

   a. In the condensed deck, Part I, card #28 change cc.59-60 from I4 to 00 or to any alpha-numeric code which is valid such as 0*.

      Write-up changes: Appendix C, Part I , SPS Listing, page 47.

      from 01862 16 00249000J4 7180 TFM Record & 148, 14, 10 Z
      to 01862 16 00249000*0 7180 TFM Record & 148, 00, 10 Z

Write-up Changes: Appendix D, Part I condensed listing, Page 53
Line 29 (card 28)

from I4 Z 0010181401874000028
to 00Z 0010181401874000028

b. This correction eliminates the asterisk altogether and places zeros in its place (or any code desired). This however, is a minor point since the asterisk is merely an eye-catcher to point out critical paths which have zero slack time. If desired, when listing the Part I or II output deck, a test can be made for zero slack or an 0-2-8 punch on the 407 and an asterisk generated in its place. The use of a negative zero was suggested but this may lead to confusion with respect to paths containing negative slack.

4. It should be pointed out that in cases where Part II is not used, cc.28-50 of the input cards to Part I may be used for job descriptions since Part I is in the alpha numeric mode. (see Page 29). This will in no way impare the operation of Part I.

5. In the write-up, Page 27, Part II input, Section II, the statement "the proper Type 3 cards is chosen ..." should be replaced by "... proper Type 2 cards ..."

6. In the write-up, Page 15, last sentence, 3rd paragraph should be: "Zero slack will be indicated by a code chosen by the user."

7. In the write-up, Page 17, under Type 1 - Heading or Description Cards. Delete the entire paragraph and insert: "These are identified by an 0-2-8 punch in cc.1 followed by any information desired. These cards cannot be used with Part II."

8. In the write-up Page 17, under Data Deck next to #3. one type 4 card Add: (if used, if not used one blank card - Type 3 - is required.

9. In the write-up, Page 20, next to "75" delete: "Contains * if this is a critical job". Add: "Contains code desired by user." (as outlined in this addendum #3a.)

10. In the write-up, Page 21 - Suggestions, Add: The specialized parametric linear programming algorithm referred to can be found in the SHARE abstracts under the IBM 7090 abstracts.

11. It has been shown that Type 1 cards in Part I have caused errors in the running of the program. The following changes will remedy this:

a. All Type 1 cards will have an 0-2-8 punch in cc.1.

Condensed Deck Changes

b. Change Card #45 Part I condensed deck to:

3700101 00500 450257800101 3900101 00400 4902530 00000
1400104 00000*...

c. Change Card #46 Part I condensed deck to:

460264601200420000000000410000000004100000000004100000000*...

d. Change Card #65 Part I condensed deck to:
37033750050045035840337539033750040049030780000032033740000*...

e. Change Card #66 Part I condensed deck to:
14033780000046039660120049036460000039033750040042000000000*...

f. Make the corresponding changes to the Part I condensed listing write-up, Page 54.

SPS Source Deck Changes Part I, Appendix C

	FROM		TO	
17040	RCD1••	RACD REC1	RCD1•••	RACD REC1 (same)
17050		SF REC1-1		BNR * & 36, REC1
17060		CM REC1&3,0		WACD REC1
17070		BE LAST CD		B READ1
17080		CM REC1, 0, 10		SF REC1-1
17090		BE DATA1		CM REC1&3, 0
17100		CM REC1, 70, 10		BE LAST CD
17110		BNL DATA1		B DATA1
17120	PCH1••	WACD REC1		WACD REC1 (same)
11170	READ••	RACD RECORD	READ•••	RACD RECORD (same)
11180		CM RECORD, 70, 10		BNR * & 36, RECORD
11190		BNL END & 12		WACD RECORD
11200		CM RECORD & 3,0		B READ
12010		BE END		CM RECORD & 3,0
12020		CM RECORD,0,10		BE END
12030		BE END & 12		BB
12040		BNF READ, READ-1		NOP
12050		WACD RECORD		NOP
12060		B READ		NOP
12070		DORG *-3		DORG *-3 (same)

The corresponding changes should be made in the SPS Part I write-up of Appendix C.

J. C. Patton

JCP:doh

TABLE OF CONTENTS

INTRODUCTION

This description of the 1620 PERT program assumes familiarity with the concepts of PERT as given in: General Information Manual PERT...a dynamic project planning and control method; IBM E20-8067.

The 1620 Program Evaluation and Review Technique (PERT) program is composed of two main parts. Part I, written by Frank H. White, is an adaptation of Ray N. Sauer's Least Cost Estimating and Scheduling (LESS) program for the 1620. A description of the modified LESS program as it applies to PERT will be given in this report. Part II, written by John C. Patton, in conjunction with Part I can be used to establish completion times as well as to adapt to given completion times for many types of contractural projects in business and industry.

In particular, Part I is used to determine the best project completion time based on critical path scheduling. After a project completion time has been selected Part II is then used to determine the risk involved in attempting to complete a given activity, in completing a portion of a project, or in completing an entire project in a specified amount of time.

The PERT program permits the adjustment of a schedule so as to arrive at a level of risk acceptable to management. Once a management policy is established as to what constitutes a desirable level of risk in meeting scheduled times, a schedule can be developed which is based on that policy and which uses the basic PERT network data. For each activity an appropriate time would be determined and assigned having the same level of risk.

The following report covers the concepts of arrow diagramming, assignment of time estimates, assignment of completion times, and all operating procedures required for the successful utilization of the 1620 PERT program - Part I. In addition, the function of PERT - Part II is covered in detail. The method of determining the risk involved in completing an activity or project is explained on the basis of the theory underlying the normal distribution function. This theory will not be discussed, but its results and impacts upon the feasible usage of probability as a good and substantial measure of risk will be handled. The operating features and procedures for PERT - Part II will be discussed in addition to the specifications for format and machine characteristics for both Parts.

PART I

ARROW DIAGRAMMING FOR 1620 PERT

Basic to the utilization of PERT is an arrow diagram which pictorially describes the network of events or activities to be performed in completing a project. It is the simulation, on paper, of the total project, and the order in which each activity is to be performed. Time duration estimates are assigned to each job which is represented by an arrow. All the job arrows are connected together in the order of their sequence within the project to form the total project network as shown in Fig. 1.

The initial information which must be supplied to the PERT program is as follows:

1) A complete list of all jobs to be performed in order to complete the project.

2) Three estimates of time duration needed to complete each job:

   a) Optimistic time (A) - the least time in which it can be expected that the job can be completed.

   b) Pessimistic time (B) - the most time in which it can be expected that the job can be completed.

   c) Most likely time (M) - that duration of time that the job would normally require for completion had the job been performed many times over. (By no means is M required to be the average of A and B, although at times it may be.)

   Example: For Job 8,1 (Fig. 1) the three time estimates are 5-7-10; A=5, M=7, B=10. (Units of weeks)

The durations are three completely separate and distinct estimations based upon the knowledge of an experienced person or persons who have performed the jobs before or in all probability will have to perform the job during the project time.

The three estimates determine the shape of a normal distribution curve upon which the results of the PERT program are based.

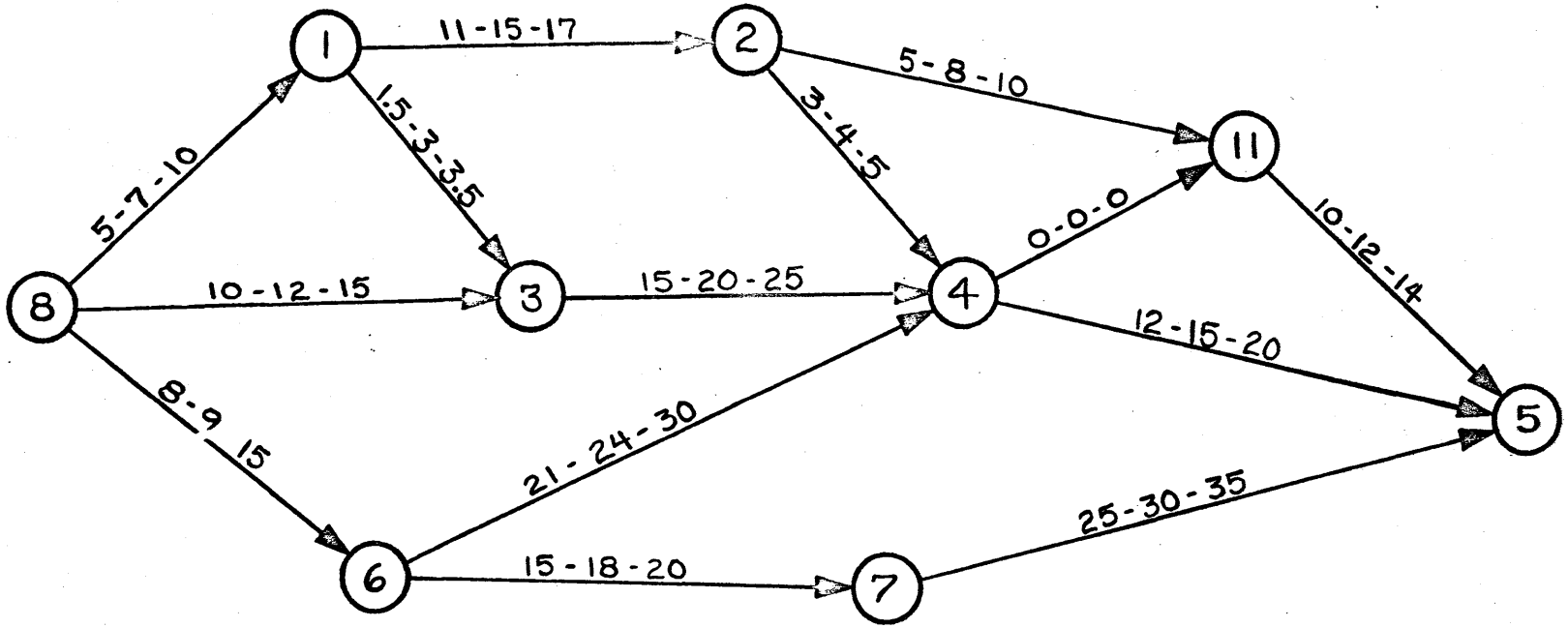
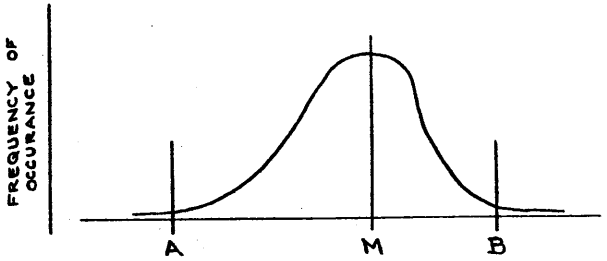

1
2
11
8
3
4
5
6
7
11-15-17
5-8-10
1.5-3-3.5
3-4-5
5-7-10
0-0-0
10-12-14
10-12-15
15-20-25
12-15-20
8-9 15
21-24-30
25-30-35
15-18-20

FIG. 1 - A,M,B

The curve has the following general form:



It simply indicates that times A and B rarely occur and that time M has the highest frequency of occurrence. (i.e., for Job 8,1 - 7 weeks is the time duration most encountered in performing the job)

Some jobs may be DUMMY jobs, that is, they may be assigned zero (0) time estimates. (Job 4,11). They are merely to complete the arrow network between jobs which are related but in which there is no real time associated in going from one to another.

3) Job identification (refer to Fig. 1) - Each job is identified by two event numbers called "nodes" (Job 6,7). The tail node (I=6) of the arrow representing the job is that event marking the beginning of that job (6,7) & (6,4) and the completion of the preceeding job (8,6). The head event node (J=7) of the arrow representing the job is that event marking the completion of that job (6,7) and the beginning of the next succeeding job (7,5). Each job must have a unique set of numbers.

The head node (6) of the preceeding job (8,6) has the same event number as the tail node (6) of the job at hand (6,7).

The head node (7) of the job at hand (6,7) has the same event number as the tail node (7) as the next succeeding job (7,5).

There may be more than one preceeding job and more than one succeeding job. Each job which must be completed (2,4);(3,4);(6,4) before other jobs can begin (4,5);(4,11), are connected to the next jobs.

The first (8) node could represent zero time, or the very start of a project such as the receipt of a contract or order. It could represent an agreement having been reached. The last node (5) could represent the delivery of

equipment, or the receipt of another contract which leads to another portion of a total project network.

There can be only one first and one last node for a total project.

The numbering of the nodes can be completely random, as long as any single job has a unique set of numbers.

The highest numbered node may be 999.

There must not be any loops in the network. (i.e., Job (8,3) could not have it's arrow in the opposite direction (3,8). This would result in a loop from (8,1) to (1,3) to (3,8) and back to (8,1) again.

PART I

OPERATIONS

The 1620 PERT program can be used for planning purposes and for the actual scheduling of a project. After I, J, A, M and B have been assigned to each job and the initial arrow diagram network has been completed, the PERT program is then used to analyze the project network to yield the following information:

Figure 2: $t_e = \frac{A+4M+B}{6}$ ...MEAN TIME DURATION...The probable mean duration time for each job based on the three time estimates.

Figure 2: ES...EARLIEST START TIME...The earliest time that a job may start and assure minimum project completion time. This is computed by summing the t_e's for all jobs along a path leading to the tail node of the job at hand. A summation is performed for each path and the largest of these is set equal to ES. The summations are performed starting with the first node. When referred to the event nodes ES is the early start time for all the jobs whose tail node is the node referred to. This means that all jobs leading up to that event node must be completed before any of the connecting jobs, whose tail nodes are the same as the given event number, may be started. (i.e., ES for Jobs (2,11) & (2,4) is 21.83 weeks.)

Figure 3: EF...EARLIEST FINISH TIME... The earliest time that a job may be completed. This is computed by adding the job's mean time (t_e), along the longest path, to the value of ES for that job. This is the expected completion time for that job represented by its head node event number.

IMPORTANT

There is a difference in the concept of EF between Part I and Part II of the PERT program. In Part I EF is the early finish time of that job only. Consequently, when several jobs join together at a node, there will be more than one early finish time (one for each job). These EF's are assigned to their respective jobs.

In Part II EF is referred to as TE (expected completion time) and represents the earliest finish time of all the jobs leading up to the given node. TE for a node is equal to the largest value of EF out of all the jobs leading

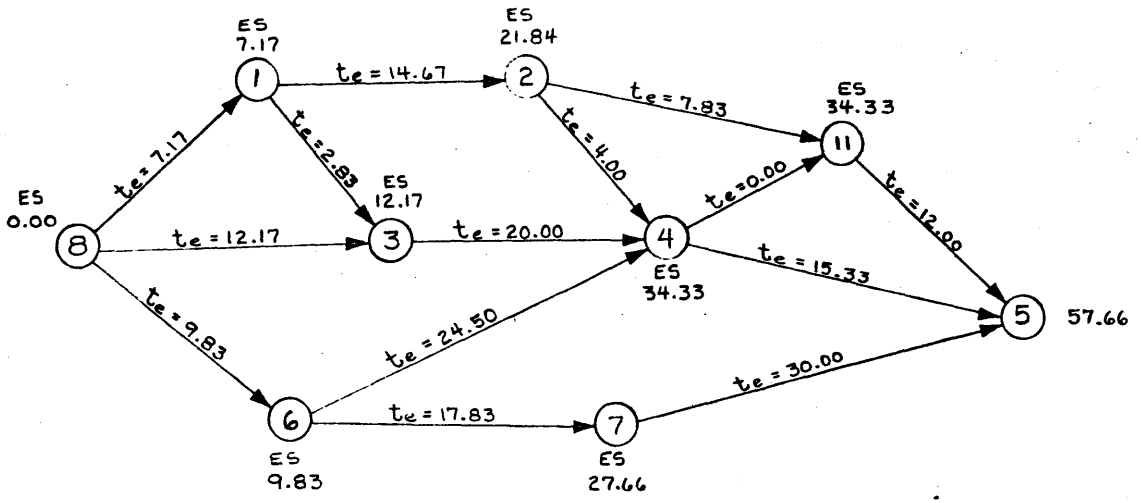


FIG. 2 - t_e & ES

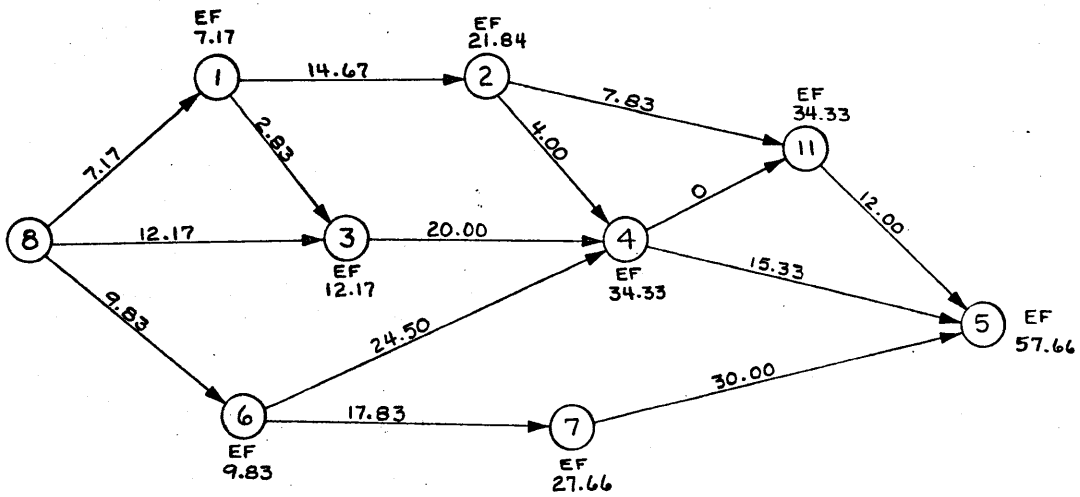


FIG. 3 - EF

up to that node. TE, therefore, represents the early start time for all jobs whose tail node is the same as the given node.

At this point in the analysis there is a choice of assigning a minimum project completion time (TE_O) or of allowing the program to assign it, depending upon Program Switch 1 being ON or OFF, respectively, when the program is started.

If Switch 1 is OFF the program will assign the TE of the last node as the project completion time. This will be the minimum completion time for the whole project (TE_O). If Switch 1 is on the program will accept a value of project completion time which as been assigned to it by reading the value off of a card which has been prepared by the operator. In either case the program continues, with its project completion time, to yield the following further results.

Figure 4: LF...LATEST FINISH TIME...the latest time that a job may finish and assure that the project will be completed within the specified project completion time (TE_O). LF is computed at the last node and working toward the first node. To begin with, LF for each job traveling from the last node is TE_O. (For Jobs (11,5); (4,5); (7,5)). To find LF for all the jobs (2,11) & (4,11) leading to the tail node (11) of the previous job (going right to left) (11,5) just subtract t_e (12.00 from TE_O (57.66).

$$LF\ (2,11);\ (4,11) = TE_O - te\ (11,5)$$
$$= 57.66 - 12.00$$
$$LF\ (11) = 45.66$$

When several jobs come together at a node (going from right to left) Jobs (4,11) & (4,5) join at node (4). LF is computed for each path and the smallest of the values of LF is assigned to the given node (4).

1) $LF\ (2,4);\ (3,4);\ (6,4) = LF\ (11) - t_e\ (4,11)$
$= 45.66 - 0$
$LF\ (4) = 45.66$

2) $LF\ (2,4);\ (3,4);\ (6,4) = LF\ (5) - t_e\ (4,5)$
$= 57.66 - 15.33$
$LF\ (4) = 42.33$ ....SMALLEST (LF (4))

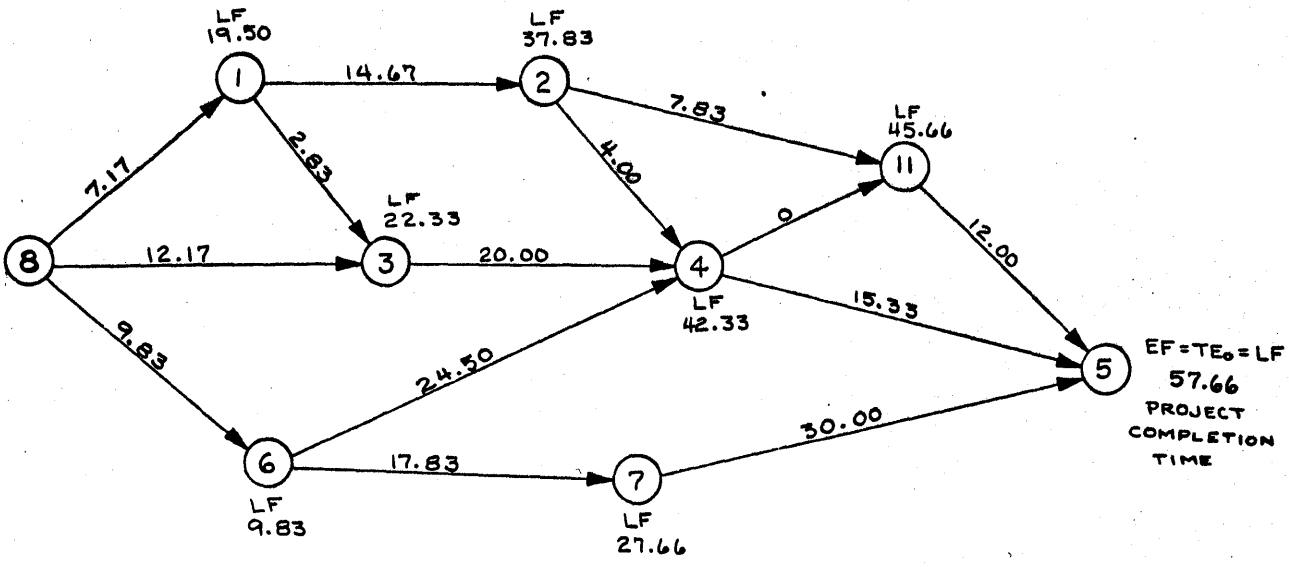


FIG. 4 : LF - TE₀ ASSIGNED BY THE 1620 (57.66)

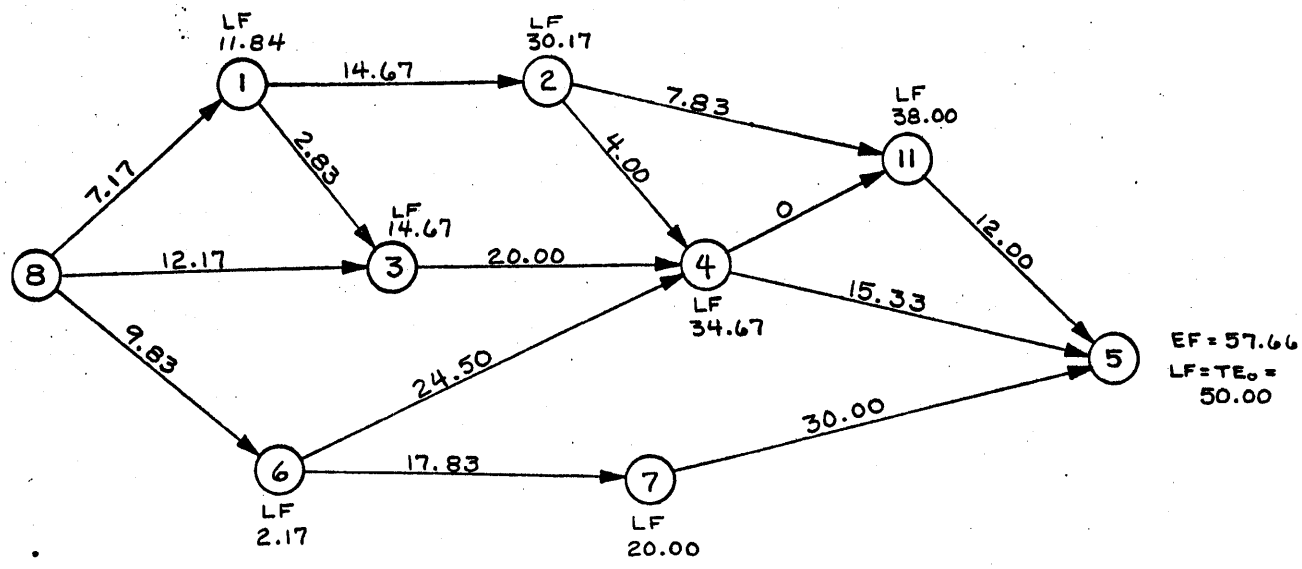


FIG. 5 LF - TE_0 = 50.00

The process continues until LF for the first jobs are found. Figure 5 shows LF values for an assigned TE_o of 50.00 weeks. (The minimum project completion time remains 57.66. The purpose of assigning TE_o is to obtain a measure of slack which will be explained under FLOAT.)

LS...LATEST START TIME...The latest time that a job may start and assure completion time specified by TE_o. Starting at the last node this is computed by subtracting t_e for each job from its LF.

$$\text{LS for Job } (8,1) = \text{LF } (1) - t_e\ (8,1)$$
$$= 19.50 - 7.17$$
$$\text{LS}(8,1) = 12.33 \text{ weeks}$$

LS is associated with the tail node of the given job. When several jobs join (4,5);(4,11) at a node (4) (going from right to left) there will be an LS for each path.

The smallest of the LS values is assigned to the tail node of all the joining jobs. LS (4) = 42.33 weeks. The LS for all jobs to the right of a node is the same as the LF for all jobs to the left of a node.

It should be noted at this point that there are two ways to look at the network:

1) Considering each job separately
2) Considering nodes

The most useful method is to consider nodes as marking either the completion or the beginning of all jobs connected to that node in order to complete the project in the time specified (TE_o).

ES (N) - earliest time that all jobs to the left of node (N) may begin.
EF (N) - latest time that all jobs to the left of node (N) must be completed by in order that all jobs to the right of node (N) may begin at their early start time.
LF (N) - latest time that all jobs to the left of node (N) may finish in order that all jobs to the right of node (N) may begin in time to accomplish latest project completion time.

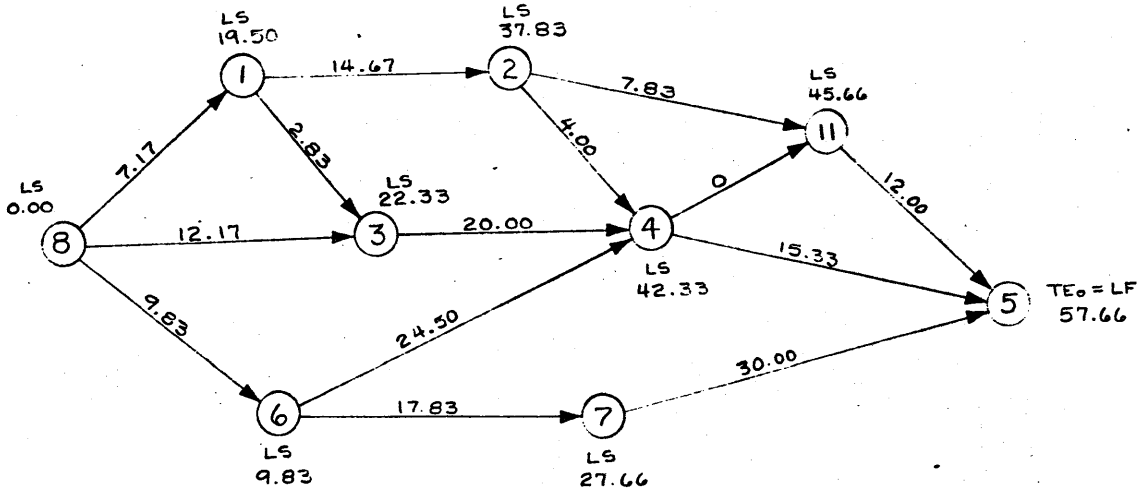


FIG. 6 LS - TE_o ASSIGNED BY THE 1620 (57.66)

LS (N) - latest time that all jobs to the right of node (N) may begin in order to be completed by their late finish time.

TF...TOTAL FLOAT TIME...The difference between LS and ES for a job. TF represents the total float or slack time allowed in beginning a job. It is the length of time that the start of a job may be delayed without changing the minimum project completion time.

Total float may be positive indicating an allowable delay in starting a job. It may be negative if a project completion time has been assigned which is less than the minimum project completion time. In such a case the negative TF indicates that the job will be behind schedule.

TF may also be zero indicating that the job must be started at early start time if the project is to be completed in minimum time. Zero slack will be indicated by an asterisk (*).

The longest chain of jobs through a project network is called the "critical path". The jobs along this path will have zero total float time if no project completion time has been assigned. Any delay in the starting or completion of these jobs will delay completion of the project by a like amount of time.

If a project completion time has been assigned which is greater than the minimum completion time then all total float time will be positive.

If a project completion time has been assigned which is less than the minimum completion time then total float may be positive, negative or zero.

FF...FREE FLOAT TIME...the length of time that the start of a job may be delayed without changing ES for another job.

PART I

SPECIFICATIONS

I. General
   - A. In order to be used in conjunction with Part II, no node may be numbered 000.
   - B. The highest numbered node may be 999.
   - C. Each job's node numbers (I,J) must be unique.
   - D. I and J may be any 3 digit numbers, however, the restrictions on maximum project sizes are in terms of the highest numbered node and not in terms of the total number of nodes, so it is best to use smaller numbers. There is also a slight speed advantage in numbering the nodes in approximately sequential order.
   - E. The numbers are to be of the following form, no decimals are punched in the cards:
     1. I & J - XXX
     2. t_e, A, M & B - XX.XX
     3. ES, EF, LS, LF, TF, FF - XXX.XX

II. Program Capacity
   - A. For a 20K 1620, the sum of the number of the highest numbered node and the number of jobs must be 1672 or less.
     For a 40K 1620, the number is 3672.
     For a 60K 1620, the number is 5672.
   - B. To work in conjunction with Part II the sum of twice the number of jobs plus the highest numbered node must be 3100 or less in addition to the previous requirement.
     For a 40K 1620, the number is 7100.
     For a 60K 1620, the number is 11,000.

III. Machine Requirements
   - A. 1620 Data Processing System
   - B. 1622 Card Read Punch
   - C. 1623 Additional Core Memory is optional.
   - D. Indirect Addressing may or may not be added.
   - E. No other special features

PART I

INPUT

The input to Part I may contain four types of data cards. Type 1 and 2 may be arranged in any desired order.

TYPE 1 - Heading or description cards

These are identified by some character in column 1, other than a blank or numeric digit. The remainder of the card may be punched with any information desired. The identifying character in column 1 may be different for each type 1 card. These cards cannot be used with Part II.

TYPE 2 - Job description cards

There is one for every job in the project. Blanks in all fields are taken as zeros.

Columns
- 1 - 3 Tail of the job arrow - I
- 4 - 6 Head of the job arrow - J
- 7 -10 Blank
- 11 -15 Cost of the Job (See Suggestions - Part I)
- 16-19 Optimistic time - A
- 20 -23 Most likely time - M
- 24 -27 Pessimistic time - B
- 28 -80 Not used, may contain anything

TYPE 3 - Blank cards

Two per deck, one is between the job description cards and the schedule card (TYPE 4), the other is the last card in the deck.

TYPE 4 - Schedule card

If a project completion time is to be assigned, this card is punched as follows:

Columns
- 1 - 5 Scheduled completion time (XXX.XX) no decimal points are punched.
- 6 -80 Blank

DATA DECK - The data deck is assembled as follows (face down):

1. All Type 1 and 2 cards (can be interspersed). It makes no difference what the order of the job cards are.
2. One Type 3 card
3. One Type 4 card
4. One Type 3 card

PART I

INSTRUCTIONS

A. PROGRAM DECK

The SPS listing of Part I is in Appendix C. The condensed program deck (Appendix D) consists of 81 cards numbered 00 through 80. Column 1 of card 56 contains a digit signifying the core memory size of the computer being used.

$\overline{2}$ 20,000 positions

$\overline{4}$ 40,000 positions

$\overline{6}$ 60,000 positions

B. SWITCHES

Parity Switch - STOP
O Flow Switch - STOP
I/O Switch - STOP
Program Switch 1 - OFF if 1620 assigns project completion time,
ON if operator assigns project completion time
Program Switch 2,3,4 - NOT INTERROGATED

C. PROCEDURE

Load Program Deck - PRESS RESET, INSERT and TYPE 160001000000, press RELEASE, START. Wait a second or two and press SEC KEY, and RESET. Place program deck in read hopper (9 edge-face down) and blank cards in punch hopper (12 edge-face down), depress LOAD. To read last card, press READER START. Computer then halts when program is loaded (48 in OP register).

Data Pass I - Place data deck in read hopper, press PUNCH START, READER START, and computer START. To read the last card, press READER START. Lift the blank cards from the punch hopper and press PUNCH NON-PROCESS RUN OUT. Remove the last two blank cards from the new data deck. This deck has been punched in c-c 7-10, with t_e, in addition to the original data. The computer does error analysis and either halts when finished or prints an error message while reading data cards.

Data Pass II - If no errors were discovered, place the newly punched deck in the read hopper and more blank cards in the punch hopper. Press PUNCH START, READER START, and computer START. Press READER START to read last card. Lift blank cards from punch hopper

and press PUNCH NON-PROCESS RUN OUT. Remove all the blank cards. This then is the output deck for PERT - PART I and the input deck for PERT - PART II. It is described under OUTPUT - PART I.

If it is desired to assign other time estimates or project completion dates after examining the results of previous outputs (by listing on a 407 Accounting Machine), the program deck must be loaded again, the scheduled completion card (TYPE 4) and job cards (TYPE 2) must be changed to the new values, and/or Program Switch 1 must be set accordingly.

D. ERROR MESSAGES AND ACTIONS

Error 1 - Available storage has been exceeded. The number of the highest numbered arrow plus the number of jobs is greater than 1672 (for 20,000 positions of storage). Typewriter prints I,J.D COST for the last job and halts. To work the next project press START.

Error 2 - More than one "last" node (a node which is not the tail of some arrow) has been found. Typewriter prints the numbers of all but the first "last" node found and halts. To find the first "last" node type out locations 3247-49. To work the next project INSERT 16 01095 00T6 49 00402, RELEASE, START.

Error 3 - More than one "first" node (a node which is not the head of some arrow) has been found. Typewriter prints the numbers of all but the first "first" node found and halts. To find the first "first" node type out location 3244-46. To work the next project INSERT 16 01095 000T6 49 00402, RELEASE, START.

Error 4 - A loop has been found in the arrow diagram. For example a series of jobs (1,2), (2,3) and (3,1) would be a loop. Typewriter prints I,J,D, COST for the first job where the error may be detected. (i.e., the earliest start for this job exceeds the sum of all job times.) This job need not be on the loop itself, but may be on a chain of jobs which passes through one of the nodes on the loop. To work the next project press START.

There is a very remote possibility that a type 1 error could go undetected as such. During data pass I a temporary table is set up in locations 4000 - 6001 to be used to find "first" and "last" nodes. If 1400 jobs or more are read, this table may be destroyed. This will cause several type 2 and 3 error messages, however.

PART I

OUTPUT

The output deck will contain all the original TYPE I cards. The TYPE 2 cards will contain the following information:

COLUMNS	(No decimal points are punched)
1 - 3	I (XXX)
4 - 6	J (XXX)
7 - 10	t_e (XX.XX)
11 - 15	Cost (See Suggestions Part I) (XXX.XX)
16 - 19	A (XX.XX)
20 - 23	M (XX.XX)
24 - 27	B (XX.XX)
28 - 32	Blank - reserved for scheduled dates for PART II
33 - 40	Blank - reserved for output data from PART II
41 - 45	Blank - not used
46 - 50	Blank - reserved for output data from PART II
51 - 55	ES (XXX.XX)
56 - 60	EF (XXX.XX)
61 - 65	LS (XXX.XX)
66 - 70	LF (XXX.XX)
71 - 75	TF (XXX.XX)
76 - 80	FF (XXX.XX)
75	Contains * if this is a critical job.

Any fields which are of negative value have an X Punch (11 punch) in the low order digit column of that field.

The last card in the output deck is a TYPE 1 card containing Project cost, Project Completion, and Project Slack. By letting the first column of the output cards be a printer format control, any desired listing may be developed.

PART I

SUGGESTIONS

Least Cost Estimating

Repeated applications of this program will give an idea of how project completion time varies with cost. First schedule the project with normal job time and normal costs, then compress the schedule along the critical path, which shortens the over-all project time at the expense of increasing some job costs. Running the schedule again will show the new project time and cost and new critical path. If the assumption is made that cost of a job varies linearly with completion time between the limits of normal job time and crash time, this estimating may be done automatically by means of a specialized parametric linear programming algorithm. In either case a series of project durations are obtained as a function of direct job costs. By combining these with the indirect costs for overhead, penalties, etc., the least cost may be estimated.

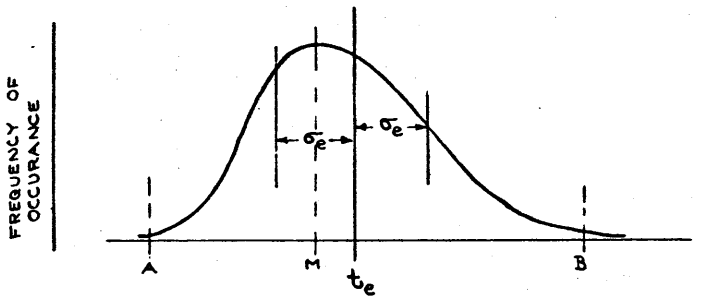
PART II

CONCEPTS

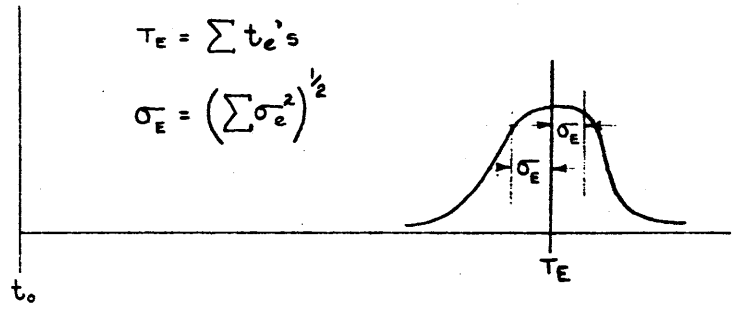
Each job of a project network has associated with it a variance determined as follows:

$$\text{VAR} = \sigma_e^2 = \left(\frac{B - A}{6}\right)^2$$

If the root of the variance is taken, the result would be a measure of probable deviation from the mean time t_e, based on the three time estimates (A, M, B) shown below. σ_e is called the standard deviation.



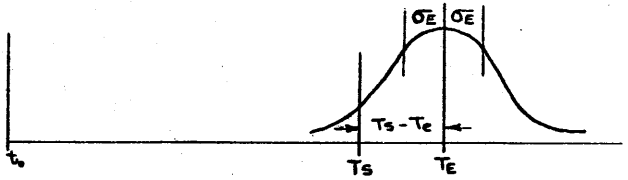
As in Part I when the t_e's were summed for each path to a node, and the largest sum was called EF, so also can the variances be summed to each node. Now instead of having t_e and σ_e for each job independent of another, there exists an EF, now called expected time (TE), and a σ_E which relates the node at hand to the first node of the project or to zero time.



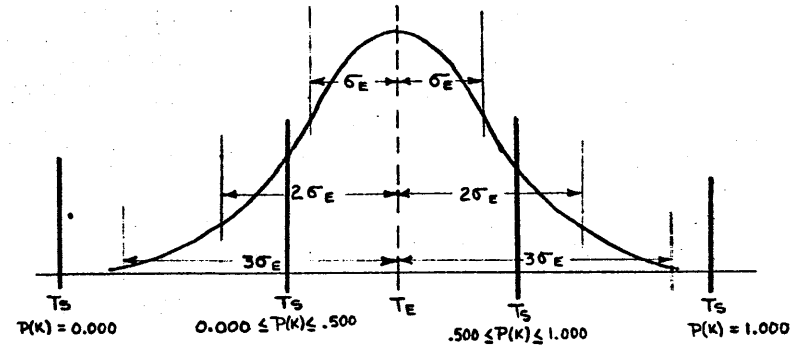
Whereas t_e was the mean expected duration time for completing the job itself, TE is the mean expected time for completing the job within the project network, referenced to the beginning of that network. In the same light, $\sigma_{\bar{e}}$ was the expected amount of standard deviation or "doubt" that can be expected in completing the job in the expected duration time t_e, whereas $\sigma_{\bar{E}}$ is that same measure of doubt that can be expected in completing the job in the expected completion time TE within the project network and referenced to the beginning of that network .

Probability is computed by determining the area under the normal distribution curve up to the point in question (TS or TE). The total area from-infinity to+ infinity is 1 unit.

If it were desirable to determine what chance or what the probability was of completing the job of some assigned scheduled time, TS, other than the expected completion time, TE, the procedure would be to determine how many standard deviations TS was away from TE. For each amount of deviation away from the mean there is a value of probability (area under the curve) that has been previously computed and stored in a table. The amount of standard deviations that TS is away from TE would then be looked up on the table. That value of probability , P (K), is then the probability of meeting the assigned scheduled time.



It should be pointed out that although the probability never reaches zero (only at infinity) it is considered as such if TS were 3 or more standard deviations away from TE as in the following figure.



To determine how many standard deviations TS is away from TE the following formula is computed:

$$\frac{TS - TE}{\sigma_E} = K$$

If TS = TE, K is then zero, or the number of deviations TS is away from TE would be zero. It might be expected at first thought that this would mean a 100% chance of completing the job in the expected time, TE.

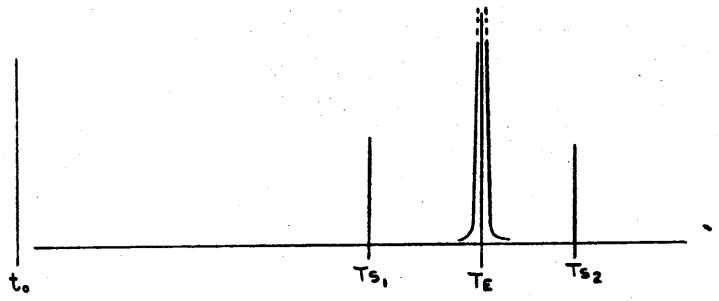
This is true as far as the relation between TS and TE, but as far as TE itself is concerned, we must now consider the probability of actually completing the job in TE time, which, since TE has deviation associated with it, would turn out to be .50 or 50% . That is, the computed expected time, TE, has an inherent risk or probability of being obtained of 50%. This inherent probability associated with TE comes about due to the fact that TE lies halfway through the area of the distribution curve.

Thus it can be seen that if a scheduled date, TS, were assigned which was greater than TE, the chances of completing the job associated with TE in the time, TS, would become greater until finally it would approach 100% (the total area under the curve up to TS is 1).

If TS were less than TE the probability would lessen (the area under the curve up to TS would lessen) until it would approach 00% where TS would be completely to the left of the distribution curve.

The function of PERT - PART II is to compute where, on the normal distribution curve, an assigned value of TS lies and hence to look up the probability associated with this position.

If the variances are so small that the deviations are negligable, then two cases arise. Such a condition is shown below.



Here the probability of completing the job in time TE is 100% since the deviation of TE itself is zero. If an assigned time (TS_1) were equal to or greater than TE the probability of completing the job in time, TS_1, would in turn be 100%. But if TS_2 were assigned the probability would be 00%.

Hence, it is seen how the risk involved in completing a job at a scheduled time depends wholly on the distribution of the curve representing the expected duration time of the job itself. This, in turn, depends upon the original values of A, M, and B assigned by management. Therefore the results are only as reliable as the original estimates themselves. It can be shown that with any three estimates (A, M & B) the normal distribution curve yields reliable and dependable results, but only as good as A, M, and B.

It should be understood by the user of any PERT program that the results are not binding by any means, but that with proper estimates, usage, and proper interpretation the results will yield reliable information upon which to base future decisions. This is the intended purpose.

John C. Patton
Systems Engineer

PART II
SPECIFICATIONS

Same as PART I except for the following additions to GENERAL (E):

Additional information will be of the following form (no decimal points are punched).

4) TS, (TS-TE) - XXX.XX
5) P (K) - X.XXX
6) σ_e^2 - XX.XX

PART II

INPUT

I. The input to this program is the PASS II output deck of PART I. From this deck certain cards are chosen which are to be punched with assigned Schedule Times of completion. There is a certain restriction to be applied at this point which stems from what was said about EF under PART I OPERATIONS. Each card of the output deck representing a job has a value of EF (TE) assigned to it. Only the largest value of TE applies to all the jobs with the same head node numbers (J). This is the TE to be used when assigning a TS to a node for purposes of determining probability. The following restrictions are stated.

A. If the probability of completing a simple job is desired, values of TS are assigned to those job cards of interest. (i.e., Node 4 represents the completing of three jobs (2,4),(3,4)& (6,4) therefore job (2,4), (3,4) & (6,4) can each be assigned a TS to determine its probability.

B. If the probability is desired of completing all the jobs which branch to a node so that all the next jobs can start on time, it is necessary to locate the job card which has the largest value of EF (TE) for all those jobs whose J node (head of arrow) is the same. To this card only there is assigned the TS of interest. In the case of node 4, job card (6,4) would be selected and TS would be punched in this card.

To facilitate the above it is best to have all jobs, whose head node numbers(J) are the same, listed next to each other. This allows quick spotting of the largest value of EF. This can be accomplished by sorting the input deck or the output deck on cc 6-5 then 4. This will in no way impare the operation of either PERT program.

II. TYPE 1 - Heading & description cards
All type I cards are to be removed from the input deck of PART II. They will impare the operation of the program. This includes the project completion card (last card) as well.

TYPE 2 - Job description cards
The proper TYPE 3 card is chosen and is punched with the desired value of TS

Columns	(No decimal points are punched)
28-32	TS (XXX.XX)

All the rest of the card columns of TYPE 2 cards shall remain intact.

TYPE 3 - Blank cards
All type 3 cards shall be removed.

TYPE 4 - Schedule cards
All type 4 cards shall be removed.

III. There will be no error analysis performed in PART II. All errors which would impare the operations of PART II are indicated in PART I.

PART II

INSTRUCTIONS

A. Program Deck

The SPS listimg of this program is in Appendix E. The condensed program deck (listing in Appendix F) consists of 76 cards numbered 00 through 75 in card columns 79 - 80. Core memory size is dictated by the following cards:

Card Number	Column	Contents
33	8	$\bar{1}$
40	39	$\bar{1}$
43	32	$\bar{1}$
	44	$\bar{1}$
44	44	$\bar{1}$
	56	$\bar{1}$
51	32	$\bar{1}$
	44	$\bar{1}$

The above columns should be changed as follows:

$\bar{1}$ for 20 K
$\bar{3}$ for 40 K
$\bar{5}$ for 60 K

B. Switches

Parity Switch - STOP
O Flow Switch - Program
I/O Switch - STOP
Program Switches - NOT INTERROGATED

C. Procedure

Load Program Deck- Press RESET, INSERT then type 160001000000, press RELEASE and computer START; wait about two seconds then press SEC key and RESET. Place program deck in read hopper, press LOAD. Press READER START to read last card. Computer then halts (48 in OP register) when program is loaded. Remove program deck from read stocker.

Data Pass I - Place data deck in read hopper, press READED START and then computer START twice. To read last card press READED START. Computer goes into a diagnostic procedure which may take from one second to 60 seconds or more depending upon the number of data cards and their node numbers. When the computer is finished, a halt (48) will appear on the OP register and the computer is ready for data pass II.

Data Pass II - Remove data deck from read stocker and place in read hopper. Load blank cards in punch hopper, press PUNCH START, READER START and Computer START. The computer will punch an output card for each input card. To read last card, press READER START. Lift remaining blank cards from punch hopper and press PUNCH NON-PROCESS READOUT. Remove the last two (blanks) cards from the output deck. The output is complete and ready for listing.

To run another data deck through or to re-run the previous data after scheduled times have been repunched, simply begin again at Data Pass I (part II)

PART II

OUTPUT

A deck of cards similar to the input deck is produced but with the following additional information:

COLUMNS	(no decimal points are punched)
1 - 27	Same as input to PART II
28 - 32	TS - scheduled time - If no scheduled time had been assigned these columns will contain TE assigned by the computer.
33 - 36	P (K) - probability
37 - 40	$\sigma_{\bar{e}}^2$ - Variance
41 - 45	Blank
46 - 50	(TS - TE) - Scheduled completion time minus expected completion time.
51 - 80	Same as input to PART II

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General Information Maunal PERT ...a dynamic project planning and control method, IBM (E20-8067) Data Processing Division, White Plains, New York.

Thompson, Van B., "PERT...Pro and con about this technique," Data Processing, October, 1961.

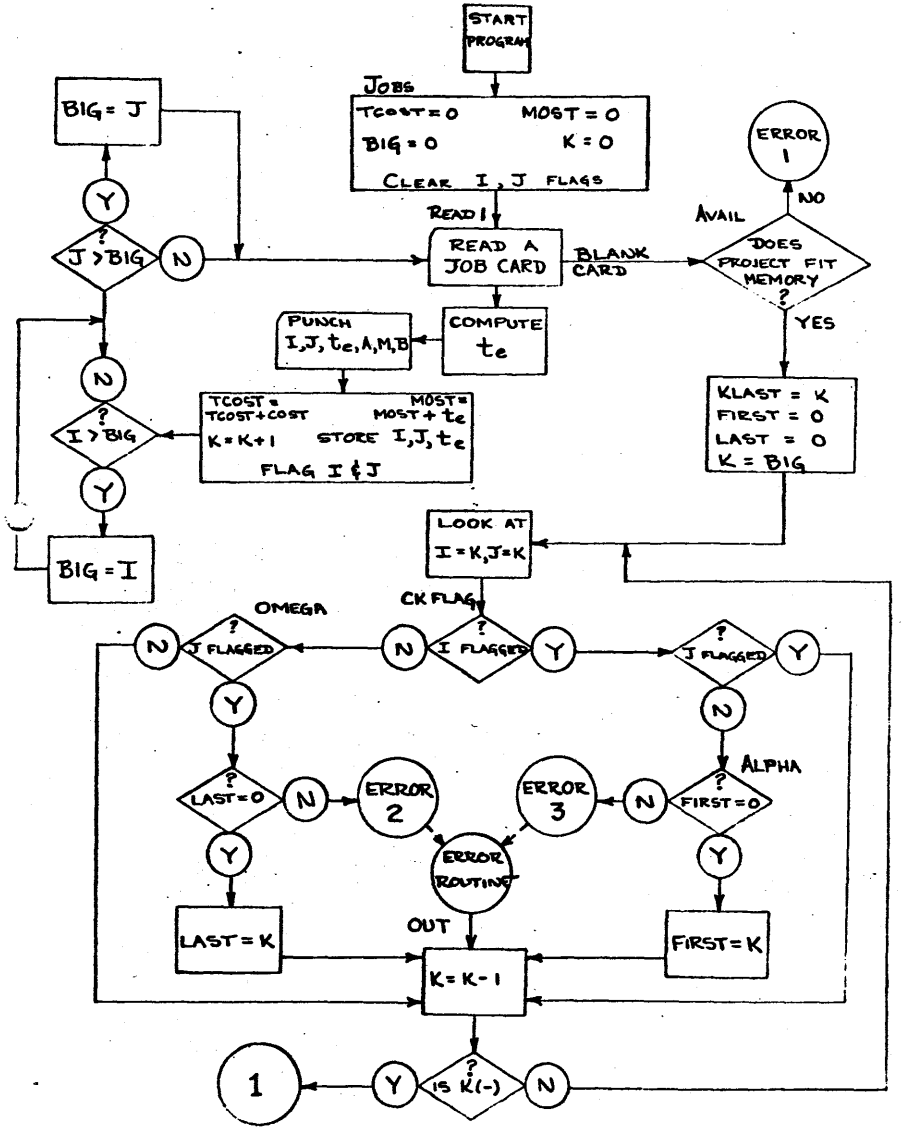
Proceedings of the Pert Coordination Task Group Meeting, Special Projects Office, Bureau of Naval Weapons, Department of the Navy, Washington, D. C., November, 1960.

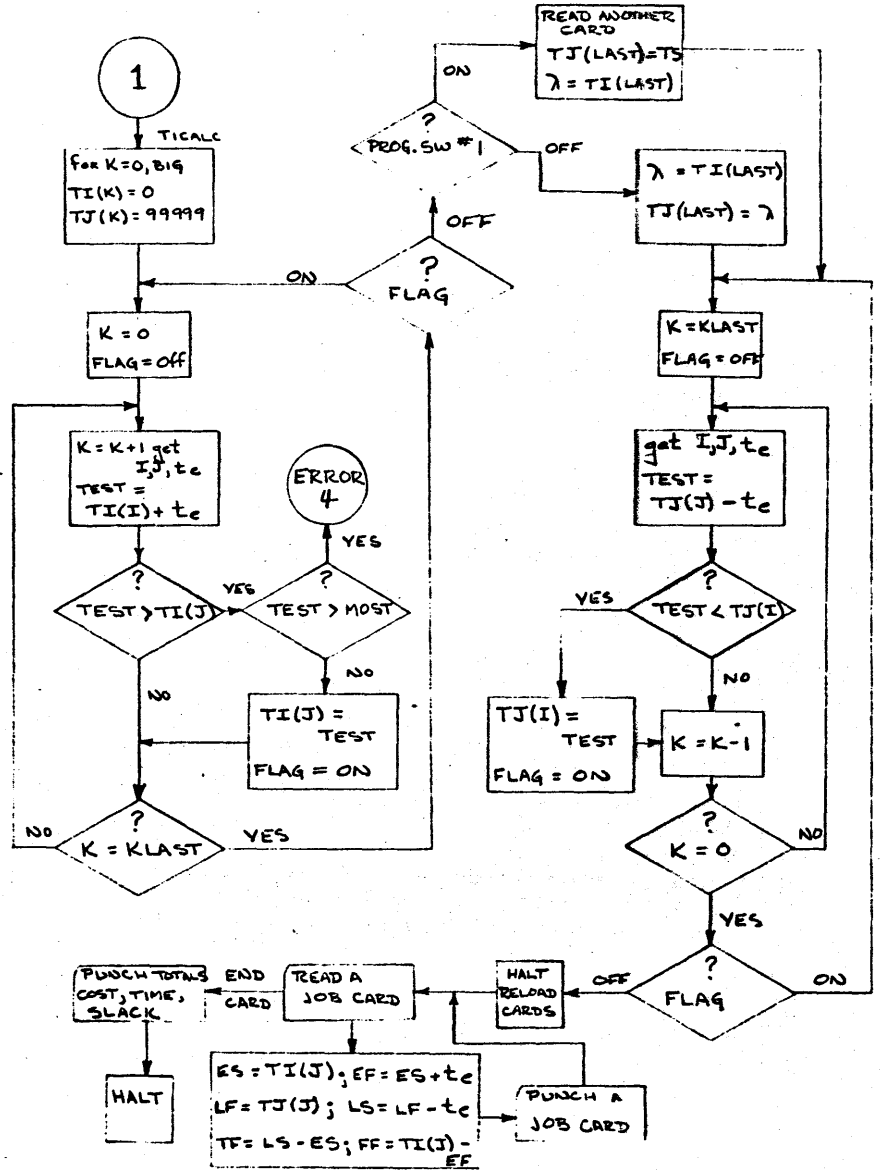
PERT - Summary Report Phase 1, Special Projects Office, Bureau of Naval Weapons, Department of the Navy, Washington, D.C., July, 1958.

PERT - Summary Report Phase 2, Special Projects Office, Bureau of Naval Weapons, Department of the Navy, Washington, D. C., September, 1958.

Sauer, Ray N., LESS - Least Cost Estimating and Scheduling, IBM Program Library, File Number 10.3.003, 590 Madison Avenue., New York 22, New York.

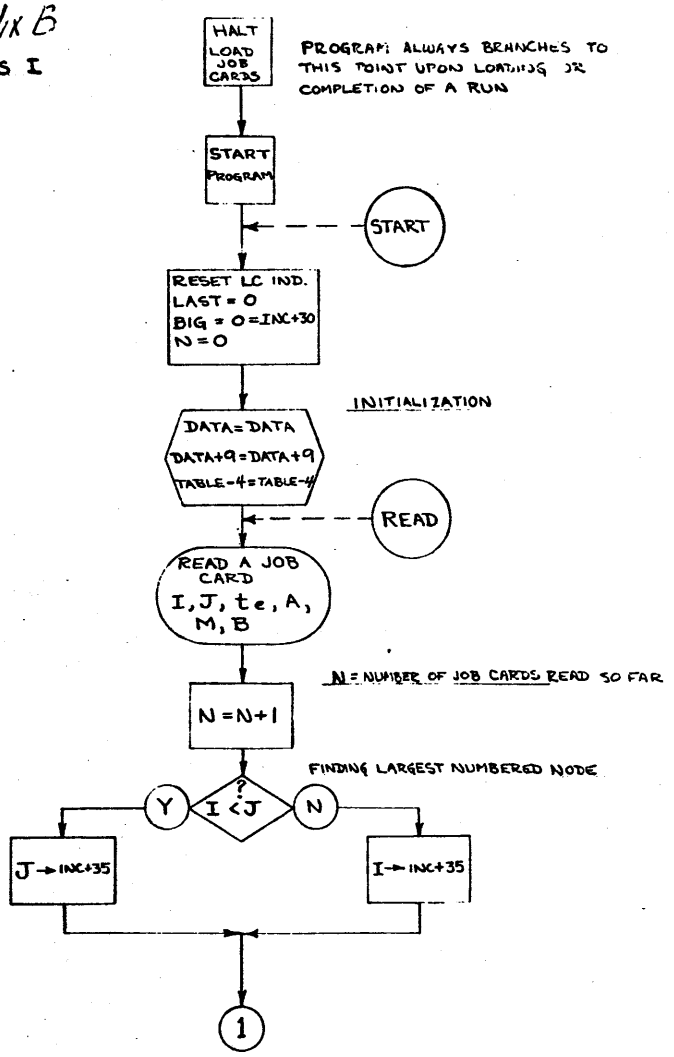
Appendix A

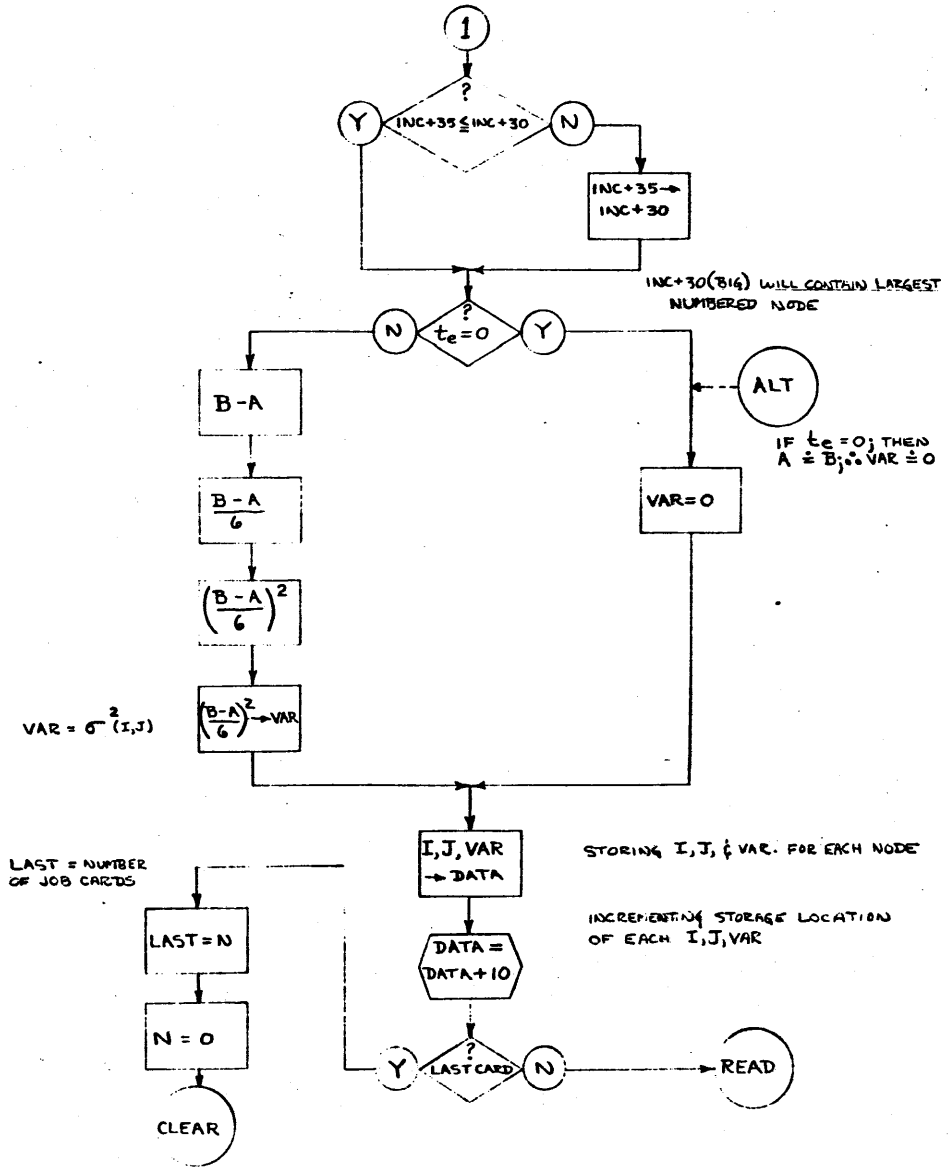

START PROGRAM
JOBS
TCOST = 0
MOST = 0
BIG = 0
K = 0
CLEAR I, J FLAGS
READ 1
READ A JOB CARD
BLANK CARD
AVAIL
DOES PROJECT FIT MEMORY ?
NO
ERROR 1
YES
COMPUTE te
PUNCH I,J,te,A,M,B
TCOST = TCOST + COST
MOST = MOST + te
K = K+1
STORE I,J,te
FLAG I & J
I > BIG
J > BIG
BIG = J
BIG = I
KLAST = K
FIRST = 0
LAST = 0
K = BIG
LOOK AT I = K, J = K
CK FLAG
I FLAGGED
J FLAGGED
OMEGA
ALPHA
LAST = 0
FIRST = 0
ERROR 2
ERROR 3
ERROR ROUTINE
LAST = K
FIRST = K
OUT
K = K-1
IS K(-)
1


1
TICALC
for K=0, BIG
TI(K) = 0
TJ(K) = 99999
K = 0
FLAG = Off
K = K+1 get I,J,te
TEST = TI(I) + te
TEST > TI(J)
TEST > MOST
ERROR 4
TI(J) = TEST
FLAG = ON
K = KLAST
READ ANOTHER CARD
TJ(LAST) = TS
λ = TI(LAST)
PROG. SW #1
λ = TI(LAST)
TJ(LAST) = λ
FLAG
K = KLAST
FLAG = Off
get I,J,te
TEST = TJ(J) - te
TEST < TJ(I)
TJ(I) = TEST
FLAG = ON
K = K-1
K = 0
FLAG
HALT RELOAD CARDS
PUNCH TOTALS COST, TIME, SLACK
END CARD
READ A JOB CARD
HALT
ES = TI(J); EF = ES + te
LF = TJ(J); LS = LF - te
TF = LS - ES; FF = TI(J) - EF
PUNCH A JOB CARD

Appendix B

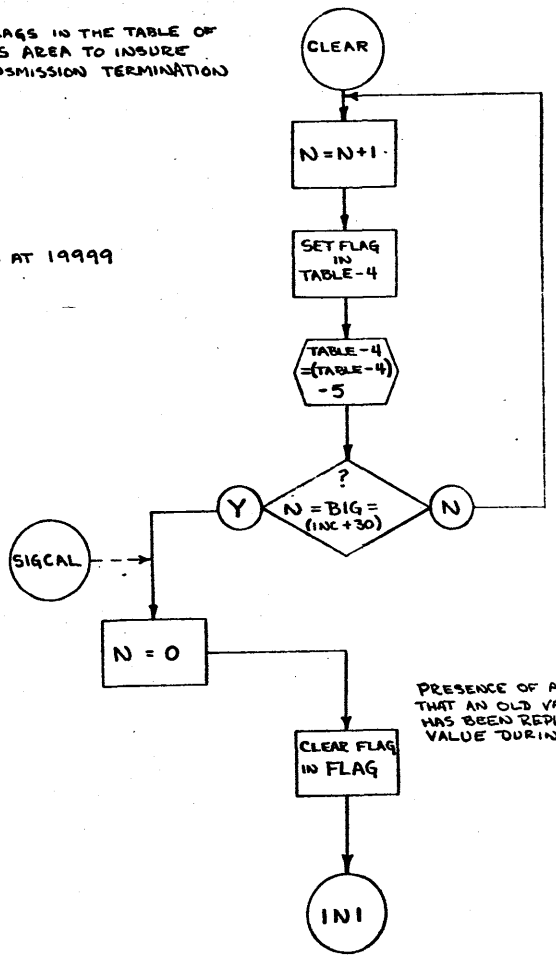
BEGINNING OF PASS I





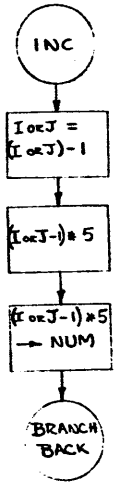
SETTING FLAGS IN THE TABLE OF SUMMATIONS AREA TO INSURE FIELD TRANSMISSION TERMINATION

TABLE IS AT 19999



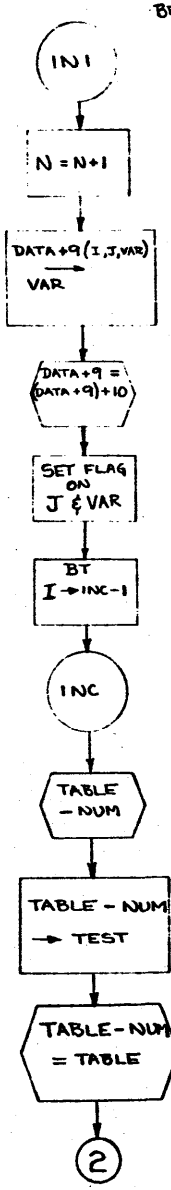
MUST DO THIS FOR THE HIGHEST NUMBERED NODE

PRESENCE OF A FLAG BIT AT "FLAG" SIGNIFIES THAT AN OLD VALUE OF VARIANCE SUMMATION HAS BEEN REPLACED BY A NEW & LARGER VALUE DURING THE "INI" LOOP



BEGINNING OF THE COMPUTATION:

$\sum \sigma_J^2$ MAX.



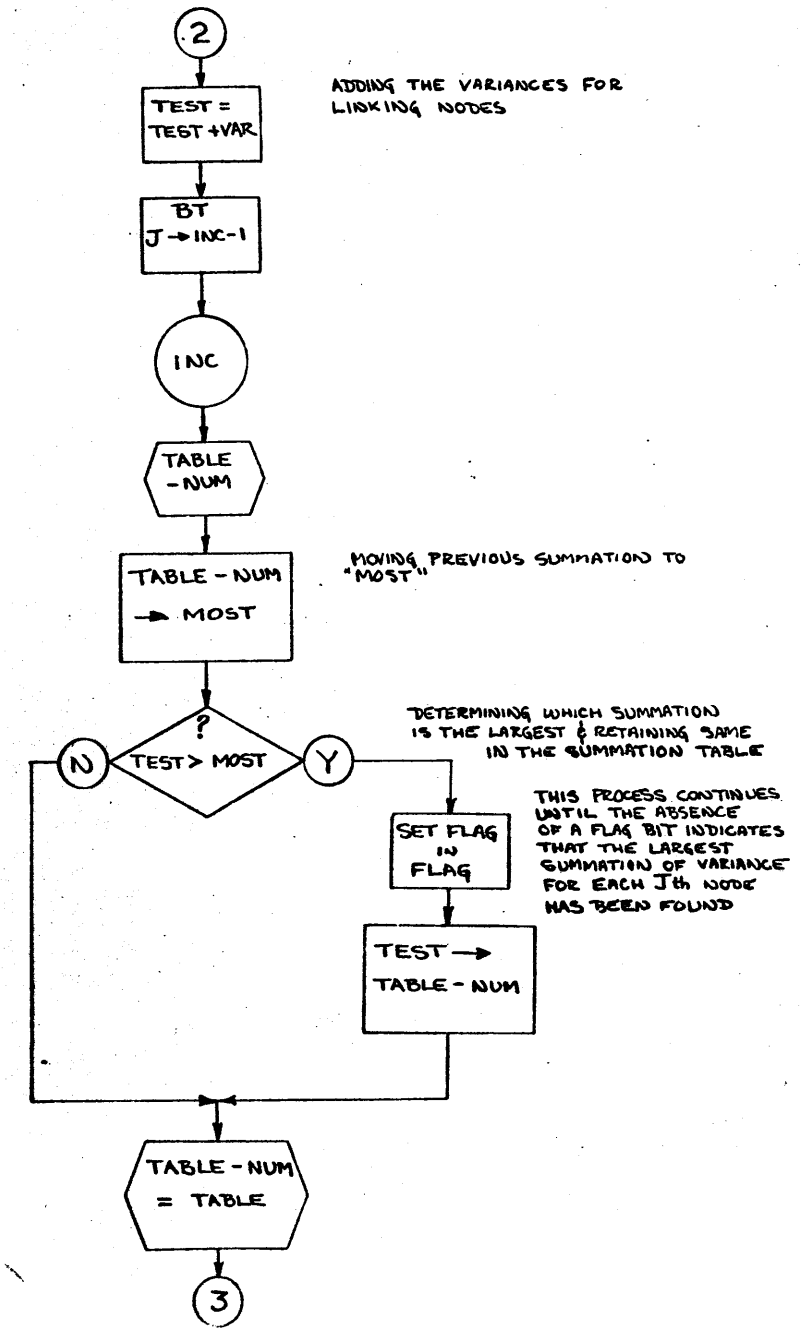
(DATA+9)+10(N-1) IS THE FIELD LOCATION OF I, J & VAR FOR THE N^{th} CARD

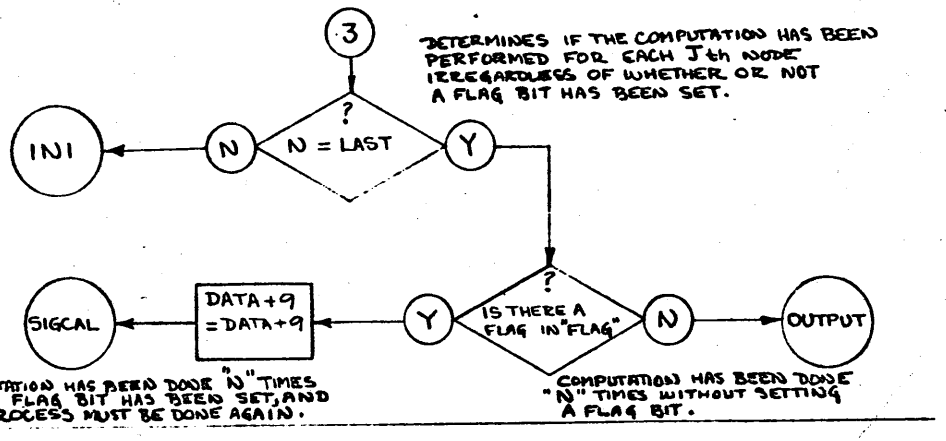
ADDRESS OF VAR

I J VAR

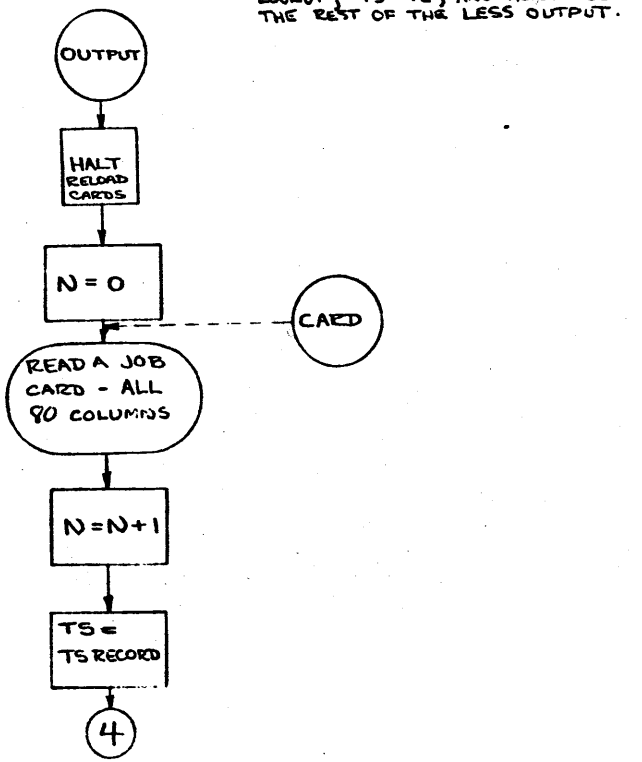
NUM = [(I or J) - 1] * 5

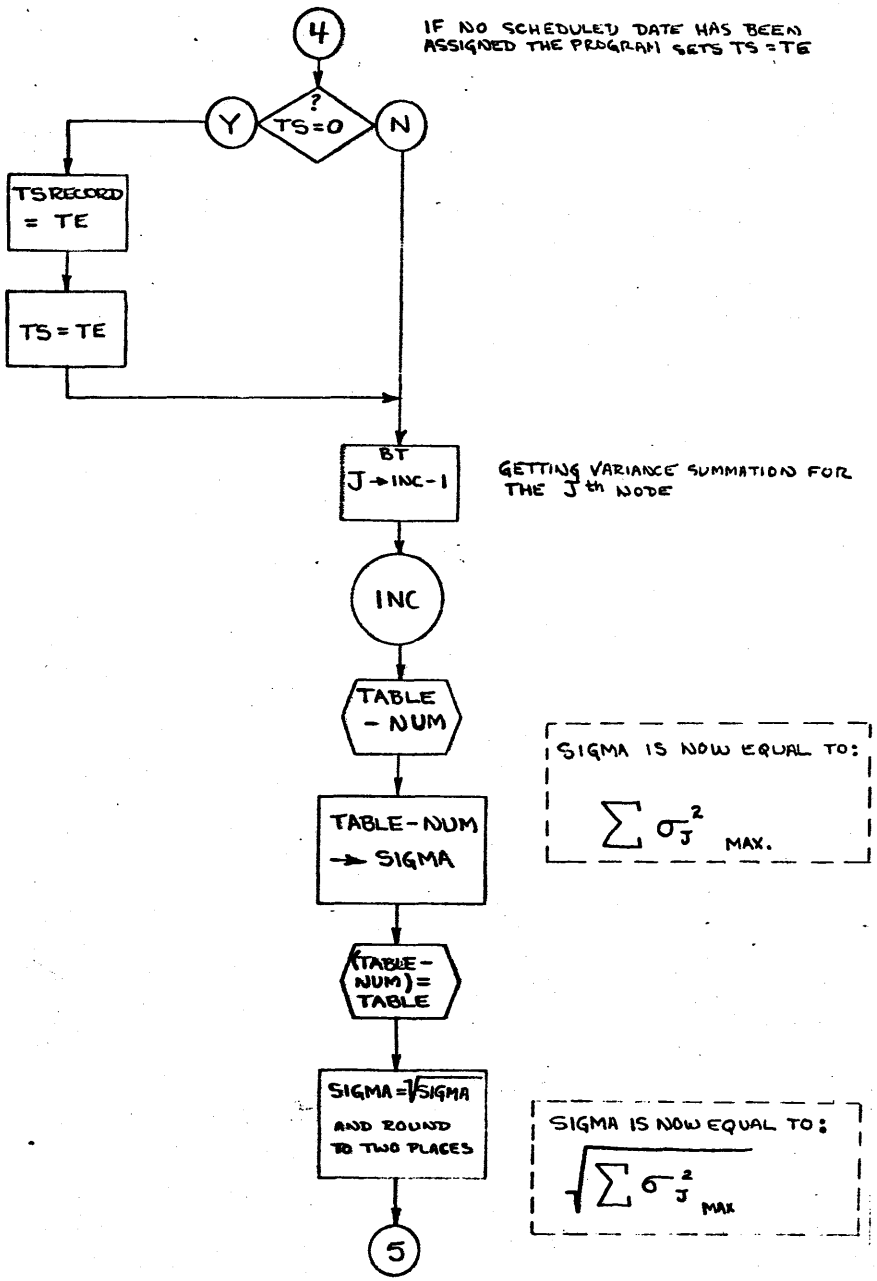
TABLE(19999) - NUM = LOCATION OF VARIANCE SUMMATION IN THE DATA TABLE FOR THE J = I th NODE

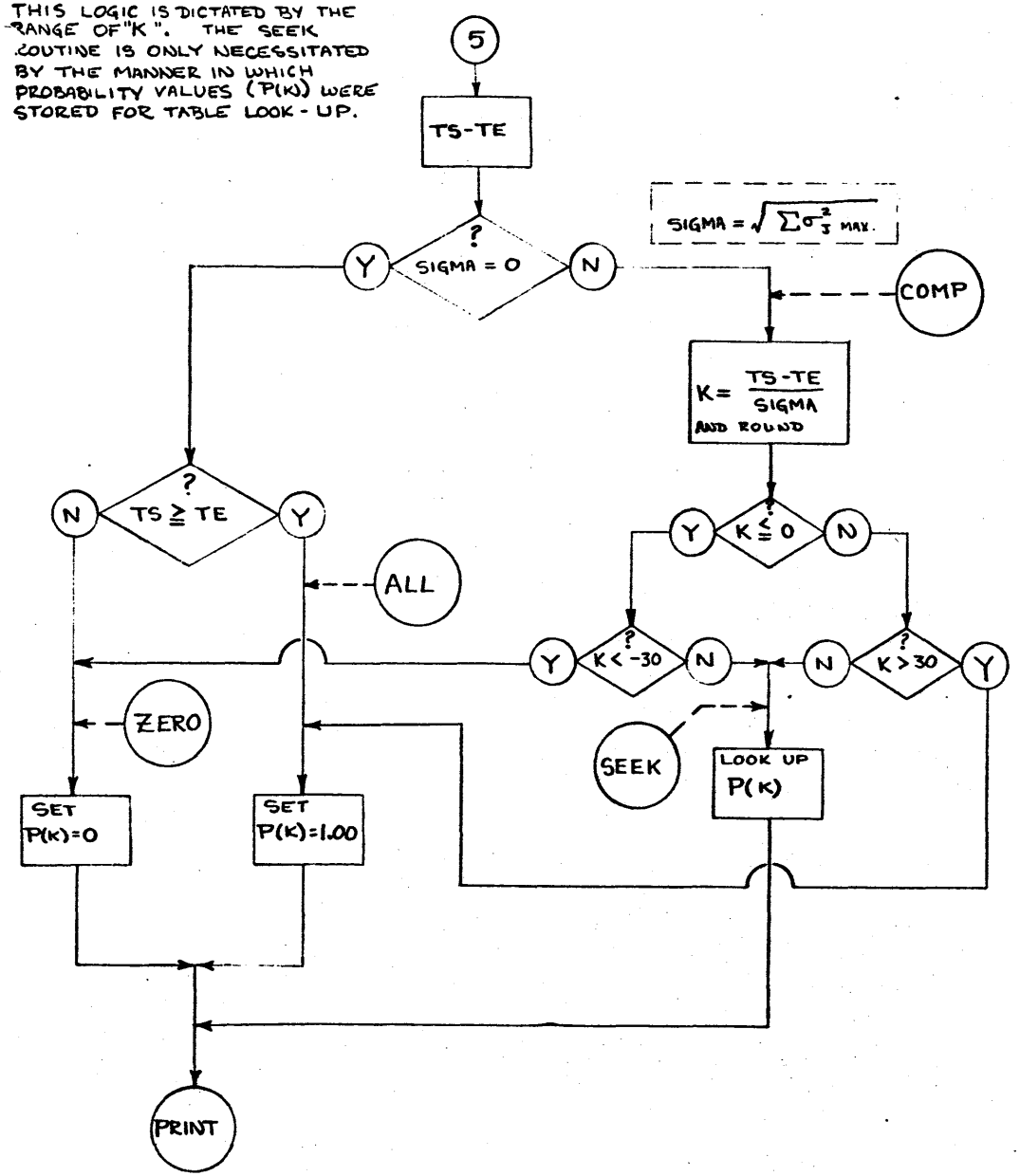


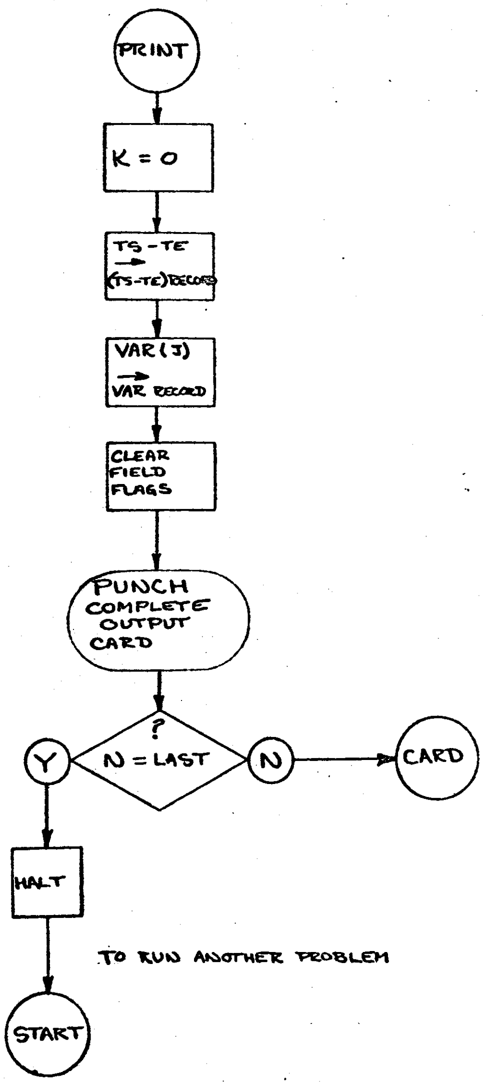


BEGINNING OF PASS II




4
IF NO SCHEDULED DATE HAS BEEN ASSIGNED THE PROGRAM SETS TS = TE
?
TS=0
Y
N
TS RECORD = TE
TS = TE
BT J→INC-1
GETTING VARIANCE SUMMATION FOR THE J th NODE
INC
TABLE - NUM
TABLE-NUM → SIGMA
SIGMA IS NOW EQUAL TO:
$\sum \sigma_J^2$ MAX.
(TABLE-NUM) = TABLE
SIGMA = √SIGMA AND ROUND TO TWO PLACES
SIGMA IS NOW EQUAL TO:
$\sqrt{\sum \sigma_J^2}$ MAX
5


THIS LOGIC IS DICTATED BY THE RANGE OF "K". THE SEEK ROUTINE IS ONLY NECESSITATED BY THE MANNER IN WHICH PROBABILITY VALUES (P(K)) WERE STORED FOR TABLE LOOK-UP.
5
TS-TE
?
SIGMA = 0
Y
N
SIGMA = √∑σ²J MAX.
COMP
K = TS-TE / SIGMA AND ROUND
?
TS ≧ TE
N
Y
ALL
?
K ≦ 0
Y
N
?
K < -30
Y
N
?
K > 30
N
Y
ZERO
SEEK
LOOK UP P(K)
SET P(K)=0
SET P(K)=1.00
PRINT



Part I SPS Listing

```
                            36000720050 0360 02010050044000120027526000590027425000110000026000900269000
                            26000950026 4310 0000020026600114002742500000000114900012000000000          -
00402                        1010       DORG 00402Z                                                    0
00402 16 02941 -2968         1020AVAIL  TFM  TEST,TJZ                                                  0
00414 21 02940 02921         1030       A    TEST-1,BIGZ                                               0
00426 21 02940 02931         1040       A    TEST-1,KZ                                                 0
00438 24 02941 02948         1050       C    TEST,SIZEZ                                                0
00450 46 02022 01100         1060       BH   ERROR1Z                                                   0
                             1070*           FIND STARTING AND ENDING NODESZ                           0
                             1080*           CHECK FOR MORE THAN ONE OF EACHZ                          0
00462 26 02936 02931         1090       TF   KLAST,KZ                                                  0
00474 16 02924 00-00         1100       TFM  FIRST,0,9,Z                                               0
00486 16 02927 00-00         1110       TFM  LAST,0,9,Z                                                0
00498 26 02931 02921         1120       TF   K,BIGZ                                                    0
00510 26 00657 02931         1130       TF   OMEGA&11,KZ                                               0
00522 26 00569 02931         1140       TF   CKFLAG&23,KZ                                              0
00534 26 00557 02931         1150       TF   CKFLAG&11,KZ                                              0
00546 44 00646 04000         1160CKFLAG BNF  OMEGA,4000Z                                               0
00558 44 00602 05000         1170       BNF  ALPHA,5000Z                                               0
00570 12 02931 00-01         1180OUT    SM   K,1,9,Z                                                   0
00582 46 00702 01200         1190       BZ   TICALCZ                                                   0
00594 49 00510 00000         1200       B    CKFLAG-36Z                                                0
00602                        1210       DORG *-3Z                                                      0
00602 14 02924 00-00         1220ALPHA  CM   FIRST,0,9,Z                                               0
00614 47 02062 01200         2010       BNE  ERROR3Z                                                   0
00626 26 02924 02931         2020       TF   FIRST,KZ                                                  0
00638 49 00570 00000         2030       B    OUTZ                                                      0
00646                        2040       DORG *-3Z                                                      0
00646 44 00570 05000         2050OMEGA  BNF  OUT,5000Z                                                 0
00658 14 02927 00-00         2060       CM   LAST,0,9,Z                                                0
00670 47 02042 01200         2070       BNE  ERROR2Z                                                   0
00682 26 02927 02931         2080       TF   LAST,KZ
00694 49 00570 00000         2090       B    OUTZ
00702                        2100       DORG *-3Z
                             2110*           COMPUTE EARLIEST STARTING TIMES - TI/I/Z                  0
                             2120*           CHECK FOR A LOOP IN ARROW DIAGRAMZ                        0
00702 16 00732 -2963         2130TICALC TFM  *630,TIZ                                                  0
00714 16 00756 -2968         2140       TFM  *642,TJZ                                                  0
00726 16 00000 -0000         2150       TFM  ,0Z                                                       0
00738 11 00732 00000         2160       AM   *-6,10,10,Z                                               0
```

Appendix C

```
00750 16 00000 R9999   2170         TFM   ,99999Z                                          0
00762 11 00756 000J0   2180         AM    *-6,10,10,Z                                      0
00774 12 02921 00-01   2190         SM    BIG,1,9,Z                                        0
00786 46 00726 01300   2200         BNN   TICALC&24Z                                       0
00798 16 02931 0-000   3010TILOOP   TFM   K,0,8,Z                                          0
00810 33 02942 00000   3020         CF    FLAGZ                                            0
00822 11 02931 0-001   3030         AM    K,1,8,Z                                          0
00834 17 02188 000-0   3040         BTM   GETIJD,0,10,Z                                    0
00846 16 00881 -2963   3050         TFM   *&35,TIZ                                         0
00858 21 00880 02844   3060         A     *&22,IZ                                          0
00870 26 02941 00000   3070         TF    TESTZ                                            0
00882 21 02941 02851   3080         A     TEST,DZ
00894 16 00929 -2963   3090         TFM   *&35,TIZ                                         0
00906 21 00928 02847   3100         A     *&22,JZ                                          0
00918 26 02897 00000   3110         TF    TIJZ
00930 24 02897 02941   3120         C     TIJ,TESTZ
00942 47 00998 01300   3130         BL    ONIZ
00954 24 02931 02936   3140BACKI    C     K,KLASTZ                                         0
00966 47 00822 01200   3150         BNE   TILOOP&24Z                                       0
00978 44 01078 02942   3160         BNF   TJCALC,FLAGZ                                     0
00990 49 00798 00000   3170         B     TILOOPZ                                          0
00998                  3180         DORG  *-3Z                                             0
00998 24 02918 02941   3190ONI      C     MOST,TESTZ                                       0
01010 47 02130 01300   3200         BL    ERROR4Z
01022 16 01052 -2963   4010         TFM   *&30,TIZ                                         0
01034 21 01051 02847   4020         A     *&17,JZ                                          0
01046 26 00000 02941   4030         TF    ,TESTZ
01058 32 02942 00000   4040         SF    FLAGZ
01070 49 00954 00000   4050         B     BACKIZ
01078                  4060         DORG  *-3Z
                       4070*              COMPUTE LATEST STARTING TIMES TJ/J/Z              0
01078 16 01113 -2963   4090TJCALC   TFM   *&35,TIZ
01090 21 01112 02927   4100         A     *&22,LASTZ                                       0
01102 26 02862 00000   4110         TF    LAMDAZ
01114 26 02958 02862   4120         TF    SCHTIM,LAMDAZ                                    0
01126 47 01174 00100   4130         BNC1  *&48Z
01138 37 00101 00500   4140         RACD  RECORDZ                                          0
01150 17 02252 000-0   4150         BTM   TNS,0,10,Z
01162 26 02958 02846   4160         TF    SCHTIM,I&2Z
01174 16 01204 -2968   4170         TFM   *&30,TJZ
```



```
01186 21 01203 02927   4180         A     *&17,LASTZ                                       0
01198 26 00000 02958   4190         TF    ,SCHTIMZ                                         0
01210 26 02931 02936   4200TJLOOP   TF    K,KLASTZ
01222 33 02942 00000   5010         CF    FLAGZ
01234 17 02188 000-0   5020         BTM   GETIJD,0,10,Z                                    0
01246 16 01281 -2968   5030         TFM   *&35,TJZ                                         0
01258 21 01280 02847   5040         A     *&22,JZ
01270 26 02941 00000   5050         TF    TESTZ
01282 22 02941 02851   5060         S     TEST,DZ
01294 16 01329 -2968   5070         TFM   *&35,TJZ                                         0
01306 21 01328 02844   5080         A     *&22,IZ
01318 26 02902 00000   5090         TF    TJIZ
01330 24 02902 02941   5100         C     TJI,TESTZ
01342 46 01398 01100   5110         BH    ONJZ
01354 12 02931 0-001   5120BACKJ    SM    K,1,8,Z
01366 47 01234 01200   5130         BNZ   TJLOOP&24Z                                       0
01378 44 01454 02942   5140         BNF   OUTPUT,FLAGZ                                     0
01390 49 01210 00000   5150         B     TJLOOPZ
01398                  5160         DORG  *-3Z
01398 16 01428 -2968   5170ONJ      TFM   *&30,TJZ
01410 21 01427 02844   5180         A     *&17,IZ
01422 26 00000 02941   5190         TF    ,TESTZ
01434 32 02942 00000   5200         SF    FLAGZ
01446 49 01354 00000   6010         B     BACKJZ
01454                  6020         DORG  *-3Z
                       6030*              CALCULATE AND PUNCH START, FINISH, AND FLOAT TIMESZ  0
01454 48 00000 00000   6040OUTPUT   H     Z
01466 17 02530 000-J   6050READ2    BTM   READ,-1,10Z
01478 44 01894 02528   6060         BNF   EOJ,READ-2Z
01490 33 02943 00000   6070         CF    CRITZ
01502 17 02252 000-0   6080         BTM   TNS,0,10,Z
01514 32 02845 00000   6090         SF    J-2Z
01526 32 02846 00000   6100         SF    D-3Z
01538 16 01573 -2963   6110         TFM   *&35,TIZ
01550 21 01572 02844   6120         A     *&22,IZ
01562 26 02867 00000   6130         TF    TIIZ
01574 16 01609 -2963   6140         TFM   *&35,TIZ
01586 21 01608 02847   6150         A     *&22,JZ
01598 26 02897 00000   6160         TF    TIJZ
```

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01610 16 01645 -2968   6170        TFM   *635,TJZ
01622 21 01644 02847   6180        A     *622,JZ
01634 26 02882 00000   6190        TF    TJJZ
01646 26 02872 02867   6200        TF    EF,TIIZ
01658 21 02872 02851   7010        A     EF,DZ
01670 26 02877 02882   7020        TF    LS,TJJZ
01682 22 02877 02851   7030        S     LS,DZ
01694 26 02887 02877   7040        TF    TF,LSZ
01706 22 02887 02867   7050        S     TF,TIIZ
01718 47 01742 01200   7060        BNZ   *624Z
01730 32 02943 00000   7070        SF    CRITZ
01742 26 02892 02897   7080        TF    FF,TIJZ
01754 22 02892 02872   7090        S     FF,EFZ
01766 16 02953 -0259   7100        TFM   STRIP,RECORD6158Z                          0
01778 27 02358 02892   7110        BT    EDIT,FFZ
01790 27 02358 02887   7120        BT    EDIT,TFZ
01802 27 02358 02882   7130        BT    EDIT,TJJZ
01814 27 02358 02877   7140        BT    EDIT,LSZ
01826 27 02358 02872   7150        BT    EDIT,EFZ
01838 27 02358 02867   7160        BT    EDIT,TIIZ
01850 44 01874 02943   7170        BNF   *624,CRITZ
01862 16 00249 000J4   7180        TFM   RECORD6148,14,10,Z                         0
01874 39 00101 00400   7190        WACD  RECORDZ
01886 49 01466 00000   7200        B     READ2Z
01894                  8010        DORG  *-3Z
                       8020*             PUNCH TOTAL COST AND COMPLETION TIMEZ       0
01894 31 00100 02660   8030EOJ     TR    RECORD-1,TITLE-1Z                          0
01906 16 02953 -0147   8040        TFM   STRIP,RECORD646Z                           0
01918 27 02358 02910   8050        BT    EDIT,TCOSTZ
01930 16 02953 -0207   8060        TFM   STRIP,RECORD6106Z                          0
01942 27 02358 02862   8070        BT    EDIT,LAMDAZ
01954 22 02958 02862   8080        S     SCHTIM,LAMDAZ
01966 16 02953 -0257   8090        TFM   STRIP,RECORD6156Z                          0
01978 27 02358 02958   8100        BT    EDIT,SCHTIMZ
01990 39 00101 00400   8110        WACD  RECORDZ
02002 48 00000 00000   8120GOBACK  H      Z
02014 49 01466 00000   8130        B     READ2Z
02022                  8140        DORG  *-3Z
                       8150*             ERROR ROUTINESZ                            0
02022 15 02835 00001   8160ERROR1  TDM   ER612,1Z
```

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02034 49 02142 00000   8170        B     ER14Z
02042                  8180        DORG  *-3Z
02042 15 02835 00002   8190ERROR2  TDM   ER612,2Z
02054 49 02074 00000   8200        B     ER23Z
02062                  9010        DORG  *-3Z
02062 15 02835 00003   9020ERROR3  TDM   ER612,3Z
02074 16 00703 000M8   9030ER23     TFM   TICALC61,48,10Z
02086 34 00000 00102   9040        RCTY   Z
02098 39 02823 00100   9050        WATY  ERZ
02110 38 02928 00100   9060        WNTY  K-3Z
02122 49 00570 00000   9070        B     OUTZ
02130                  9080        DORG  *-3Z
02130 15 02835 00004   9090ERROR4  TDM   ER612,4Z
02142 34 00000 00102   9100ER14    RCTY   Z
02154 39 02823 00100   9110        WATY  ERZ
02166 38 02842 00100   9120        WNTY  1-2Z
02178 49 02002 00000   9130        B     GOBACKZ
02186                  9140        DORG  *-3Z
                       9150*             SUBROUTINE TO GET IJK/K/ FROM STORAGEZ      0
02187         2 00000  9160        DS    2Z
02188 26 02223 02948   9170GETIJD  TF    *635,SIZEZ
02200 22 02222 02931   9180        S     *622,KZ
02212 26 02851 00000   9190        TF    DZ
02224 32 02845 00000   9200        SF    J-2Z
02236 32 02848 00000   10010       SF    D-3Z
02248 42 00000 00000   10020       BB     Z
02250                  10030       DORG  *-9Z
                       10040*            SUBROUTINE TO TRANSFER, NUMERIC STRIP FOR I,J,D, COST,Z     0
02251         2 00000  10050       DS    2Z
02252 16 02282 -2842   10060INS    TFM   *630,1-2Z
02264 16 02287 -0101   10070       TFM   *623,RECORDZ
02276 25 00000 00000   10080       TD     Z
02288 11 02287 000-2   10090       AM    *-1,2,10,Z
02300 11 02282 000-1   10100       AM    *-18,1,10,Z
02312 14 02282 -2857   10110       CM    *-30,COST61Z
02324 47 02276 01200   10120       BNE   *-48Z
02336 32 02842 00000   10130       SF    1-2Z
02348 42 00000 00000   10140       BB     Z
02350                  10150       DORG  *-9Z
                       10160*            SUBR TO NUMERIC FILL & PUNCH NEGATIVE SIGNS AS, AN X PCHZ   0
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                            10170*             OVER THE UNITS POSITION OF FIELDZ                            0
02357          8 00000      10180        DS    8Z
02358 16 02465 -2357        10190EDIT    TFM   SECOND&23,EDIT-1Z                                             0
02370 26 02412 02953        10200        TF    *&42,STRIPZ
02382 44 02442 02357        11010        BNF   SECOND,EDIT-1Z
02394 25 02417 02357        11020        TD    *&23,EDIT-1Z
02406 16 99999 000N0        11030        TFM   99999,50,10,Z
02418 12 02953 000-2        11040        SM    STRIP,2,10,Z
02430 12 02465 000-1        11050        SM    SECOND&23,1,10,Z
02442 26 02472 02953        11060SECOND  TF    *&30,STRIPZ
02454 25 02477 99999        11070        TD    *&23,99999Z
02466 16 99999 000P0        11080        TFM   99999,70,10,Z
02478 26 02525 02465        11090        TF    *&47,SECOND&23Z
02490 12 02953 000-2        11100        SM    STRIP,2,10,Z
02502 12 02465 000-1        11110        SM    SECOND&23,1,10,Z
02514 44 02442 99999        11120        BNF   SECOND,99999Z
02526 42 00000 00000        11130        BB     Z
02528                       11140        DORG  *-9Z
                            11150*             READ ROUTINEZ
02529          2 00000      11160        DS    2Z
02530 37 00101 00500        11170READ    RACD  RECORDZ
02542 14 00101 000P0        11180        CM    RECORD,70,10,Z
02554 46 02658 01300        11190        BNL   END&12Z
02566 14 00104 -0000        11200        CM    RECORD&3Z
02578 46 02646 01200        12010        BE    ENDZ
02590 14 00101 000-0        12020        CM    RECORD,0,10,Z
02602 46 02658 01200        12030        BE    END&12Z
02614 44 02530 02529        12040        BNF   READ,READ-1Z
02626 39 00101 00400        12050        WACD  RECORDZ
02638 49 02530 00000        12060        B     READZ
02646                       12070        DORG  *-3Z
02646 33 02528 00000        12080END     CF    READ-2Z
02658 42 00000 00000        12090        BB     Z
02660                       12100        DORG  *-9Z
                            12110*             AREA AND STORAGE DEFINITIONSZ                                 0
00101         80 00000      12120RECORD  DAS   80,101Z
02661         40 00000      12130TITLE   DAC   40,-PROJECT COST                PROJECT COMPZ                 0
                            12130K05759 5651 45436300435662630000000000                 20000000602660027100
                            12130000000 5759 56514543630043565457Z0000000000             -602710027400
02741         41 00000      12140        DAC   41,LETION             PROJECT SLACK          @Z                0
                            12140N34563 4956 550000000000                      57595651454363Z000000060274002790O
                            12140006253 4143 520000000000          20000000000           -602790028220

02823         10 00000      12150ER      DAC   10,ERROR 0  @Z                                                0
                            12150M55959 5659 0070000000200000000                                     -602820028420
02844          3 00000      12160I       DS    3Z
02847          3 00000      12170J       DS    3Z
02851          4 00000      12180D       DS    4Z
02856          5 00000      12190COST    DS    5Z
02857          1 00000      12200        DC    1,@Z
                            12200200000 0000 0                                                    -602850702858O
02862          5 00000      13010LAMDA   DS    5Z
02867          5 00000      13020TII     DS    5Z
02872          5 00000      13030EF      DS    5Z
02877          5 00000      13040LS      DS    5Z
02882          5 00000      13050TJJ     DS    5Z
02887          5 00000      13060TF      DS    5Z
02892          5 00000      13070FF      DS    5Z
02897          5 00000      13080TIJ     DS    5Z
02902          5 00000      13090TJI     DS    5Z
02910          8 00000      13100TCOST   DC    8,0Z
                            13100000000 0020 00000                                                -602903029110
02918          8 00000      13110MOST    DC    8,0Z
                            13110000000 0020 00000                                                -602911029190
02921          3 00000      13120BIG     DS    3Z
02924          3 00000      13130FIRST   DS    3Z
02927          3 00000      13140LAST    DS    3Z
02931          4 00000      13150K       DS    4Z
02932          1 00000      13160        DC    1,@Z
                            13160200000 0000 0                                                    -602932029330
02936          4 00000      13170KLAST   DS    4Z
02941          5 00000      13180TEST    DS    5Z
02942          1 00000      13190FLAG    DS    1Z
02943          1 00000      13200CRIT    DS    1Z
02948          5 00000      14010SIZE    DC    5,20009,,CHANGE THIS FOR 40 OR 60KZ                          0
                            14010K00092 0000 000                                                  -602944029490
02953          5 00000      14020STRIP   DS    5Z
02958          5 00000      14030SCHTIM  DS    5Z
02963          5 00000      14040TI      DS    5Z
02968          5 00000      14050TJ      DS    5Z
02970 16 03000 -3999        15010JOBS    TFM   *&30,3999Z
02982 11 03000 000-1        15020        AM    *&18,1,10,Z
02994 33 99999 00000        15030        CF    99999Z
03006 14 03000 -6001        15040        CM    *-6,6001Z
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03018 47 02982 01200   15050          BNE   JOBS&12Z
03030 22 02910 02910   15060          S     TCOST,TCOSTZ
03042 22 02918 02918   15070          S     MOST,MOSTZ
03054 16 02921 00-00   15080          TFM   BIG,0,9Z
03066 16 02931 0-000   15090          TFM   K,0,8Z
03078 17 03536 000-0   15100READ1     BTM   RCD1,0,10,Z
03090 44 00402 03534   15110          BNF   AVAIL,RCD1-2Z
03102 11 02931 000-1   15120          AM    K,1,10,Z
03114 26 03144 02948   15130          TF    *&30,SIZEZ
03126 22 03143 02931   15140          S     *&17,KZ
03138 26 00000 02851   15150          TF    ,DZ
03150 32 02845 00000   15160          SF    J-2Z
03162 32 02848 00000   15170          SF    D-3Z
03174 32 02852 00000   15180          SF    COST-4Z
03186 21 02910 02856   15190          A     TCOST,COSTZ
03198 21 02918 02851   15200          A     MOST,DZ
03210 26 03240 02844   16010          TF    FLAGIJ&6,IZ
03222 26 03252 02847   16020          TF    FLAGIJ&18,JZ
03234 32 04000 00000   16030FLAGIJ    SF    4000Z
03246 32 05000 00000   16040          SF    5000Z
03258 24 02844 02921   16050          C     I,BIGZ
03270 47 03294 01100   16060          BNH   *&24Z
03282 26 02921 02844   16070          TF    BIG,IZ
03294 24 02847 02921   16080          C     J,BIGZ
03306 47 03330 01100   16090          BNH   *&24Z
03318 26 02921 02847   16100          TF    BIG,JZ
03330 49 03078 00000   16110          B     READ1Z
03338                  16120          DORG  *-3Z
03345           8 00000 17009FILL1    DC    8,70707070Z
                       17009P07070 7020 000000 0                    -603338033460
03372          27 00000 17010COMPRS   DS    27Z
03375          80 00000 17020REC1     DAS   80Z
03535           2 00000 17030         DS    2Z
03536 37 03375 00500   17040RCD1      RACD  REC1Z
03548 32 03374 00000   17050          SF    REC1-1Z
03560 14 03378 -0000   17060          CM    REC1&3,0Z
03572 46 03966 01200   17070          BE    LASTCDZ
03584 14 03375 000-0   17080          CM    REC1,0,10,Z
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03596 46 03646 01200   17090          BE    DATA1Z
03608 14 03375 000P0   17100          CM    REC1,70,10Z
03620 46 03646 01300   17110          BNL   DATA1Z
03632 39 03375 00400   17120PCH1      WACD  REC1Z
03644 42 00000 00000   17130          BB    Z
03646                  17140          DORG  *-9Z
03646 16 03681 -3375   17150DATA1     TFM   *&35,REC1Z
03658 16 03676 -3346   17160          TFM   *&18,COMPRS-26Z
03670 25 99999 99999   17170          TD    99999,99999Z
03682 11 03681 000-2   17180          AM    *-1,2,10,Z
03694 11 03676 000-1   17190          AM    *-18,1,10,Z
03706 14 03676 -3373   17200          CM    *-30,COMPRS&1Z
03718 47 03670 01200   18010          BNE   *-48Z
03730 32 03369 00000   18020          SF    COMPRS-3Z
03742 32 03365 00000   18030          SF    COMPRS-7Z
03754 32 03361 00000   18040          SF    COMPRS-11Z
03766 13 03368 000M0   18050          MM    COMPRS-4,40,10,Z
03778 21 00098 03372   18060          A     98,COMPRSZ
03790 21 00098 03364   18070          A     98,COMPRS-8Z
03802 26 03372 00098   18080          TF    COMPRS,98Z
03814 13 03372 J6666   18090          MM    COMPRS,16666Z
03826 11 00095 000-5   18100          AM    95,5,10,Z
03838 32 00091 00000   18110          SF    91Z
03850 26 03355 00094   18120          TF    COMPRS-17,94Z
03862 33 03352 00000   18130          CF    COMPRS-20Z
03874 32 03346 00000   18140          SF    COMPRS-26Z
03886 26 02856 03360   18150          TF    COST,COMPRS-12Z
03898 26 03393 03345   18160          TF    REC1&18,FILL1Z
03910 25 03393 00094   18170          TD    REC1&18,94Z
03922 25 03391 00093   18171          TD    REC1&16,93Z
03934 25 03389 00092   18172          TD    REC1&14,92Z
03946 25 03387 00091   18173          TD    REC1&12,91Z
03958 49 03632 00000   18180          B     PCH1Z
03966                  18190          DORG  *-3Z
03966 33 03534 00000   18200LASTCD    CF    RCD1-2Z
03978 32 00100 00000   18210          SF    100Z
03990 49 03632 00000   18220          B     PCH1Z
02970                  18230          DEND  JOBSZ
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Part I Condensed Listing

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42000000000Z00000000000                                      -1022480226000003 9
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```

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Z00000000                                                    1010285702858000053
000000000- 0    Z0000000000                                  1010290302919000054
Z00000000                                                    1010293202933000055
K0009Z0000000                                                1010294402949000056
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M8000000000049029700P90JKLMNOPQZ0000L10038800019M9000000000M900036000000000000080
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Appendix D

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00402                          24        DORG 402Z
00402 49 02154 00000           25        B    START-12Z
00414 26 00953 00000           26DIV     TF   SUB&11,,,          DIVIDE SUBROUTINEZ
00426 11 00425 -0005           27        AM   DIV&11,5Z
00438 26 00461 00425           28        TF   *&23,DIV&11Z
00450 26 00528 00000           29        TF   POSIT&6Z
00462 11 00425 -0005           30        AM   DIV&11,5Z
00474 26 00497 00425           31        TF   *&23,DIV&11Z
00486 26 00948 00000           32        TF   SUB&6Z
00498 13 00509 000-0           33        MM   *&11,,10,Z
00510 33 00096 00000           34        CF   96Z
00522 26 00000 00000           35POSIT   TF    Z
00534 15 00544 00-01           36        TDM  POSIT&22,1,9,Z
00546 26 00569 00533           37        TF   POSIT&47,POSIT&11Z
00558 44 00606 00000           38        BNF  *&48Z
00570 15 00544 0000-           39        TDM  POSIT&22,,11,Z
00582 26 00600 00528           40        TF   *&18,POSIT&6Z
00594 33 00000 00000           41        CF    Z
00606 15 00943 00002           42        TDM  SUB&1,2Z
00618 15 01043 00001           43        TDM  PQ-11,1Z
00630 26 00653 00953           44        TF   *&23,SUB&11Z
00642 44 00690 00000           45        BNF  *&48Z
00654 12 00544 000-1           46        SM   POSIT&22,1,10,Z
00666 15 00943 00001           47        TDM  SUB&1,1Z
00678 15 01043 00002           48        TDM  PQ-11,2Z
00690 26 00725 00948           49        TF   *&35,SUB&6Z
00702 12 00725 -0001           50        SM   *&23,1Z
00714 44 00702 00000           51        BNF  *-12Z
00726 26 00761 00953           52        TF   *&35,SUB&11Z
00738 12 00761 -0001           53        SM   *&23,1Z
00750 44 00738 00000           54BFLG    BNF  *-12Z
00762 21 00761 00948           55        A    *-1,SUB&6Z
00774 22 00761 00953           56        S    BFLG&11,SUB&11Z
00786 24 00761 00725           57        C    BFLG&11,BFLG-25Z
00798 46 00858 01300           58        BNL  *&60Z
00810 26 00828 00725           59        TF   *&18,BFLG-25Z
00822 33 00000 00000           60        CF    Z
00834 26 00852 00761           61        TF   *&18,BFLG&11Z
00846 32 00000 00000           62        SF    Z
00858 16 00984 -0998           63        TFM  SUB&42,NZQZ
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00870 26 01060 00761           64        TF   PQ&6,BFLG&11Z
00882 12 01060 -0001           65        SM   PQ&6,1Z
00894 26 01176 01060           66        TF   EMD&6,PQ&6Z
00906 26 01053 00953           67        TF   PQ-1,SUB&11Z
00918 15 01313 00000           68        TDM  SET&11Z
00930 16 00939 000-0           69        TFM  *&9,,10,Z
00942 22 00000 00000           70SUB     S     Z
00954 47 01030 01300           71        BN   PQ-24Z
00966 11 00939 00001           72        AM   SUB-3,11,10,Z
00978 43 00000 00939           73        BD   ,SUB-3Z
00990 49 01290 00000           74        B    SET-12Z
00998                          75        DORG *-3Z
00998 15 01313 00001           76NZQ     TDM  SET&11,1Z
01010 16 00984 -0942           77        TFM  SUB&42,SUBZ
01022 49 00942 00000           78        B    SUBZ
01030                          79        DORG *-3Z
01030 26 01048 00948           80        TF   *&18,SUB&6Z
01042 21 00000 00000           81        A     Z
01054 25 00000 00939           82PQ      TD   ,SUB-3Z
01066 47 01102 01200           83        BNZ  *&36Z
01078 26 01096 00948           84        TF   *&18,SUB&6Z
01090 33 00000 00000           85        CF    Z
01102 11 00948 -0001           86        AM   SUB&6,1Z
01114 43 01170 00946           87        BD   EMD,SUB&4Z
01126 11 01060 -0001           88        AM   PQ&6,1Z
01138 26 01156 01060           89        TF   *&18,PQ&6Z
01150 32 00000 00000           90        SF    Z
01162 49 00930 00000           91        B    SUB-12Z
01170                          92        DORG *-3Z
01170 32 00000 00000           93EMD     SF    Z
01182 43 01230 00544           94        BD   *&48,POSIT&22Z
01194 26 01212 01060           95        TF   *&18,PQ&6Z
01206 32 00000 00000           96        SF    Z
01218 32 01313 00000           97        SF   SET&11Z
01230 11 01060 -0001           98        AM   PQ&6,1Z
01242 26 01260 01060           99        TF   *&18,PQ&6Z
01254 32 00000 00000           100       SF    Z
01266 44 01290 00544           101       BNF  *&24,POSIT&22Z
01278 32 00099 00000           102       SF   99Z
01290 11 00429 -0001           103       AM   DIV&11,1Z
01302 11 01313 000-0           104SET    AM   *&11,,10,Z
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Appendix E

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01314 26 01332 00425      105          TF    *&18,DIV&11Z
01326 49 00000 00000      106          B     ,,,                        END DIVIDE SUBROUTINEZ                 0
01354                     107          DORG  *&17Z
01371          18 00000   108CIPHER    DC    18,0Z
                          108000000    0000  0            Z00000000                             -601354013720
01413          42 00000   109NEG       DC    42,55454703005559004555634559454400625859630@Z                0
                          109N54547    0300  5559004555634559454400625859630Z00000000000000 -601372014140
01447          34 00000   110OVR       DC    34,5665455946535666004955006258596 30@Z                        0
                          110N66545    5946  53566600495500625859630Z000000000000                -601414014480
01457          10 00000   111COUNT     DS    10Z
01469          12 00000   112ODDINT    DS    12Z
01487          18 00000   113WA18      DS    18Z
01505          18 00000   114          DS    18Z
01506 44 01530 01505      115SQRT      BNF   *&24,SQRT-1,,              SQUARE ROOT SUBROUTINEZ                0
01518 49 01746 00000      116          B     ROOT&96Z
01530 16 01692 -1489      117          TFM   ROOT&42,SQRT-17Z
01542 16 01932 -1449      118          TFM   ANS&6,COUNT-8Z
01554 26 01487 01505      119LOCATE    TF    WA18,SQRT-1Z
01566 26 01505 01371      120          TF    SQRT-1,CIPHERZ
01578 26 01505 01487      121          TF    SQRT-1,WA18Z
01590 16 01608 -1489      122CLEAN     TFM   *&18,SQRT-17Z
01602 33 01489 00000      123          CF    SQRT-17Z
01614 11 01608 000-1      124          AM    CLEAN&18,1,10,Z
01626 14 01608 -1505      125          CM    CLEAN&18,SQRT-1Z
01638 47 01602 01200      126          BNE   CLEAN&12Z
01650 26 01457 01363      127ROOT      TF    COUNT,CIPHER-8Z
01662 16 01469 000-1      128          TFM   ODDINT,1,10,Z
01674 15 01469 00001      129          TDM   ODDINT,1Z
01686 22 -1489 01469      130          S     SQRT-17,ODDINT,2,Z
01698 47 01782 01400      131          BNV   *&84Z
01710 34 00000 00102      132          RCTY  Z
01722 39 01415 00100      133          WATY  OVR-32Z
01734 48 00000 00000      134          H     Z
01746 34 00000 00102      135          RCTY  Z
01758 39 01373 00100      136          WATY  NEG-40Z
01770 48 00000 00000      137          H     Z
01782 26 01800 01692      138          TF    *&18,ROOT&42Z
01794 14 01489 000-0      139          CM    SQRT-17,0,10,Z
01806 47 01830 01200      140          BNZ   *&24Z
01818 49 01926 00000      141          B     ANSZ
01830 46 01926 01100      142          BH    ANSZ
```



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01842 26 01860 01692      143          TF    *&18,ROOT&42Z
01854 21 01489 01469      144          A     SQRT-17,ODDINTZ
01866 26 01884 01692      145          TF    *&18,ROOT&42Z
01878 33 01489 00000      146          CF    SQRT-17Z
01890 14 01692 -1505      147          CM    ROOT&42,SQRT-1,7,Z
01902 46 02118 01200      148          BE    ENDSQRZ
01914 49 02010 00000      149          B     *&96Z
01926 11 01449 000-1      150ANS       AM    COUNT-8,1,10,Z
01938 11 01469 000-2      151          AM    ODDINT,2,10,Z
01950 26 01968 01692      152          TF    *&18,ROOT&42Z
01962 24 01489 01469      153          C     SQRT-17,ODDINTZ
01974 46 01686 01300      154          BNL   ROOT&36Z
01986 14 01692 -1505      155          CM    ROOT&42,SQRT-1,7,Z
01998 46 02118 01200      156          BE    ENDSQRZ
02010 11 01692 000-2      157          AM    ROOT&42,2,10,Z
02022 26 02040 01932      158          TF    *&18,ANS&6Z
02034 13 01449 000-2      159          MM    COUNT-8,2,10,Z
02046 14 01692 -1491      160          CM    ROOT&42,SQRT-15Z
02058 47 02082 01200      161          BNE   *&24Z
02070 32 00098 00000      162          SF    98Z
02082 26 01468 00099      163          TF    ODDINT-1,99Z
02094 11 01932 000-1      164          AM    ANS&6,1,10,Z
02106 49 01674 00000      165          B     ROOT&24Z
02118 32 01449 00000      166ENDSQR    SF    COUNT-8Z
02130 26 01505 01457      167          TF    SQRT-1,COUNTZ
02142 42 00000 00000      168          BB    ,,,                        END SQUARE ROOT SUBROUTINEZ            0
02153                     169          DORG  *Z
02154 48 00000 00000      170          H     ,,,                        START OF 1620 PERTZ                    0
02166 46 02178 00900      171START     BI    *&12,900,,                 RESET LAST CARD INDICATORZ             0
02178 16 04348 0-000      172          TFM   LAST,0,8,Z
02190 16 03108 00-00      173          TFM   INC&30,0,9,Z
02202 16 02616 -4405      174          TFM   ALT&30,DATAZ
02214 16 03903 -4414      175          TFM   PRINT&47,DATA&9Z
02226 16 02688 J9995      176          TFM   CLEAR&18,TABLE-4Z
02238 16 02789 -4414      177          TFM   INI&23,DATA&9Z
02250 16 04259 0-000      178          TFM   N,0,8,                     INITIALIZE COUNT OF EVENT CARDSZ       0
02262 36 04260 00500      179READ      RNCD  RECORD-79,,,               FIRST PASS READZ                       0
02274 11 04259 000-1      180          AM    N,1,10,Z
02286 25 04270 00400      181          TD    RECORD-69,400,,            SET RECORD MARKZ                       0
02298 32 04260 00000      182          SF    RECORD-79Z
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02310 32 04275 00000     183          SF   RECORD-64Z
02322 32 04283 00000     184          SF   RECORD-56Z
02334 32 04266 00000     185          SF   RECORD -73Z
02346 32 04263 00000     186          SF   RECORD-76Z
02358 24 04262 04265     187          C    RECORD-77,RECORD-74,,   FINDING LARGEST NUMBERED NODEZ      0
02370 46 02406 01100     188          BH   *&36Z
02382 26 03113 04265     189          TF   INC&35,RECORD-74,, STORE J IF LARGESTZ                      0
02394 49 02418 00000     190          B    *&24Z
02406 26 03113 04262     191          TF   INC&35,RECORD-77,, STORE I IF LARGESTZ                      0
02418 33 04263 00000     192          CF   RECORD-76Z
02430 24 03108 03113     193          C    INC&30,INC&35,,    COMPARE NEW I OR J WITH LARGEST I OR JZ 0
02442 46 02466 01300     194          BNL  *&24Z
02454 26 03108 03113     195          TF   INC&30,INC&35  ,,    NEW I OR J WAS LARGESTZ                0
02466 14 04269 0-000     196          CM   RECORD-70,0,8,     DETERMINE IF A AND B ARE EQUALZ          0
02478 46 02586 01200     197          BE   ALT,,,             IF EQUAL THEN VARIANCE IS ZEROZ          0
02490 22 04286 04278     198          S    RECORD-53,RECORD-61,,   IF NOT EQUAL SUBTRACT B FROM AZ     0
02502 13 04286 J6667     199          MM   RECORD-53,16667,7, DIVIDE B MINUS A BY SIXZ                 0
02514 26 04344 00094     200          TF   A,94Z
02526 23 04344 04344     201          M    A,A,,              SQUARING TO DETERMINE VARIANCEZ          0
02538 32 00094 00000     202          SF   94Z
02550 11 00098 000-5     203          AM   98,5,10,Z
02562 26 04269 00097     204          TF   RECORD-70,97Z
02574 49 02598 00000     205          B    *&24Z
02586 16 04269 0-000     206ALT       TFM  RECORD-70,0,8,     SETTING VARIANCE EQUAL TO ZEROZ          0
02598 33 04266 00000     207          CF   RECORD-73Z
02610 31 -4405 04260     208          TR   DATA,RECORD-79,2,  STORING I, J, AND VARZ                   0
02622 11 02616 000J0     209          AM   *-6,10,10,Z
02634 47 02262 00900     210          BNI  READ,900Z
02646 26 04348 04259     211          TF   LAST,N,,           STORING NUMBER OF EVENT CARDSZ           0
02658 16 04259 0-000     212          TFM  N,0,8,             SET CARD COUNT TO ZEROZ                  0
02670 11 04259 000-1     213CLEAR     AM   N,1,10,Z
02682 32 J9995 00000     214          SF   TABLE-4,,2,Z
02694 12 02688 000-5     215          SM   *-6,5,10,Z
02706 24 04259 03108     216          C    N,INC&30Z
02718 46 02742 01200     217          BE   *&24Z
02730 49 02670 00000     218          B    CLEARZ
02742 16 04259 0-000     219SIGCAL    TFM  N,0,8,          FIND SUMMATION OF VARIANCES FOR EACH NODEZ  0
02754 33 04350 00000     220          CF   FLAGZ
02766 11 04259 000-1     221INI       AM   N,1,10,Z
02778 26 04360 -4414     222          TF   VAR,DATA&9,7,Z
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02790 11 02789 000J0     223          AM   *-1,10,10,Z
02802 32 04354 00000     224          SF   J-2Z
02814 32 04357 00000     225          SF   VAR-3Z
02826 27 03078 04353     226          BT   INC,IZ
02838 22 02861 04365     227          S    *&23,NUMZ
02850 26 04370 J9999     228          TF   TEST,TABLE,7,Z
02862 16 02861 J9999     229          TFM  *-1,TABLEZ
02874 21 04370 04360     230          A    TEST,VARZ
02886 27 03078 04356     231          BT   INC,JZ
02898 22 02933 04365     232          S    *&35,NUMZ
02910 26 02988 02933     233          TF   *&78,*&23Z
02922 26 04375 J9999     234          TF   MOST,TABLE,7,Z
02934 16 02933 J9999     235          TFM  *-1,TABLEZ
02946 24 04370 04375     236          C    TEST,MOSTZ
02958 47 03006 01100     237          BNP  *&48Z
02970 32 04350 00000     238          SF   FLAGZ
02982 26 19999 04370     239          TF   TABLE,TESTZ
02994 41 00000 00000     240          NOP   Z
03006 24 04348 04259     241          C    LAST,NZ
03018 47 02766 01200     242          BNE  INIZ
03030 44 03138 04350     243          BNF  OUTPUT,FLAGZ
03042 16 02789 -4414     244          TFM  INI&23,DATA&9Z
03054 49 02742 00000     245          B    SIGCALZ
03066 41 00000 00000     246          NOP   Z
03078 12 03077 000-1     247INC       SM   *-1,1,10,Z
03090 13 03077 000-5     248          MM   *-13,5,10,Z
03102 41 00-00 00000     249          NOP  ,,4,Z
03114 26 04365 00099     250          TF   NUM,99Z
03126 42 00000 00000     251          BB    Z
03138 48 00000 00000     252OUTPUT    H    ,,,                SECOND PASS READ AND OUTPUTZ          0
03150 16 04259 0-000     253          TFM  N,0,8,Z
03162 36 04260 00500     254CARD      RNCD RECORD-79Z
03174 11 04259 000-1     255          AM   N,1,10,Z
03186 25 04340 00400     256          TD   RECORD&1,400Z
03198 32 04287 00000     257          SF   RECORD-52Z
03210 32 04315 00000     258          SF   RECORD-24Z
03222 26 04401 04291     259          TF   TS,RECORD-48Z
03234 14 04401 -0000     260          CM   TS,0Z
03246 47 03282 01200     261          BNE  *&36Z
03258 26 04291 04319     262          TF   RECORD-48,RECORD-20Z
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03270 26 04401 04319     263        TF    TS,RECORD-20Z
03282 32 04263 00000     264        SF    RECORD-76Z
03294 27 03078 04265     265        BT    INC,RECORD-74Z
03306 33 04263 00000     266        CF    RECORD-76Z
03318 22 03341 04365     267        S     *&23,NUMZ
03330 26 04387 J9999     268        TF    SIGMA,TABLE,7,Z
03342 16 03341 J9999     269        TFM   *-1,TABLEZ
03354 33 04383 00000     270        CF    SIGMA-4Z
03366 32 04376 00000     271        SF    SIGMA-11Z
03378 48 03390 01400     272        BV    *&12Z
03390 27 01506 04393     273        BT    SQRT,SIGMA&6Z
03402 32 01499 00000     274        SF    SQRT-7Z
03414 11 01504 000-5     275        AM    SQRT-2,5,10,Z
03426 26 04387 01503     276        TF    SIGMA,SQRT-3Z
03438 22 04401 04319     277        S     TS,RECORD-20Z
03450 14 04387 -0000     278        CM    SIGMA,0Z
03462 47 03546 01200     279        BNE   COMPZ
03474 14 04291 -4319     280        CM    RECORD-48,RECORD-20Z
03486 47 03522 01300     281        BL    ZEROZ
03498 16 04295 0J000     282ALL     TFM   RECORD-44,1000,8,Z
03510 49 03856 00000     283        B     PRINTZ
03522 16 04295 0-000     284ZERO    TFM   RECORD-44,0,8,Z
03534 49 03856 00000     285        B     PRINTZ
03546 16 00425 -3581     286COMP    TFM   DIV&11,*&35Z
03558 16 00533 -4401     287        TFM   DIV&119,TSZ
03570 49 00414 -4387     288        B     DIV,SIGMA,7,Z
03586          5 -0097   289        DSA   00097,00097Z
03591          5 -0097
03592 11 00094 000-5     290        AM    94,5,10,Z
03604 44 03628 00094     291        BNF   *&24,94Z
03616 32 00093 00000     292        SF    93Z
03628 26 04396 00093     293        TF    K,93Z
03640 14 04396 000-0     294        CM    K,0,10,Z
03652 46 03736 01100     295        BH    KPOSZ
03664 33 04396 00000     296        CF    KZ
03676 33 04395 00000     297        CF    K-1Z
03688 32 04394 00000     298        SF    K-2Z
03700 14 04396 000L0     299        CM    K,30,10,Z
03712 46 03522 01100     300        BH    ZEROZ
03724 49 03772 00000     301        B     SEEKZ
03736 14 04396 000L0     302KPOS    CM    K,30,10,Z
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03748 46 03498 01100     303        BH    ALLZ
03760 49 03784 00000     304        B     *&24Z
03772 11 04396 000L1     305SEEK    AM    K,31,10,Z
03784 26 04404 04396     306        TF    KA,KZ
03796 21 04396 04404     307        A     K,KAZ
03808 21 04396 04404     308        A     K,KAZ
03820 21 03843 04396     309        A     *&23,KZ
03832 26 04295 -4072     310        TF    RECORD-44,PROB,7,Z
03844 16 03843 -4072     311        TFM   *-1,PROBZ
03856 16 04396 00-00     312PRINT   TFM   K,0,9,Z
03868 26 04309 04401     313        TF    RECORD-30,TSZ
03880 33 04305 00000     314        CF    RECORD-34Z
03892 26 04360 -4414     315        TF    VAR,DATA&9,7,Z
03904 11 03903 000J0     316        AM    *-1,10,10,Z
03916 32 04357 00000     317        SF    VAR-3Z
03928 26 04299 04360     318        TF    RECORD-40,VARZ
03940 33 04296 00000     319        CF    RECORD-43Z
03952 33 04287 00000     320        CF    RECORD-52Z
03964 33 04292 00000     321        CF    RECORD-47Z
03976 33 04293 00000     322        CF    RECORD-46Z
03988 33 04315 00000     323        CF    RECORD-24Z
04000 41 00000 00000     324        NOP   Z
04012 38 04260 00400     325        WNCD  RECORD-79Z
04024 24 04348 04259     326        C     LAST,NZ
04036 47 03162 01200     327        BNE   CARDZ
04048 48 00000 00000     328        H     Z
04060 49 02154 00000     329        B     START-12Z
04072          1 00000   330PROB    DS    1Z
04075          3 00000   331        DC    3,540Z
                         331N40Z00 0000 000                    -604073040760
04078          3 00000   332        DC    3,579Z
                         332N79Z00 0000 000                    -604076040790
04081          3 00000   333        DC    3,618Z
                         333018Z00 0000 000                    -604079040820
04084          3 00000   334        DC    3,655Z
                         334055Z00 0000 000                    -604082040850
04087          3 00000   335        DC    3,692Z
                         335092Z00 0000 000                    -604085040880
04090          3 00000   336        DC    3,726Z
```

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		336P26Z00	0000	00	-604088040910
04093	3 00000	337	DC	3,758Z	
		337P58Z00	0000	00	-604091040940
04096	3 00000	338	DC	3,788Z	
		338P88Z00	0000	00	-604094040970
04099	3 00000	339	DC	3,816Z	
		339Q16Z00	0000	000	-604097041000
04102	3 00000	340	DC	3,841Z	
		340Q41Z00	0000	00	-604100041030
04105	3 00000	341	DC	3,864Z	
		341Q64Z00	0000	00	-604103041060
04108	3 00000	342	DC	3,885Z	
		342Q85Z00	0000	00	-604106041090
04111	3 00000	343	DC	3,903Z	
		343R03Z00	0000	000	-604109041120
04114	3 00000	344	DC	3,919Z	
		344R19Z00	0000	000	-604112041150
04117	3 00000	345	DC	3,933Z	
		345R33Z00	0000	000	-604115041180
04120	3 00000	346	DC	3,945Z	
		346R45Z00	0000	000	-604118041210
04123	3 00000	347	DC	3,955Z	
		347R55Z00	0000	000	-604121041240
04126	3 00000	348	DC	3,964Z	
		348R64Z00	0000	00	-604124041270
04129	3 00000	349	DC	3,971Z	
		349R71Z00	0000	000	-604127041300
04132	3 00000	350	DC	3,977Z	
		350R77Z00	0000	00	-604130041330
04135	3 00000	351	DC	3,982Z	
		351R82Z00	0000	000	-604133041360
04138	3 00000	352	DC	3,986Z	
		352R86Z00	0000	000	-604136041390
04141	3 00000	353	DC	3,989Z	
		353R89Z00	0000	000	-604139041420
04144	3 00000	354	DC	3,992Z	
		354R92Z00	0000	00	-604142041450
04147	3 00000	355	DC	3,994Z	
		355R94Z00	0000	000	-604145041480
04150	3 00000	356	DC	3,995Z	

C3

		356R95Z00	0000	00	-604148041510
04153	3 00000	357	DC	3,996Z	
		357R96Z00	0000	000	-604151041540
04156	3 00000	358	DC	3,997Z	
		358R97Z00	0000	000	-604154041570
04159	3 00000	359	DC	3,998Z	
		359R98Z00	0000	00	-604157041600
04162	3 00000	360	DC	3,999Z	
		360R99Z00	0000	00	-604160041630
04165	3 00000	361	DC	3,500Z	
		361N00Z00	0000	00	-604163041660
04168	3 00000	362	DC	3,460Z	
		362M60Z00	0000	000	-604166041690
04171	3 00000	363	DC	3,421Z	
		363M21Z00	0000	000	-604169041720
04174	3 00000	364	DC	3,382Z	
		364L82Z00	0000	00	-604172041750
04177	3 00000	365	DC	3,345Z	
		365L45Z00	0000	000	-604175041780
04180	3 00000	366	DC	3,308Z	
		366L08Z00	0000	00	-604178041810
04183	3 00000	367	DC	3,274Z	
		367K74Z00	0000	00	-604181041840
04186	3 00000	368	DC	3,242Z	
		368K42Z00	0000	000	-604184041870
04189	3 00000	369	DC	3,212Z	
		369K12Z00	0000	000	-604187041900
04192	3 00000	370	DC	3,184Z	
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04195	3 00000	371	DC	3,159Z	
		371J59Z00	0000	000	-604193041960
04198	3 00000	372	DC	3,136Z	
		372J36Z00	0000	000	-604196041990
04201	3 00000	373	DC	3,115Z	
		373J15Z00	0000	000	-604199042020
04204	3 00000	374	DC	3,097Z	
		374097Z00	0000	00	-604202042050
04207	3 00000	375	DC	3,081Z	
		375081Z00	0000	00	-604205042080
04210	3 00000	376	DC	3,067Z	

C4

```
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                    377055Z00 0000 000                                                   -604211042140
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04219      3 00000  379       DC   3,036Z
                    379036Z00 0000 00                                                    -604217042200
04222      3 00000  380       DC   3,029Z
                    380029Z00 0000 00                                                    -604220042230
04225      3 00000  381       DC   3,023Z
                    381023Z00 0000 00                                                    -604223042260
04228      3 00000  382       DC   3,018Z
                    382018Z00 0000 00                                                    -604226042290
04231      3 00000  383       DC   3,014Z
                    383014Z00 0000 00                                                    -604229042320
04234      3 00000  384       DC   3,011Z
                    384011Z00 0000 00                                                    -604232042350
04237      3 00000  385       DC   3,008Z
                    385008Z00 0000 00                                                    -604235042380
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                    386006Z00 0000 00                                                    -604238042410
04243      3 00000  387       DC   3,005Z
                    387005Z00 0000 00                                                    -604241042440
04246      3 00000  388       DC   3,004Z
                    388004Z00 0000 00                                                    -604244042470
04249      3 00000  389       DC   3,003Z
                    389003Z00 0000 00                                                    -604247042500
04252      3 00000  390       DC   3,002Z
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04255      3 00000  391       DC   3,001Z
                    391001Z00 0000 00                                                    -604253042560
04259      4 00000  392N      DS   4Z
04339     80 00000  393RECORD  DS   80Z
04340      1 00000  394       DS   1Z
04344      4 00000  395A      DS   4Z
04348      4 00000  396LAST   DS   4Z
04350      2 00000  397FLAG   DS   2Z
04353      3 00000  398I      DS   3Z
04356      3 00000  399J      DS   3Z
04360      4 00000  400VAR    DS   4Z
```



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04365      5 00000  401NUM    DS   5Z
04370      5 00000  402TEST   DS   5Z
04375      5 00000  403MOST   DS   5Z
04387     12 00000  404SIGMA  DS   12Z
04393      6 00000  405       DS   6Z
04396      3 00000  406K      DS   3Z
04401      5 00000  407TS     DS   5Z
04404      3 00000  408KA     DS   3Z
19999      1 00000  409TABLE  DS   1,19999Z
04405      1 00000  410DATA   DS   1Z
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```

Appendix G

Sample Problem Input

I	J	A	M	B	
8	1	5.00	7.00	10.00	
8	3	10.00	12.00	15.00	
8	6	8.00	9.00	15.00	
1	2	11.00	15.00	17.00	
2	4	3.00	4.00	5.00	
4	11				((Dummy Job))
3	4	15.00	20.00	25.00	
6	4	21.00	24.00	30.00	
7	5	25.00	30.00	35.00	
4	5	12.00	15.00	20.00	
11	5	10.00	12.00	14.00	
1	3	1.50	3.00	3.50	
6	7	15.00	18.00	20.00	
2	11	5.00	8.00	10.00	

50 (First assigned project completion time)

60 (Second assigned project completion time)

Appendix H

Sample Problem Output (No assigned project completion time)

I	J	te	A	M	B	TS	P(K)	VAR	TS-TE	ES	EF(TE)	LS	LF	TF	FF
8	1	7.17	5.00	7.00	10.00						7.17	12.33	19.50	12.33	
8	3	12.17	10.00	12.00	15.00	12.00					12.17	10.16	22.33	10.16	
8	6	9.83	8.00	9.00	15.00						9.83		9.83	@	
1	2	14.67	11.00	15.00	17.00					7.17	21.84	23.16	37.83	15.99	
2	4	4.00	3.00	4.00	5.00					21.84	25.84	38.33	42.33	16.49	8.49
4	11									34.33	34.33	45.66	45.66	11.33	
3	4	20.00	15.00	20.00	25.00					12.17	32.17	22.33	42.33	10.16	2.16
6	4	24.50	21.00	24.00	30.00	30.00				9.83	34.33	17.83	42.33	8.00	
7	5	30.00	25.00	30.00	35.00	55.00				27.66	57.66	27.66	57.66	@	
4	5	15.33	12.00	15.00	20.00					34.33	49.66	42.33	57.66	8.00	8.00
11	5	12.00	10.00	12.00	14.00					34.33	46.33	45.66	57.66	11.33	11.33
1	3	2.83	1.50	3.00	3.50					7.17	10.00	19.50	22.33	12.33	2.17
6	7	17.83	15.00	18.00	20.00	25.00				9.83	27.66	9.83	27.66	@	
2	11	7.83	5.00	8.00	10.00					21.84	29.67	37.83	45.66	15.99	4.66
							PROJECT COMPLETION			57.66		PROJECT SLACK			

Part II Output (No scheduled times assigned)

I	J	te	A	M	B	TS	P(K)	VAR	TS-TE	ES	EF(TE)	LS	LF	TF	FF
8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	12.33	19.50	12.33	
8	3	12.17	10.00	12.00	15.00	12.17	.500	.69			12.17	10.16	22.33	10.16	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83		9.83	@	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	23.16	37.83	15.99	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	38.33	42.33	16.49	8.49
4	11					34.33	.500			34.33	34.33	45.66	45.66	11.33	
3	4	20.00	15.00	20.00	25.00	32.17	.500	2.76		12.17	32.17	22.33	42.33	10.16	2.16
6	4	24.50	21.00	24.00	30.00	34.33	.500	2.25		9.83	34.33	17.83	42.33	8.00	
7	5	30.00	25.00	30.00	35.00	57.66	.500	2.76		27.66	57.66	27.66	57.66	@	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	42.33	57.66	8.00	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	45.66	57.66	11.33	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	19.50	22.33	12.33	2.17
6	7	17.83	15.00	18.00	20.00	27.66	.500	.69		9.83	27.66	9.83	27.66	@	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	37.83	45.66	15.99	4.66

Part II Output (Scheduled times assigned)

I	J	te	A	M	B	TS	P(K)	VAR	TS-TE	ES	EF(TE)	LS	LF	TF	FF
8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	12.33	19.50	12.33	
8	3	12.17	10.00	12.00	15.00	12.00	.460	.69	- .17		12.17	10.16	22.33	10.16	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83		9.83	@	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	23.16	37.83	15.99	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	38.33	42.33	16.49	8.49
4	11					34.33	.500			34.33	34.33	45.66	45.66	11.33	
3	4	20.00	15.00	20.00	25.00	32.17	.500	2.76		12.17	32.17	22.33	42.33	10.16	2.16
6	4	24.50	21.00	24.00	30.00	30.00	.014	2.25	- 4.33	9.83	34.33	17.83	42.33	8.00	
7	5	30.00	25.00	30.00	35.00	55.00	.159	2.76	- 2.66	27.66	57.66	27.66	57.66	@	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	42.33	57.66	8.00	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	45.66	57.66	11.33	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	19.50	22.33	12.33	2.17
6	7	17.83	15.00	18.00	20.00	25.00	.036	.69	- 2.66	9.83	27.66	9.83	27.66	@	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	37.83	45.66	15.99	4.66

Sample Problem Output (Assigned project completion time is 50.00 weeks)

I	J	te	A	M	B	TS	P(K)	VAR	TS-TE	ES	EF(TE)	LS	LF	TF	FF
8	1	7.17	5.00	7.00	10.00						7.17	4.67	11.84	4.67	
8	3	12.17	10.00	12.00	15.00	15.00					12.17	2.50	14.67	2.50	
8	6	9.83	8.00	9.00	15.00						9.83	- 7.66	2.17	- 7.66	
1	2	14.67	11.00	15.00	17.00					7.17	21.84	15.50	30.17	8.33	
2	4	4.00	3.00	4.00	5.00					21.84	25.84	30.67	34.67	8.83	8.49
4	11									34.33	34.33	38.00	38.00	3.67	
3	4	20.00	15.00	20.00	25.00					12.17	32.17	14.67	34.67	2.50	2.16
6	4	24.50	21.00	24.00	30.00					9.83	34.33	10.17	34.67	.34	
7	5	30.00	25.00	30.00	35.00	50.00				27.66	57.66	20.00	50.00	- 7.66	
4	5	15.33	12.00	15.00	20.00					34.33	49.66	34.67	50.00	.34	8.00
11	5	12.00	10.00	12.00	14.00					34.33	46.33	38.00	50.00	3.67	11.33
1	3	2.83	1.50	3.00	3.50					7.17	10.00	11.84	14.67	4.67	2.17
6	7	17.83	15.00	18.00	20.00	30.00				9.83	27.66	2.17	20.00	- 7.66	
2	11	7.83	5.00	8.00	10.00					21.84	29.67	30.17	38.00	8.33	4.66
							PROJECT COMPLETION			57.66		PROJECT SLACK		- 7.66	

Part II Output (No scheduled times assigned)

8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	4.67	11.84	4.67	
8	3	12.17	10.00	12.00	15.00	12.17	.500	.69			12.17	2.50	14.67	2.50	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83	- 7.66	2.17	- 7.66	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	15.50	30.17	8.33	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	30.67	34.67	8.83	8.49
4	11					34.33	.500			34.33	34.33	38.00	38.00	3.67	
3	4	20.00	15.00	20.00	25.00	32.17	.500	2.76		12.17	32.17	14.67	34.67	2.50	2.16
6	4	24.50	21.00	24.00	30.00	34.33	.500	2.25		9.83	34.33	10.17	34.67	.34	
7	5	30.00	25.00	30.00	35.00	57.66	.500	2.76		27.66	57.66	20.00	50.00	- 7.66	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	34.67	50.00	.34	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	38.00	50.00	3.67	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	11.84	14.67	4.67	2.17
6	7	17.83	15.00	18.00	20.00	27.66	.500	.69		9.83	27.66	2.17	20.00	- 7.66	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	30.17	38.00	8.33	4.66

Part II Output (Scheduled times assigned)

8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	4.67	11.84	4.67	
8	3	12.17	10.00	12.00	15.00	15.00	1.000	.69	2.83		12.17	2.50	14.67	2.50	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83	- 7.66	2.17	- 7.66	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	15.50	30.17	8.33	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	30.67	34.67	8.83	8.49
4	11					34.33	.500			34.33	34.33	38.00	38.00	3.67	
3	4	20.00	15.00	20.00	25.00	32.17	.500	2.76		12.17	32.17	14.67	34.67	2.50	2.16
6	4	24.50	21.00	24.00	30.00	34.33	.500	2.25		9.83	34.33	10.17	34.67	.34	
7	5	30.00	25.00	30.00	35.00	50.00		2.76	- 7.66	27.66	57.66	20.00	50.00	- 7.66	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	34.67	50.00	.34	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	38.00	50.00	3.67	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	11.84	14.67	4.67	2.17
6	7	17.83	15.00	18.00	20.00	30.00	.945	.69	2.34	9.83	27.66	2.17	20.00	- 7.66	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	30.17	38.00	8.33	4.66

Sample Problem Output (Assigned project completion time is 60.00 weeks)

I	J	te	A	M	B	TS	P(K)	VAR	TS-TE	ES	EF(TE)	LS	LF	TF	FF
8	1	7.17	5.00	7.00	10.00						7.17	14.67	21.84	14.67	
8	3	12.17	10.00	12.00	15.00						12.17	12.50	24.67	12.50	
8	6	9.83	8.00	9.00	15.00						9.83	2.34	12.17	2.34	
1	2	14.67	11.00	15.00	17.00					7.17	21.84	25.50	40.17	18.33	
2	4	4.00	3.00	4.00	5.00					21.84	25.84	40.67	44.67	18.83	8.49
4	11									34.33	34.33	48.00	48.00	13.67	
3	4	20.00	15.00	20.00	25.00	44.00				12.17	32.17	24.67	44.67	12.50	2.16
6	4	24.50	21.00	24.00	30.00					9.83	34.33	20.17	44.67	10.34	
7	5	30.00	25.00	30.00	35.00	60.00				27.66	57.66	30.00	60.00	2.34	
4	5	15.33	12.00	15.00	20.00					34.33	49.66	44.67	60.00	10.34	8.00
11	5	12.00	10.00	12.00	14.00					34.33	46.33	48.00	60.00	13.67	11.33
1	3	2.83	1.50	3.00	3.50					7.17	10.00	21.84	24.67	14.67	2.17
6	7	17.83	15.00	18.00	20.00	30.00				9.83	27.66	12.17	30.00	2.34	
2	11	7.83	5.00	8.00	10.00					21.84	29.67	40.17	48.00	18.33	4.66
							PROJECT COMPLETION			57.66		PROJECT SLACK		2.34	

Part II Output (No scheduled times assigned)

8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	14.67	21.84	14.67	
8	3	12.17	10.00	12.00	15.00	12.17	.500	.69			12.17	12.50	24.67	12.50	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83	2.34	12.17	2.34	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	25.50	40.17	18.33	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	40.67	44.67	18.83	8.49
4	11					34.33	.500			34.33	34.33	48.00	48.00	13.67	
3	4	20.00	15.00	20.00	25.00	32.17	.500	2.76		12.17	32.17	24.67	44.67	12.50	2.16
6	4	24.50	21.00	24.00	30.00	34.33	.500	2.25		9.83	34.33	20.17	44.67	10.34	
7	5	30.00	25.00	30.00	35.00	57.66	.500	2.76		27.66	57.66	30.00	60.00	2.34	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	44.67	60.00	10.34	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	48.00	60.00	13.67	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	21.84	24.67	14.67	2.17
6	7	17.83	15.00	18.00	20.00	27.66	.500	.69		9.83	27.66	12.17	30.00	2.34	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	40.17	48.00	18.33	4.66

Part II Output (Scheduled times assigned)

8	1	7.17	5.00	7.00	10.00	7.17	.500	.69			7.17	14.67	21.84	14.67	
8	3	12.17	10.00	12.00	15.00	12.17	.500	.69			12.17	12.50	24.67	12.50	
8	6	9.83	8.00	9.00	15.00	9.83	.500	1.35			9.83	2.34	12.17	2.34	
1	2	14.67	11.00	15.00	17.00	21.84	.500	1.00		7.17	21.84	25.50	40.17	18.33	
2	4	4.00	3.00	4.00	5.00	25.84	.500	.11		21.84	25.84	40.67	44.67	18.83	8.49
4	11					34.33	.500			34.33	34.33	48.00	48.00	13.67	
3	4	20.00	15.00	20.00	25.00	44.00	1.000	2.76	11.83	12.17	32.17	24.67	44.67	12.50	2.16
6	4	24.50	21.00	24.00	30.00	34.33	.500	2.25		9.83	34.33	20.17	44.67	10.34	
7	5	30.00	25.00	30.00	35.00	60.00	.841	2.76	2.34	27.66	57.66	30.00	60.00	2.34	
4	5	15.33	12.00	15.00	20.00	49.66	.500	1.77		34.33	49.66	44.67	60.00	10.34	8.00
11	5	12.00	10.00	12.00	14.00	46.33	.500	.44		34.33	46.33	48.00	60.00	13.67	11.33
1	3	2.83	1.50	3.00	3.50	10.00	.500	.11		7.17	10.00	21.84	24.67	14.67	2.17
6	7	17.83	15.00	18.00	20.00	30.00	.945	.69	2.34	9.83	27.66	12.17	30.00	2.34	
2	11	7.83	5.00	8.00	10.00	29.67	.500	.69		21.84	29.67	40.17	48.00	18.33	4.66