VALIDATION OF THE SLIM METHODOLOGY TO ESTIMATING REAL TIME, COMMAND AND CONTROL APPLICATIONS DEVELOPMENT PROJECTS

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This set of visuals describes how SLIM (Software Life Cycle Management), an automated software cost estimating and life cycle planning tool belonging to Quantitative Software Management, Inc., was used to "replay" the development history of four real time, command and control system development projects done by Sperry Univac for the U.S. Air Force.

The development history (data) are taken from a Rome Air Development Center report and were incorporated into a thesis done at the Air Force Institute of Technology by a Captain Walker (AFIT/GCS/EE/78-21), who was working on variants of the Rayleigh/Norden Life Cycle Model used in SLIM. These data are shown in the next two pages as they appeared in Captain Walker's thesis. Manpower vs. time histories for 4 projects are given together with the more important aspects of the project and the development environment. This information is sufficient to calibrate SLIM, determine the technology constant representing complexity factors (like real time code) and environmental influences (tools, language, development discipline (MPP, TDSP, CPT, etc.)) and development constraints (development machine availability, batch vs on-line development, etc.) and then "replay" an idealization of the development time history as SLIM would have produced it.

This "replay" serves several useful purposes.

- It shows how easy it is to calibrate to past experience – thus tuning the estimating system to the skills, tools, and development, customer interface and administrative environment.
- It validates that the Rayleigh/Norden life cycle model (as implemented in SLIM) is a very satisfactory representation of what really happens in effectively managed software projects.
- It shows the model's adaptability to all size regimes of practical interest in the systems context (small – 16,000 HOL equivalent source statements example presented; medium – 46,000 HOL equivalent source statements example presented; and large – 500,000 HOL source statement example presented).
- It shows the specific applicability of the model to real time, command and control applications (Indeed, the model has been found to be applicable to any type of software system).
- It shows that the mixed language environment can be effectively handled by the SLIM methodology.

A few assumptions were made by me in fitting the data to the SLIM input file building editor. For example, the calendar starting dates were assumed since these were not given in the data. A burdened labor rate of $50,000 per man year was assumed. An inflation rate of 6.5% was assumed for this time frame. All other relevant input information could be deduced from the development history obtained from the thesis. Only minor interpretation of this information was necessary.

Sperry Univac Programs 1 and 3 were done in a mix of languages. Sperry Univac Program 1 was 38% HOL and Sperry Univac Program 3 was 53% HOL. These were handled by converting to equivalent number of statements in one language or the other with due regard for the uncertainty in the conversion assumptions. Sperry Univac Program 1 was done both ways; converting everything to equivalent assembly language statements in the first case and converting everything to equivalent HOL statements in the second case. Very different technology constants were obtained; yet, because of the relationship exhibited by the software equation, $S_s = C_k K^{1/3} t_d^{4/3}$, nearly the same time–effort combination was obtained and a very similar time–varying manloading pattern emerged. In my opinion, the system acted more like an HOL development than an assembly language development and the fit seems to be slightly better.

The conversion process was handled this way for Sperry Univac Program 1. There were 90,000 DSLOC, 38%of which were HOL.

HOL Conversion

HOL Statements 0.38(90,000) = 34,200. We will assume an uncertainty on this of ±5000 HOL statements (Std Dev).

Assembly Statements 0.62(90,000) = 55,800. Assume possible conversion ratios from assembly to HOL:

	Equivalent HOL Statements
a (1% Prob.) 1 to 7	7971
m (most likely) 1 to 5	11160
b (99% Prob.) 1 to 3	18600

Using the PERT algorithm (modified)

a	m	b	Expected	Std Deviation
			34200	5000
7971	11160	18600	11868	2000 (1772 actual)
Expected HOL Equivalent Size			46068	
Approx. Standard Deviation on Size				5385 (RMS criterion)

The input to SLIM using the 99% range approach then is:

LOW: 46068 - 3(5385) = 29913 HOL Equivalent Statements

HIGH: 46068 + 3(5385) = 62223 HOL Equivalent Statements

with a normal disrtibution assumed.

The same procedure was used in converting the equivalent assembly language statements. The result obtained was an expected 226,800 equivalent assembly language instructions with an approximate standard deviation of 25,385 instructions.

Sperry Univac Program 3 was treated as an essentially HOL system (53% of the DSLOC) since a high percentage of the machine language instructions were HOL generated. This was born out by the manloading profile obtained from this conversion – characteristic of a small system with peak manpower obtained well prior to completion of development. An HOL to assembly conversion would have produced a profile with peak manpower occurring very close to the end of development – typical of large system behavior. The actual profile resembled the former rather than the latter confirming this reasoning.

A Sample Data

The data used in the sample calculations of Chapter IV was provided by Sperry-Univac Defense Systems in a Rome Air Development Center sponsored technical report (Ref. 23: 1-31). The data tabulated in Table A-I is the manning data for the four software systems reported in the report.

Table A-I I

Sperry-Univac Manning Data

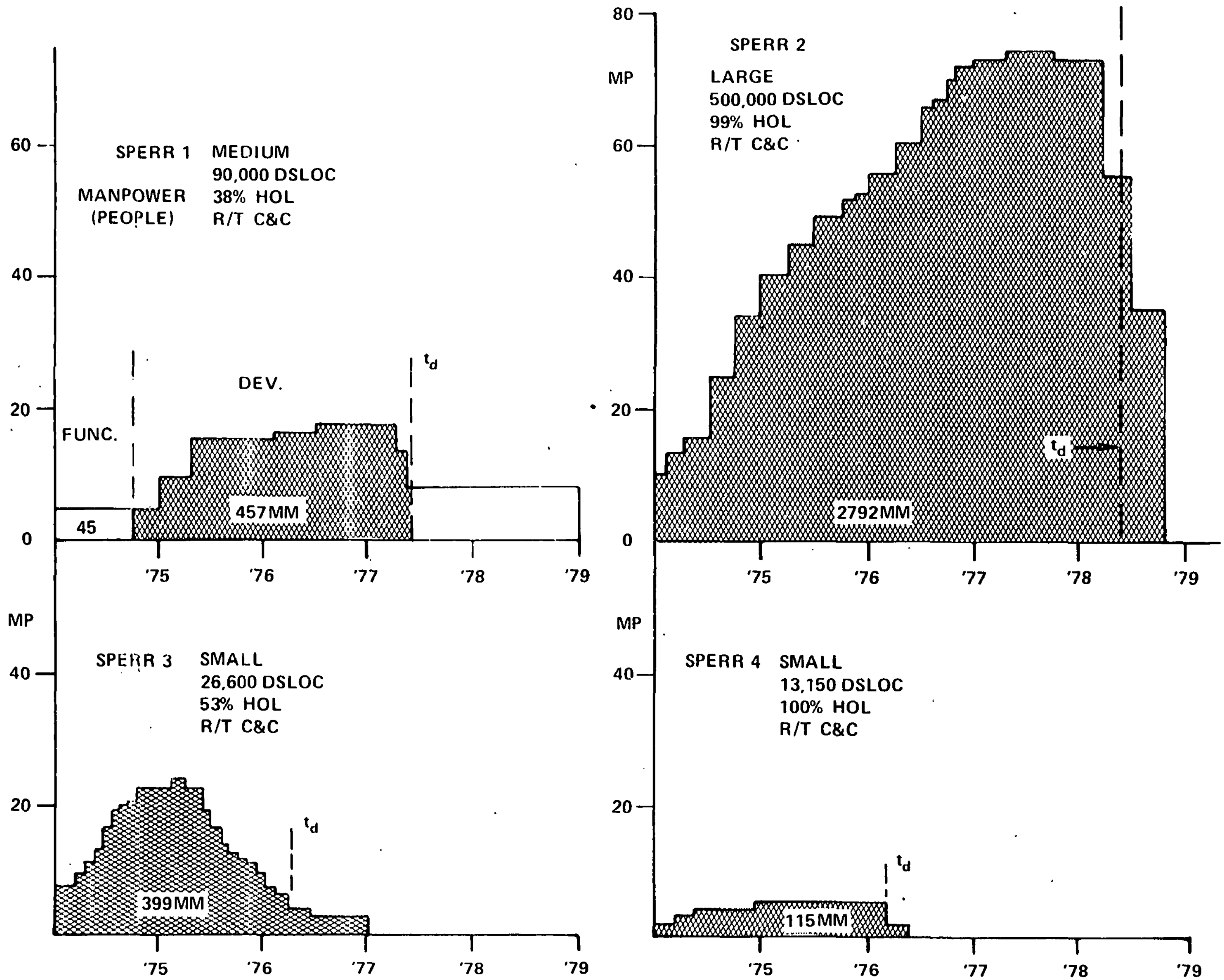
Month	Program				Month	Program				Month	Program		
	1	2	3	5		1	2	3	4		1	2	3
1	5	10	5	2	31	17	66	3	–	61	7	–	–
2	5	13	8	2	32	17	67	3	–	62	7	–	–
3	5	13	8	3	33	17	67	3	–	63	7	–	–
4	5	15	10	3	34	17	71	3	–	64	7	–	–
5	5	15	12	4	35	17	72	–	–	65	7	–	–
6	5	15	14	4	36	17	72	–	–	66	7	–	–
7	5	25	16	4	37	17	73	–	–	67	7	–	–
8	5	25	19	4	38	17	73	–	–	68	3	–	–
9	5	25	20	4	39	17	73	–	–	69	3	–	–
10	5	34	21	4	40	13	73	–	–	70	2	–	–
11	5	34	22	4	41	8	74	–	–	71	2	–	–
12	5	34	22	5	42	8	74	–	–	72	3	–	–
13	10	40	22	5	43	8	74	–	–	73	3	–	–
14	10	40	23	5	44	8	74	–	–	74	7	–	–
15	10	40	22	5	45	8	74	–	–	75	7	–	–
16	10	45	22	5	46	8	74	–	–	76	8	–	–
17	15	45	22	5	47	8	73	–	–	77	8	–	–
18	15	45	19	5	48	8	73	–	–	78	7	–	–
19	15	49	17	5	49	8	73	–	–	79	7	–	–
20	15	49	14	5	50	8	73	–	–	80	3	–	–
21	15	49	13	5	51	8	73	–	–	81	–	–	–
22	15	52	12	5	52	8	55	–	–				
23	15	53	11	5	53	8	55	–	–				
24	15	53	10	5	54	8	55	–	–				
25	15	56	8	5	55	8	35	–	–				
26	16	56	7	5	56	8	35	–	–				
27	16	56	6	1	57	8	35	–	–				
28	16	60	4	1	58	8	35	–	–				
29	16	60	4	–	59	8	–	–	–				
30	16	60	3	–	60	7	–	–	–				

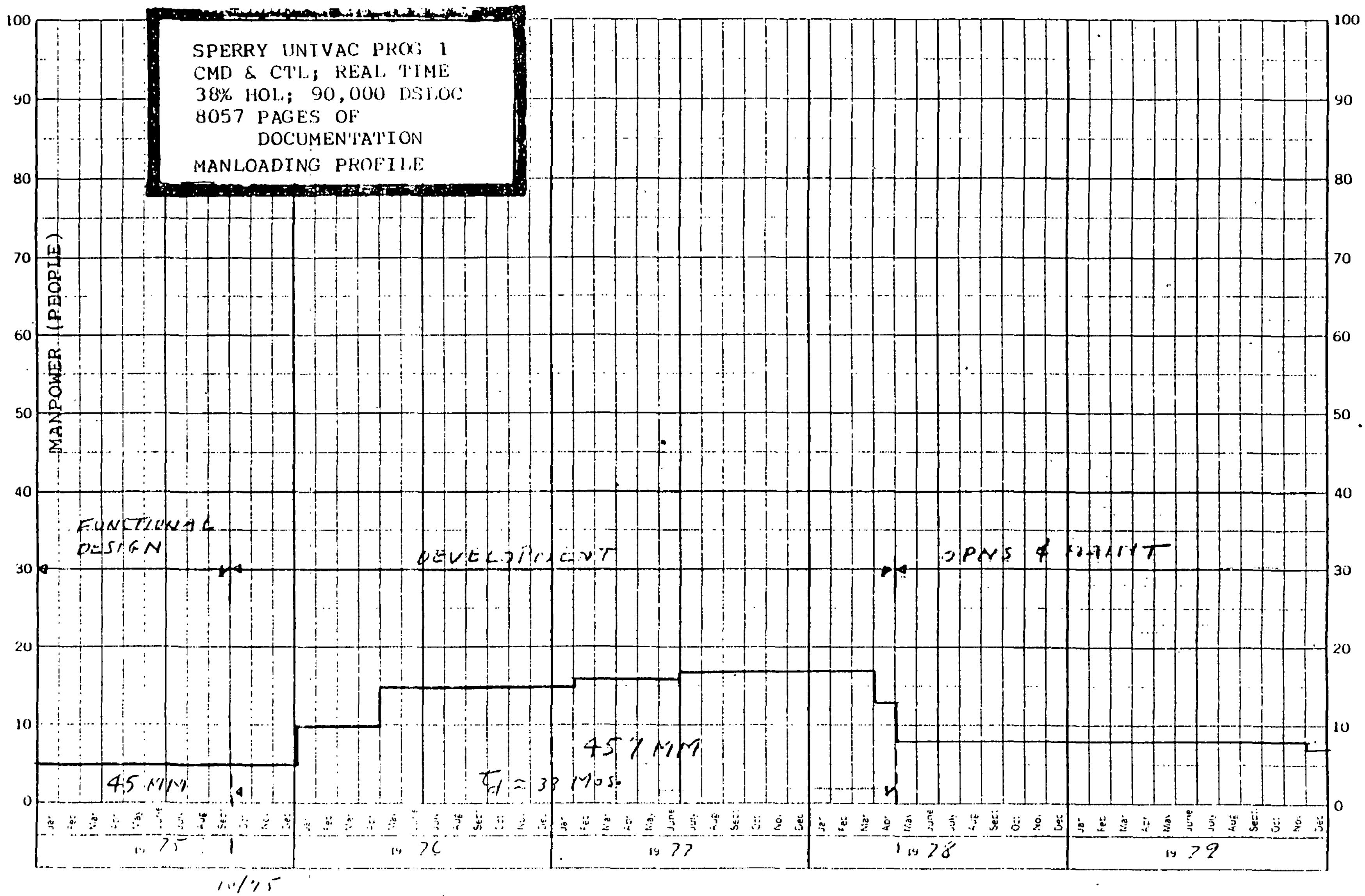
The units are man-months per month. Table A-II shows the factor data available on the four systems also found in the technical report.

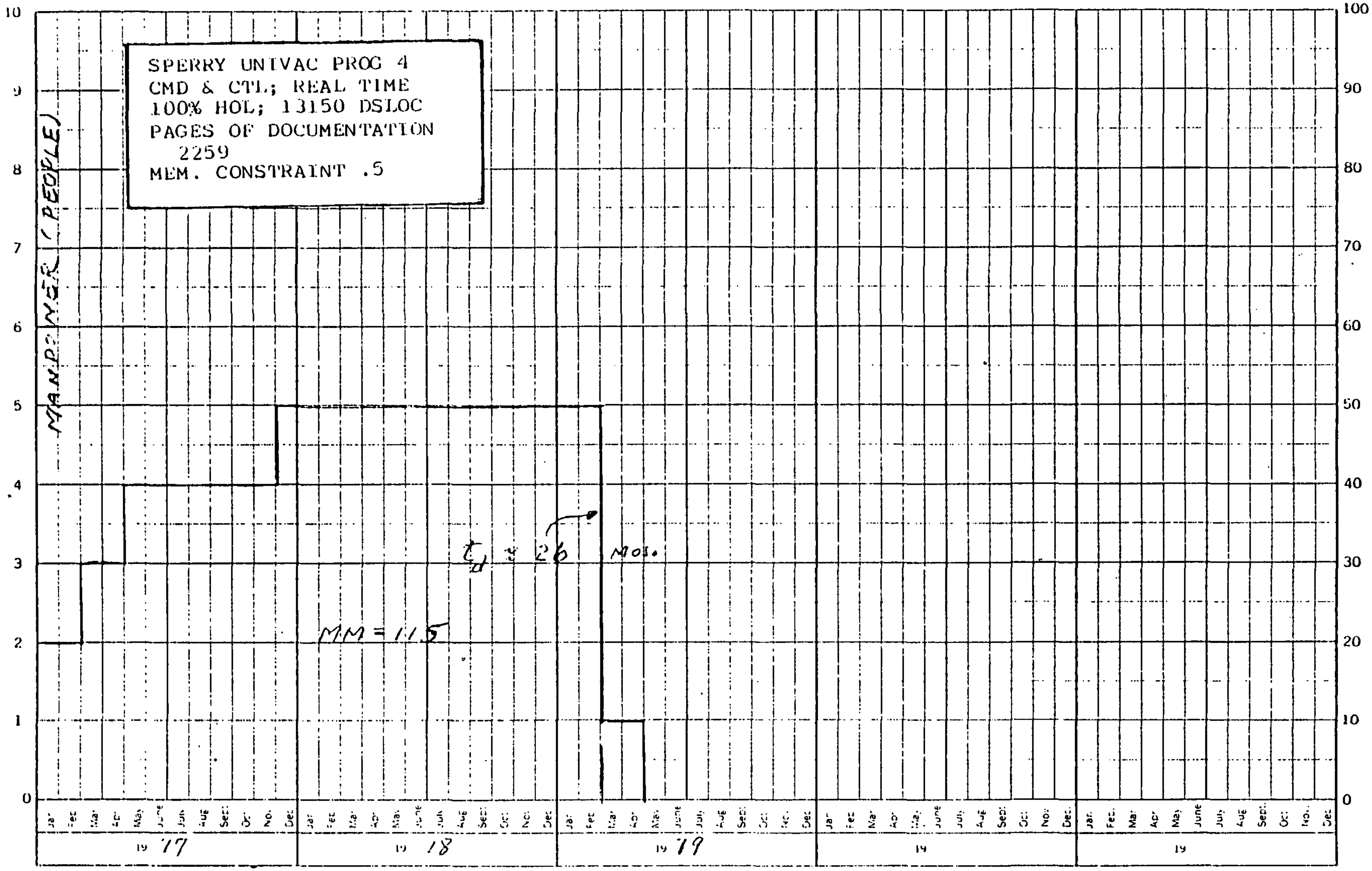
Table A-II

Sperry-Univac Factor Data

Factor	Program			
	1	2	3	4
Size in delivered source	90000	500000	26600	13150
Real-time application	1	1	1	1
Top-down structured design	0	0	1	1
Structured coding	1	0	0	1
Memory constraint	0.50	0.50	0.52	0.50
Percent HOL used	38	99	53	100
Programmer qualification education and training	39.0	37.1	62.8	82.4
Developed on target machine	1	1	0	0
Pages of documentation	8059	27014	3507	2259
Command and control application	1	1	1	1
Modular design	0	0	1	1
Program librarian	1	0	1	1
Structured narrative	1	0	0	1
Flow Charts	1	1	1	1


SPERR 1
MEDIUM
90,000 DSLOC
MANPOWER
(PEOPLE)
38% HOL
R/T C&C
FUNC.
DEV.
t_d
45
457MM
SPERR 2
MP
LARGE
500,000 DSLOC
99% HOL
R/T C&C
t_d
2792MM
MP
SPERR 3
SMALL
26,600 DSLOC
53% HOL
R/T C&C
t_d
399MM
MP
SPERR 4
SMALL
13,150 DSLOC
100% HOL
R/T C&C
t_d
115MM
0
20
40
60
80
'75
'76
'77
'78
'79


SPERRY UNIVAC PROG 1
CMD & CTL; REAL TIME
38% HOL; 90,000 DSLOC
8057 PAGES OF
DOCUMENTATION
MANLOADING PROFILE
MANPOWER (PEOPLE)
FUNCTIONAL DESIGN
DEVELOPMENT
OPNS & MAINT
45 MM
457 MM
19 75
19 76
19 77
19 78
19 79
10/75


SPERRY UNIVAC PROG 4
CMD & CTL; REAL TIME
100% HOL; 13150 DSLOC
PAGES OF DOCUMENTATION
2259
MEM. CONSTRAINT .5
MANPOWER (PEOPLE)
t_d = 26 MOS.
MM = 115
19 77
19 78
19 79
19
19

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SUMMARY OF INPUT PARAMETERS

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SYSTEM: SPERRY UNIVAC 4 DATE: 16-Nov-79

PROJECT START: 177

COST ELEMENTS			
$/MY	50000.	INFLATION RATE	.080
STD DEV ($/MY)	5000.		
ENVIRONMENT			
ONLINE DEV	0.00	HOL USAGE	1.00
DEVELOPMENT TIME	0.10	PRODUCTION TIME	0.90
LANGUAGE	JOVIAL		
SYSTEM			
TYPE	COMMAND & CONTROL	REAL TIME CODE	0.30
LEVEL	1	UTILIZATION	0.50
MODERN PROGRAMMING PRACTICES			
STRUCTURED PROG	3	DESIGN/CODE INSP	3
TOP-DOWN DEVELOPMENT	3	CHIEF PROGRAMMER TEAMS	3
EXPERIENCE			
OVERALL	3	SYSTEM TYPE	2
LANGUAGE	3	HARDWARE	3
TECHNOLOGY			
FACTOR	3		
SIZE			
LOW	9150.	HIGH	17150.

$C_K = 1220$

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SIMULATION

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TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

*** SIMULATION RUNNING - PLEASE WAIT ***

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	13150.	1333.
MINIMUM DEVELOPMENT TIME (MONTHS)	25.0	1.2
DEVELOPMENT EFFORT (MANMONTHS)	125.8	20.1
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	525.	98.
(INFLATED DOLLARS)	569.	107.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	9150.	21.4	79.	329.
(-1 SD)	11817.	23.9	110.	457.
MOST LIKELY	13150.	25.0	126.	525.
(+1 SD)	14483.	26.1	142.	594.
(+3 SD)	17150.	28.0	177.	738.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (126.)	WITHIN NORMAL RANGE
PROJECT DURATION (25.0 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE(5.)	WITHIN NORMAL RANGE
PRODUCTIVITY (105. LINES/MM)	WITHIN NORMAL RANGE

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MANLOADING

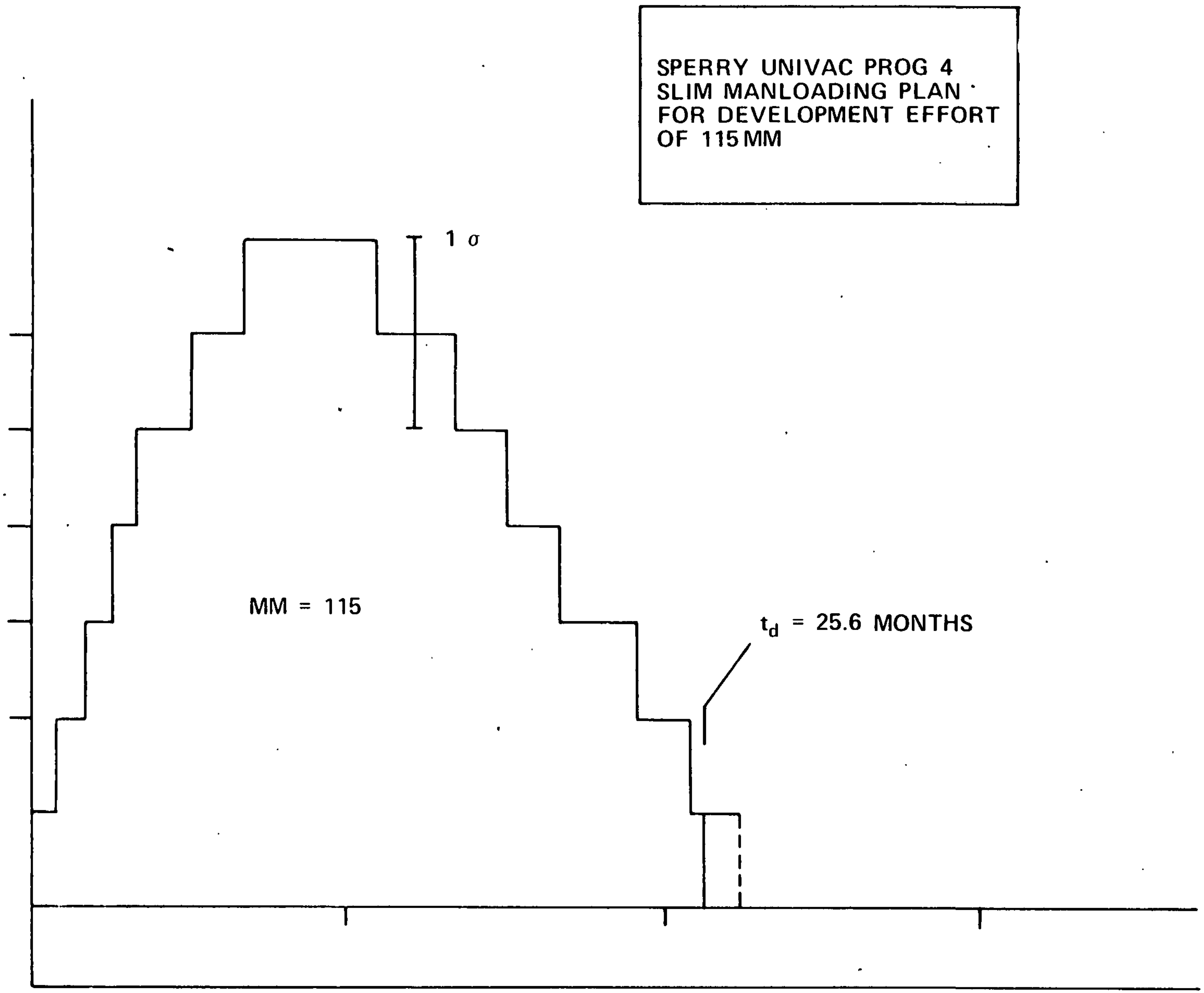
TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND ASSOCIATED (+ OR -) STANDARD DEVIATION REQUIRED FOR DEVELOPMENT. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT EFFORT (MM)	125.8	20.1
DEVELOPMENT TIME (MONTHS)	25.0	1.2

*** SIMULATION RUNNING - PLEASE WAIT ***

TIME	PEOPLE/MONTH	STD DEV	CUMULATIVE MANMONTHS	CUM STD DEV
JAN 77	1.	0.	1.	0.
FEB 77	2.	0.	3.	0.
MAR 77	3.	0.	6.	1.
APR 77	4.	1.	10.	2.
MAY 77	5.	1.	15.	2.
JUN 77	6.	1.	21.	3.
JUL 77	7.	1.	28.	5.
AUG 77	7.	1.	35.	6.
SEP 77	8.	1.	43.	7.
OCT 77	8.	1.	51.	8.
NOV 77	8.	1.	58.	9.
DEC 77	8.	1.	66.	11.
JAN 78	7.	1.	73.	12.
FEB 78	7.	1.	80.	13.
MAR 78	7.	1.	87.	14.
APR 78	6.	1.	93.	15.
MAY 78	6.	1.	99.	16.
JUN 78	5.	1.	104.	17.
JUL 78	5.	1.	108.	17.
AUG 78	4.	1.	112.	18.
SEP 78	3.	1.	116.	18.
OCT 78	3.	1.	119.	19.
NOV 78	2.	1.	121.	19.
DEC 78	2.	0.	123.	20.
JAN 79	2.	0.	125.	20.
FEB 79	1.	0.	126.	20.


SPERRY UNIVAC PROG 4
SLIM MANLOADING PLAN
FOR DEVELOPMENT EFFORT
OF 115 MM
1 σ
MM = 115
t_d = 25.6 MONTHS

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LINEAR PROGRAM

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TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

THIS FUNCTION USES THE TECHNIQUE OF LINEAR PROGRAMMING (SIMPLEX ALGORITHM) TO DETERMINE THE MINIMUM EFFORT (AND COST) OR THE MINIMUM TIME IN WHICH A SYSTEM CAN BE BUILT. THE RESULTS ARE BASED ON THE ACTUAL MANPOWER, COST, AND SCHEDULE CONSTRAINTS OF THE USER, COMBINED WITH THE SYSTEM CONSTRAINTS YOU HAVE PROVIDED EARLIER TO YIELD A CONSTRAINED OPTIMAL SOLUTION.

ENTER THE MAXIMUM DEVELOPMENT COST IN DOLLARS> 1500000

ENTER MAXIMUM DEVELOPMENT TIME IN MONTHS> 28

ENTER THE MINIMUM AND MAXIMUM NUMBER OF PEOPLE YOU CAN HAVE ON BOARD AT PEAK MANLOADING TIME> 3,5

	TIME	EFFORT	COST (X $1000)
MINIMUM COST	28.0 MONTHS	80. MM	335.
MINIMUM TIME	27.4 MONTHS	88. MM	365.

MANPOWER CONSTRAINED

YOUR REALISTIC TRADE-OFF REGION LIES BETWEEN THE LIMITS OF THE TABLE ABOVE.

(INTERPOLATION IN THE TRADE-OFF TABLE BETWEEN THESE LIMITS WILL PRODUCE ALL ACCEPTABLE ALTERNATIVES. WOULD YOU LIKE TO SEE A TRADE-OFF ANALYSIS WITHIN THESE LIMITS (Y OR N) ? Y

TIME	MANMONTHS	COST (X $1000)
27.4	88.	365.
27.5	86.	360.
27.6	85.	355.
27.7	84.	349.
27.8	83.	344.
27.9	81.	340.
28.0	80.	335.

THE RESULTS SHOWN IN THIS TABLE CAN BE USED WITH DESIGN-TO-COST OR NEW TIME TO GENERATE AN UPDATED FILE AND AN ENTIRELY NEW ARRAY OF CONSEQUENT RESULTS FOR MANLOADING, CASHFLOW, LIFE CYCLE, RISK ANALYSIS, COMPUTER TIME AND FRONT END ESTIMATES.

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NEW SCHEDULE DEFINITION

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TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

SLIM HAS PROVIDED ITS BEST ESTIMATE OF THE MINIMUM TIME AND CORRESPONDING EFFORT AND COST TO DEVELOP YOUR SYSTEM. THESE VALUES ARE:

MINIMUM TIME:		25.0 MONTHS
EFFORT:		126. MANMONTHS
COST (X $1000):	$	524.

A SHORTER DEVELOPMENT TIME CANNOT BE SPECIFIED ARBITRARILY BY THE USER. HOWEVER, IF A LONGER TIME (WITHIN REASONABLE LIMITS) IS SPECIFIED, THE SYSTEM CAN BE DEVELOPED FOR CONSIDERABLY LESS EFFORT - AND COST.

ENTER DESIRED DEVELOPMENT TIME IN MONTHS> 27.5

	MEAN	STD DEV
NEW DEVELOPMENT EFFORT (MANMONTHS)	86.	14.
NEW DEVELOPMENT COST (X $1000)	360.	57.

YOUR FILE IS UPDATED WITH THESE NEW PARAMETERS. RUN MANLOADING AND CASHFLOW OR LIFE CYCLE TO SEE HOW THESE SAVINGS CAN BE REALIZED.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (86.)	WITHIN NORMAL RANGE
PROJECT DURATION (27.5 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE(3.)	WITHIN NORMAL RANGE
PRODUCTIVITY (152. LINES/MM)	WITHIN NORMAL RANGE

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SUMMARY OF INPUT PARAMETERS

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TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND ASSOCIATED (+ OR -) STANDARD DEVIATION REQUIRED FOR DEVELOPMENT. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT EFFORT (MM)	86.3	13.8
DEVELOPMENT TIME (MONTHS)	27.5	1.4

*** SIMULATION RUNNING - PLEASE WAIT ***

TIME	PEOPLE/MONTH	STD DEV	CUMULATIVE MANMONTHS	CUM STD DEV
JAN 77	0.	0.	0.	0.
FEB 77	1.	0.	1.	0.
MAR 77	2.	0.	3.	1.
APR 77	2.	0.	6.	1.
MAY 77	3.	1.	9.	1.
JUN 77	4.	1.	12.	2.
JUL 77	4.	1.	16.	3.
AUG 77	4.	1.	20.	3.
SEP 77	5.	1.	25.	4.
OCT 77	5.	1.	30.	5.
NOV 77	5.	1.	35.	6.
DEC 77	5.	1.	39.	6.
JAN 78	5.	1.	44.	7.
FEB 78	5.	1.	49.	8.
MAR 78	5.	1.	53.	9.
APR 78	4.	1.	58.	9.
MAY 78	4.	1.	62.	10.
JUN 78	4.	1.	65.	10.
JUL 78	3.	1.	69.	11.
AUG 78	3.	0.	72.	11.
SEP 78	3.	1.	75.	12.
OCT 78	2.	0.	77.	12.
NOV 78	2.	0.	79.	13.
DEC 78	2.	0.	81.	13.
JAN 79	2.	0.	83.	13.
FEB 79	1.	0.	84.	13.
MAR 79	1.	0.	85.	14.
APR 79	1.	0.	86.	14.
MAY 79	0.	0.	87.	14.

PEAK MP

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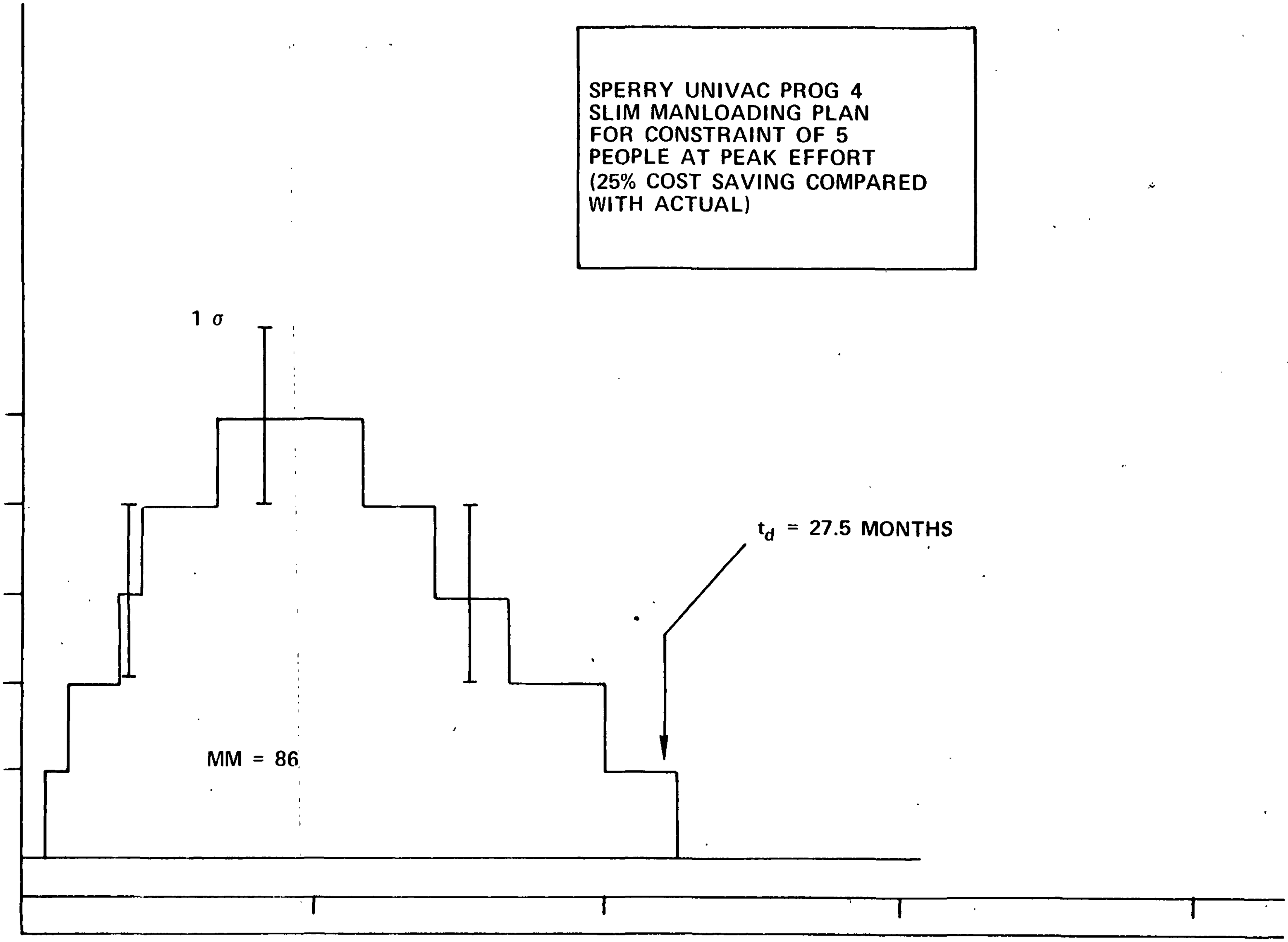
SPERRY UNIVAC PROG 4
SLIM MANLOADING PLAN
FOR CONSTRAINT OF 5
PEOPLE AT PEAK EFFORT
(25% COST SAVING COMPARED
WITH ACTUAL)
1 σ
t_d = 27.5 MONTHS
MM = 86

RISK ANALYSIS

TITLE: SPERRY UNIVAC 4 DATE: 16-Nov-79

THE TABLES BELOW SHOW THE PROBABILITY THAT IT WILL NOT TAKE MORE THAN THE INDICATED AMOUNT OF TIME, EFFORT, AND DOLLARS TO DEVELOP YOUR SYSTEM.

PROBABILITY	TIME (MONTHS)
1. %	24.3
5. %	25.3
10. %	25.8
20. %	26.4
30. %	26.8
40. %	27.2
50. %	27.5
60. %	27.8
70. %	28.2
80. %	28.6
90. %	29.2
95. %	29.7
99. %	30.7

PROBABILITY PROFILE

EXPECTED → (50. %)

PROBABILITY	MANMONTHS	COST (X $1000)	INFLATED COST(X $1000)
1. %	54.	226.	247.
5. %	64.	265.	289.
10. %	69.	286.	312.
20. %	75.	311.	340.
30. %	79.	329.	360.
40. %	83.	345.	377.
50. %	86.	360.	393.
60. %	90.	374.	409.
70. %	94.	390.	426.
80. %	98.	408.	445.
90. %	104.	433.	473.
95. %	109.	454.	496.
99. %	118.	493.	539.

PROBABILITY PROFILE

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****************************************************************************
                                   CALIBRATE
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THIS FUNCTION ENABLES THE USER TO MAKE FUTURE ESTIMATES BASED ON HISTORICAL
DATA FROM HIS ORGANIZATION AS WELL AS ON THE TYPE AND SIZE OF THE SYSTEM.  IN
ESSENCE, **CALIBRATE** TAKES TIME AND MANPOWER DATA FROM PAST SOFTWARE
PROJECTS AND COMPUTES A TECHNOLOGY FACTOR FOR THE USER'S  ORGANIZATION.  THIS
FACTOR IS REALLY AN INDICATION OF THE STATE OF TECHNOLOGY WHICH A PARTICULAR
ORGANIZATION APPLIES TO A SOFTWARE PROJECT.

THE FOLLOWING HISTORICAL DATA IS REQUIRED:
 (1) SYSTEM NAME (UP TO 20 CHARACTERS)
 (2) TOTAL SYSTEM SIZE IN SOURCE STATEMENTS
 (3) NUMBER OF MONTHS TO DEVELOP
 (4) NUMBER OF MANMONTHS TO DEVELOP

HISTORICAL DATA WILL BE PROVIDED FOR HOW MANY SYSTEMS? 1

ENTER ALL DATA FOR EACH SYSTEM ON 1 LINE, SEPARATED BY COMMAS.


ENTER SYSTEM NAME, SIZE, MONTHS, AND MANMONTHS FOR SYSTEM  1.
> SPERR1,226800,33,357
```

SYSTEM NAME	SIZE	DEV. TIME (MONTHS)	DEV. EFFORT (MANMONTHS)	LEVEL	TECHNOLOGY FACTOR
SPERR1 ASSY.	226800.	33.0	357.0	1	13

NEW / INT.

$C_K = 13530$

AVERAGE TECHNOLOGY FACTOR IS 13.

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                      SUMMARY OF INPUT PARAMETERS
******************************************************************************
SYSTEM:   SPERRY UNIVAC PROG 1                               DATE: 14-Nov-79

PROJECT START:   1075

COST ELEMENTS
  $/MY                50090.                         INFLATION RATE   .065
  STD DEV ($/MY)       5000.

ENVIRONMENT
  ONLINE DEV          0.40                                HOL USAGE  0.38
  DEVELOPMENT TIME    1.00                          PRODUCTION TIME  0.00
  LANGUAGE       ASSEMBLER

SYSTEM
  TYPE  COMMAND & CONTROL                            REAL TIME CODE  0.50
  LEVEL                  1  NEW W/ INT.                 UTILIZATION  0.50

MODERN PROGRAMMING PRACTICES
  STRUCTURED PROG        1                         DESIGN/CODE INSP     2
  TOP-DOWN DEVELOPMENT   2                   CHIEF PROGRAMMER TEAMS     1

EXPERIENCE
  OVERALL                2                              SYSTEM TYPE     1
  LANGUAGE               1                                 HARDWARE     2

TECHNOLOGY FACTOR       13  C_K = 13530

SIZE
  LOW               150648                              HIGH   302952

                          ASSY EQUIV.
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SIMULATION

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TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

*** SIMULATION RUNNING - PLEASE WAIT ***

ASSY. EQUIV.

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	226800.	25384.
MINIMUM DEVELOPMENT TIME (MONTHS)	30.2	1.6
DEVELOPMENT EFFORT (MANMONTHS)	544.7	90.4
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	2273.	441.
(INFLATED DOLLARS)	2461.	478.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	150648.	25.4	326.	1358.
(-1 SD)	201416.	28.7	473.	1973.
MOST LIKELY	226800.	30.2	545.	2273.
(+1 SD)	252184.	31.6	632.	2634.
(+3 SD)	302952.	34.2	800.	3334.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (545.)	WITHIN NORMAL RANGE
PROJECT DURATION (30.2 MONTHS)	WITHIN NORMAL RANGE
AVG # PEOPLE(18.)	WITHIN NORMAL RANGE
PRODUCTIVITY (416. LINES/MM)	WITHIN NORMAL RANGE

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LINEAR PROGRAM

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TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

THIS FUNCTION USES THE TECHNIQUE OF LINEAR PROGRAMMING (SIMPLEX ALGORITHM) TO DETERMINE THE MINIMUM EFFORT (AND COST) OR THE MINIMUM TIME IN WHICH A SYSTEM CAN BE BUILT. THE RESULTS ARE BASED ON THE ACTUAL MANPOWER, COST, AND SCHEDULE CONSTRAINTS OF THE USER, COMBINED WITH THE SYSTEM CONSTRAINTS YOU HAVE PROVIDED EARLIER TO YIELD A CONSTRAINED OPTIMAL SOLUTION.

ENTER THE MAXIMUM DEVELOPMENT COST IN DOLLARS> 2500000

ENTER MAXIMUM DEVELOPMENT TIME IN MONTHS> 36

ENTER THE MINIMUM AND MAXIMUM NUMBER OF PEOPLE YOU
CAN HAVE ON BOARD AT PEAK MANLOADING TIME> 10,30

	TIME	EFFORT	COST (X $1000)
MINIMUM COST	36.0 MONTHS	275. MM	1144.
MINIMUM TIME	30.2 MONTHS	552. MM	2298.

YOUR REALISTIC TRADE-OFF REGION LIES BETWEEN THE LIMITS OF THE TABLE ABOVE.

(INTERPOLATION IN THE TRADE-OFF TABLE BETWEEN THESE LIMITS WILL PRODUCE ALL ACCEPTABLE ALTERNATIVES. WOULD YOU LIKE TO SEE A TRADE-OFF ANALYSIS WITHIN THESE LIMITS (Y OR N) ? Y

TIME	MANMONTHS	COST (X $1000)
30.2	552.	2298.
31.2	484.	2018.
32.2	427.	1779.
33.2	378.	1574.
34.2	336.	1398.
35.2	299.	1246.
36.0	275.	1144.

THE RESULTS SHOWN IN THIS TABLE CAN BE USED WITH DESIGN-TO-COST OR NEW TIME TO GENERATE AN UPDATED FILE AND AN ENTIRELY NEW ARRAY OF CONSEQUENT RESULTS FOR MANLOADING, CASHFLOW, LIFE CYCLE, RISK ANALYSIS, COMPUTER TIME AND FRONT END ESTIMATES.

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FRONT-END ESTIMATES

****

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

	TIME (MONTHS) (LOW)	(EXPECTED)	(HIGH)	EFFORT (MM) (LOW)	(EXPECTED)	(HIGH)
FEASIBILITY STUDY	6.3	7.5	8.8	8.	30.	53.
FUNCTIONAL DESIGN	8.4	10.1	11.7	54.	107.	161.

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DESIGN TO COST

****

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

SLIM HAS PROVIDED ITS BEST ESTIMATE OF THE MINIMUM TIME AND CORRESPONDING MAXIMUM EFFORT (AND COST) TO DEVELOP YOUR SYSTEM. THESE VALUES ARE:

MINIMUM TIME:		30.2 MONTHS
EFFORT:		545. MANMONTHS
COST (X $1000):	$	2270.

A GREATER EFFORT (OR COST) WOULD RESULT IN A VERY RISKY TIME SCHEDULE. HOWEVER, IF A LOWER EFFORT IS SPECIFIED (WITHIN REASONABLE LIMITS), DEVELOPMENT IS STILL FEASIBLE AS LONG AS YOU CAN TAKE MORE TIME.

ENTER DESIRED EFFORT IN MANMONTHS> 457

		MEAN	STD DEV
NEW DEVELOPMENT TIME (MONTHS)		31.7	1.7
NEW DEVELOPMENT COST (X $1000)	$	1904.	316.

YOUR FILE IS UPDATED WITH THESE NEW PARAMETERS. RUN MANLOADING AND CASHFLOW OR LIFE CYCLE TO SEE HOW THESE SAVINGS CAN BE REALIZED.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (457.)	WITHIN NORMAL RANGE
PROJECT DURATION (31.7 MONTHS)	WITHIN NORMAL RANGE
AVG # PEOPLE(14.)	WITHIN NORMAL RANGE
PRODUCTIVITY (496. LINES/MM)	WITHIN NORMAL RANGE

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****
LIFE CYCLE
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SYSTEM: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

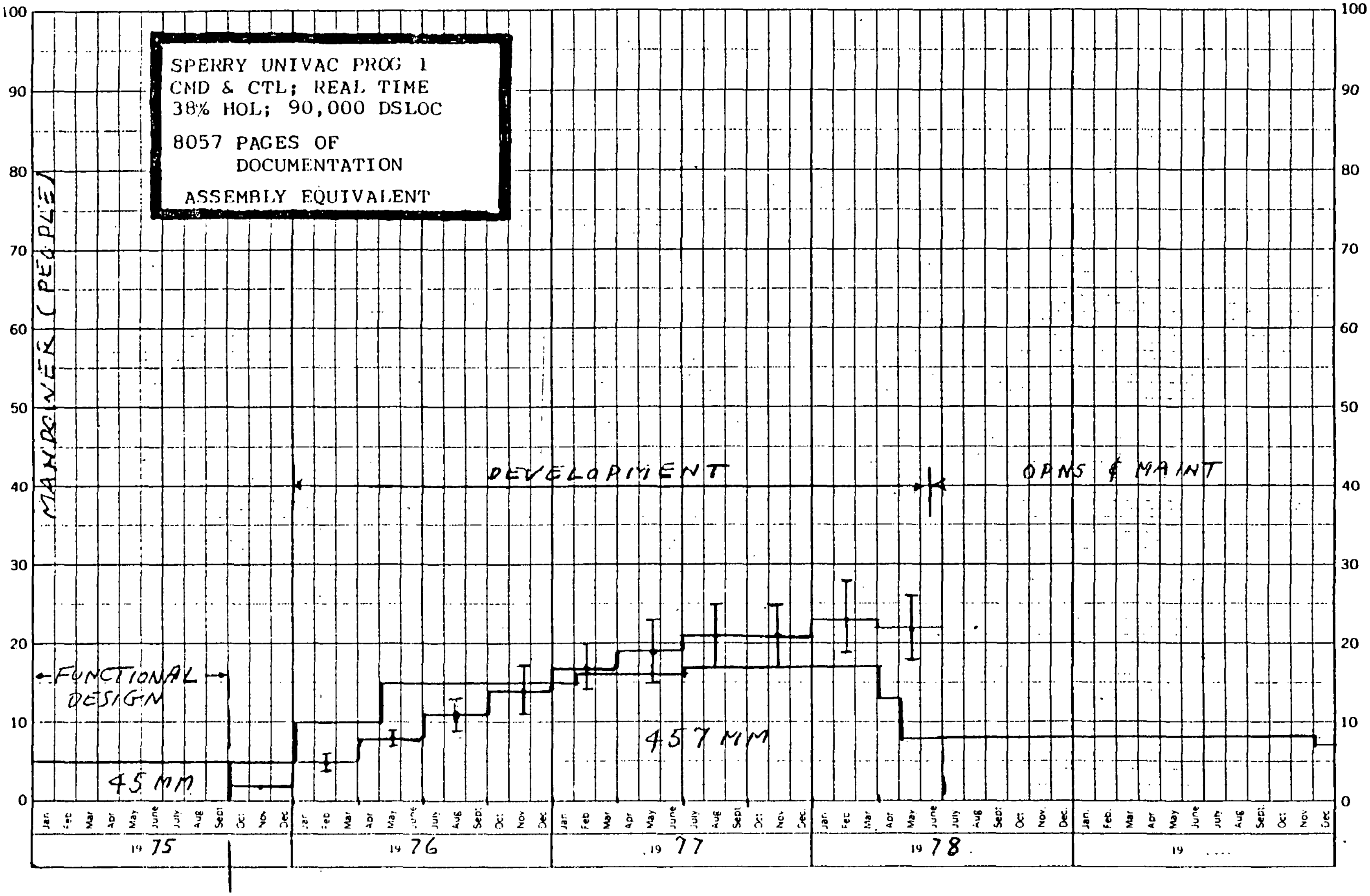
ASSEMBLY EQUIV.

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND CASHFLOW (AND ASSOCIATED STANDARD DEVIATIONS) OVER THE LIFE CYCLE OF THE SYSTEM. ALL PROJECTIONS ARE BASED ON AN OPTIMAL APPLICATION OF RESOURCES OVER TIME. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT TIME (MONTHS)	31.7	1.7
LIFE CYCLE EFFORT(MM)	1161.5	192.7
AVG COST/MY (X $1000)	50.	5.
INFLATION RATE	0.065	0.010

QTR ENDING	PEOPLE MEAN	PEOPLE STD DEV	COST/QTR (X $1000) MEAN	COST/QTR (X $1000) STD DEV	CUM COST (X $1000) MEAN	CUM COST (X $1000) STD DEV
DEC 75	2.	0.	22.	5.	22.	4.
MAR 76	5.	1.	67.	17.	89.	17.
JUN 76	8.	1.	108.	21.	197.	38.
SEP 76	11.	2.	152.	36.	347.	68.
DEC 76	14.	3.	189.	46.	537.	104.
MAR 77	17.	3.	226.	47.	761.	148.
JUN 77	19.	4.	260.	62.	1019.	198.
SEP 77	21.	4.	291.	62.	1307.	254.
DEC 77	21.	4.	303.	64.	1614.	314.
MAR 78	23.	4.	331.	65.	1937.	376.
JUN 78	22.	4.	322.	65.	2267.	441.
SEP 78	22.	3.	333.	57.	2595.	504.
DEC 78	22.	4.	330.	62.	2924.	568.
MAR 79	21.	4.	321.	70.	3245.	631.
JUN 79	20.	3.	310.	63.	3554.	691.
SEP 79	18.	3.	282.	54.	3841.	747.
DEC 79	17.	3.	273.	55.	4110.	799.
MAR 80	15.	2.	256.	52.	4364.	848.
JUN 80	14.	3.	234.	53.	4598.	894.
SEP 80	12.	2.	210.	43.	4808.	935.
DEC 80	11.	2.	188.	43.	4996.	971.
MAR 81	9.	2.	162.	36.	5161.	1003.
JUN 81	8.	2.	142.	37.	5303.	1031.
SEP 81	7.	2.	127.	32.	5428.	1055.
DEC 81	6.	2.	112.	32.	5539.	1076.
MAR 82	5.	1.	93.	26.	5633.	1095.
JUN 82	4.	1.	77.	23.	5710.	1110.
SEP 82	3.	1.	63.	19.	5774.	1122.
DEC 82	3.	1.	50.	18.	5825.	1132.
MAR 83	2.	1.	45.	16.	5868.	1140.
JUN 82	2.	1.	34.	14.	5903.	1147.
SEP 82	1.	0.	27.	11.	5930.	1153.

LIFE CYCLE PROJECTIONS


SPERRY UNIVAC PROG 1
CMD & CTL; REAL TIME
38% HOL; 90,000 DSLOC
8057 PAGES OF DOCUMENTATION
ASSEMBLY EQUIVALENT
MANPOWER (PEOPLE)
FUNCTIONAL DESIGN
DEVELOPMENT
OPNS & MAINT
45 MM
457 MM
100
90
80
70
60
50
40
30
20
10
0
19 75
19 76
19 77
19 78
19

RISK ANALYSIS

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

THE TABLES BELOW SHOW THE PROBABILITY THAT IT WILL NOT TAKE MORE THAN THE INDICATED AMOUNT OF TIME, EFFORT, AND DOLLARS TO DEVELOP YOUR SYSTEM.

PROBABILITY	TIME (MONTHS)
1. %	27.8
5. %	28.9
10. %	29.6
20. %	30.3
30. %	30.8
40. %	31.3
EXPECTED → 50. %	31.7
60. %	32.1
70. %	32.6
80. %	33.1
90. %	33.8
95. %	34.4
99. %	35.6

PROBABILITY PROFILE

PROBABILITY	MANMONTHS	COST (X $1000)	INFLATED COST(X $1000)
1. %	281.	1169.	1271.
5. %	332.	1384.	1505.
10. %	360.	1499.	1629.
20. %	393.	1638.	1780.
30. %	417.	1739.	1889.
40. %	438.	1824.	1982.
→ 50. %	457.	1904.	2069.
60. %	476.	1984.	2156.
70. %	497.	2070.	2249.
80. %	521.	2170.	2358.
90. %	554.	2309.	2509.
95. %	582.	2424.	2634.
99. %	633.	2639.	2868.

PROBABILITY PROFILE

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DOCUMENTATION

****

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

IT IS POSSIBLE TO ESTIMATE THE NUMBER OF PAGES OF DOCUMENTATION, BASED ON DATA COLLECTED FROM SEVERAL HUNDRED SYSTEMS.

THE EXPECTED NUMBER FOR YOUR SYSTEM IS 15876 PAGES.

THE 90% RANGE IS FROM 4536 TO 38556 PAGES.

****

ACTUAL: 8057

ENTER SYSTEM NAME, SIZE, MONTHS, AND MANMONTHS FOR SYSTEM 1.
> SPERR1 HOL,46068,33,457

SYSTEM NAME	SIZE	DEV. TIME (MONTHS)	DEV. EFFORT (MANMONTHS)	LEVEL	TECHNOLOGY FACTOR
SPERR1 HOL	46068.	33.0	457.0	1	6

NEW W/ INT.

$C_K = 2584$

AVERAGE TECHNOLOGY FACTOR IS 6.

****

SUMMARY OF INPUT PARAMETERS

****

SYSTEM: SPERRY UNIVAC PROG 1 DATE: 16-Nov-79

PROJECT START: 1075

COST ELEMENTS
- $/MY 50000.
- STD DEV ($/MY) 5000.

INFLATION RATE .065

ENVIRONMENT
- ONLINE DEV 0.40
- DEVELOPMENT TIME 1.00
- LANGUAGE JOVIAL

HOL USAGE 0.38
PRODUCTION TIME 0.00

SYSTEM
- TYPE COMMAND & CONTROL
- LEVEL 1

REAL TIME CODE 0.50
UTILIZATION 0.50

MODERN PROGRAMMING PRACTICES
- STRUCTURED PROG 1
- TOP-DOWN DEVELOPMENT 2

DESIGN/CODE INSP 2
CHIEF PROGRAMMER TEAMS 1

EXPERIENCE
- OVERALL 2
- LANGUAGE 1

SYSTEM TYPE 1
HARDWARE 2

TECHNOLOGY FACTOR 6

SIZE
- LOW 29913.

HIGH 62223.

HOL EQUIV.

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****

SIMULATION

****

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

HOL EQUIV.

*** SIMULATION RUNNING - PLEASE WAIT ***

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	46068.	5385.
MINIMUM DEVELOPMENT TIME (MONTHS)	31.0	1.7
DEVELOPMENT EFFORT (MANMONTHS)	536.7	92.8
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	2234.	437.
(INFLATED DOLLARS)	2423.	474.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	29913.	25.8	246.	1025.
(-1 SD)	40683.	29.4	439.	1829.
MOST LIKELY	46068.	31.0	537.	2234.
(+1 SD)	51453.	32.6	643.	2680.
(+3 SD)	62223.	35.3	853.	3553.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (537.)	WITHIN NORMAL RANGE
PROJECT DURATION (31.0 MONTHS)	WITHIN NORMAL RANGE
AVG # PEOPLE(17.)	WITHIN NORMAL RANGE
PRODUCTIVITY (86. LINES/MM)	WITHIN NORMAL RANGE

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LINEAR PROGRAM

****

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

THIS FUNCTION USES THE TECHNIQUE OF LINEAR PROGRAMMING (SIMPLEX ALGORITHM) TO DETERMINE THE MINIMUM EFFORT (AND COST) OR THE MINIMUM TIME IN WHICH A SYSTEM CAN BE BUILT. THE RESULTS ARE BASED ON THE ACTUAL MANPOWER, COST, AND SCHEDULE CONSTRAINTS OF THE USER, COMBINED WITH THE SYSTEM CONSTRAINTS YOU HAVE PROVIDED EARLIER TO YIELD A CONSTRAINED OPTIMAL SOLUTION.

ENTER THE MAXIMUM DEVELOPMENT COST IN DOLLARS> 2250000

ENTER MAXIMUM DEVELOPMENT TIME IN MONTHS> 36

ENTER THE MINIMUM AND MAXIMUM NUMBER OF PEOPLE YOU CAN HAVE ON BOARD AT PEAK MANLOADING TIME> 10,30

	TIME	EFFORT	COST (X $1000)
MINIMUM COST	36.0 MONTHS	299. MM	1246.
MINIMUM TIME	31.1 MONTHS	540. MM	2250.

YOUR REALISTIC TRADE-OFF REGION LIES BETWEEN THE LIMITS OF THE TABLE ABOVE.

(INTERPOLATION IN THE TRADE-OFF TABLE BETWEEN THESE LIMITS WILL PRODUCE ALL ACCEPTABLE ALTERNATIVES. WOULD YOU LIKE TO SEE A TRADE-OFF ANALYSIS WITHIN THESE LIMITS (Y OR N) ? Y

TIME	MANMONTHS	COST (X $1000)
31.1	540.	2250.
32.1	476.	1982.
33.1	421.	1753.
34.1	373.	1556.
35.1	333.	1386.
36.0	299.	1246.

THE RESULTS SHOWN IN THIS TABLE CAN BE USED WITH DESIGN-TO-COST OR NEW TIME TO GENERATE AN UPDATED FILE AND AN ENTIRELY NEW ARRAY OF CONSEQUENT RESULTS FOR MANLOADING, CASHFLOW, LIFE CYCLE, RISK ANALYSIS, COMPUTER TIME AND FRONT END ESTIMATES.

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                              DESIGN TO COST
*****************************************************************************
TITLE:  SPERRY UNIVAC PROG 1                                  DATE: 14-Nov-79


 SLIM HAS PROVIDED ITS BEST ESTIMATE OF THE MINIMUM TIME AND CORRESPONDING
 MAXIMUM EFFORT (AND COST) TO DEVELOP YOUR SYSTEM. THESE VALUES ARE:

                  MINIMUM TIME:                31.0 MONTHS
                  EFFORT:                      537. MANMONTHS
                  COST (X $1000):     $       2236.

 A GREATER EFFORT (OR COST) WOULD RESULT IN A VERY RISKY TIME SCHEDULE.
 HOWEVER, IF A LOWER EFFORT IS SPECIFIED (WITHIN REASONABLE LIMITS),
 DEVELOPMENT IS STILL FEASIBLE AS LONG AS YOU CAN TAKE MORE TIME.

 ENTER DESIRED EFFORT IN MANMONTHS> 457
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ACTUAL

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                                                  MEAN       STD DEV

        NEW DEVELOPMENT TIME (MONTHS)             32.4         1.8

        NEW DEVELOPMENT COST (X $1000)     $    1904.        329.


YOUR FILE IS UPDATED WITH THESE NEW PARAMETERS.  RUN MANLOADING AND CASHFLOW
OR LIFE CYCLE TO SEE HOW THESE SAVINGS CAN BE REALIZED.


 A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

    TOTAL MANMONTHS (    457.)            WITHIN NORMAL RANGE
    PROJECT DURATION (    32.4 MONTHS)    LONGER THAN NORMAL TIME DURATION
    AVG # PEOPLE(     14.)                WITHIN NORMAL RANGE
    PRODUCTIVITY (    101. LINES/MM)      WITHIN NORMAL RANGE

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LIFE CYCLE

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SYSTEM: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

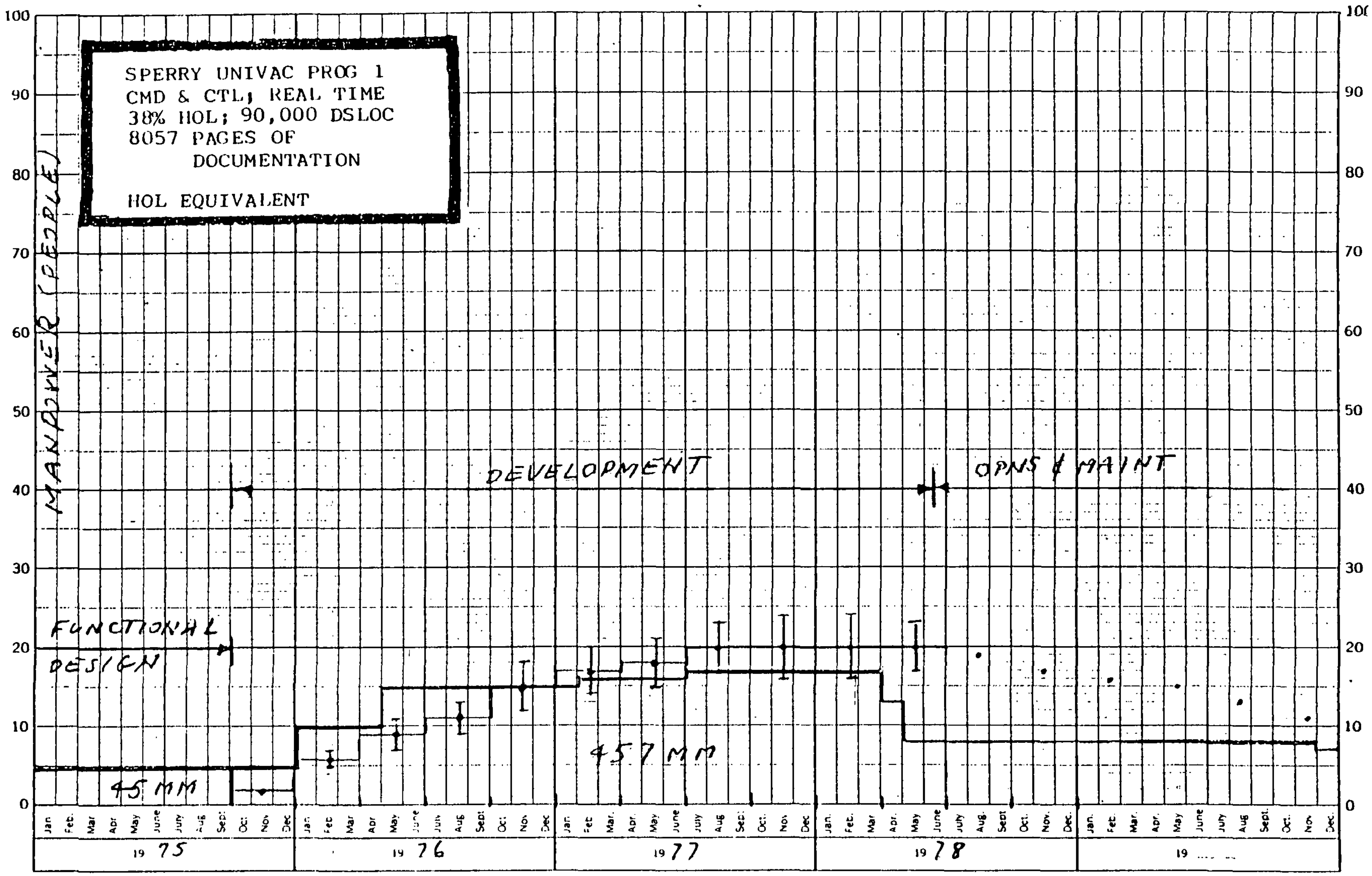
HOL EQUIV.

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND CASHFLOW (AND ASSOCIATED STANDARD DEVIATIONS) OVER THE LIFE CYCLE OF THE SYSTEM. ALL PROJECTIONS ARE BASED ON AN OPTIMAL APPLICATION OF RESOURCES OVER TIME. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT TIME (MONTHS)	32.4	1.8
LIFE CYCLE EFFORT(MM)	888.6	153.7
AVG COST/MY (X $1000)	50.	5.
INFLATION RATE	0.065	0.010

QTR ENDING	PEOPLE MEAN	PEOPLE STD DEV	COST/QTR (X $1000) MEAN	COST/QTR (X $1000) STD DEV	CUM COST (X $1000) MEAN	CUM COST (X $1000) STD DEV
DEC 75	2.	0.	23.	6.	23.	5.
MAR 76	6.	1.	71.	16.	94.	18.
JUN 76	9.	2.	117.	26.	211.	41.
SEP 76	11.	2.	153.	36.	366.	72.
DEC 76	15.	3.	196.	47.	559.	109.
MAR 77	17.	3.	231.	52.	787.	154.
JUN 77	18.	3.	248.	55.	1039.	203.
SEP 77	20.	3.	271.	51.	1307.	256.
DEC 77	20.	4.	281.	58.	1588.	311.
MAR 78	20.	4.	286.	59.	1873.	366.
JUN 78	20.	3.	290.	57.	2159.	422.
SEP 78	19.	3.	284.	54.	2441.	477.
DEC 78	17.	3.	265.	55.	2708.	530.
MAR 79	16.	3.	244.	56.	2953.	578.
JUN 79	15.	3.	233.	50.	3181.	622.
SEP 79	13.	3.	204.	45.	3388.	663.
DEC 79	11.	2.	183.	36.	3569.	698.
MAR 80	9.	2.	158.	31.	3728.	729.
JUN 80	8.	2.	134.	32.	3863.	756.
SEP 80	7.	2.	113.	31.	3977.	778.
DEC 80	5.	1.	95.	25.	4072.	796.
MAR 81	5.	1.	82.	25.	4152.	812.
JUN 81	4.	1.	64.	20.	4218.	825.
SEP 81	3.	1.	51.	17.	4269.	835.
DEC 81	2.	1.	39.	15.	4309.	843.
MAR 82	2.	1.	32.	12.	4340.	849.
JUN 82	1.	1.	26.	11.	4366.	854.
SEP 82	1.	0.	19.	10.	4386.	858.
DEC 82	1.	0.	15.	7.	4401.	861.
MAR 83	1.	0.	10.	5.	4411.	863.

LIFE CYCLE PROJECTIONS


SPERRY UNIVAC PROG 1
CMD & CTL; REAL TIME
38% HOL; 90,000 DSLOC
8057 PAGES OF
DOCUMENTATION
HOL EQUIVALENT
MANPOWER (PEOPLE)
FUNCTIONAL DESIGN
DEVELOPMENT
OPNS & MAINT
45 MM
457 MM
1975
1976
1977
1978
19

RISK ANALYSIS

TITLE: SPERRY UNIVAC PROG 1 DATE: 14-Nov-79

THE TABLES BELOW SHOW THE PROBABILITY THAT IT WILL NOT TAKE MORE THAN THE INDICATED AMOUNT OF TIME, EFFORT, AND DOLLARS TO DEVELOP YOUR SYSTEM.

PROBABILITY	TIME (MONTHS)
1. %	28.2
5. %	29.4
10. %	30.1
20. %	30.8
30. %	31.4
40. %	31.9
EXPECTED → 50. %	32.4
60. %	32.8
70. %	33.3
80. %	33.9
90. %	34.7
95. %	35.4
99. %	36.6

PROBABILITY PROFILE

PROBABILITY	MANMONTHS	COST (X $1000)	INFLATED COST(X $1000)
1. %	273.	1138.	1239.
5. %	327.	1362.	1483.
10. %	356.	1482.	1613.
20. %	390.	1627.	1771.
30. %	416.	1732.	1885.
40. %	437.	1821.	1982.
→ 50. %	457.	1904.	2073.
60. %	477.	1987.	2164.
70. %	498.	2077.	2261.
80. %	524.	2181.	2375.
90. %	558.	2326.	2533.
95. %	587.	2446.	2663.
99. %	641.	2671.	2907.

PROBABILITY PROFILE

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*******************************************************************************
                                DOCUMENTATION
*******************************************************************************
TITLE:  SPERRY UNIVAC PROG 1                                    DATE: 14-Nov-79


 IT IS POSSIBLE TO ESTIMATE THE NUMBER OF PAGES OF DOCUMENTATION, BASED
 ON DATA COLLECTED FROM SEVERAL HUNDRED SYSTEMS.

 THE EXPECTED NUMBER FOR YOUR SYSTEM IS       3224 PAGES.

 THE 90% RANGE IS FROM        921 TO       7831 PAGES.

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ACTUAL: 8057

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CALIBRATE

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.HIS FUNCTION ENABLES THE USER TO MAKE FUTURE ESTIMATES BASED ON HISTORICAL DATA FROM HIS ORGANIZATION AS WELL AS ON THE TYPE AND SIZE OF THE SYSTEM. IN ESSENCE, **CALIBRATE** TAKES TIME AND MANPOWER DATA FROM PAST SOFTWARE PROJECTS AND COMPUTES A TECHNOLOGY FACTOR FOR THE USER' ˜O...
1

ENTER ALL DATA FOR EACH SYSTEM ON 1 LINE, SEPARATED BY COMMAS.

ENTER SYSTEM NAME, SIZE, MONTHS, AND MANMONTHS FOR SYSTEM 1.
> SPERRY UNIVAC 2,500000,51,2682

SYSTEM NAME	SIZE	DEV. TIME (MONTHS)	DEV. EFFORT (MANMONTHS)	LEVEL	TECHNOLOGY FACTOR
SPERRY UNIVAC 2	500000.	51.0	2682.0	1	11

NEW W/ INT.

AVERAGE TECHNOLOGY FACTOR IS 11. C_K = 8362

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                       SUMMARY OF INPUT PARAMETERS
*******************************************************************************
SYSTEM:  SPERRY UNIVAC PROGV 2                                 DATE: 13-Aug-79


PROJECT START:  175

COST ELEMENTS
  $/MY                 50000.                         INFLATION RATE  .065
  STD DEV ($/MY)        5000.

ENVIRONMENT
  ONLINE DEV            0.90                               HOL USAGE  0.99
  DEVELOPMENT TIME      1.00                         PRODUCTION TIME  0.10
  LANGUAGE            JOVIAL

SYSTEM
  TYPE  COMMAND & CONTROL                             REAL TIME CODE  0.05
  LEVEL                    1                             UTILIZATION  0.50

MODERN PROGRAMMING PRACTICES
  STRUCTURED PROG          1                        DESIGN/CODE INSP     1
  TOP-DOWN DEVELOPMENT     1                  CHIEF PROGRAMMER TEAMS     1

EXPERIENCE
  OVERALL                  2                             SYSTEM TYPE     2
  LANGUAGE                 2                                HARDWARE     2

TECHNOLOGY
  FACTOR                  11

SIZE
  LOW                 450000.                            HIGH  550000.

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SIMULATION

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TITLE: SPERRY UNIVAC PROG 2 DATE: 13-Aug-79

*** SIMULATION RUNNING - PLEASE WAIT ***

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	500000.	16667.
MINIMUM DEVELOPMENT TIME (MONTHS)	52.3	1.4
DEVELOPMENT EFFORT (MANMONTHS)	2811.1	274.9
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	11688.	1654.
(INFLATED DOLLARS)	13406.	1914.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	450000.	49.9	2471.	10295.
(-1 SD)	483333.	51.4	2709.	11286.
MOST LIKELY	500000.	52.3	2811.	11688.
(+1 SD)	516667.	52.9	2951.	12296.
(+3 SD)	550000.	54.3	3198.	13326.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (2811.)	WITHIN NORMAL RANGE
PROJECT DURATION (52.3 MONTHS)	WITHIN NORMAL RANGE
AVG # PEOPLE(54.)	WITHIN NORMAL RANGE
PRODUCTIVITY (178. LINES/MM)	WITHIN NORMAL RANGE

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RISK ANALYSIS

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TITLE: SPERRY UNIVAC PROG 2 DATE: 13-Aug-79

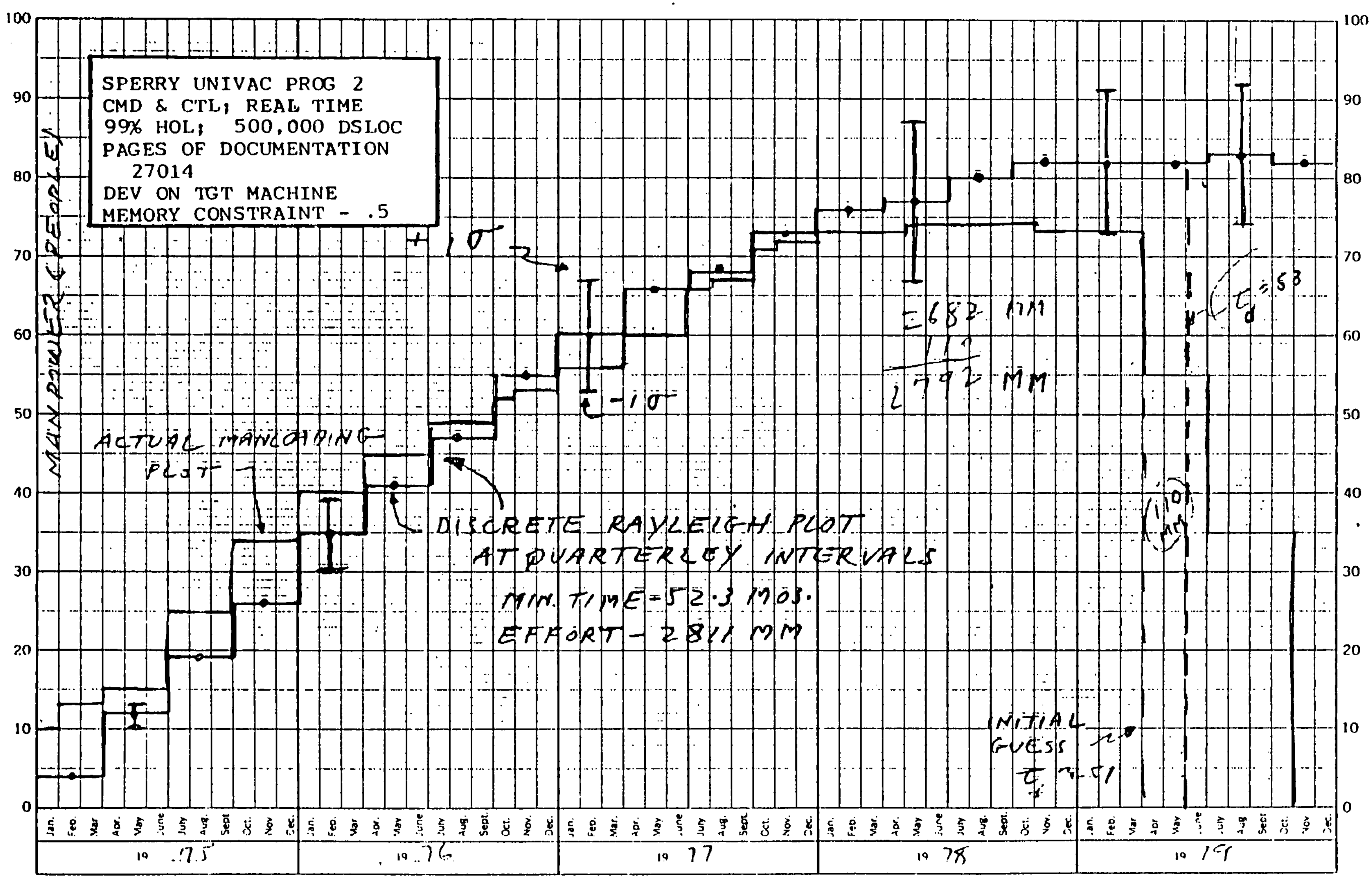
THE TABLES BELOW SHOW THE PROBABILITY THAT IT WILL NOT TAKE MORE THAN THE INDICATED AMOUNT OF TIME, EFFORT, AND DOLLARS TO DEVELOP YOUR SYSTEM.

PROBABILITY	TIME (MONTHS)
1. %	49.0
5. %	50.0
10. %	50.5
20. %	51.1
30. %	51.5
40. %	51.9
EXPECTED → 50. %	52.3
60. %	52.6
70. %	53.0
80. %	53.5
90. %	54.1
95. %	54.6
99. %	55.5

PROBABILITY PROFILE

PROBABILITY	MANMONTHS	COST (X $1000)	INFLATED COST(X $1000)
1. %	2171.	9047.	10378.
5. %	2359.	9828.	11273.
10. %	2459.	10245.	11751.
20. %	2580.	10749.	12329.
30. %	2667.	11113.	12746.
40. %	2742.	11423.	13103.
→ 50. %	2811.	11713.	13435.
60. %	2881.	12003.	13767.
70. %	2955.	12313.	14123.
80. %	3042.	12677.	14541.
90. %	3163.	13181.	15119.
95. %	3263.	13597.	15597.
99. %	3451.	14378.	16492.

PROBABILITY PROFILE


SPERRY UNIVAC PROG 2
CMD & CTL; REAL TIME
99% HOL; 500,000 DSLOC
PAGES OF DOCUMENTATION
27014
DEV ON TGT MACHINE
MEMORY CONSTRAINT - .5
MANPOWER (PEOPLE)
ACTUAL MANLOADING PLOT
DISCRETE RAYLEIGH PLOT AT QUARTERLY INTERVALS
MIN. TIME = 52.3 MOS.
EFFORT - 2811 MM
+1σ
-1σ
INITIAL GUESS
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
19 75
19 76
19 77
19 78
19 79

```
AVAILABLE FUNCTIONS ARE:
CALIBRATE
EDITOR
ESTIMATE
BYE

FUNCTION? EST

INPUT FILENAME? SPERR3

INPUT DATA CHECK - OK
```

```
******************************************************************************
                                 CALIBRATE
******************************************************************************


THIS FUNCTION ENABLES THE USER TO MAKE FUTURE ESTIMATES BASED ON HISTORICAL
DATA FROM HIS ORGANIZATION AS WELL AS ON THE TYPE AND SIZE OF THE SYSTEM.  IN
ESSENCE, **CALIBRATE** TAKES TIME AND MANPOWER DATA FROM PAST SOFTWARE
PROJECTS AND COMPUTES A TECHNOLOGY FACTOR FOR THE USER'S  ORGANIZATION.  THIS
FACTOR IS REALLY AN INDICATION OF THE STATE OF TECHNOLOGY WHICH A PARTICULAR
ORGANIZATION APPLIES TO A SOFTWARE PROJECT.

THE FOLLOWING HISTORICAL DATA IS REQUIRED:
 (1) SYSTEM NAME (UP TO 20 CHARACTERS)
 (2) TOTAL SYSTEM SIZE IN SOURCE STATEMENTS
 (3) NUMBER OF MONTHS TO DEVELOP
 (4) NUMBER OF MANMONTHS TO DEVELOP

HISTORICAL DATA WILL BE PROVIDED FOR HOW MANY SYSTEMS? 1

ENTER ALL DATA FOR EACH SYSTEM ON 1 LINE, SEPARATED BY COMMAS.


ENTER SYSTEM NAME, SIZE, MONTHS, AND MANMONTHS FOR SYSTEM  1.
> SPERR3,16724,26,399


.............................................................................
SYSTEM NAME               SIZE    DEV. TIME    DEV. EFFORT    LEVEL  TECHNOLOGY
                                  (MONTHS)     (MANMONTHS)              FACTOR
.............................................................................

SPERR3                   16724.      26.0          399.0        3          2

.............................................................................


                 AVERAGE TECHNOLOGY FACTOR IS     2.


******************************************************************************
```

SUMMARY OF INPUT DATA PRINTED (Y OR N)? Y

```
********************************************************************************
                        SUMMARY OF INPUT PARAMETERS
********************************************************************************
SYSTEM:   SPERRY UNIVAC 3                                       DATE: 16-Nov-79

PROJECT START:  175

COST ELEMENTS
  $/MY                50000.                          INFLATION RATE  .070
  STD DEV ($/MY)       5000.

ENVIRONMENT
  ONLINE DEV           0.25                                HOL USAGE  0.53
  DEVELOPMENT TIME     0.20                          PRODUCTION TIME  0.80
  LANGUAGE           JOVIAL

SYSTEM
  TYPE  COMMAND & CONTROL                             REAL TIME CODE  0.20
  LEVEL                   2                              UTILIZATION  0.52

MODERN PROGRAMMING PRACTICES
  STRUCTURED PROG         2                         DESIGN/CODE INSP     2
  TOP-DOWN DEVELOPMENT    3                  CHIEF PROGRAMMER TEAMS      2

EXPERIENCE
  OVERALL                 3                              SYSTEM TYPE     2
  LANGUAGE                3                                 HARDWARE     3

TECHNOLOGY
  FACTOR                  5

SIZE
  LOW                20600.                              HIGH   32600.


********************************************************************************
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SIMULATION

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TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

*** SIMULATION RUNNING - PLEASE WAIT ***

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	16724.	776.
MINIMUM DEVELOPMENT TIME (MONTHS)	25.3	0.8
DEVELOPMENT EFFORT (MANMONTHS)	471.6	51.7
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	1961.	290.
(INFLATED DOLLARS)	2106.	312.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	14396.	23.6	391.	1630.
(-1 SD)	15948.	24.7	446.	1859.
MOST LIKELY	16724.	25.3	472.	1961.
(+1 SD)	17500.	25.7	503.	2095.
(+3 SD)	19052.	26.7	605.	2520.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (472.)	GREATER THAN NORMAL EFFORT
PROJECT DURATION (25.3 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE (19.)	GREATER THAN NORMAL # OF PEOPLE
PRODUCTIVITY (35. LINES/MM)	LESS THAN NORMAL PRODUCTIVITY

****

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AVAILABLE OPTIONS ARE:

NEW TIME              LINEAR PROGRAM     RISK ANALYSIS        DOCUMENTATION
DESIGN-TO-COST        MANLOADING         BENEFIT ANALYSIS     ALL ANALYSES
PERT SIZING           CASHFLOW           MILESTONES           HELP
DESIGN-TO-RISK(DTR)   LIFE CYCLE         CPU USAGE            END
FRONT-END ESTIMATES

OPTION? LIN
```

```
******************************************************************************
                              LINEAR PROGRAM
******************************************************************************
TITLE:  SPERRY UNIVAC 3                                        DATE: 16-Nov-79
```

THIS FUNCTION USES THE TECHNIQUE OF LINEAR PROGRAMMING (SIMPLEX ALGORITHM) TO DETERMINE THE MINIMUM EFFORT (AND COST) OR THE MINIMUM TIME IN WHICH A SYSTEM CAN BE BUILT. THE RESULTS ARE BASED ON THE ACTUAL MANPOWER, COST, AND SCHEDULE CONSTRAINTS OF THE USER, COMBINED WITH THE SYSTEM CONSTRAINTS YOU HAVE PROVIDED EARLIER TO YIELD A CONSTRAINED OPTIMAL SOLUTION.

```
ENTER THE MAXIMUM DEVELOPMENT COST IN DOLLARS> 2000000

ENTER MAXIMUM DEVELOPMENT TIME IN MONTHS> 30

ENTER THE MINIMUM AND MAXIMUM NUMBER OF PEOPLE YOU
CAN HAVE ON BOARD AT PEAK MANLOADING TIME> 15,30
```

	TIME	EFFORT	COST (X $1000)
MINIMUM COST	28.8 MONTHS	277. MM	1153.
MINIMUM TIME	25.3 MONTHS	471. MM	1962.

YOUR REALISTIC TRADE-OFF REGION LIES BETWEEN THE LIMITS OF THE TABLE ABOVE.

(INTERPOLATION IN THE TRADE-OFF TABLE BETWEEN THESE LIMITS WILL PRODUCE ALL ACCEPTABLE ALTERNATIVES. WOULD YOU LIKE TO SEE A TRADE-OFF ANALYSIS WITHIN THESE LIMITS (Y OR N) ? Y

TIME	MANMONTHS	COST (X $1000)
25.3	471.	1962.
26.3	403.	1680.
27.3	347.	1447.
28.3	301.	1253.
28.8	277.	1153.

THE RESULTS SHOWN IN THIS TABLE CAN BE USED WITH DESIGN-TO-COST OR NEW TIME TO GENERATE AN UPDATED FILE AND AN ENTIRELY NEW ARRAY OF CONSEQUENT RESULTS FOR MANLOADING, CASHFLOW, LIFE CYCLE, RISK ANALYSIS, COMPUTER TIME AND FRONT END ESTIMATES.

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DESIGN TO COST

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TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

SLIM HAS PROVIDED ITS BEST ESTIMATE OF THE MINIMUM TIME AND CORRESPONDING MAXIMUM EFFORT (AND COST) TO DEVELOP YOUR SYSTEM. THESE VALUES ARE:

MINIMUM TIME:		25.3 MONTHS
EFFORT:		472. MANMONTHS
COST (X $1000):	$	1965.

A GREATER EFFORT (OR COST) WOULD RESULT IN A VERY RISKY TIME SCHEDULE. HOWEVER, IF A LOWER EFFORT IS SPECIFIED (WITHIN REASONABLE LIMITS), DEVELOPMENT IS STILL FEASIBLE AS LONG AS YOU CAN TAKE MORE TIME.

ENTER DESIRED EFFORT IN MANMONTHS> 399

		MEAN	STD DEV
NEW DEVELOPMENT TIME (MONTHS)		26.3	0.8
NEW DEVELOPMENT COST (X $1000)	$	1663.	182.

YOUR FILE IS UPDATED WITH THESE NEW PARAMETERS. RUN MANLOADING AND CASHFLOW OR LIFE CYCLE TO SEE HOW THESE SAVINGS CAN BE REALIZED.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (399.)	GREATER THAN NORMAL EFFORT
PROJECT DURATION (26.3 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE (15.)	GREATER THAN NORMAL # OF PEOPLE
PRODUCTIVITY (42. LINES/MM)	LESS THAN NORMAL PRODUCTIVITY

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RISK ANALYSIS

****

TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

THE TABLES BELOW SHOW THE PROBABILITY THAT IT WILL NOT TAKE MORE THAN THE INDICATED AMOUNT OF TIME, EFFORT, AND DOLLARS TO DEVELOP YOUR SYSTEM.

PROBABILITY	TIME (MONTHS)
1. %	24.5
5. %	25.0
10. %	25.3
20. %	25.7
30. %	25.9
40. %	26.1
50. %	26.3
60. %	26.5
70. %	26.7
80. %	27.0
90. %	27.3
95. %	27.6
99. %	28.2

PROBABILITY PROFILE

PROBABILITY	MANMONTHS	COST (X $1000)	INFLATED COST(X $1000)
1. %	297.	1239.	1334.
5. %	327.	1363.	1468.
10. %	343.	1429.	1539.
20. %	362.	1509.	1625.
30. %	376.	1567.	1688.
40. %	388.	1616.	1741.
50. %	399.	1663.	1791.
60. %	410.	1709.	1840.
70. %	422.	1758.	1893.
80. %	436.	1816.	1956.
90. %	455.	1896.	2042.
95. %	471.	1962.	2113.
99. %	501.	2086.	2247.

PROBABILITY PROFILE

MANLOADING

TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND ASSOCIATED (+ OR -) STANDARD DEVIATION REQUIRED FOR DEVELOPMENT. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT EFFORT (MM)	399.0	41.4
DEVELOPMENT TIME (MONTHS)	26.3	0.8

*** SIMULATION RUNNING - PLEASE WAIT ***

TIME	PEOPLE/MONTH	STD DEV	CUMULATIVE MANMONTHS	CUM STD DEV
JAN 75	1.83	0.22	2.	0.
FEB 75	5.38	0.63	7.	1.
MAR 75	8.88	1.06	16.	2.
APR 75	12.17	1.44	28.	3.
MAY 75	14.99	1.78	43.	4.
JUN 75	17.61	2.07	61.	6.
JUL 75	19.71	2.17	80.	8.
AUG 75	21.53	2.50	102.	11.
SEP 75	22.63	2.52	124.	13.
OCT 75	23.35	2.55	148.	15.
NOV 75	23.54	2.60	171.	18.
DEC 75	23.61	2.55	195.	20.
JAN 76	23.05	2.48	218.	23.
FEB 76	22.24	2.40	240.	25.
MAR 76	21.15	2.12	261.	27.
APR 76	19.93	2.07	281.	29.
MAY 76	18.43	1.99	299.	31.
JUN 76	16.89	1.76	316.	33.
JUL 76	15.18	1.71	331.	34.
AUG 76	13.66	1.50	345.	36.
SEP 76	11.94	1.38	357.	37.
OCT 76	10.44	1.22	368.	38.
NOV 76	9.12	1.13	377.	39.
DEC 76	7.78	1.02	384.	40.
JAN 77	6.63	0.95	391.	41.
FEB 77	5.56	0.86	397.	41.
MAR 77	2.30	0.37	399.	42.

****
SIMULATION
****

TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

*** SIMULATION RUNNING - PLEASE WAIT ***

HOL EQUIV.

	MEAN	STD DEV
SYSTEM SIZE (STMTS)	16724.	776.
MINIMUM DEVELOPMENT TIME (MONTHS)	25.3	0.8
DEVELOPMENT EFFORT (MANMONTHS)	472.1	49.0
DEVELOPMENT COST (X $1000) (UNINFLATED DOLLARS)	1969.	288.
(INFLATED DOLLARS)	2114.	310.

SENSITIVITY PROFILE FOR MINIMUM TIME SOLUTION
(EXPECTED VALUES OF TIME, EFFORT, AND COST FOR VARIOUS SYSTEM SIZES)

	SOURCE STMTS	MONTHS	MANMONTHS	COST (X $1000)
(-3 SD)	14396.	23.6	391.	1630.
(-1 SD)	15948.	24.7	446.	1859.
MOST LIKELY	16724.	25.3	472.	1969.
(+1 SD)	17500.	25.7	503.	2095.
(+3 SD)	19052.	26.7	605.	2520.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (472.)	GREATER THAN NORMAL EFFORT
PROJECT DURATION (25.3 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE (19.)	GREATER THAN NORMAL # OF PEOPLE
PRODUCTIVITY (35. LINES/MM)	LESS THAN NORMAL PRODUCTIVITY

****

****

DESIGN TO COST

****

TITLE: SPERRY UNIVAC 3 DATE: 16-Nov-79

SLIM HAS PROVIDED ITS BEST ESTIMATE OF THE MINIMUM TIME AND CORRESPONDING MAXIMUM EFFORT (AND COST) TO DEVELOP YOUR SYSTEM. THESE VALUES ARE:

MINIMUM TIME:		25.3 MONTHS
EFFORT:		472. MANMONTHS
COST (X $1000):	$	1967.

A GREATER EFFORT (OR COST) WOULD RESULT IN A VERY RISKY TIME SCHEDULE. HOWEVER, IF A LOWER EFFORT IS SPECIFIED (WITHIN REASONABLE LIMITS), DEVELOPMENT IS STILL FEASIBLE AS LONG AS YOU CAN TAKE MORE TIME.

ENTER DESIRED EFFORT IN MANMONTHS> 399

		MEAN	STD DEV
NEW DEVELOPMENT TIME (MONTHS)		26.3	0.8
NEW DEVELOPMENT COST (X $1000)	$	1663.	173.

YOUR FILE IS UPDATED WITH THESE NEW PARAMETERS. RUN MANLOADING AND CASHFLOW OR LIFE CYCLE TO SEE HOW THESE SAVINGS CAN BE REALIZED.

A CONSISTENCY CHECK WITH DATA FROM OTHER SYSTEMS OF THE SAME SIZE SHOWS:

TOTAL MANMONTHS (399.)	GREATER THAN NORMAL EFFORT
PROJECT DURATION (26.3 MONTHS)	LONGER THAN NORMAL TIME DURATION
AVG # PEOPLE (15.)	GREATER THAN NORMAL # OF PEOPLE
PRODUCTIVITY (42. LINES/MM)	LESS THAN NORMAL PRODUCTIVITY

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LIFE CYCLE

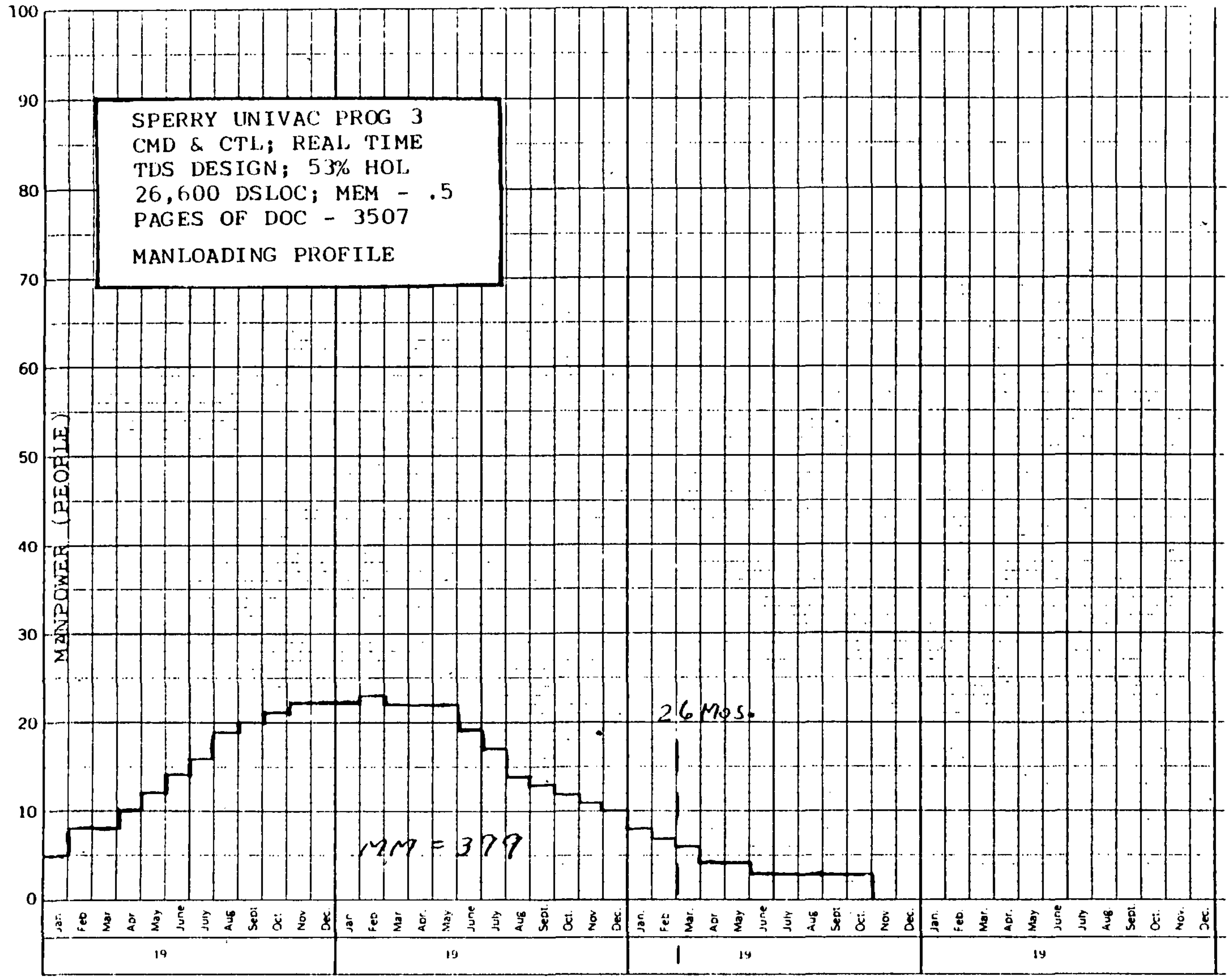
****

SYSTEM: SPERRY UNIVAC 3 DATE: 16-Nov-7

THE TABLE BELOW SHOWS THE MEAN PROJECTED EFFORT AND CASHFLOW (AND ASSOCIATED STANDARD DEVIATIONS) OVER THE LIFE CYCLE OF THE SYSTEM. ALL PROJECTIONS ARE BASED ON AN OPTIMAL APPLICATION OF RESOURCES OVER TIME. THE INPUT PARAMETERS ARE:

	MEAN	STD DEV
DEVELOPMENT TIME (MONTHS)	26.3	0.8
LIFE CYCLE EFFORT(MM)	419.9	43.6
AVG COST/MY (X $1000)	50.	5.
INFLATION RATE	0.070	0.011

MONTH	PEOPLE		COST/MTH (X $1000)		CUM COST (X $1000)	
	MEAN	STD DEV	MEAN	STD DEV	MEAN	STD DEV
JAN 75	2.	0.	8.	1.	8.	1.
FEB 75	5.	1.	23.	4.	30.	4.
MAR 75	9.	1.	38.	6.	68.	10.
APR 75	12.	1.	51.	8.	119.	17.
MAY 75	15.	2.	65.	11.	183.	27.
JUN 75	18.	2.	76.	12.	259.	38.
JUL 75	20.	2.	85.	14.	344.	50.
AUG 75	21.	2.	93.	14.	437.	64.
SEP 75	23.	3.	99.	15.	536.	79.
OCT 75	23.	3.	103.	16.	638.	94.
NOV 75	24.	3.	104.	16.	742.	109.
DEC 75	24.	3.	106.	15.	847.	124.
JAN 76	23.	2.	103.	15.	951.	140.
FEB 76	22.	2.	100.	15.	1051.	154.
MAR 76	21.	2.	95.	14.	1146.	168.
APR 76	20.	2.	91.	13.	1236.	181.
MAY 76	19.	2.	85.	12.	1321.	194.
JUN 76	17.	2.	77.	11.	1399.	205.
JUL 76	15.	2.	71.	10.	1469.	216.
AUG 76	14.	2.	63.	9.	1532.	225.
SEP 76	12.	1.	56.	9.	1589.	233.
OCT 76	11.	1.	50.	8.	1639.	240.
NOV 76	9.	1.	44.	7.	1682.	247.
DEC 76	8.	1.	37.	6.	1720.	252.
JAN 77	7.	1.	32.	5.	1752.	257.
FEB 77	6.	1.	27.	5.	1778.	261.
MAR 77	5.	1.	23.	4.	1801.	264.
APR 77	4.	1.	18.	4.	1820.	267.
MAY 77	3.	1.	15.	3.	1835.	269.
JUN 77	3.	0.	12.	3.	1847.	271.
JUL 77	2.	0.	10.	2.	1857.	272.
AUG 77	2.	0.	8.	2.	1865.	274.
SEP 77	1.	0.	6.	2.	1871.	275.
OCT 77	1.	0.	5.	1.	1876.	275.
NOV 77	1.	0.	4.	1.	1880.	276.
DEC 77	1.	0.	3.	1.	1883.	276.
JAN 78	0.	0.	2.	1.	1885.	277.


SPERRY UNIVAC PROG 3
CMD & CTL; REAL TIME
TDS DESIGN; 53% HOL
26,600 DSLOC; MEM - .5
PAGES OF DOC - 3507
MANLOADING PROFILE
MANPOWER (PEOPLE)
100
90
80
70
60
50
40
30
20
10
0
26 Mos.
MM = 377
Jan. Feb Mar Apr May June July Aug Sept Oct. Nov Dec
19
19
19
19

SPERRY UNIVAC PROG 3
SLIM MANLOADING PROFILE
FOR 399MM OF DEVELOPMENT
EFFORT. 16,724 HOL EQUIV.
SOURCE STATEMENTS