POUGHKEEPSIE

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March 16, 1959

MEMO TO: Mr. D. W. Pendery
Mr. S. W. Dunwell

SUBJECT: Project 7000 (STRETCH) Minimum Performance Criteria

REFERENCE: Letter dated March 5, 1958, by M. B. Smith entitled "Procedure for Implementation of DP Staff Letter No. 38 - Machine Serviceability".

The enclosed minimum performance criteria, which have been prepared according to the above referenced letter, are presented for your approval. It is understood that they are to become part of the Engineering Project File and the Product Planning Project Record File for Project 7000 (STRETCH) if approved. They are to replace the memos of the same title dated December 30, 1957, amended May 5, 1958, presently in the Files.

Enclosure: Minimum Performance Criteria
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Project 7000 (STRETCH) Minimum Performance Criteria

I. General

A. The STRETCH Computer System will provide a computing and data processing facility of tremendous power and versatility. In addition to its speed, the system being made of solid state components and containing a considerable amount of error detection and correction circuitry should also set a new record for reliability and maintainability.

B. To set standards for minimum performance criteria, we must examine some of the uses presently envisioned for the STRETCH system and estimate their demands upon the equipment.

The systems considered are:

(1) The Senior Scientific Computing System.

This system, typified by the AEC Los Alamos computer, needs the full power of internal computing speed. The high speed disk files will be used extensively. The demands on other I/O are not great in volume but reliability is important. The system will eventually be used 24 hours a day. Much of the evening and night shift operation is expected to be unattended operation. Occasional isolated machine errors causing automatic problem restarts are not serious.

(2) As part of the Harvest System

The STRETCH computer serves as an integral part of the Harvest System, which is essentially a high speed data processor. Since Harvest cannot operate unless the computer is operable, its reliability is of direct concern to the Harvest System. The system will be operated continuously on a 24 hour a day basis with huge amounts of I/O activity. Occasional isolated machine errors are not considered serious if the system is not stopped.

(3) Real Time Analysis and Control System

In this type of application the computer is only one part of a larger system. The requirements are in terms of large amounts of computation during relatively short intervals under outside control. Availability (hence reliability) is extremely important in such operation. The real time data is presented once only and must be acted upon with little delay. Occasional isolated errors can be tolerated if they are recognizable and do not stop the computer.

(4) Commercial Data Processing System

The requirements for such systems is more on reliability than on speed, although rerun procedures can make occasional errors less serious. Commercial systems will tend to have a smaller number of memory units and more tapes.

C. Because of the variation in number and type of units which can make up a STRETCH system, it is difficult to give a single set of performance criteria which would hold for all combinations. The probability of the system making an error is really the sum of the probabilities of the individual units making errors independently, plus possible interaction errors. In practice, failures of certain units will completely stop the computer, while failures of other components will make only a minor inconvenience and not disable the system at all.

In arriving at the following criteria, we have separated the mechanical devices, which tend to be less reliable, from the rest of the system. The assumption is that there will be stand-by I/O units in those applications where mechanical failures might be critical.

In the following, a "machine stop" is defined as a machine failure which cannot be automatically corrected either by built-in ECC equipment or by simply programmed restart procedures.

II. Time Criteria for STRETCH System (excluding certain I/O devices listed in the next section)

A typical STRETCH System should meet the following requirements based on a total time T = 168 hours per week on three shift, seven day per week operation. The following are for the AEC System.

A. Productive Time

The system should run at rated speed 160 hours of the 168 hours per week operation (95%).

B. <u>Operator Service Time</u>

This time will depend considerably on the customer's problems and method of operation, so it will not be considered as a criteria for the STRETCH System. It is understood, however, that the design is in the direction of keeping the amount of necessary operator service as low as possible.

C. <u>Maximum Unscheduled Maintenance Delay</u>

The average length of an unscheduled service call should be 15 minutes. An unscheduled maintenance delay of more than two hours would then be so unlikely (less than .04%) that it may be called a maximum delay provided Customer Engineering service and parts are immediately available.

D. <u>Mean Unscheduled Maintenance Free Time:</u>

There should be an average of 45 hours between service calls resulting from a machine stop (i.e., a non-correctible, catastrophic failure).

E. <u>Minimum Unscheduled-Maintenance-Free Time</u>

There should be a 90% probability of the STRETCH System running 24 hours with no more than one period of unscheduled maintenance resulting from a machine stop. (This is equivalent to a 58% probability of no such periods in 24 hours.)

F. <u>Maximum Individual Scheduled-Maintenance Delay</u>

There should be one regularly scheduled maintenance period per 7 day week of 3-shift operation with a duration of 6 to 8 hours. (Two periods of 3 to 4 hours each may be substituted.)

G. <u>Mean Scheduled-Maintenance-Free Time</u>

The STRETCH System should regularly run 160 hours between regularly scheduled maintenance periods on 3-shift 7 day per week operation. (or 80 hours if two shorter periods are used.)

H. Idle Time

The number of hours that the machine is in good operating condition but not being used is largely a function of the customer's operating procedure. It is expected that STRETCH Systems will be operated so as to make Idle Time as nearly zero as possible. (This is considering time during which the system is standing by as useful time even though no calculations may be proceeding at the moment.)

I. Restart Time

The details of restart procedures and the times required depend critically on the problems being run and the I/O equipment available. This must be studied for each system as a particular case. In any event it should be no more than about 1/2 hour per 168 hour week.

J. Customer Machine Availability Time

This can be considered as the same 160 hours per week mentioned in Section A, since the times mentioned for Operator Service Time, Restart Time, and Idle Time are all considered essentially zero.

For a single shift operation (173 hours per month) the equivalent time is considered to be 156 hours per month.

K. Total Permissible Customer Engineering Time

The total Customer Engineering time for scheduled and unscheduled maintenance should not exceed the 8 hours per week given in Section F. Appendix II lists estimates of the Permissible Customer Engineering Time in man hours for most of the individual units being considered for the AEC STRETCH System. Other combinations may be built up from the individual unit figures.

The times listed in Appendix II are on the basis of single shift operation T = 173 hours per month. They represent "Productive Time" on the machines only; that is, they do not include necessary paper work, etc. They do include both on-line and off-line maintenance.

III Permissible Error Criteria

The number of uncorrectible errors allowable from the components under the above performance criteria are discussed in Appendix I.

IV Time Criteria for Certain I/O Devices used in STRETCH System

The following units are those for which figures are available now. Others, such as the Disk Unit will be added when they become available.

1. Card Punch and Adapter Control Unit

T = 173 hours per month, single shift

A. Productive Time	151. hours
B. Operator Service Time	11. hours
C. Max. Unscheduled-Maintenance Delay	5.0 hours
D. Mean Unscheduled-Maintenance Free Time	100. hours
E. Min. Unscheduled-Maintenance Free Time	40. hours
F. Max. Individual Scheduled Maintenance Delay	5. hours
G. Mean Scheduled-Maintenance Free Time	346. hours
H. Idle Time	not applicable
I. Restart Time	not applicable
J. Customer Machine availability time	162. hours
K. Total Permissible C.E. Time (estimate)	see Appendix II
L. Permissible Error Criteria	
(1) Freq. of detailed errors	3 per 40 hours
(2) Freq. of undetected errors-Non checked functions	1 per 346 hours
(3) Freq. of undetected errors-checked functions	1 per 1038 hours

2. Card Reader and Adapter Control Unit

T = 173 hours per month, single shift.

A. Productive Time	151. hours
B. Operator Service Time	11. hours
C. Maximum Unscheduled Maintenance Delay	5.0 hours
D. Mean Unscheduled-Maintenance Free Time	200. hours
E. Min. Unscheduled-Maint. Free Time	40. hours
F. Max. Individual Scheduled Maint. Delay	5. hours
G. Mean Scheduled Maintenance Free Time	356. hours
H. Idle Time	not applicable
I. Restart Time	not applicable
J. Customer Machine Availability Time	162. hours
K. Total Permissible Customer Engineering Time	see Appendix II
L. Permissible Error Criteria	
(1) Freq. of detected errors	2 per 40 hours
(2) Freq. of undetected errors-non checked functions	1 per 346 hours
(3) Freq. of undetected errors-checked functions	1 per 1038 hours

3. Chain Printer and Adapter Control Unit

T. = 173 hours per month, single shift

*A. Productive Time	145. hours
*B. Operator Service Time	11. hours
C. Max. Unscheduled-Maintenance Delay	6.0 hours
D. Mean Unscheduled-Maintenance Free Time	80. hours
*E. Min. Unscheduled-Maint. Free Time	40. hours
F. Max. Individual Scheduled Maintenance Delay	6. hours
G. Mean Scheduled Maintenance Free Time	80. hours
H. Idle Time	not applicable
I. Restart Time	not applicable
*J. Customer Machine Availability Time	156. hours
K. Total Permissible Customer Engineering Time	17. hours
L. Permissible Error Criteria	
(1) Freq. of detected errors	1 per 40 hours
(2) Freq. of undetected error-non checked functions	1 per 100 hours
(3) Freq. of undetected errors-checked functions	1 per 1500 hours

*Unofficial estimates

4. 729 Tapes and Tape Control Units

		729-II	729-IV
A.	Production Time	166. 4 hr/173	161.5/173
B.	Operator's Service Time	-----------	-------------
C.	Max. Unscheduled Maint. Delay	3. 2 hours	3. 2 hours
D.	Mean Unscheduled Main Free Time	66. 6 hours	66. 6 hours
E.	Min. Unscheduled Maint. Free Time	(not given)	(not given)
F.	Max. Ind. Sched. Maint. Delay	4. 0 h once 3 mo.	4. 0 h once 3 mo.
G.	Mean Sched. Maint. Free Time	8. 0 hours	8. 0 hours
H.	Idle Time	} Not applicable	Not applicable
I.	Restart Time		
J.	Cust. Machine Avail. Time	166. 4 hr/173 hr.	165. 5/173
K.	Total Previous C.E. Time	6. 6 hr/173	7. 5 hr/173
L.	Permissible Error Criteria		
	(1) Frequency Error Criteria	*	
	(2) Freq. of undetected errors-non checked	*	
	(3) Freq. of undetected errors- checked	*	

* 95% probability of making 1500 references daily to a system tape holding 25-2000 character records without a read error. Error is defined as an error which persists through 3 successive attempts to read the same record.

APPENDIX I Component Reliability

The reliability required for the STRETCH System as a whole has a direct implication upon the reliability of the individual components used in the construction of the computer. The following calculations are an attempt to derive this general figure of reliability for the components in a straight-forward manner.

The following assumptions have been made:

1. The system includes six two microsecond memories.
2. The only contacts that will enter into the reliability of the system will be card contacts and that these will only contribute to catastrophic failures.
3. That a 90% probability exists of having no more than one uncorrectable error for each 24 hours of operation.
4. That one eight hour period of preventive maintenance be scheduled per week. (two four hour periods may be substituted.)
5. That 12 detected faults can be repaired during the eight hour preventive maintenance period.
6. That one degradation failure out of each one hundred is caused by a passive component.
7. All degradation failures will be detected during this preventive maintenance period through use of marginal checking procedures.
8. That all contacts on each socket are used.
9. That the catastrophic failure rates for all components are the same.

The following counts were taken from recent estimates:

1. Card Count
   - 3,000 double cards in the computer
   - 2,088 single cards in the memory
   - 800 driver cards for a memory
   - 18,000 single cards in the computer and exchange
2. Transistor Count
   - Average number of transistors per cards are:
     - 21 transistors per double card
     - 4.25 transistors per single card

6 transistors per driver card

(3,000) (21)	=	63,000
(30,528)(4.25)	=	129,744
(4,800)(6)	=	28,800
		221,544

3. Passive Component Count

Average numbers of passive components per card are:

68 passive components per double card
17 passive components per single card
18 passive components per driver card

(3,000)(68)	=	204,000
(30,528)(17)	=	518,976
(4,800)(18)	=	86,400
		809,376

4. Card Contact Count

(35,328)(16)	=	565,248
(3,000)(32)	=	96,000
		661,248

Summary of Component Counts -

Transistor Count	=	221,544
Passive Component Count	=	809,376
Card Contact Count	=	661,248
		1,692,168

The probability for no more than one failure may be calculated from Poisson's exponential formula:

$$P = 1 - \left(1 + \frac{T}{T_m}\right) \exp\left(-\frac{T}{T_m}\right)$$

where T_m = mean time to failure

T = time elapsed for the failure count

P = probability of having no more than one failure during the period T.

If we take for catastrophic failures:

T = 24 hours

P = 90%

we find $\frac{T}{T_m} = 0.532$

$T_m = 45.0$ hours

$\# \text{ Failures}/1000 \text{ hours} = \frac{1000}{45.0} = 22.2$

$$\text{Failure rate}/1000 \text{ hours} = \frac{\# \text{ failures}/1000 \text{ hours}}{\# \text{ components}}$$

$$= \frac{22.2}{1.69 \times 10^6} = 13.2 \times 10^{-6}$$

$$= .00132\%/1000 \text{ hours}$$

The degradation failure rate is calculated as follows:

No. Failures = 12
P = 90%
T = 168 hours

From Poisson distribution cumulative probability curves, the probability of no more than 12 errors occuring is 90% when:

$$\frac{T}{T_m} = 8.5$$

So $T_m = 19.8$ hours

$\text{Failures}/1000 \text{ hours} = \frac{1000}{19.8} = 50.6$

$$\text{Failure rate}/1000 \text{ hours} = \frac{\# \text{ failures}/1000 \text{ hours}}{\# \text{ components}}$$

$$\# \text{ Components} = \text{total } \# \text{ transistors} + \frac{\text{total } \# \text{ passive components}}{100}$$

$= 221,544 + 8,093 = 229,637$

$$\text{Failure rate}/1000 \text{ hours} = \frac{50.6}{2.29 \times 10^5} = 22 \times 10^{-5}$$

$$= .022\%/1000 \text{ hours}$$

The total failure rate permissible due to any type of failure in a transistor is the sum of the catastrophic and degradation rates:

$$.0013\% + .022\% = .0233\%/1000 \text{ hours}$$

It will be noted that the degradation failure rate is the major allowable cause for failure in this total failure rate.

APPENDIX II

AEC STRETCH SYSTEM
TOTAL PERMISSIBLE CUSTOMER
ENGINEERING TIME

T = 173 hours per month, 1 shift

Unit	Quantity	Total 01 - 19 Man hours/month
SIGMA CPU & Basic Exchange	1	119.6
2 usec memory	6	44.8
Tape Adapter and Control Unit	2	9.4
729 IV Tape Drive	4	16.0
Card Reader Adapter	1	3.2
Card Reader (1000 cpm)	1	3.0
Printer Control Unit	1	3.6
Printer (600 lpm)	1	8.2
Punch Control Unit	1	2.7
Punch	1	2.9
Typewriter, Console & Adapter	1	4.0
Event Recorder	2	4.2
High Speed Exchange & Disk Control Unit	1	15.1
Disk File	1	7.7
Memory Maintenance Console	1	2.3
Total		246.7 hours/month