III 1-68

ASSESSMENT OF RISK FOR ENGINEERING CHANGE DECISIONS

CURRENT BASIS FOR APPROVAL OF ECPs

NEW PART	EXISTING PART
. ENGINEERING CONFIDENCE	. ENGINEERING JUDGMENT OF SERIOUSNESS OF FAILURE
. MANUFACTURING CONFIDENCE	. TEST HISTORY (FAILURES, TESTS, SECONDS)
. INSPECTION AND VERIFICATION	+ NEW PART ITEMS
. TESTS TO QUAL LIFE	

JANUARY 30, 1968

By E.L. Bombard
I-E-Q: 1/30/68 NASA-MSFC

30 Jan 1968

EQUIVALENT SECONDS OF FATIGUE LIFE AFTER MOV LINE STRESS REDUCTION USING NEW BRACKETS

STRESS REDUCTION USING NEW BRACKETS = 21.2%

FATIGUE LIFE INCREASE FACTOR IS $(1.212)^5 = 2.615$

154 SEC FLIGHT TIME REQUIRED

154/2.62 = 59 SEC

OLD BRACKETS	NEW BRACKETS
154 SEC → $\lambda 154$	154 SEC → $\lambda 59$
59 SEC → $\lambda 59$	

WHERE λ_{154}, λ_{59} ARE FAILURE RATES IN NEXT 154 AND 59 SEC RESPECTIVELY, BOTH BASED ON TESTS USING OLD BRACKETS.

ALL LINES & LOCATIONS

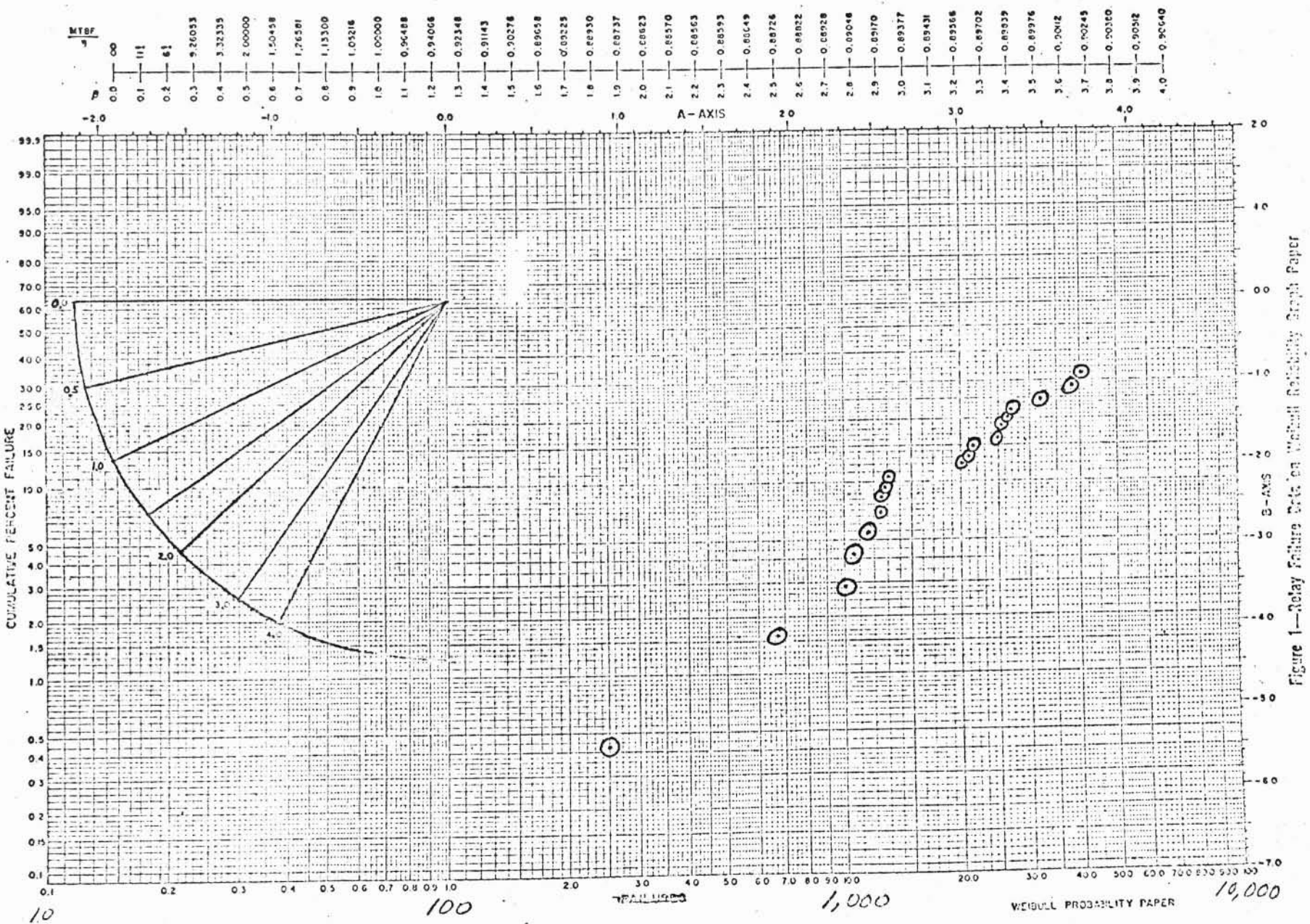


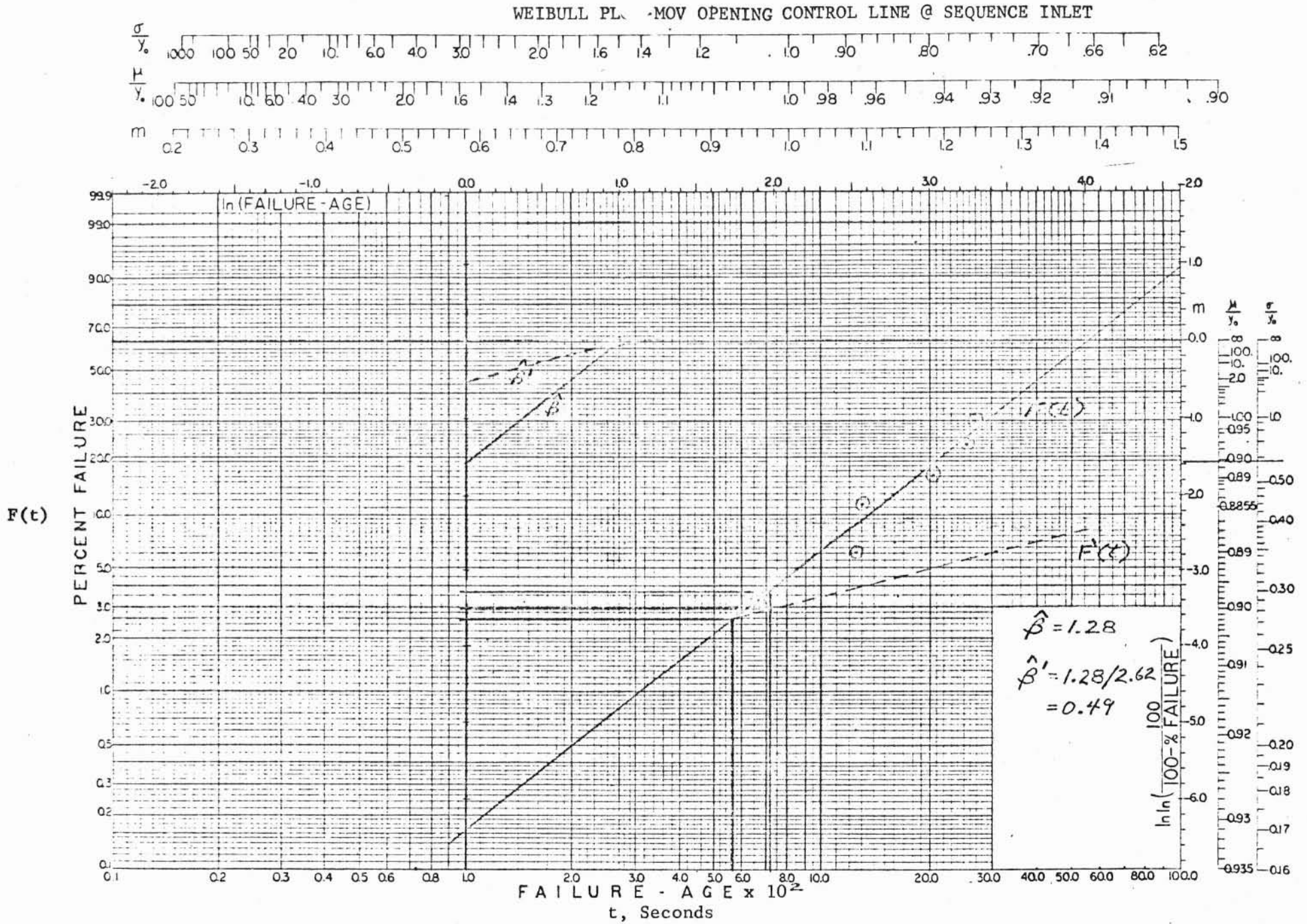
Figure 1—Delay Failure Data on Weibull Probability Graph Paper

0.1 1.0 100 1,000 10,000

t_f IN SECONDS

ESTIMATION OF CUMULATIVE FAILURE RATE, F(t) MOV OPENING CONTROL LINES AT SEQ. INLET

FAILURES, F_i	TIME TO FAILURE, t_i, SEC	LINE EXPOSURES TO t_i OR MORE, N_i	IN INTERVAL, $\lambda_i = 1/(N_i+1)$	IN INTERVAL, $1 - \lambda_i$	IN INTERVAL 0 THROUGH t_F, $\hat{R}$	IN INTERVAL 0 THROUGH t_F, $F(t) = 1 - \hat{R}$
0	0	88	0	1.0	1.0	0
1	670	29	.0333	.9667	.9667	.0333
1	1250	24	.0400	.9600	= .9280	.0720
1	1302	21	.0455	.9545	.8858	.1142
1	2038	18	.0526	.9474	.8392	.1608
1	2543	11	.0833	.9167	.7693	.2307
1	2670	10	.0909	.9091	.6994	.3006



SIGNAL CORPS ELECTRON TUBE RESEARCH FOR RELIABILITY

DEPT. OF ELECTRICAL ENGINEERING, CORNELL UNIVERSITY, ITHACA, N.Y.

ESTIMATION OF CONDITIONAL PROBABILITY OF NO CRACKS
IN MOV LINE DURING FLIGHT

SECONDS ON TYPICAL LINE PRIOR TO FLIGHT = 564

FROM WEIBULL PLOT, 1-F (564) = .974

OLD BRACKETS

FLIGHT TIME = 154 SEC

1-F (564 + 154) = 1-F (718) = .963

P(NO CRACKED LINE IN NEXT 154 SEC) = .963/.974 = .989

NEW BRACKETS

EQUIVALENT FLIGHT TIME = 59 SEC

1-F(564 + 59) = 1-F(623) = .970

P(NO CRACKED LINE IN NEXT 154 SEC) = .970/.974 = .996

OR, CALCULATE SLOPE USING NEW BRACKETS = 1.28/2.62 = 0.49. USING THIS SLOPE BEGINNING AT 564 SEC,

1-F (564 + 154) = 1-F(718) = .970, AND .970/.974 = .996

COMPARATIVE RISKS IN INCORPORATING
F-1 ECP 530, HYDRAULIC LINE BRACKETS
ON AS-502

PROBABILITY OF NO CRACKED LINES:

	WITH OLD BRACKETS	NEW BRACKETS INSTALLED	DIFFERENCE	% REDUCTION IN FAILURE RATE
OPENING CONTROL AT SEQ. INLET	.987	.996	.008	62%
MOV LINE AT TEE	.991	.997	.006	67%
MOV OPENING CONTROL AT OPEN PORT AND CLOSING CONTROL LINE	.990	.996	.006	60%
IMV LINE	.994	.998	.004	67%
PRODUCT (ONE ENGINE)	.962	.987	.025	66%
VEHICLE (FIVE ENGINES)	.824	.937		

THE PROBABILITIES OF NO CRACKED LINES ON AS-502 ARE .824 WITH OLD BRACKETS AND .937 WITH NEW BRACKETS. IN OTHER WORDS, THE RISK OF ONE OR MORE CRACKED LINES ON AS-502 IS 17.6% WITH OLD BRACKETS AND 6.3% WITH NEW BRACKETS.

COST SAVINGS DUE TO CHANGING OUT BRACKETS

PROB. OF ONE OR MORE CRACKED F-1 ENGINE LINES PER VEHICLE,

USING OLD DAMPER BRACKETS = .176

USING NEW DAMPER BRACKETS = .063

PROB. THAT CRACKED LINE CAUSES ENGINE SHUTDOWN AND MISSION LOSS $\cong$ .05

RELIABILITY OF SATURN V VEHICLE $\geq$ .8

COST OF SATURN V VEHICLE $\cong$ \$300M

EXPECTED COST SAVINGS FOR 12 VEHICLES DUE TO CHANGING OUT BRACKETS:

(.176 - .063) (.05) (.8) (\$300M) (12) $\cong$ \$16M

COST OF CHANGING BRACKETS ON 12 VEHICLES = \$0.5M