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LEM ENGINEERING MEMO LMO-540-61
May 14, 1963

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MINUTES OF RADAR REQUIREMENTS COORDINATION MEETING #1

BETWEEN

GRUMMAN AIRCRAFT ENGINEERING CORPORATION (GAEC)

AND

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)

LOCATION: GAEC

DATE: March 22, 1963

[U]

(NASA-CR-116630) MINUTES OF RADAR REQUIREMENTS COORDINATION MEETING NO. 1 BETWEEN GRUMMAN AIRCRAFT ENGINEERING CORPORATION /GAEC/ AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY /MIT/ (Grumman

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MINUTES APPROVED:

E. Stern
Erick Stern
Systems Analysis, Code 540
GAEC

Arnold B. Whitaker
Arnold B. Whitaker
LEM Systems Project Engineer, GAEC

MIT

CLASSIFICATION CHANGE

To UNCLASSIFIED
By authority of GDS - EO 11652
Changed by R Shirley Date 12/3/72
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[redacted]

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Meeting No. 1
Date 3/22/63
Page 1

065-8608

LIST OF ATTENDEES:

NASA

R. Lewis - ASP
H. Toy - STD
P. Cramer - FCOD

MIT

M. Traegeser
N. Sears
P. Felleman
W. Tanner
J. Dahlen

GAEC

J. Gavin
C. W. Rathke
T. J. Kelly
A. B. Whitaker
R. Carbee
K. Speiser
J. Cook
G. Sullivan

S. Chomak
M. Olstad
T. Haggerty
G. Scheuerlein
J. Green
W. Schoen
J. Roth
R. Peters
E. Stern

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[redacted]

Agenda

Backup Guidance Design Concepts	E. Stern
Proposed Rendezvous Technique	"
Gimbaled vs. Fixed Antenna Comparison	"
Mission	
Hardware	
Reliability	
Proposed Radar Configuration	"
Results of Altimeter Utilization Study	"
Results of Mid-course Guidance Study	"
Results of Homing Rendezvous Study	"
Radar Requirements Summary	"
Radar System Tradeoff Factors	J. Greene
Justification of Selected Implementation	"
Weight and Power Summary	"
Summarization	A. Whitaker
Discussion of Radar Requirements	

[redacted]

General:

E. Stern made the initial presentation covering backup guidance and rendezvous concepts, results of studies to establish radar requirements and a summary of such requirements as generated by both primary and backup Navigation and Guidance (N&G) considerations. The basic Backup Guidance Design Concepts are shown in Figures 1 & 2. The Rendezvous Technique proposed by GAEC is illustrated in Figures 3-8. A comparison of gimbaled versus fixed antenna configurations with respect to mission requirements, hardware implications and system reliability is shown in Figures 9-14. The radar system configurations proposed is shown in Figure 15. Figure 16 gives the preliminary results of a study aimed at establishing the feasibility of utilizing only radar altimetry data for IMU updating during the terminal descent phase. Results obtained so far indicate that this procedure will yield satisfactory results. Figures 17-25 present the results of mid-course correction and rendezvous homing studies. Table I is the radar requirements summary as mutually agreed upon by MIT and GAEC.

J. Green gave the second presentation concerning the hardware implementation of the proposed radar system. The tradeoff factors considered are shown in Figures 27-28. The considerations on which the proposed implementation scheme is based are given in Figures 29-33. Modulation scheme tradeoffs are presented as Enclosure I.

Figures 34-36 indicate the weight and power requirements of the LEM radar system based on data from several manufacturers who submitted proposals for radars to satisfy assumed LEM requirements. This data was normalized to be compatible with the requirements of Figures 30 and 31.

During the summarization (by A. Whitaker) and discussion following the formal presentation, a number of conclusions and agreements were reached. N. Sears has prepared a set of tables and diagrams outlining MIT's concepts on radar utilization and requirements (Figures 36-44) and these were discussed in some detail. Figure 26 was generated as a result of these discussions. It was agreed that the range accuracy of the rendezvous radar would remain at 1% ± 5 ft. as specified by GAEC, unless a penalty in weight or power is associated with achieving this tolerance, in which case it could be relaxed to 1.5% ± 30 ft. The specification of fixed and random boresight errors of the rendezvous radar of 15 mr and 3 mr respectively (3) represents a compromise between the GAEC specification of 9 mr total and the MIT requirements of 20 mr fixed and 6 mr random.

As far as the doppler altimeter is concerned, the altitude range was agreed to be specified as 70,000 feet, unless the time interval betweeen reading this altitude and attaining pericynthion (nominal descent injection point) is inadequate to properly check out the radar. The range of V_H to be accomodated by the doppler altimeter is as yet undermined, but it was

[redacted]

agreed that 200 fps is a typical value at which the specified accuracy is to be attained and that 5000 fps is a desirable range which would allow complete checkout of all three beams of the radar prior to initiation of powered descent.

MIT proposed that the rendezvous radar be capable of being slaved to the OMU, and vice versa, to allow visual acquisition and visual monitoring as well as to minimize angular readout equipment. This concept imposes certain attitude and location constraints on the radar, but these, with the one exception discussed below, do not appear insurmountable. The basic approach seems reasonable and offers some attractive features and GAEC agreed to provide this capability.

In several instances, the GAEC and MIT viewpoints could not be reconciled. These involved primarily the primary and backup rendezvous procedures. In contrast to the technique outlined in Figures 3-8, MIT proposed a completely automatic rendezvous operation consisting of a series of long range mid-course corrections, an initial high-thrust pre-computed thrust phase to within 5 n.mi. and 100 fps relative velocity, and a final (high thrust) phase to docking initiation. GAEC feels that the automatic mode should be compatible with the manual mode to permit crew monitoring and override.

Another basic difference of viewpoint involves the backup procedures. MIT considers the first tier backup mode to be centered in the CSM (CSM tracking radar inputs to the AGC resulting in LEM guidance commands transmitted to LEM for execution via the voice communication link). GAEC proposes that the homing technique described be considered a manual alternate to the primary automatic mode, and, in the event of a non-radar failure in the primary N&G system, that it become the logical back-up mode. Apparently, further resolution by N.A.S.A., is required, since D. Gilberts' memo of 3/1/63 entitled "Guidance Radar Requirements" is subject to multiple interpretations.

One item of discussion involved the possibility of using the existing C-band transponder on the CSM instead of a separate X-band transponder. The possibility of providing interferometer type rendezvous radar instead of a gimbaled antenna radar was also briefly mentioned. MIT feels that such an approach would result in a hardware implementation comparable in flexibility to a fixed antenna radar and that if a interferometer is seriously considered, the fixed antenna approach should be re-examined.

As far as radar mounting is concerned, MIT suggests that the radar be mounted on the navigation base in order to reduce angular misalignment of the radar boresight axis relative to the coordinate system of the IMU and OMU. This would require that the radar mounting structure pierce the LEM pressure shell. GAEC would avoid this unless it can be shown to be absolutely necessary, since it is considered essential not to compromise the integrity of the pressure vessel. MIT agreed that this was a reasonable approach.

[redacted]

The action items generated at the meeting were:

1. The penalty involved in specifying 1% ± 5 ft. range accuracy for the rendezvous radar was to be investigated by GAEC.
2. The adequacy of 70,000 ft. altitude range for the doppler altimeter, in terms of checkout capability was to be established by GAEC.
3. The upper limit of V_H capability in the coppler-altimeter was to be determined jointly by MIT and GAEC.

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RADAR PERFORMANCE REQUIREMENTS [1]

A - Radar Altimeter

Quantity	Maximum	Minimum	Typical	Accuracy
Altitude (h)	70,000 ft.	5 ft.	20,000 ft.	1% ± 5 ft.
Altitude rate ($\dot{h}$)	500 fps.	1 fps.	--	1% ± 1 fps.
Horizontal Velocity	2,000 fps.[2]	1 fps.	--	1% ± 1 fps.
Position [3]	50°	0°	--	20 mr.

B - Rendezvous Radar

Quantity	Maximum	Minimum	Typical	Accuracy
Range (r)	400 N. Mi.	500 ft.	30-0.2 N.M.	1% ± 5 ft.
Range rate ($\dot{r}$)	± 4800 fps.	1 fps.	200-1000 fps.	1.0% ± 1 fps.
Angle (θ)	--	--	--	15 mr. bias 3 mr. random
Angle Rate ($\dot{\theta}$) [4]	± 15 mr/sec.	0.2 mr/sec.	--	0.2 mr/sec.

1. 3σ Values.
2. 5000 fps design objective.
3. Angle of axis of symmetry with respect to X axis.
4. Not required by Primary Guidance.

Table 1

[redacted]

GUIDANCE DESIGN CONCEPTS

- *ALT. MANUAL MODES WHERE INCORPORATION INCREASES CREW SAFETY*
- *DIRECT SENSOR DISPLAY FOR MANUAL MODES*
- *BACKUP SIMPLER & MORE RELIABLE THAN PRIMARY MODE*
- *AUTOMATIC MODES COMPATIBLE WITH MANUAL MONITORING AND OVERIDE WHEN MANUAL MODES ARE PROVIDED*

BACKUP GUIDANCE DESIGN CONCEPTS

- *CREW SAFETY IS PRIMARY CONSIDER'N*
- *ABILITY TO ABORT & TO RETURN SAFELY: FOR FAILURE OF ANY MAJOR ELEMENT OF PRIMARY SYSTEM*
- *ABILITY TO ABORT TO CLEAR TRAJECTORY INDEP. OF PRIMARY SYSTEM*
- *CREW TO BE UTILIZED FOR MAXIMUM CREW SAFETY*

RENDEZVOUS CONCEPTS

CREW CAN PERFORM VISUALLY

- *COURSE CORRECTION TO OBTAIN COLLISION COURSE*
- *RANGE & RANGE RATE ESTIMATES MAY BE POSSIBLE*

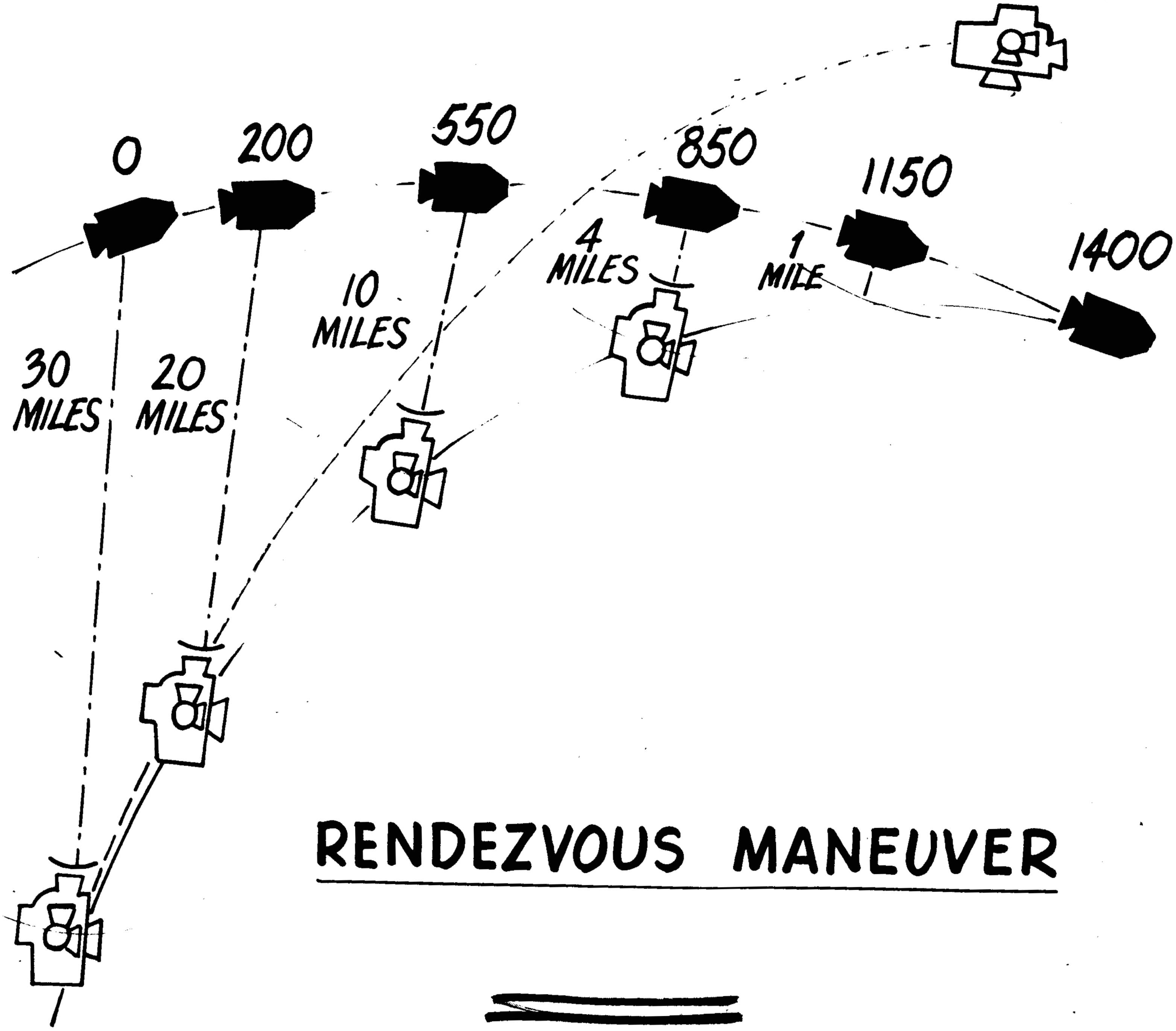
CREW CAN RENDEZVOUS MANUALLY WITH DISPLAY OF— –

- *DIRECTION OF LOS*
- *LOS RATE IN INERTIAL COORD.*
- *RANGE*
- *RANGE RATE*

RENDEZVOUS CONCEPTS (CONT.)

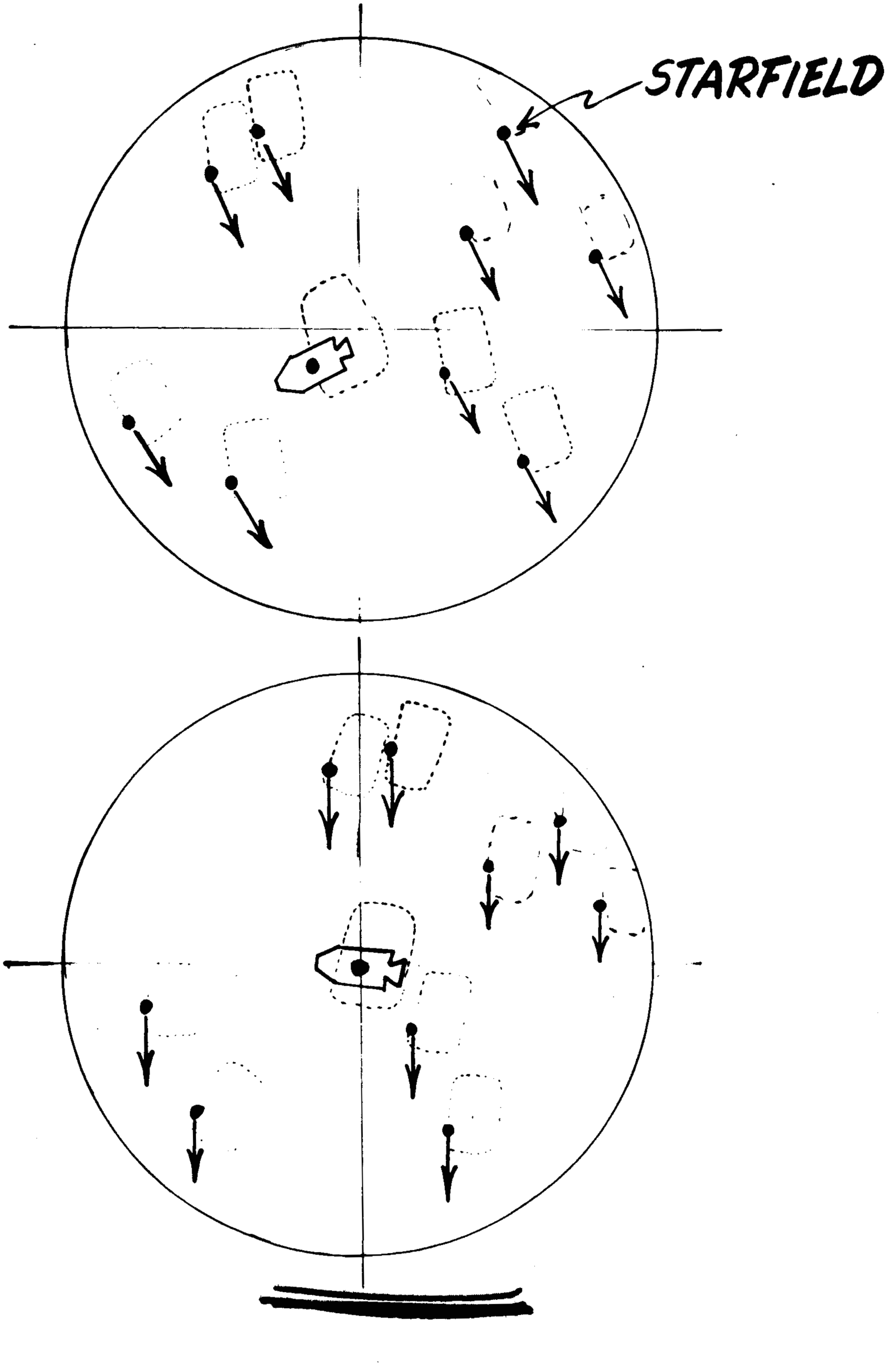
MANUAL CONTROL FUNCTIONS

- *ORIENT VEHICLE Z-AXIS PARALLEL TO LOS*
- *ORIENT X-AXIS TO PLANE OF LOS RATE*
- *NULL LOS RATE*
- *ADJUST RANGE RATE AS A FUNCTION OF RANGE*

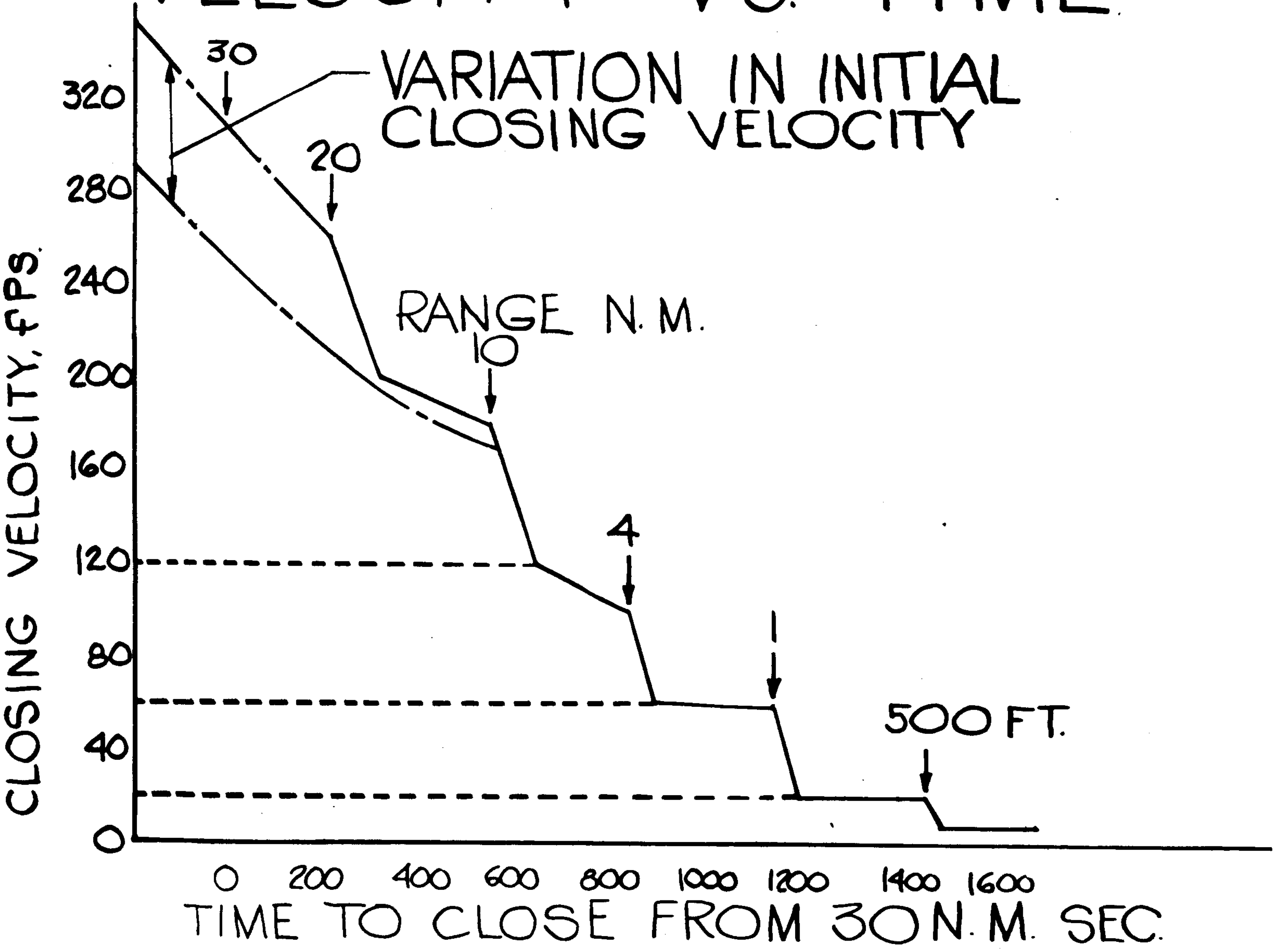


RENDEZVOUS MANEUVER

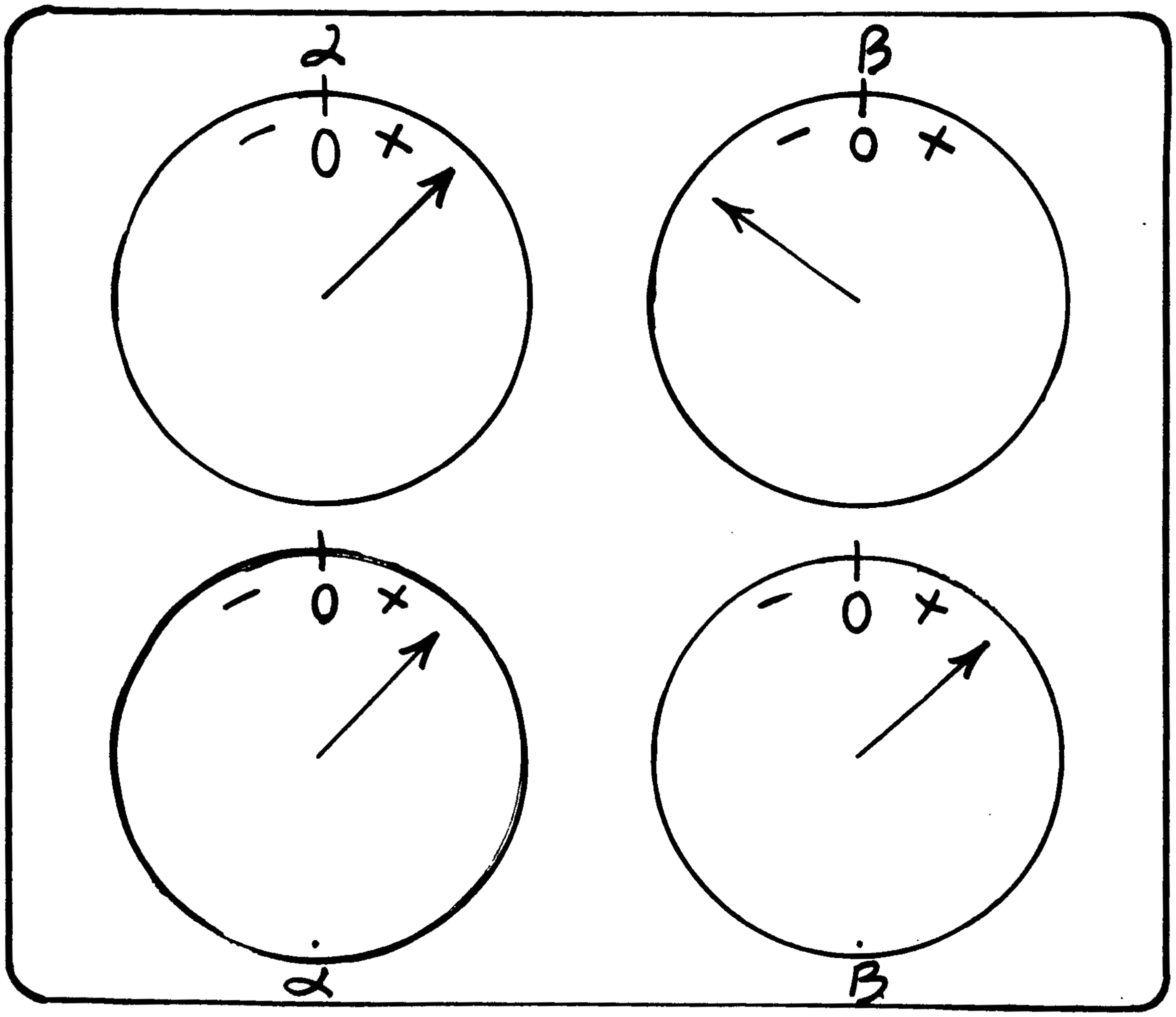
MANUAL-VISUAL RENDEZVOUS TECHNIQUE

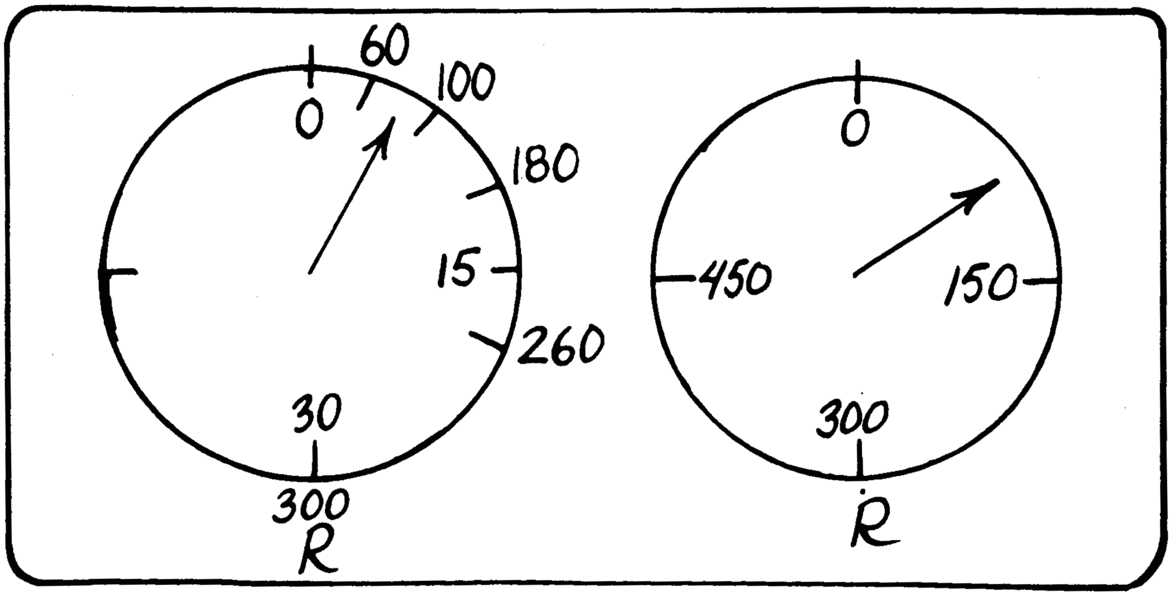


RENDEZVOUS CLOSING VELOCITY VS. TIME



TRACKING RADAR DISPLAYS FOR RENDEZVOUS





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GIMBALED vs. FIXED ANTENNA SYSTEM UTILIZ. STUDIES

PHASE	POWER DESCENT	ABORT	LUNAR STAY	ASCENT	MID-C., REND, & DOCK
RADAR UTIL.	*TRACK BEACON*	*ACQUIRE & TRACK CSM*			*TRACK C-SM*
OTHER ATTITUDE CONSTR.	*TVC* — *VIS MON OF LAND-MARKS*	*TVC*	*SURF. ORIENT*	—	*MON C-SM WITH SCAN TELES. & UNAID VISUAL*

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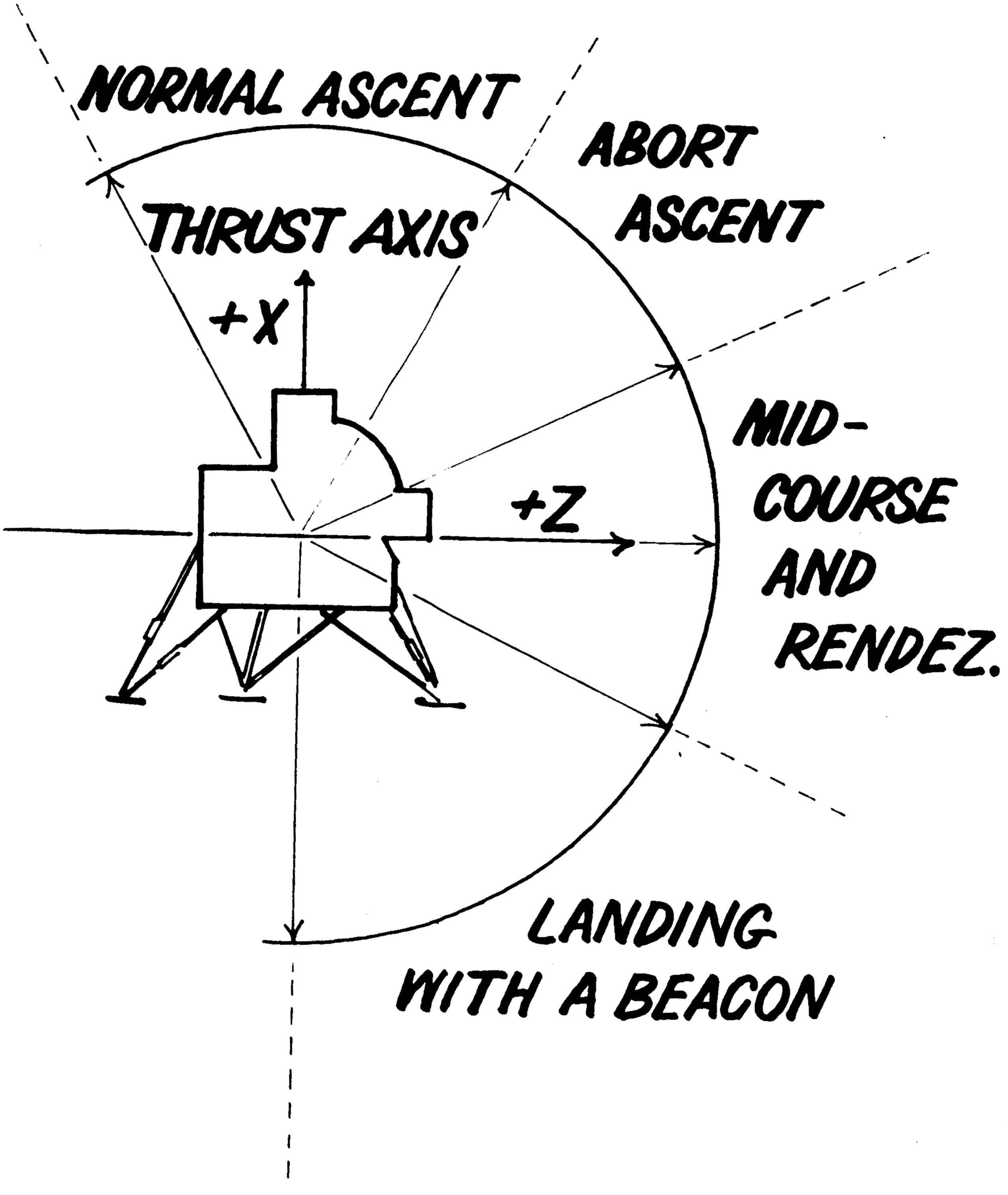
RENDEZVOUS RADAR POINTING



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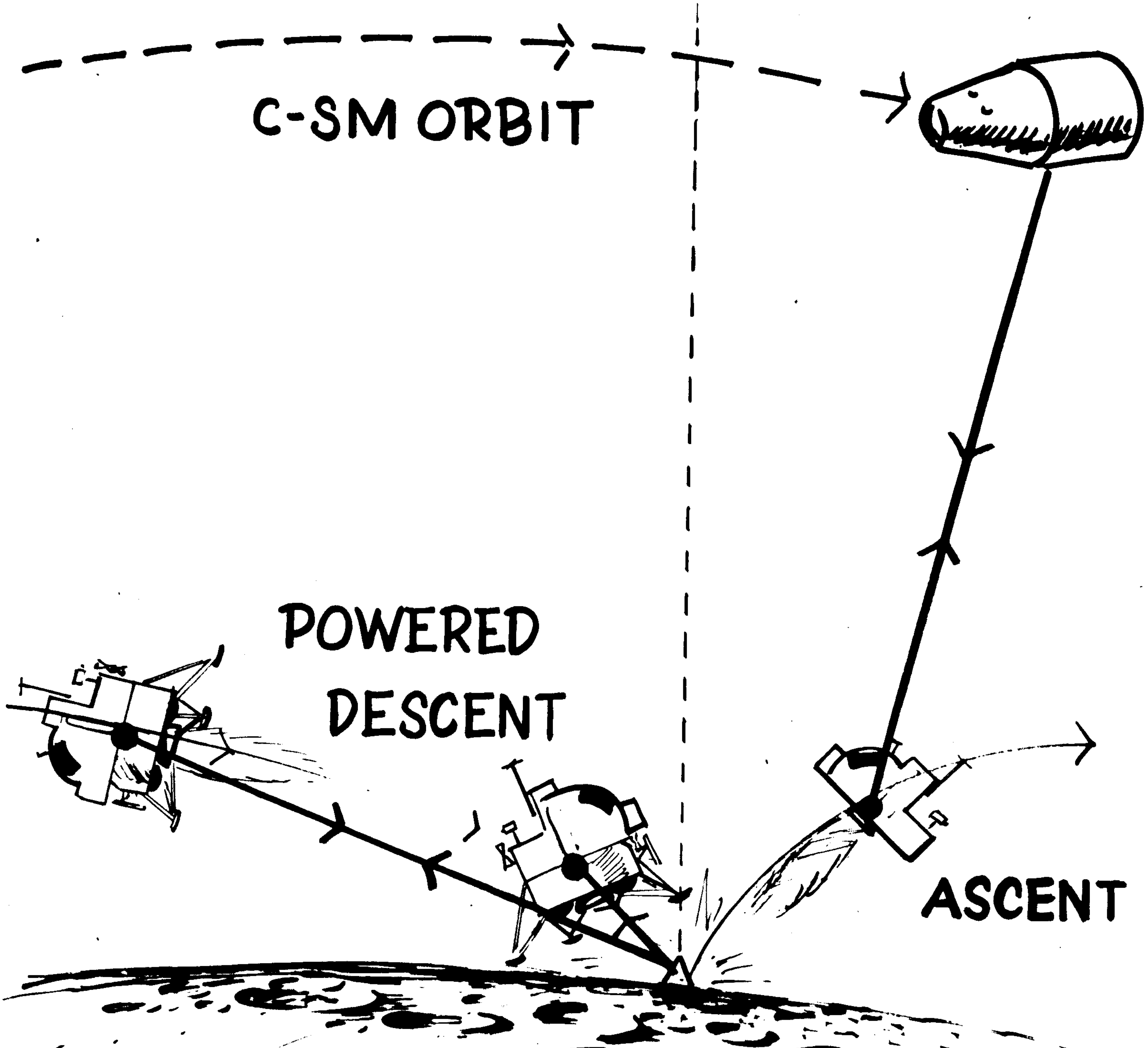

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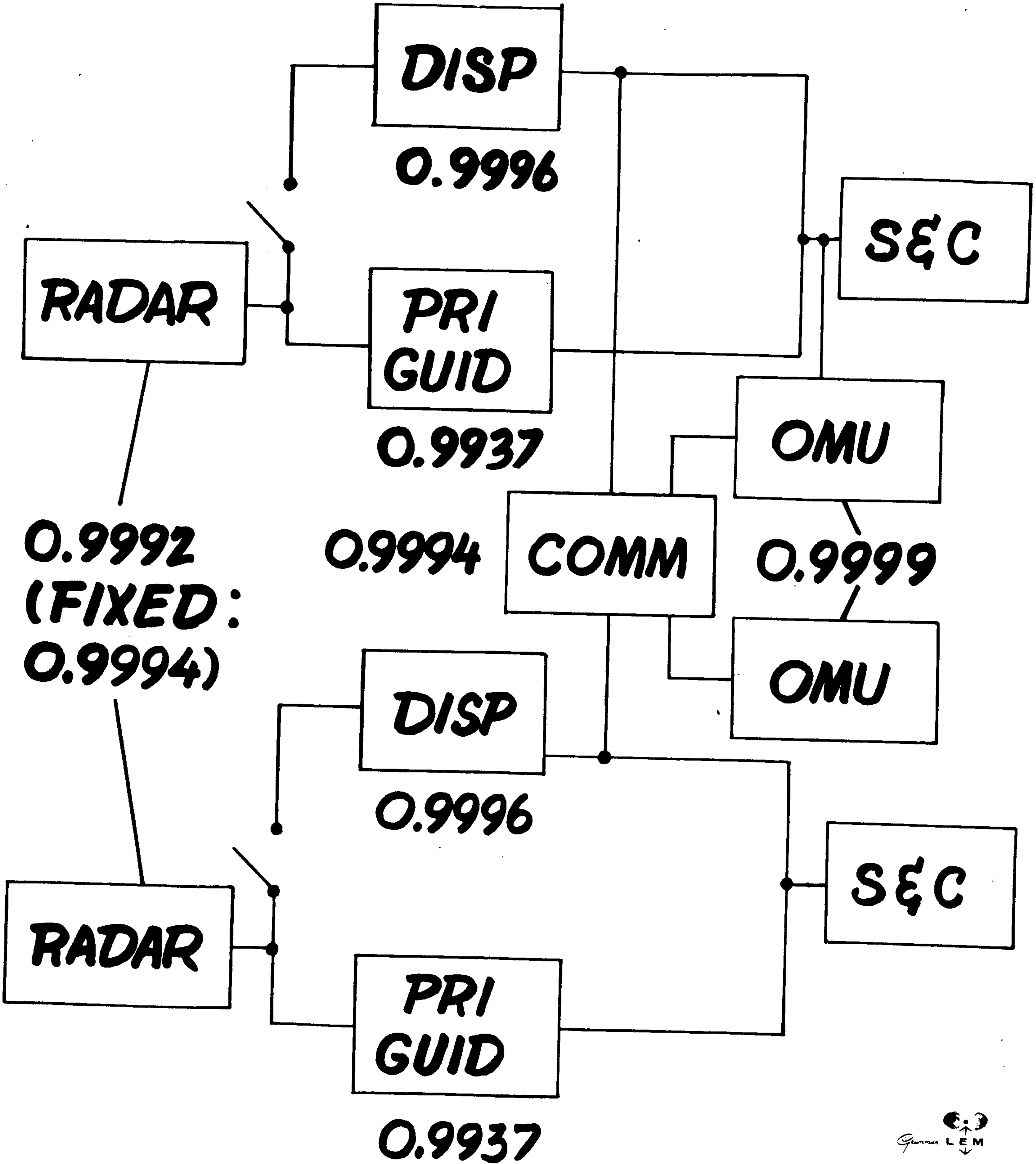
GIMBALED vs FIXED ANTENNA HARDWARE TRADE-OFFS

		GIMB	FIXED
• BEAMWIDTH, deg.		4	10
• DIAMETER, inches	C-BAND	40	17
	X-BAND	20	8
• GAIN, db		32	24
• ANG. RES., mr (3σ)		3	7.5
• BORESIGHT ACCURACY		EQUIV.	
• WEIGHT, lb.		31	28
• POWER, watts		67 (+ GYRO HTR)	57

EXPERIENCE FACTOR

- *__GIMBALED__: LARGE SELECTION OF QUAL. COMP. & EXTENS. DATA FOR X-BAND RADARS*
- *__FIXED__: FEW COMP., LITTLE DATA FOR C-BAND RADARS*

RELIABILITY DIAGRAM



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GIMBALED VS FIXED ANT. RADAR RELIABILITY TRADE-OFF

A. GIMBALED

					$P_{(p)}$
1	R_L	G_L			0.9929
2	R_L	D_L			0.9988
3	R_A	G_A			0.9929
4	R_A	D_A	C_{A-L}	O_L	0.9981
5	R_L	D_L	C_{A-L}	O_A	0.9981

1 TO 5 IN ACTIVE PARALLEL REDUNDANCY:

$P_S = 0.999\,999\,999\,999\,781\,6$

B. FIXED

1	R_{fL}	G_L	0.9931
2	R_{fL}	G_A	0.9931

1 & 2 IN ACTIVE PARALLEL REDUNDANCY

$P_S = 0.999\,952\,39$

Grumman LEM

[redacted]

[redacted]

PROPOSED RADAR CONFIGURATION

1. RADAR ALTIMETER
    - *3-BEAM DOPPLER*
    - *FIXED, 2-POSITION ANTENNA*
    - *VELOCITY & POSITION DATA REL. TO BODY AXES*

2. RENDEZVOUS RADAR
    - *MONOPULSE DOPPLER*
    - *2-DEG OF FREEDOM GIMBALED ANT.*
    - *SPACE-STAB LOS RATE DATA*
    - *$R, \dot{R}$ & LOS ANGLE DATA IN REL. COORDS.*

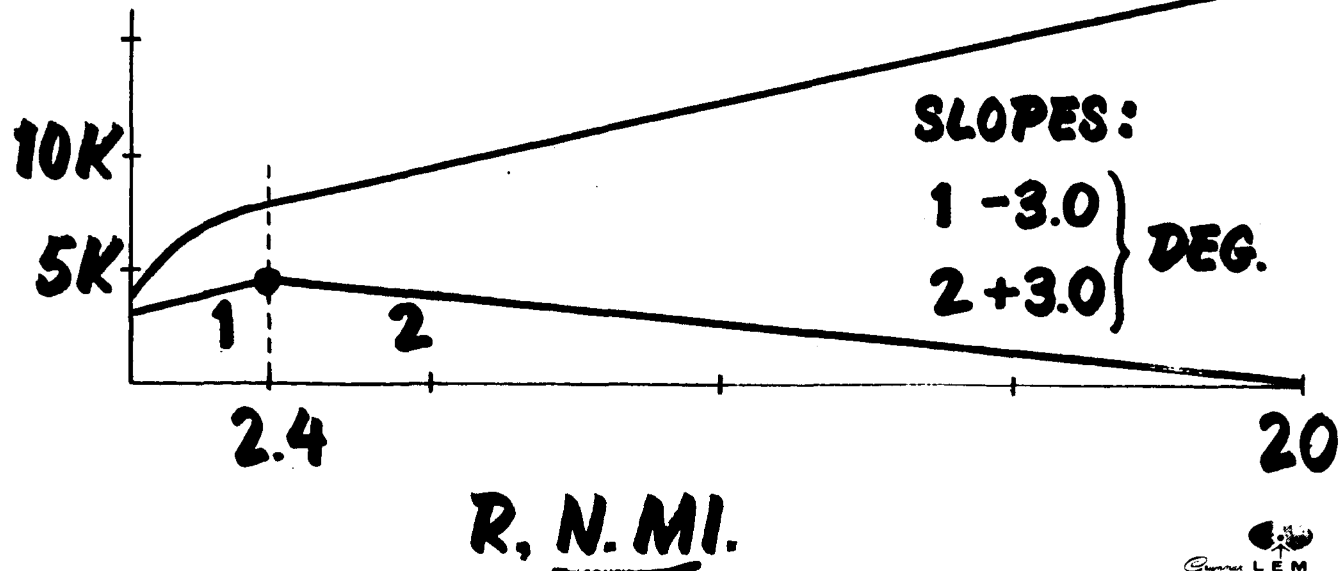
[redacted]

VARIATIONS IN FINAL V PARAMETERS
DOUBLE-SLOPE SURFACES

t^*, 2^{nd} SURF SLOPE APPEARS, SEC	FINAL VALUES, fps		
	V_V	V_H	ΔV (+HORIZ)
12	-1.26	8.63	2307.6
22	0.02	2.38	2306.4
47	-1.09	7.23	2299.9
72	-0.01	5.80	2300.4
82	-2.23	8.09	2289.1
92	-3.87	13.85	2295.2

*NOM. t OF FLT. FOR FINAL DESC. ≈ 112 SEC

TRAJECTORY PROFILE



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RADAR UTILIZATION ANALYSIS

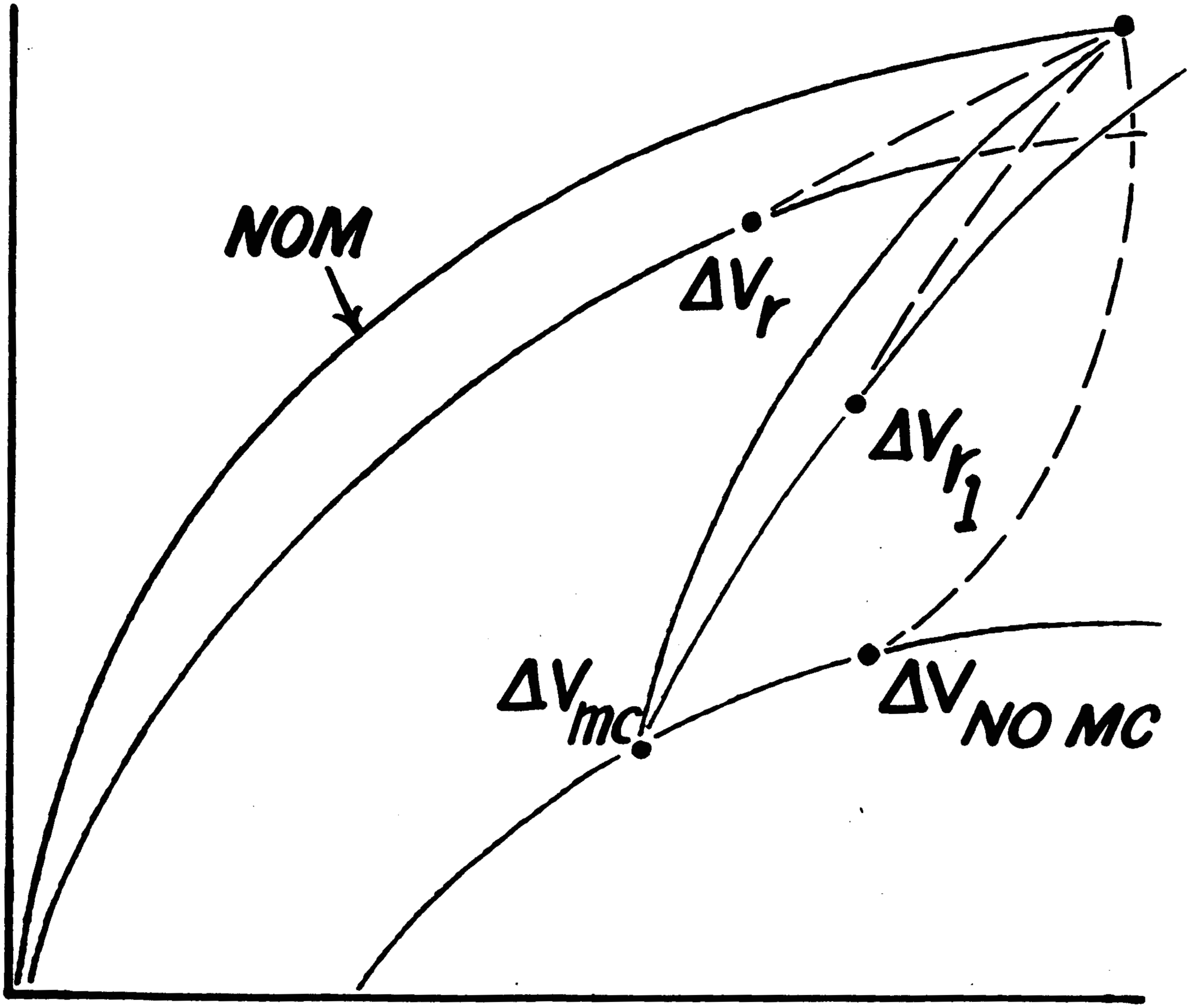
④ USE OF TRACKING RADAR DURING ASCENT AND RENDEZVOUS

STUDY–

- *FEAS. OF MID-COURSE CORRECTIONS*
- *NON-HOMING RENDEZVOUS WITH BACK-UP GUIDANCE*
- *L-O-S RATE ACCURACY vs. ΔV PENALTY FOR HOMING RENDEZ.*
- *ANT. PLACEM'T: DEPLOYM'T PROB'S, EXT. ENV. CONSTR, VIB. EFFECTS, ETC.*
- *COMP. WT., COMPLEXITY & RELIAB. OF FIXED vs. GIMBALLED ANT.*
- *HARDWARE TRADE-OFFS TO DETERMINE RADAR IMPLEMENT.*

[redacted]

FEAS. OF MIDCOURSE CORRECT.

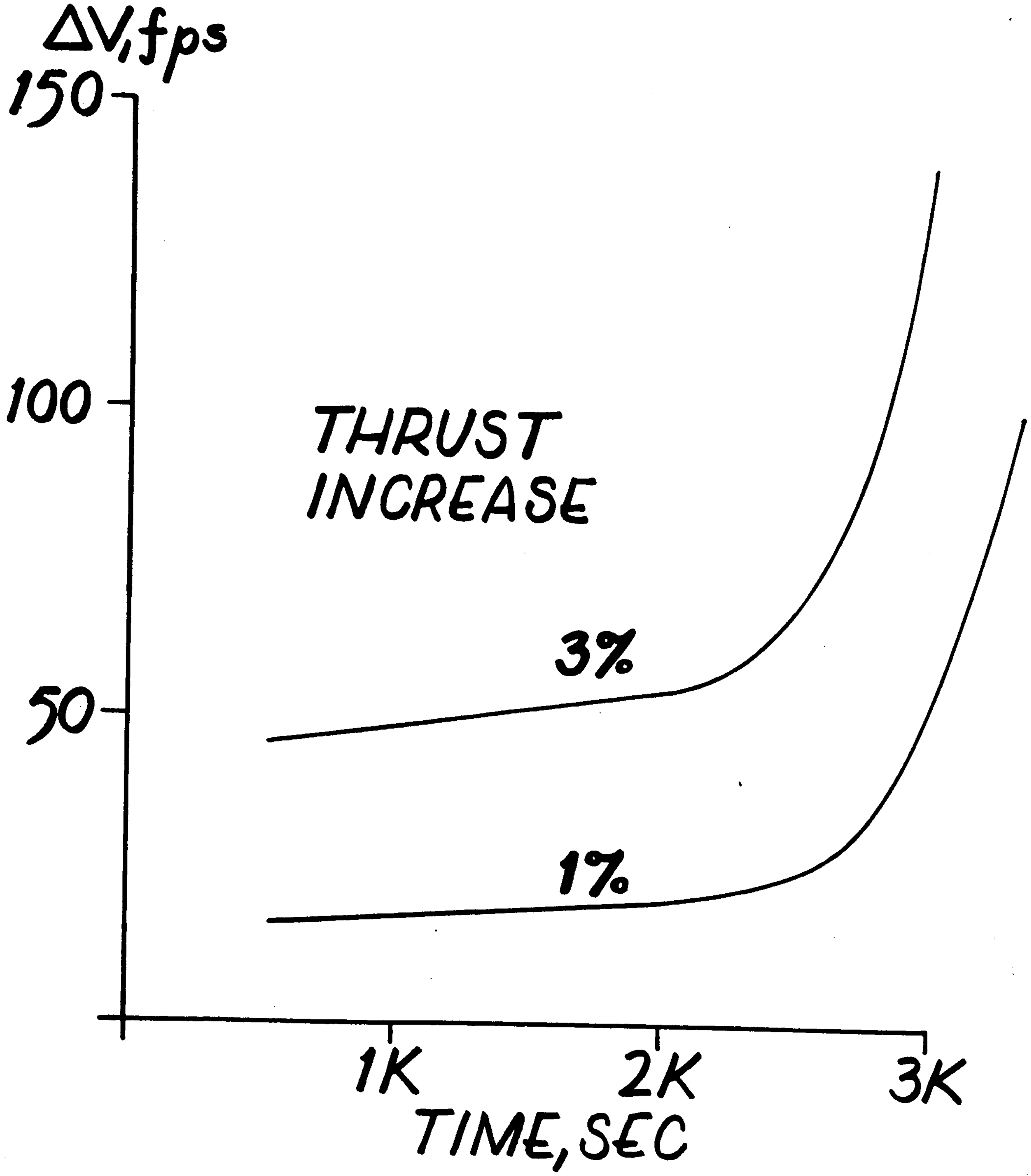


$\Delta V_{NO\ MC}$ VS $\Delta V_{MC} + \Delta V_{r_1}$

$\Delta V_r \cong \Delta V_{r_1}$

[redacted]

MIDCOURSE CORRECTION ΔV



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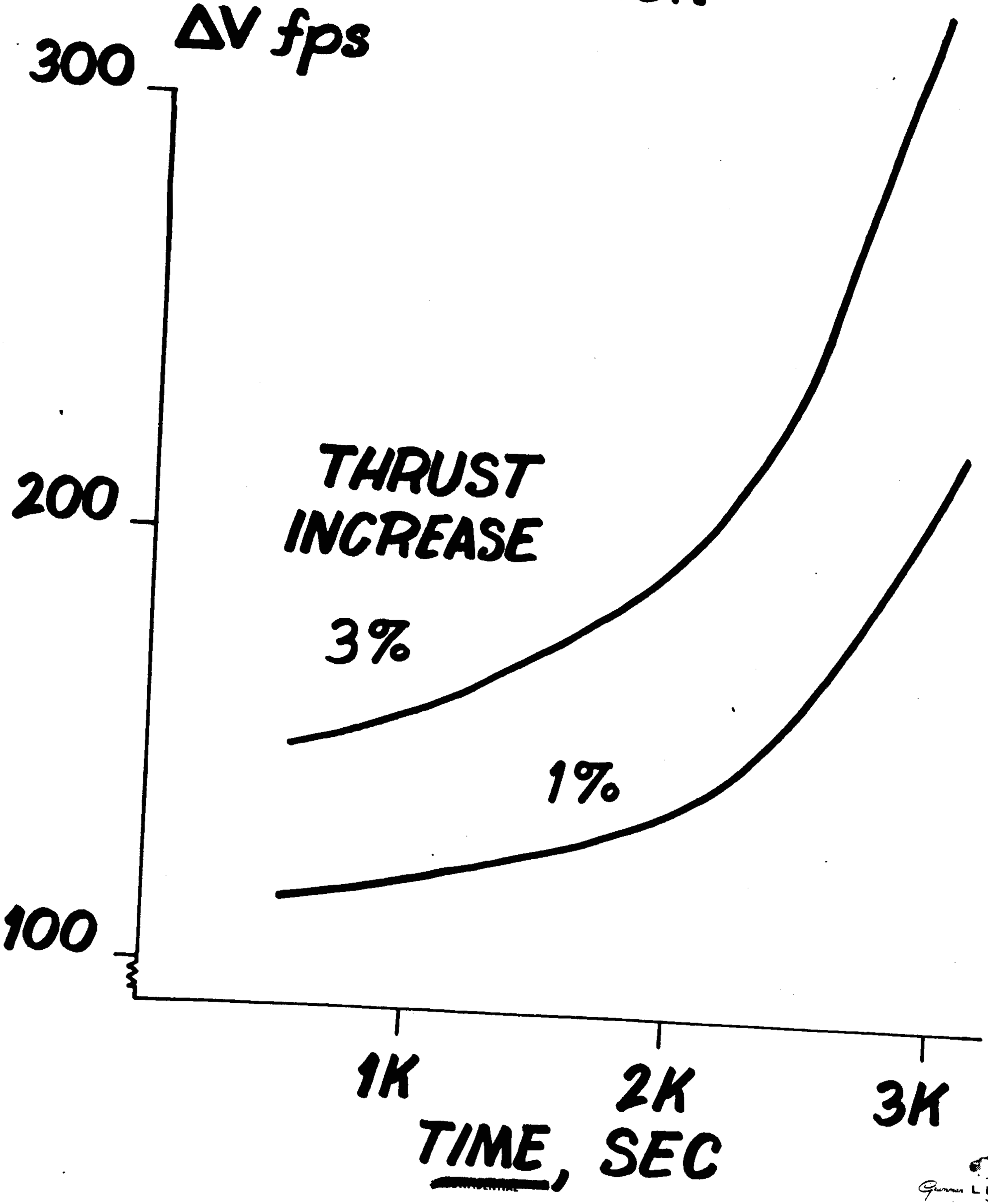
TOTAL ΔV FOR MID-COURSE CORRECTION



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[redacted]

CASE 1: $\theta\dot{R}$

ACCURACIES		1,750 SEC	2,000 SEC
$\dot{R}$,%	θ,mr	9,470 FT	4,290 FT
1.0	2	1.00	1.00
0.3	4	1.99	2.02
1.0	6	2.98	3.08
0.3	2	1.00	1.00
1.0	4	2.04	2.38
0.3	6	2.95	2.87
5.0	2	1.04	1.14
5.0	4	2.04	2.14
5.0	6	2.95	3.08

- REL. INSENSITIVE TO R, $\dot{R}$
- ERROR PROPORTIONAL TO θ

[redacted]

CASE 2: θR

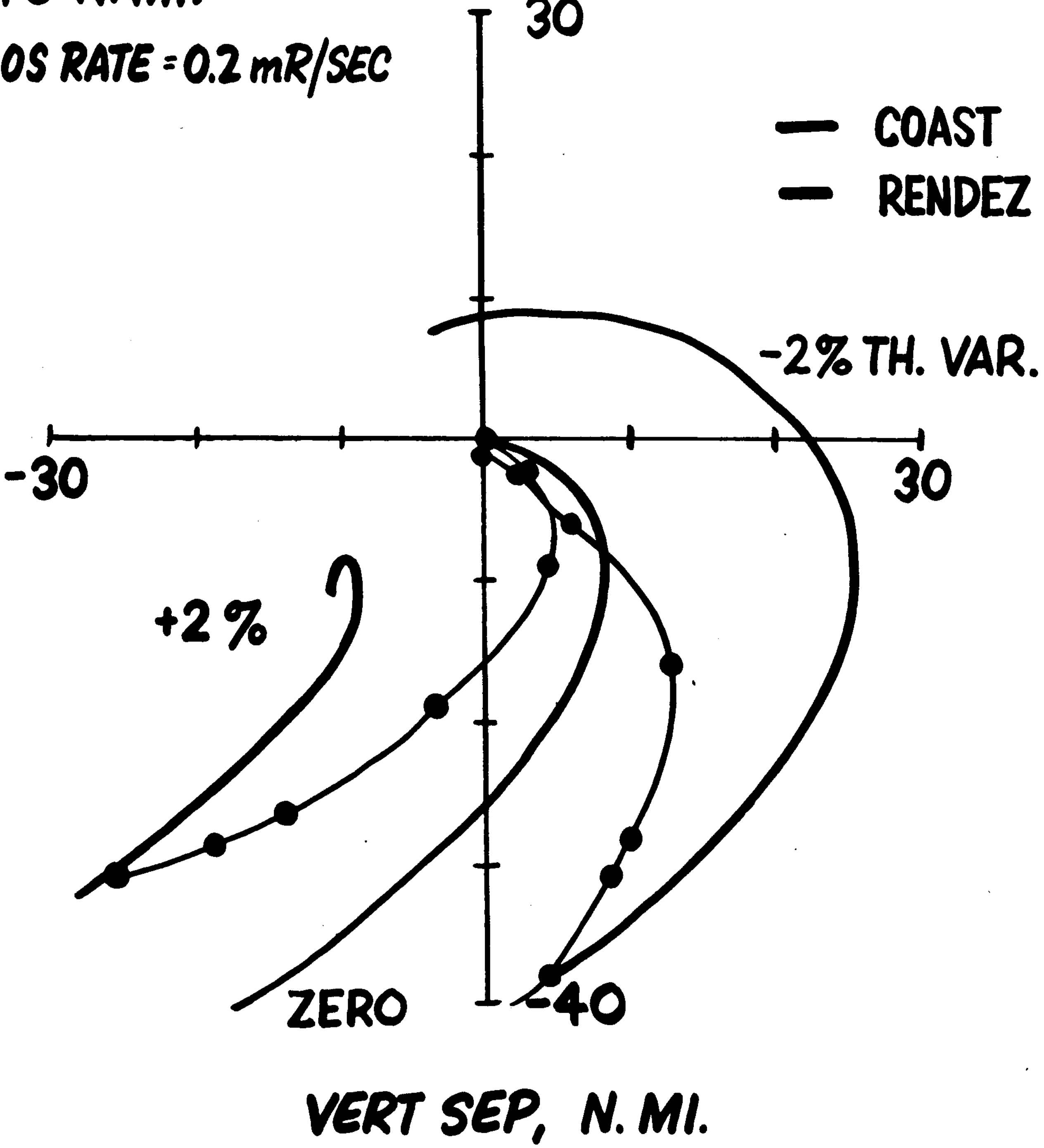
[illegible]		1,750 SEC	2,000 SEC
R,%	θ, mr	5,000 FT	2,690 FT
0.05	2	1.01	1.00
0.05	4	2.04	2.00
0.05	6	3.10	3.00
0.5	2	1.07	1.04
0.5	4	2.06	2.01
0.5	6	3.10	3.00
1.0	4	2.14	2.08
1.0	8	4.12	4.02
1.0	12	6.20	6.00

- REL. INSENSITIVE TO R
- ERROR PROPORTIONAL TO θ

2-DEG FREEDOM RENDEZ STUDY

R_i = 40 N. MI.

MAX LOS RATE = 0.2 mR/SEC



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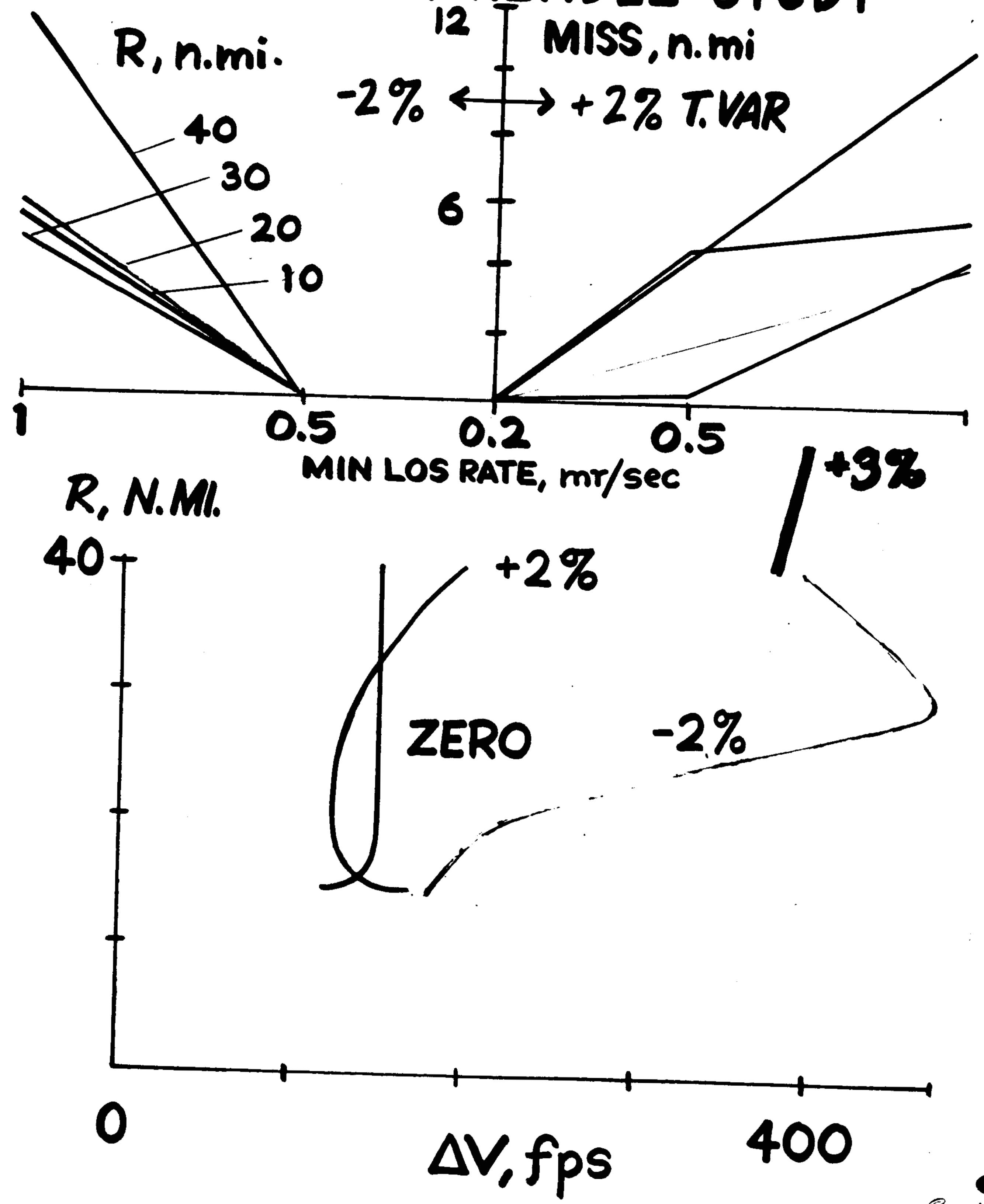
2-DEG FREEDOM RENDEZ STUDY



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RENDEZVOUS STUDY RESULTS

- *LOS RATE MEAS. ERRORS SHOULD BE HELD TO 0.2 mr/sec TO ASSURE RENDEZ. WITH REASONABLE ΔV PENALTY*
- *FOR REASONABLE (±2%) OFF-NOM. TRAJECTS, RENDEZ. SHOULD BEGIN AT APPROX. 20 N.MI. REL. DISTANCE BETWEEN LEM & C-SM*

RADAR DESIGN GROUND RULES

- GIMBALED OR ELECT. STEERABLE ANTENNA REQ'D
- RADARS MUST BE SELF-CONTAINED INCL. ALL REQ'D DATA PROCESSING
- RADARS MUST PROVIDE ANALOG OUTPUTS SUITABLE FOR USE IN MANUAL MODE
- RADAR LOS RATES REQ'D WITH RESPECT TO INERTIAL SPACE

[redacted]

RADAR TRADE-OFFS

FREQ BAND	ANGLE TRACK	R-F GEN	MOD
K	AMPL MONO⎍	SOLID STATE	PULSE
X	ELECT SCAN	S.S. + 2 KLYST	CW
C	MECH SCAN	S.S. + AMP'TRON	FM/CW
			ICW

[redacted]

MICROWAVE FREQ. TRADE-OFF

ASSUME:

- ANT. BW 4 DEG (32 db GAIN)
- ALL SOLID STATE MULTIPLIER
- ALT & REND RADAR FREQ EQUAL

ANT SYS: 2-AXIS GIMB. PARAB, MONO-⎍ FEED

	FREQ, Kmc		
	5	10	16
DISH DIA, IN.	42	21	14
DISH WT, LB	14.4	2.8	1.1
FEED WT, LB	2.1	0.5	0.13
MICROWAVE COMP	3	2	1.5
ELECTRONIC COMP	4	4	4
GIMBAL WT, LB	23.5	9.3	6.7
TOT. ANTENNA WT., LB	47	18.6	13.4
TOT. REND. RADAR WT., LB	68	39.6	34.4
POWER OUTPUT, mw	600	200	120
MIXER NOISE FIG, db	8	8.5	9.5
RELATIVE RANGE	$2.7R_0$	$1.5R_0$	R_0

ANGLE TRACKING TRADE-OFF

		AMPL MONO-⎍L	ELECT SCAN	MECH SCAN
REL. EFF., db	XMIT	0	0	-3
	RCV	0	-6	-3
SENSITIVITY TO SCINTILL. OR AM NOISE		SLIGHT	MODER.	MOST
HI-SPEED ROT. JOINTS IN ERR SENSOR		NO	NO	YES
NO RCVRS		3	1	1
REL. ∡ ERR. SENSIT., db		0	-1.4	-2.3

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R-F POWER SOURCE TRADE-OFFS

	SOLID STATE	S.S.+ AMP'TRON	S.S.+ 2 KLYST
MTBF, HR	8300	< 7500	7500
WT, LB	2.5	2.25	4.0
PWR IN, WATTS	25	8	15
MOUNT ANT.	YES	NO	NO
2 ROT. JOINTS	NO	YES	YES

- ASSUME X-BAND COHERENT DOPPLER RADAR MONOPULSE

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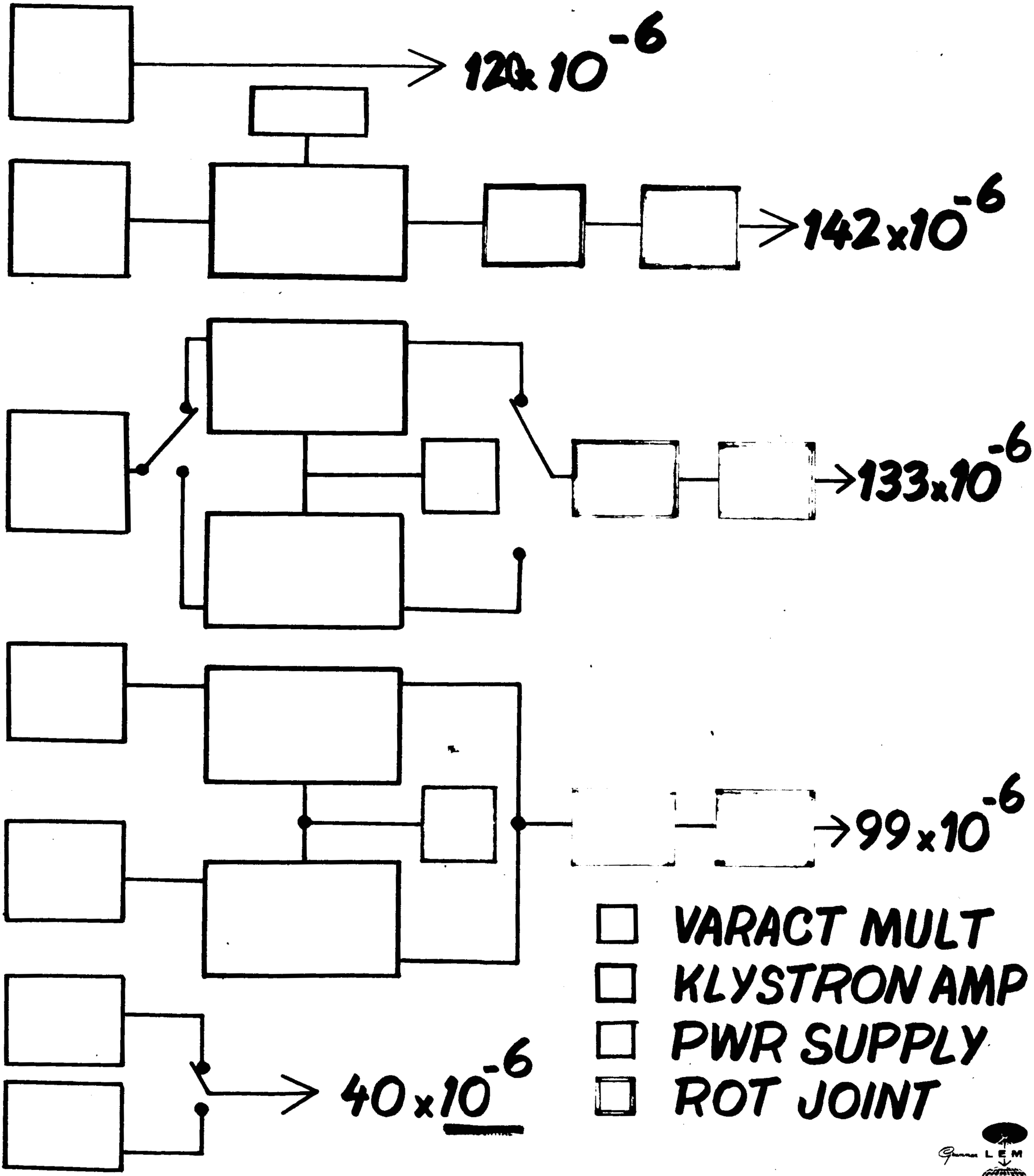
FREQUENCY CHAIN RELIABILITY



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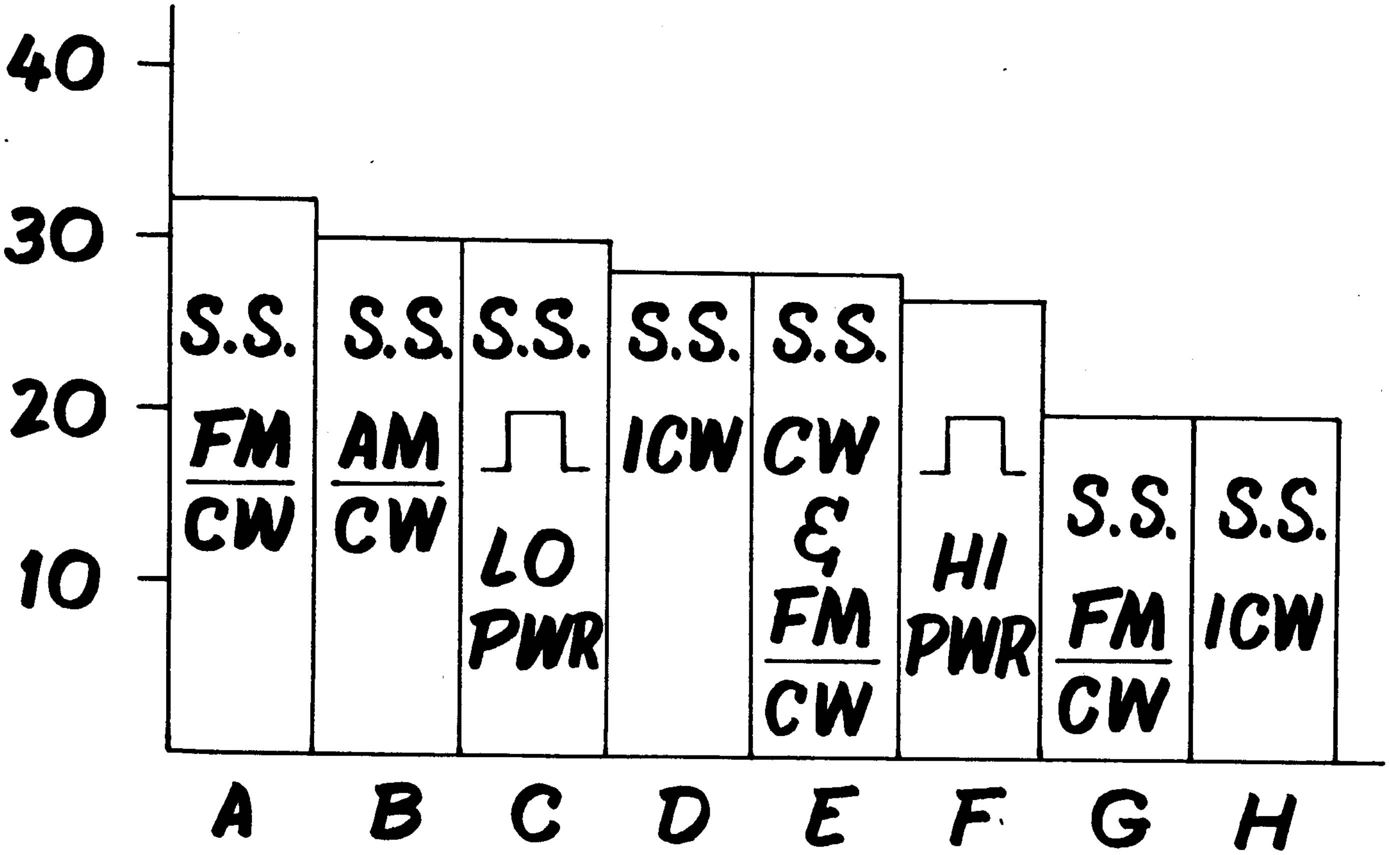
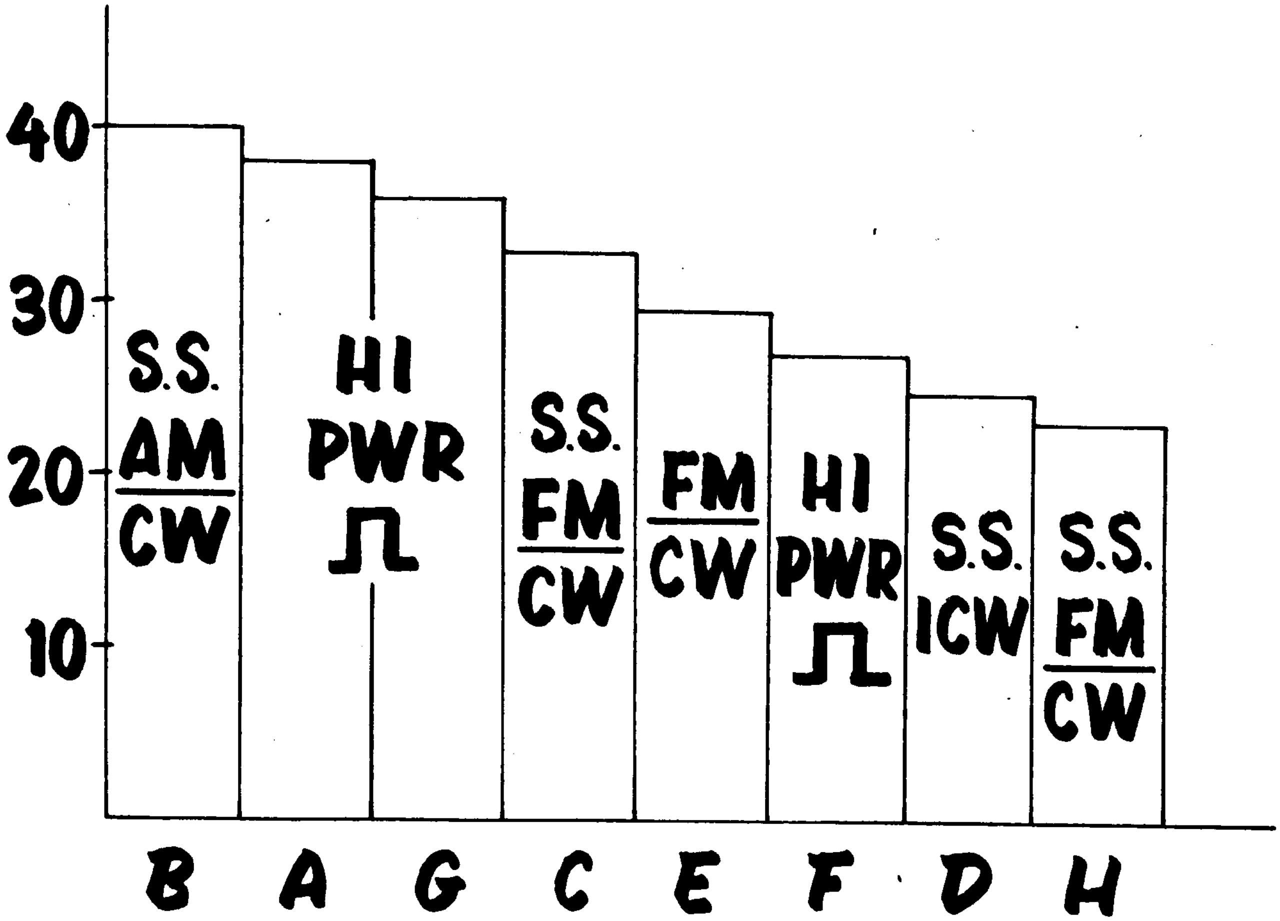
ALTIMETER VENDOR WEIGHTS



A - EMERSON
B - GPL
C - LFE
D - RCA
E - RAYTHEON
F - SPERRY
G - STL
H - SYLVANIA

[redacted]

RENDEZVOUS RADAR VENDOR WTS.



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D - RCA

E - RAYTHEON

F - SPERRY

G - STL

H - SYLVANIA

[redacted]

TENTATIVE LANDING RADAR SPECIFICATIONS

1. TRAJECTORY LIMITS

	ALTITUDE (y)	RANGE VEL ($\dot{x}$)	ALT. VEL ($\dot{y}$)	TRACK VEL. ($\dot{z}$)	ACCEL.
MAXIMUM	100,000 FT*	+5700 FPS -100 FPS	-500 FPS +100 FPS	± 100 FPS	25 FPS^2
MINIMUM	5 FT	0	0	0	0
TYPICAL MAXIMUM OPERATING REGION	20,000 FT	+1500 FPS	- 250 FPS	≈0	2-5 FPS^2

*CHECK-OUT PROCEDURE REQUIREMENT

2. DESIRED PERFORMANCE REQUIREMENTS FOR TYPICAL OPERATING REGION (3σ)

ALTITUDE ACCURACY	1% ± 5 FT
VELOCITY ACCURACY	1% ± 1 FPS
BORESIGHT UNCERTAINTY OF REFERENCE (ALTITUDE) BEAM	20 MR

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LUNAR LANDING RADAR
TENTATIVE SPECIFICATIONS

TYPE	COHERENT, X-BAND	
ANTENNA	3-BEAM, 2 POSITION, AXIS OF SYMMETRY AT 50° + 0° FROM THRUST AXIS	
WEIGHT	25 LBS	
POWER CONSUMPTION	100 WATTS	
VOLUME	1.0 FT^3 + ANTENNA	
OPERATION LIMITS	ALTITUDE	5 TO 100,000 FT
	VELOCITY	0 TO 6000 FT/SEC
	ACCELERATION	0 TO 10 FT/SEC^2

X

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LANDING RADAR ANTENNA POSITIONS

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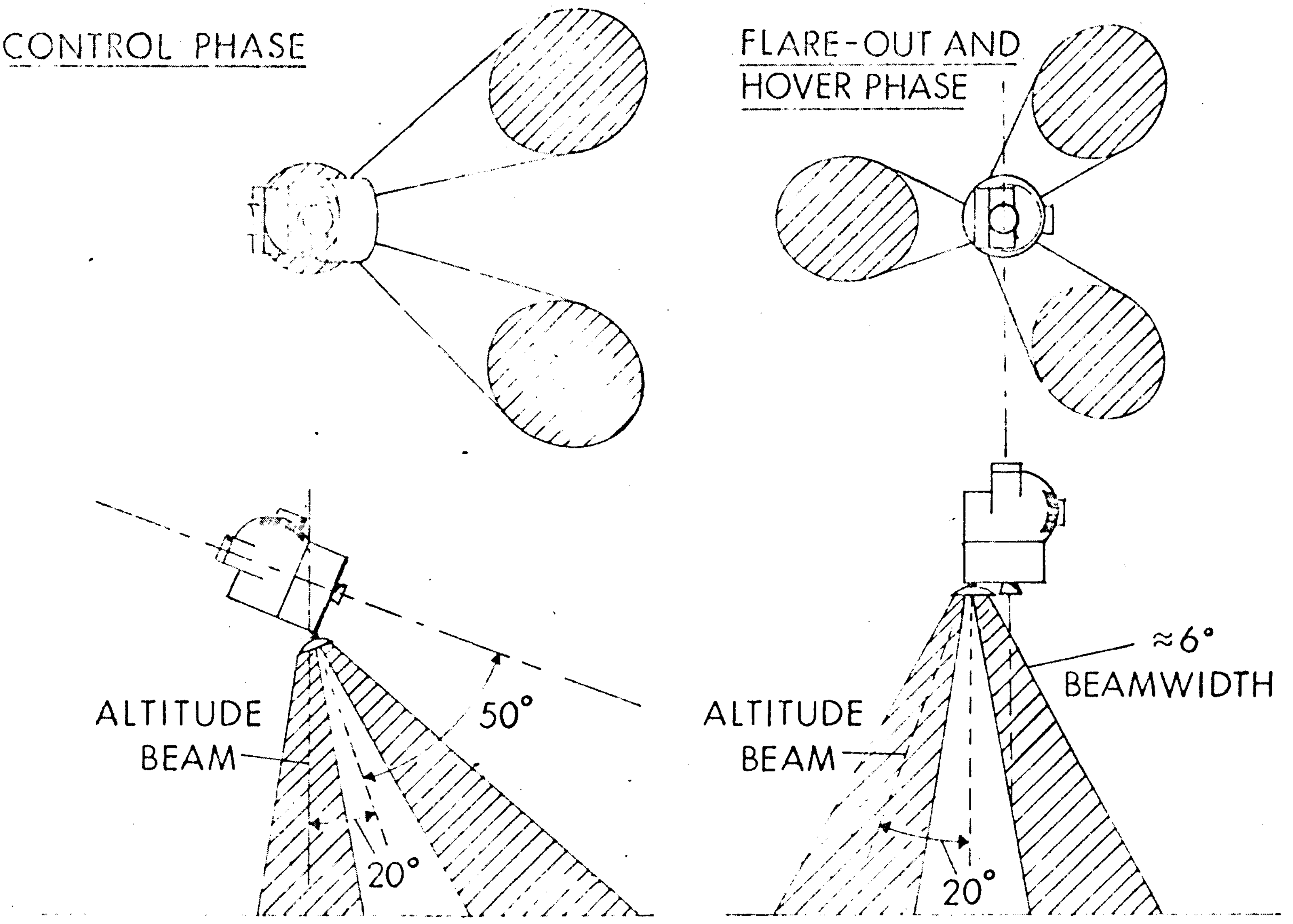

CONTROL PHASE

FLARE-OUT AND HOVER PHASE

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RENDEZVOUS RADAR OPERATING PHASES AND LIMITS

	R_{max} (N.M.)	R_{min} (FT)	$\dot{R}_{max}$ (FPS)	$\dot{R}_{min}$ (FPS)	A_{LS-I} SECT. (DEG.)	W_{LS} (max) (mr/sec)
I ASCENT AND ABORT TRAJECTORIES						
a) TYPICAL ASCENT	227	500*	-794	-125	38	0.64
b) EARLY ABORT	366	500*	+875 -784	-462	152	0.63
c) LATE ABORT	149	500*	+376 -415	-381	72	0.7
II C-SM TRACKING FROM LUNAR SURFACE						
a) 3° HORIZON LIMITS	400	100 NM	±4700	0	174	8.7
III LUNAR LANDING TO TRANSPONDER						
a) TYPICAL CONDITIONS FOR CONTROL PHASE ($\delta A_{LS} \approx 20$ mr)	34	—	-2740	0	≈ 60**	1.2

*DOCKING REQUIREMENTS

**ANGLE RELATIVE TO THRUST AXIS

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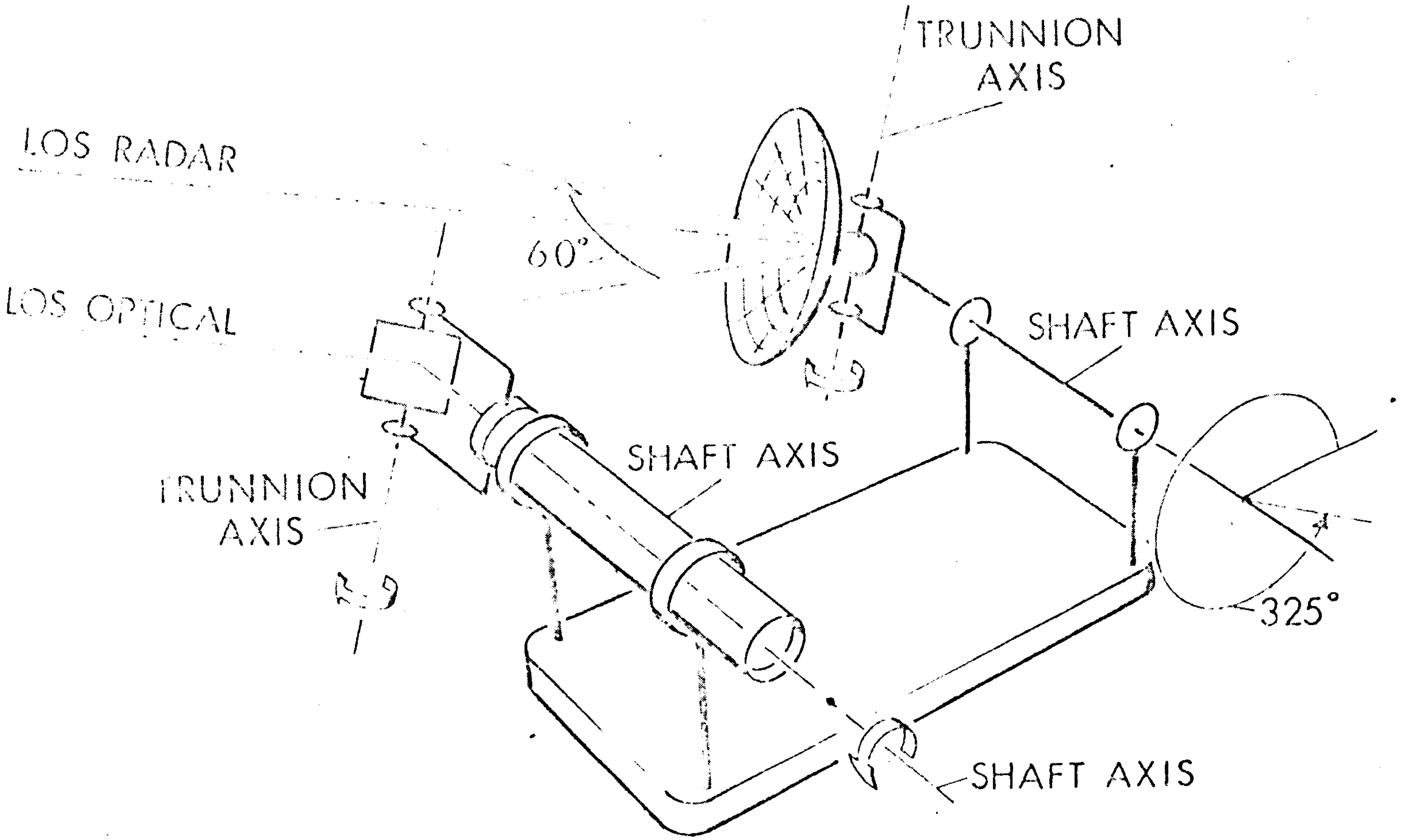
RADAR - OPTICS GIMBAL ORDER



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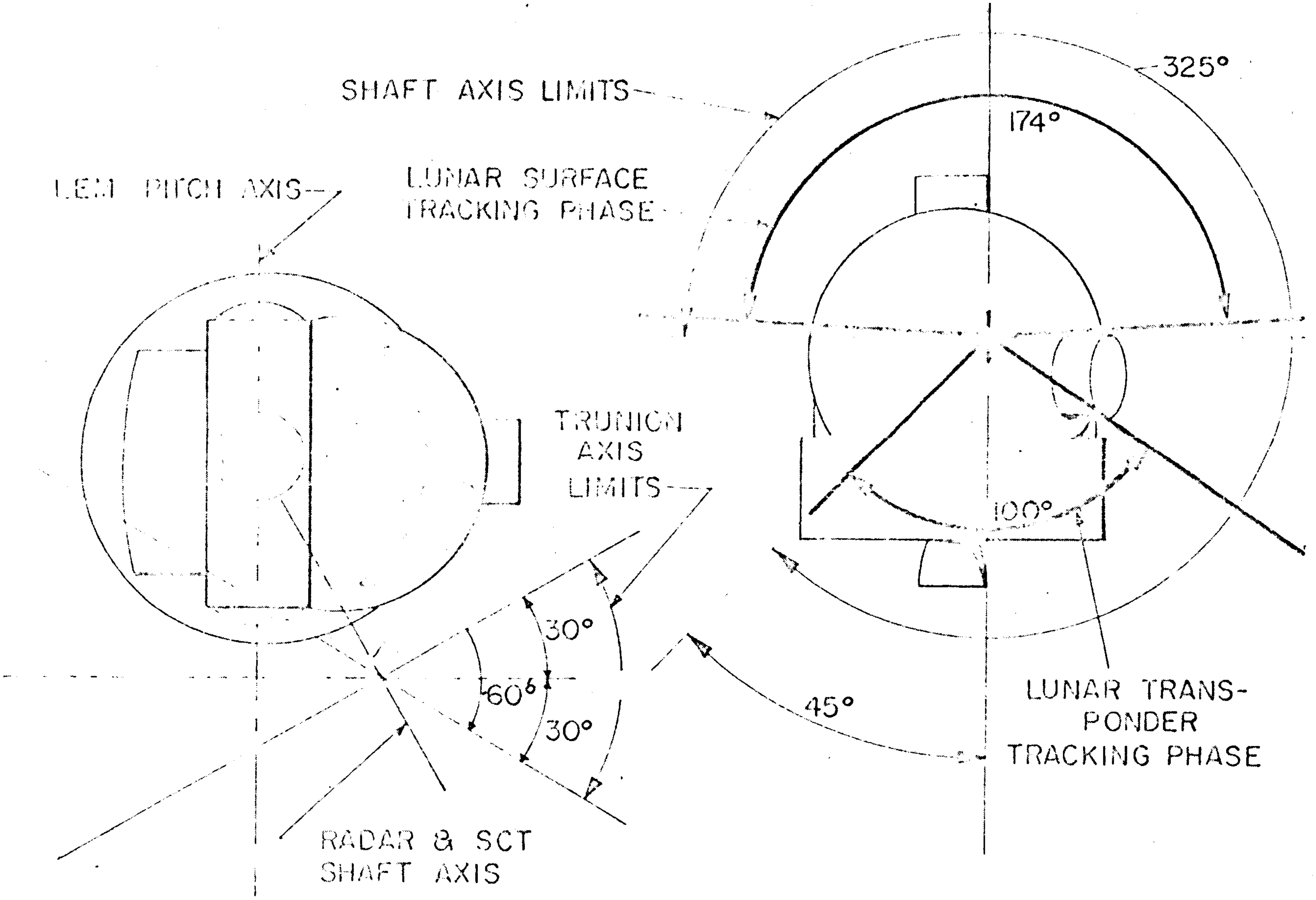
RENDEZVOUS RADAR GIMBAL LIMITS



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TENTATIVE RENDEZVOUS RADAR SPECIFICATIONS

1. REQUIRED OPERATING LIMITS

	RANGE (R)	RANGE RATE ($\dot{R}$)	RANGE ACCEL. ($\ddot{R}$)
MAXIMUM	400 nm	± 4800 fps	50 fps^2
MINIMUM	500 ft*	1 fps*	0
TYPICAL ORBITAL CONDITIONS	220 nm	-800 fps	1 fps^2

*DOCKING REQUIREMENTS NOT CONSIDERED

2. DESIRED PERFORMANCE REQUIREMENTS (3σ)

ANGLE UNCERTAINTY (RANDOM ERRORS)	3-6 mr
ANGLE UNCERTAINTY (MAX FIXED BIAS)	20 mr
RANGE RATE ACCURACY	1.5% ± 1 fps
RANGE ACCURACY	1.5% ± 30 ft

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RENDEZVOUS RADAR – TENTATIVE SPECIFICATIONS

TYPE	COHERENT	
FREQUENCY	ANGLE TRACKING AT X-BAND	
ANTENNA	2 GIMBAL SYSTEM, 4° BEAMWIDTH	
WEIGHT (MAX)	35 LBS	
POWER CONSUMPTION (MAX)	100 WATTS	
VOLUME	1 FT^3	
OPERATION LIMITS	RANGE	500 FT TO 400 NM
	RANGE RATE	1 TO 5000 FT/SEC
	ACCELERATION	0 TO 50 FT/SEC^2

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TRANSPONDER
TENTATIVE SPECIFICATIONS

TYPE :	COHERENT
FREQUENCY :	X-BAND
ANTENNAS :	FIXED, 180° BEAMWIDTH
WEIGHT :	10 LBS.
POWER CONSUMPTION :	30 WATTS
VOLUME :	0.2 $FT.^3$