(NASA-CR-73541) ALTERNATIVE ATM MISSION STUDY (Bellcomm, Inc.) 42 p

N79-71582

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SUBJECT: Alternative ATM Mission Study, Presentation to H. T. Luskin July 25, 1968 - Case 620

DATE: July 26, 1968

FROM: G. M. Anderson

MEMORANDUM FOR FILE

[redacted]

Results of a six week study of Alternative Missions for the ATM were presented to Mr. Luskin, the Apollo Applications Program Manager, on July 25, 1968. Technical contributions were made from the following departments:

1011	Radiation Dose Levels	R. H. Hilberg J. S. Ingley
1015	Scientific Yield	D. B. Wood
1022	Solar Viewing	B. D. Elrod
	Attitude Control	W. Levidow P. G. Smith
	Electrical Power	B. W. Moss
	Structure and S/C Weights	W. W. Hough
1025	Mission Analysis	D. A. DeGraaf K. E. Martersteck I. Hirsch
1031	Computer Systems Impact	P. S. Schaenman B. H. Liebowitz
2034	Tracking and Communication Coverage	R. L. Selden J. P. Malloy A. G. Weygand H. Kraus

The Vu-graphs used in the presentation are attached.

The prime conclusion is that a satisfactory alternative mission can be flown. Parameters are:

Duration	28 days
Inclination	50°
Elliptical Orbit	150 x 400 NM
Summer Solstice 71 Launch	

The expected scientific yield is not equal to the Cluster Mission flown on the ML-14 schedule. However, the mission exceeds minimum Principal Investigator requirements and has the property of requiring no major system modifications.

FEB 1969

G. M. Anderson

G. M. Anderson

1022:GMA:ms
Attachments

Pages - 42
Code - None
Cr # 73541

Program _____ Sequence No. ____

CM-SM/LM-ATM BACKUP MISSION STUDY

MLS/BELLCOMM

JULY 27, 1968

Program

Sequence No.

OBJECTIVES

- DEVELOP LM-ATM BACKUP MISSION ALTERNATIVES TO THE CLUSTER MISSION
- COMPARE SCIENTIFIC YIELD WITH CLUSTER MISSION
- IDENTIFY ADDITIONAL SYSTEM REQUIREMENTS

OUTLINE OF PRESENTATION

- INTRODUCTION
- MISSION ANALYSIS
- SOLAR VIEWING CAPABILITY
- SCIENTIFIC YIELD
- RADIATION EXPOSURE
- COMPUTER SYSTEMS IMPACT
- STRUCTURAL CONSIDERATIONS AND ATTITUDE CONTROL
- COMMUNICATION AND TRACKING COVERAGE
- CONCLUSIONS AND RECOMMENDATION

ASSUMPTIONS AND CONDITIONS

- CONFIGURATION - CM-SM DOCKED TO LM-ATM
- CM-SM

  STANDARD AAP CM-SM EXCEPT CRYOGENIC TANKAGE IS OPTIMIZED FOR EXPECTED DURATION. TWO GAS ATMOSPHERE RETAINED
- LM-ATM

  LM-A BASELINE - CAPABILITY FOR FOUR DAYS OF INDEPENDENT LIFE PRIOR TO DOCKING OF CM-SM
- ELECTRICAL POWER

  FUEL CELLS SUPPLY 1.8 KW OF CM-SM REQUIREMENTS
  REMAINDER SUPPLIED FROM LM-ATM EPS
- ATTITUDE CONTROL

  LM-ATM CONTROL MOMENT GYROS
  DESATURATION BY SM RCS
- LAUNCH SCHEDULE

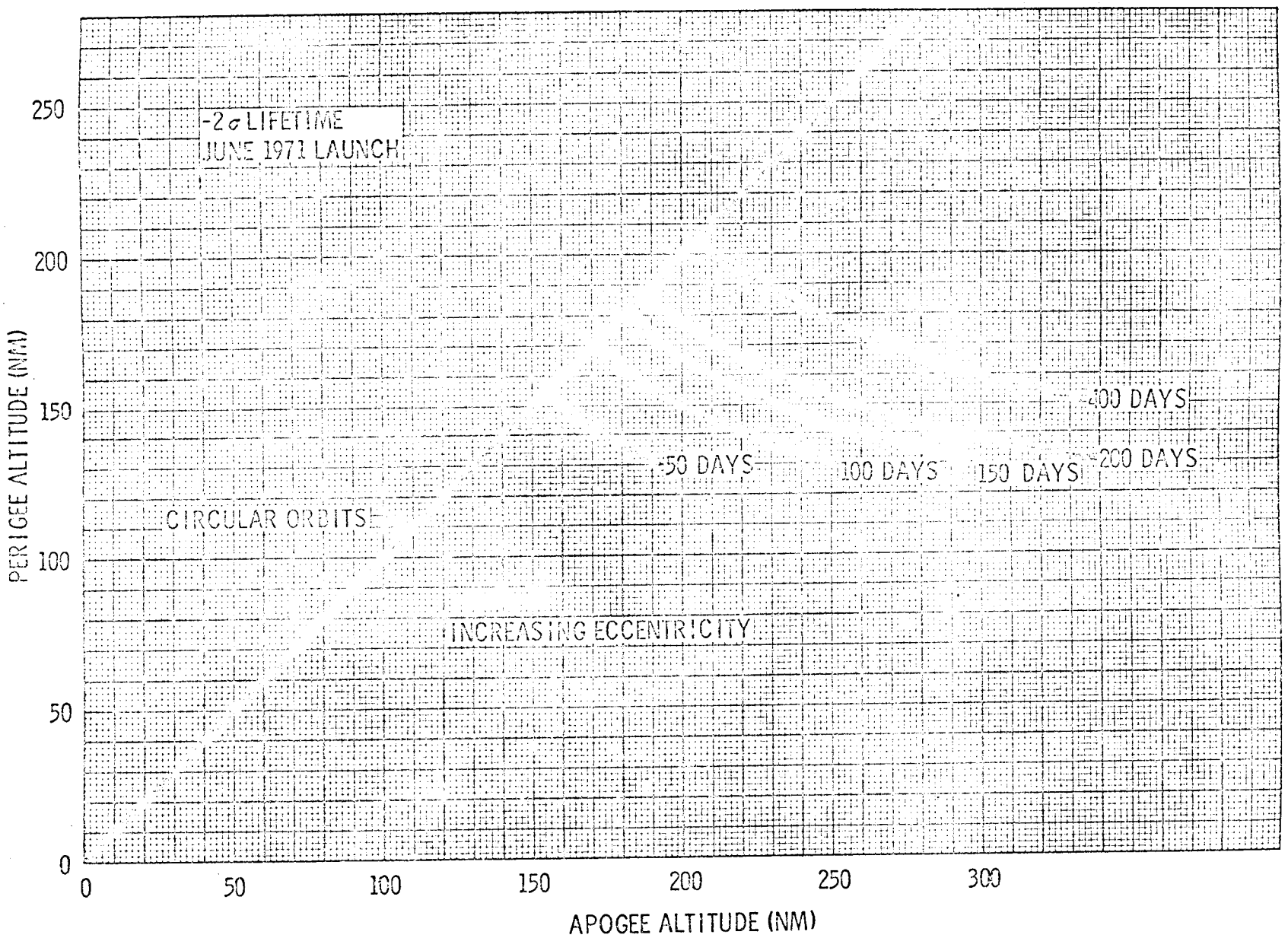
  SUMMER OF 1971 IS THE EARLIEST LAUNCH DATE CONSIDERED

DURATION AND ORBITAL PARAMETERS

DURATION DAYS	INCLINATION DEGREES	ALTITUDE N. M.	2-1/2 STAGE TO ORBIT
56 (CLUSTER)	28-1/2	230x230	NO
56	50	150x400	YES
28	50	150x400	NO
	50	150x600	YES
	50	375x375	YES
28	63.5	150x300	YES
	63.5	225x225	YES

150 NM PERIGEE DETERMINED BY RENDEZVOUS CONSIDERATIONS. APOGEE AND CIRCULAR ALTITUDES BASED ON VEHICLE PERFORMANCE LIMITS.

ORBIT LIFETIME VS. INITIAL APOGEE & PERIGEE ALTITUDE



Program _____ Sequence No. _____

MAJOR MISSION EVENTS

LM/ATM

S-IB IGNITION

S-IVB IGNITION

YAW

ORBIT INSERTION (81 x 150)

RCS CIRCULARIZATION (150 x 150)

CM/SM

S-IB IGNITION

S-IVB IGNITION

YAW

SPS IGNITION

ORBIT INSERTION (81 x 120)

PHASING, RENDEZVOUS & DOCKING (150 x 150)

CM/SM - LM/ATM

TRANSFER TO MISSION ORBIT (ELLIPTICAL OR CIRCULAR) WITH SM-SPS

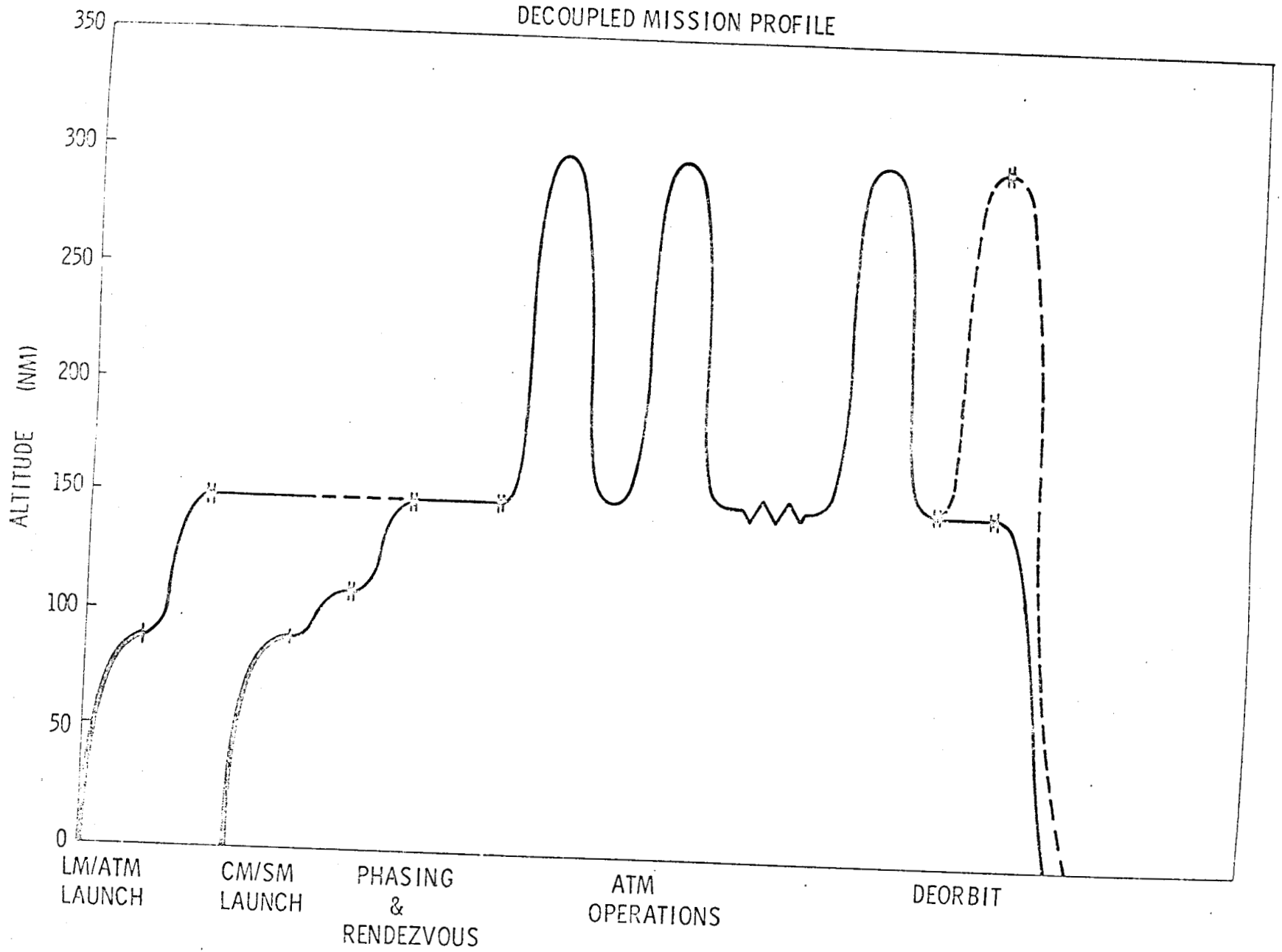
CONDUCT ATM MISSION

CM/SM SEPARATE FROM LM

CM/SM

RETRO & CM RETURN TO EARTH

Program _____ Sequence No: ____



S/C WEIGHT SUMMARY

DURATION	SPACECRAFT (NO USABLE PROPELLANT) CM/SM	LM/ATM
14 DAYS	24760 LBS	25701 LBS
28 DAYS	26070 LBS	25801 LBS
56 DAYS	28234 LBS	26101 LBS

TO THE CM/SM WAS ADDED:

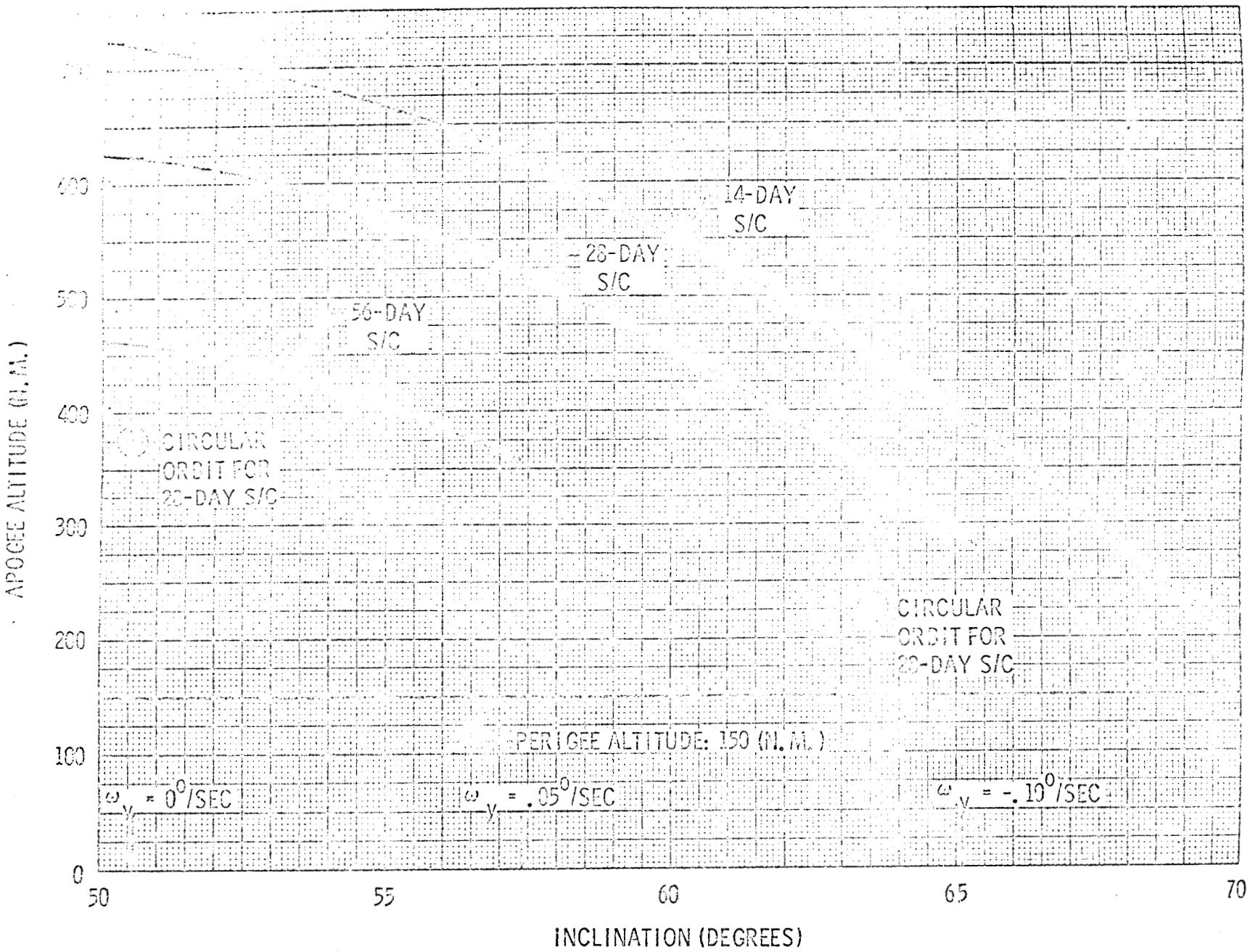
- RCS PROPELLANT FOR ORBIT MANEUVERS, RENDEZVOUS, BACKUP DEORBIT
- SPS PROPELLANT FOR ORBIT INSERTION WHERE SUBORBITAL IGNITION USED, ORBIT TRANSFER MANEUVERS, DEORBIT

TO THE LM/ATM WAS ADDED:

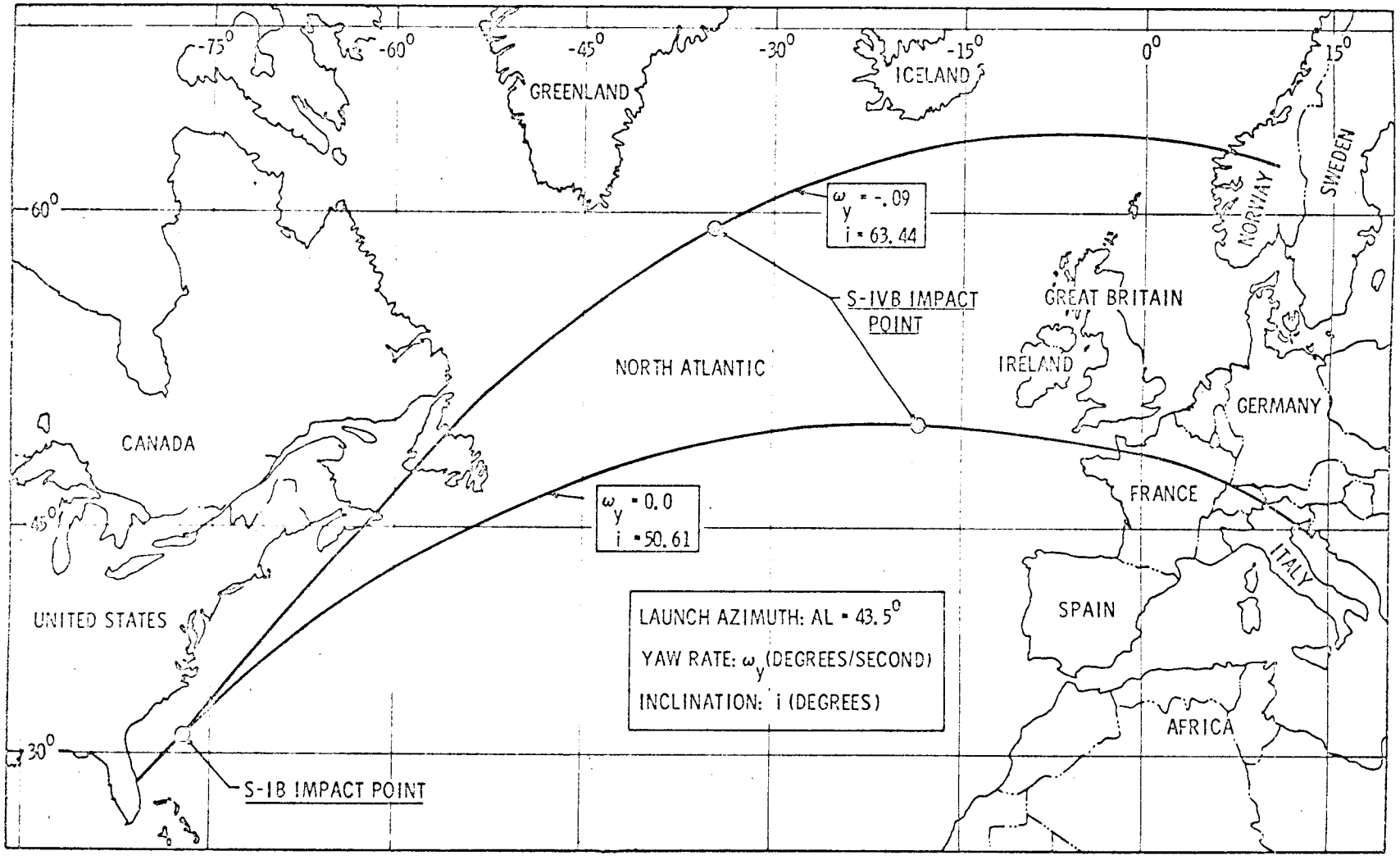
- RCS PROPELLANT FOR CIRCULARIZATION AND ATTITUDE HOLD (400 LBS)

STANDARD AAP WEIGHTS FOR LAUNCH VEHICLE, SLA, NOSE CONE, ETC. WERE USED.

[illegible] VS. INCLINATION FOR CM/SM-LM/ATM MISSIONS WITH SPS SUBORBITAL IGNITION



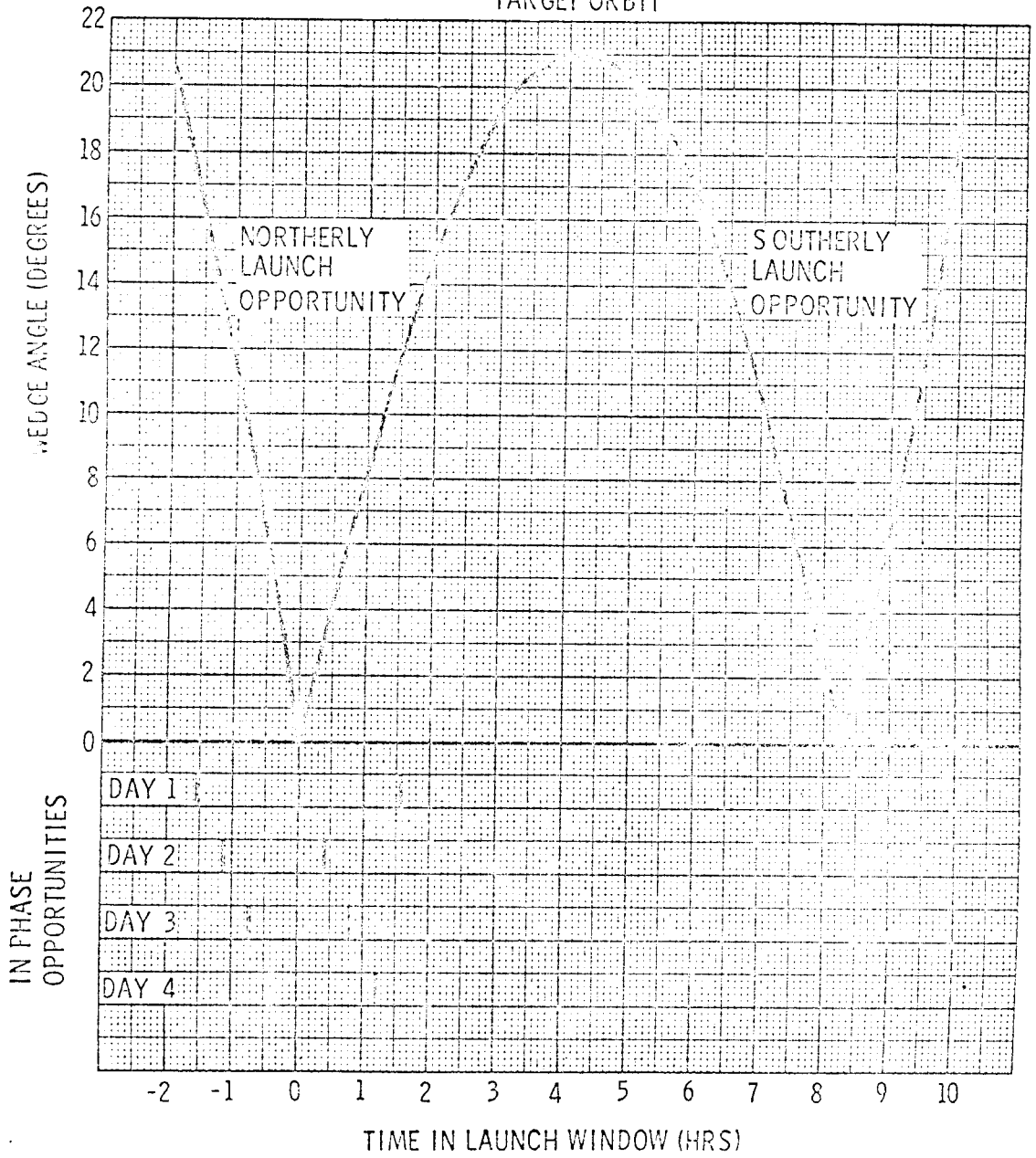
INSTANTANEOUS IMPACT POINTS FOR HIGH INCLINATION MISSIONS



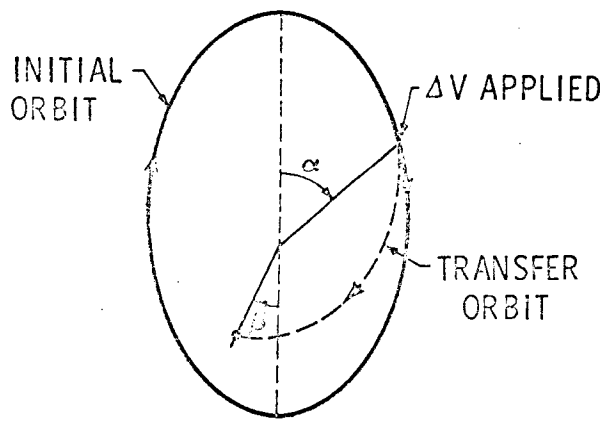
OPERATIONAL CONSIDERATIONS

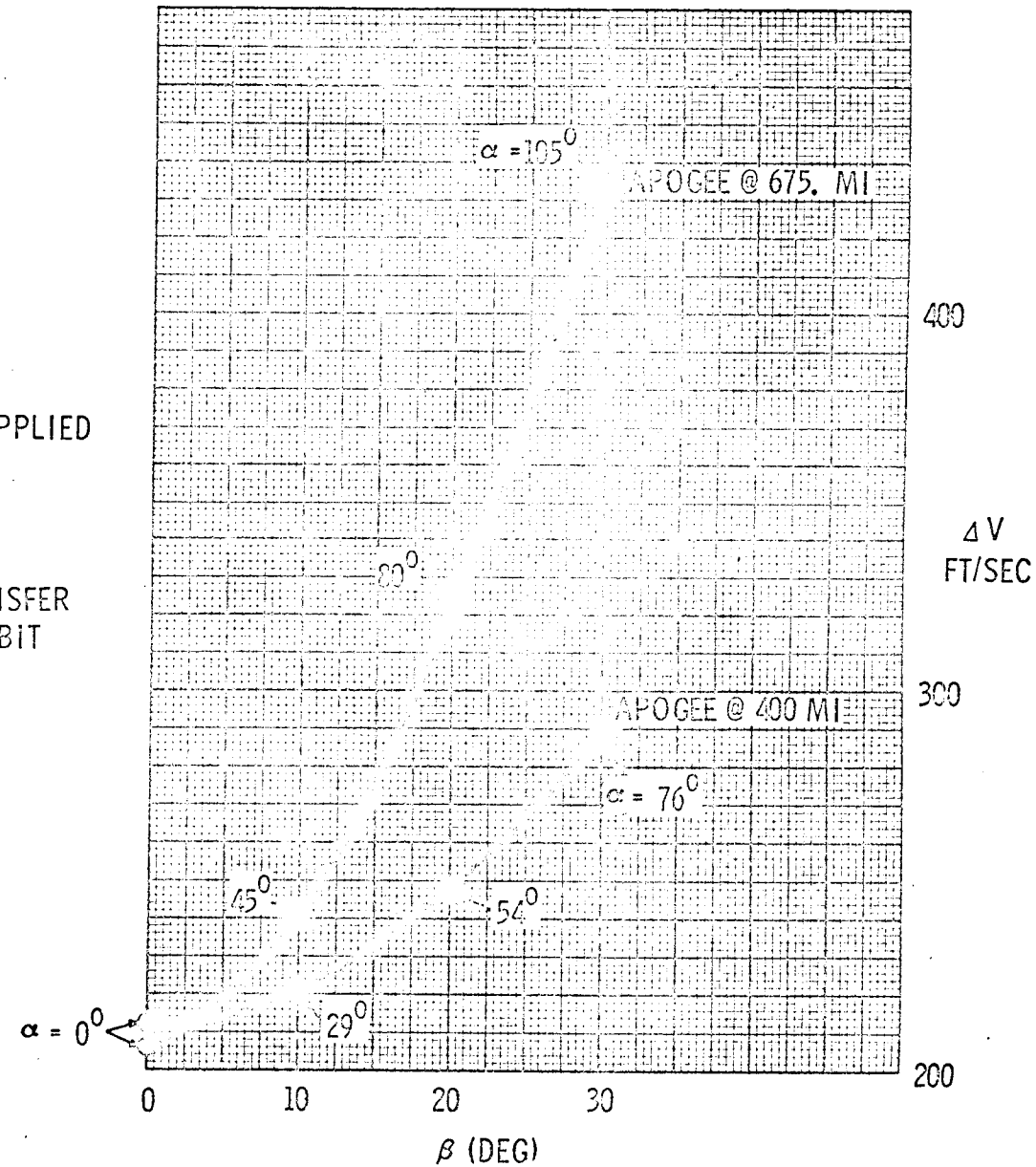
- RENDEZVOUS
- BACKUP DEORBIT
- LANDING AND RECOVERY

RENDEZVOUS LAUNCH WINDOW
FOR 50° INCLINATION, 150 x 150 NM
TARGET ORBIT



MINIMUM ΔV REQUIRED TO LOWER PERIGEE FROM 150 TO 30 NM AND SHIFT IT BY β DEG.



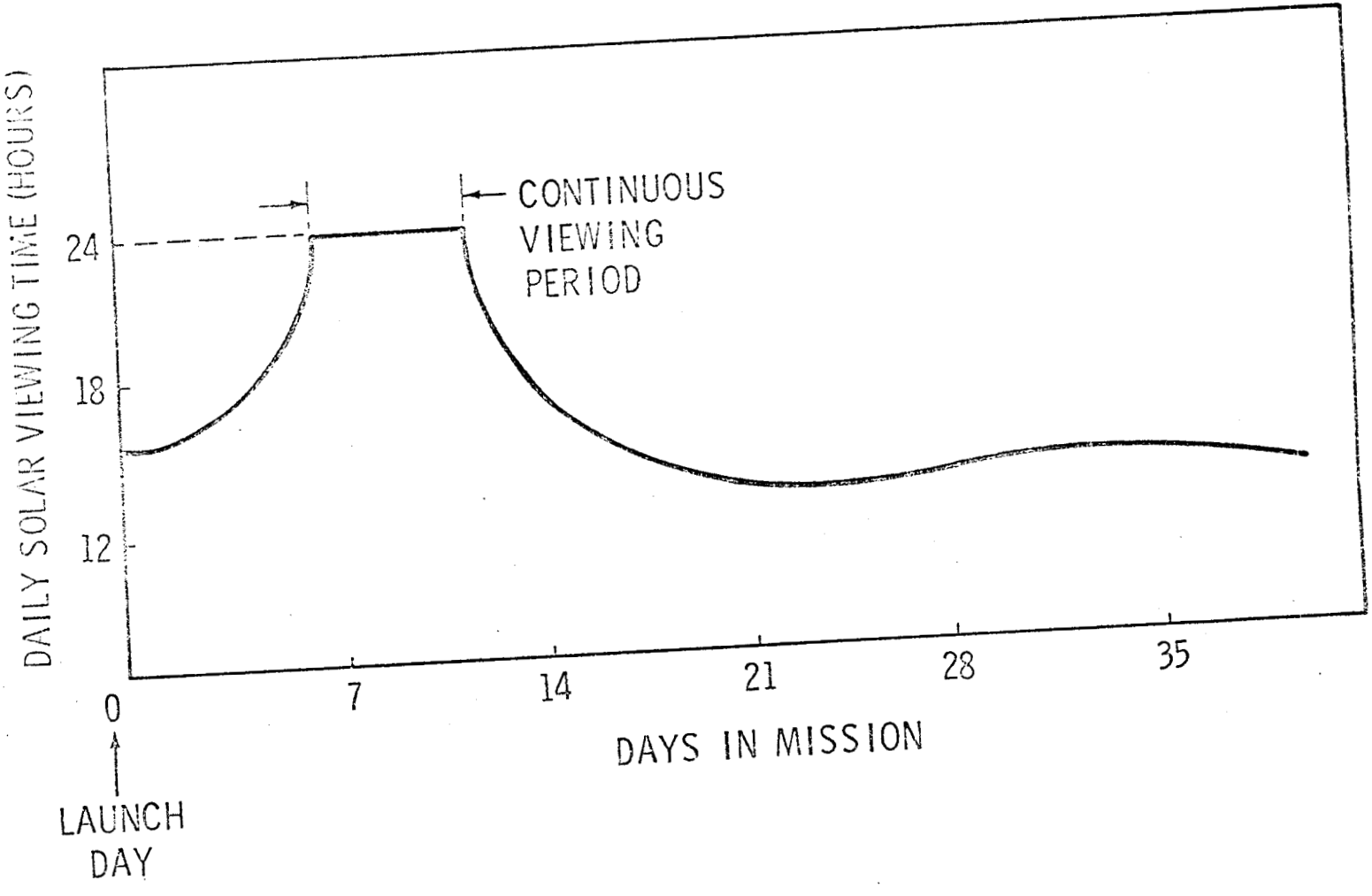


SOLAR VIEWING CAPABILITY IN 28.5°, 50° AND 63.5° ORBITS

VIEWING FACTORS CONSIDERED:

- TOTAL-SOLAR-VIEWING-TIME - TOTAL TIME (HOURS) AVAILABLE DURING MISSION
- MAXIMUM DURATION OF 100% SOLAR VIEWING TIME - MAXIMUM DURATION (DAYS) OF CONTINUOUS SOLAR VIEWING DURING MISSION
- MINIMUM SUN LINE / EARTH HORIZON ANGLE - MINIMUM ANGLE BETWEEN SUN-LINE AND EARTH HORIZON (DURING 100% VIEWING DAYS.)

TYPICAL VIEWING PROFILE WITH OPTIMUM LAUNCH

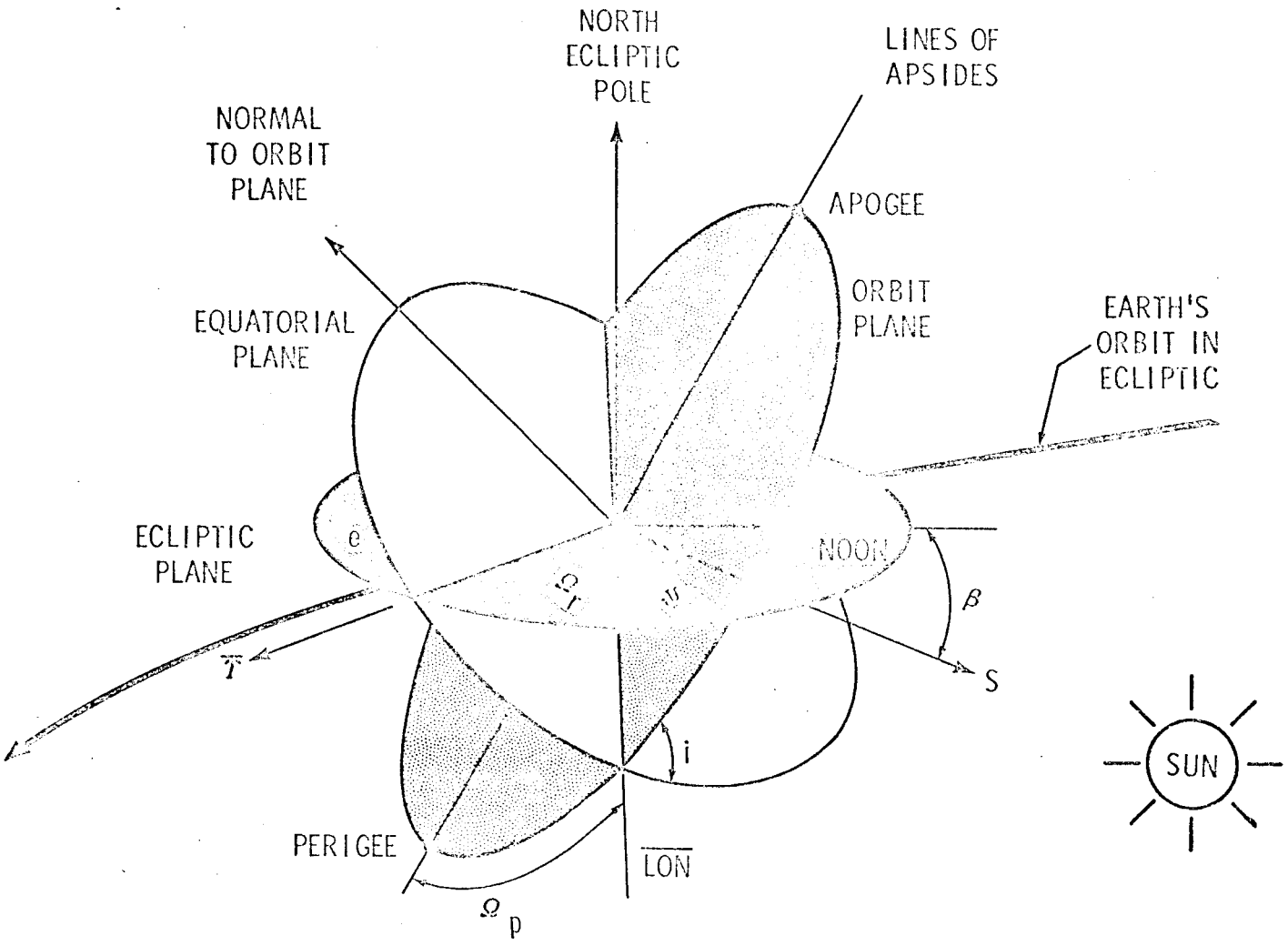


MAXIMUM SOLAR VIEWING CAPABILITY*

MISSION DURATION (DAYS)	28					56	
INCLINATION (DEG.)	50			63.5		28.5	50
TYPE OF ORBIT	ELLIPTICAL	ELLIPTICAL	CIRCULAR	ELLIPTICAL	CIRCULAR	CIRCULAR	ELLIPTICAL
CIRCULAR ALTITUDE OR APOGEE/PERIGEE (NM)	580x150**	400x150**	375	300x150	225	230***	400x150**
TOAL-SOLAR-VIEWING TIME (HOURS)	520	478	503	480	478	777	872
AVERAGE VIEWING TIME PER DAY (HOURS/DAY)	18.5	17.1	18.0	17.1	17.1	13.9	15.6
MAXIMUM DURATION OF CONTINUOUS VIEWING (DAYS)	8	5	5	6	6	0	5

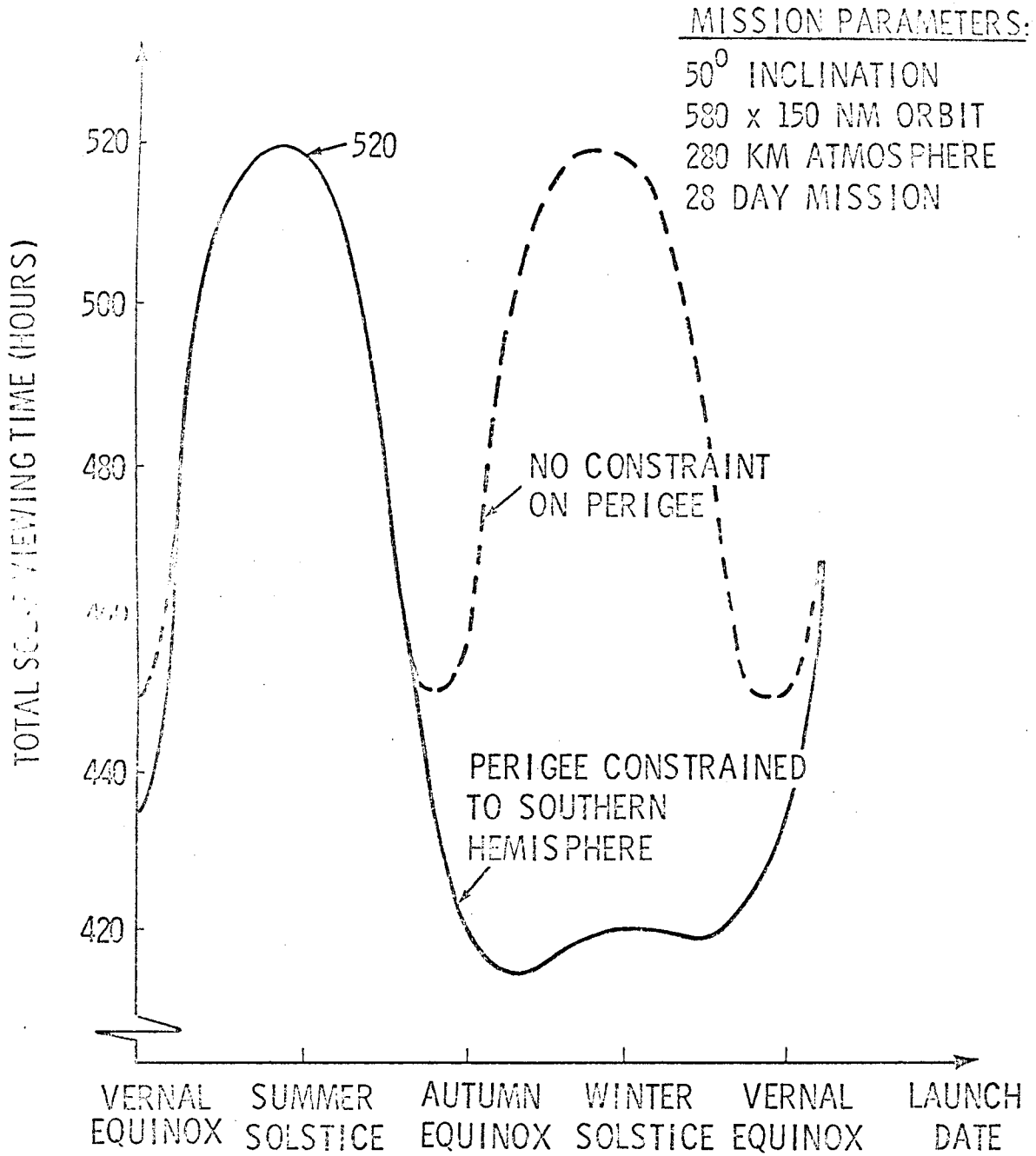
*DATA BASED ON 280 KM EFFECTIVE ATMOSPHERE
**ONE POSSIBLE LAUNCH PERIOD PER YEAR (NEAR SUMMER SOLSTICE)
***CURRENT BASELINE MISSION

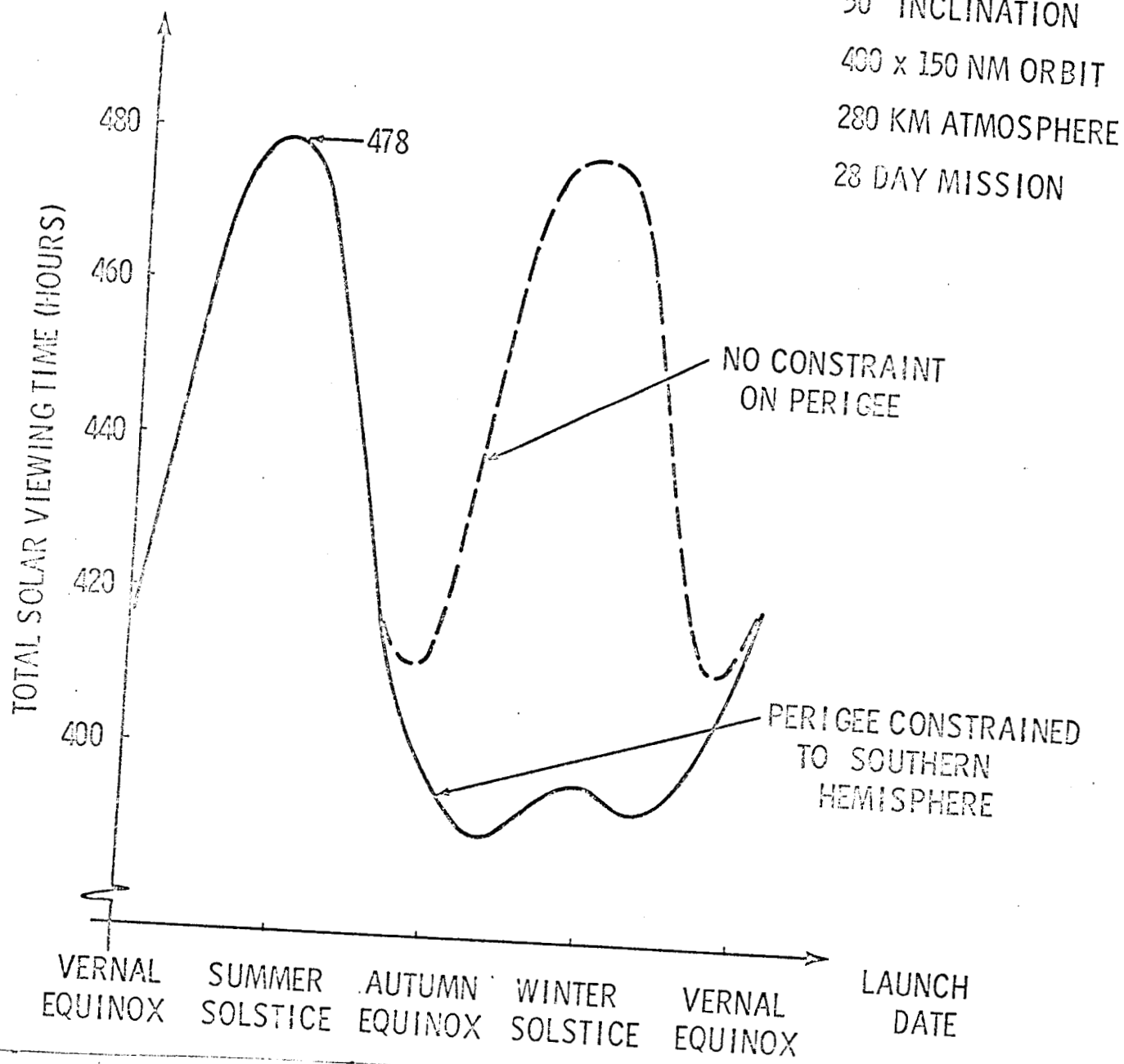
SOLAR POINTING GEOMETRY

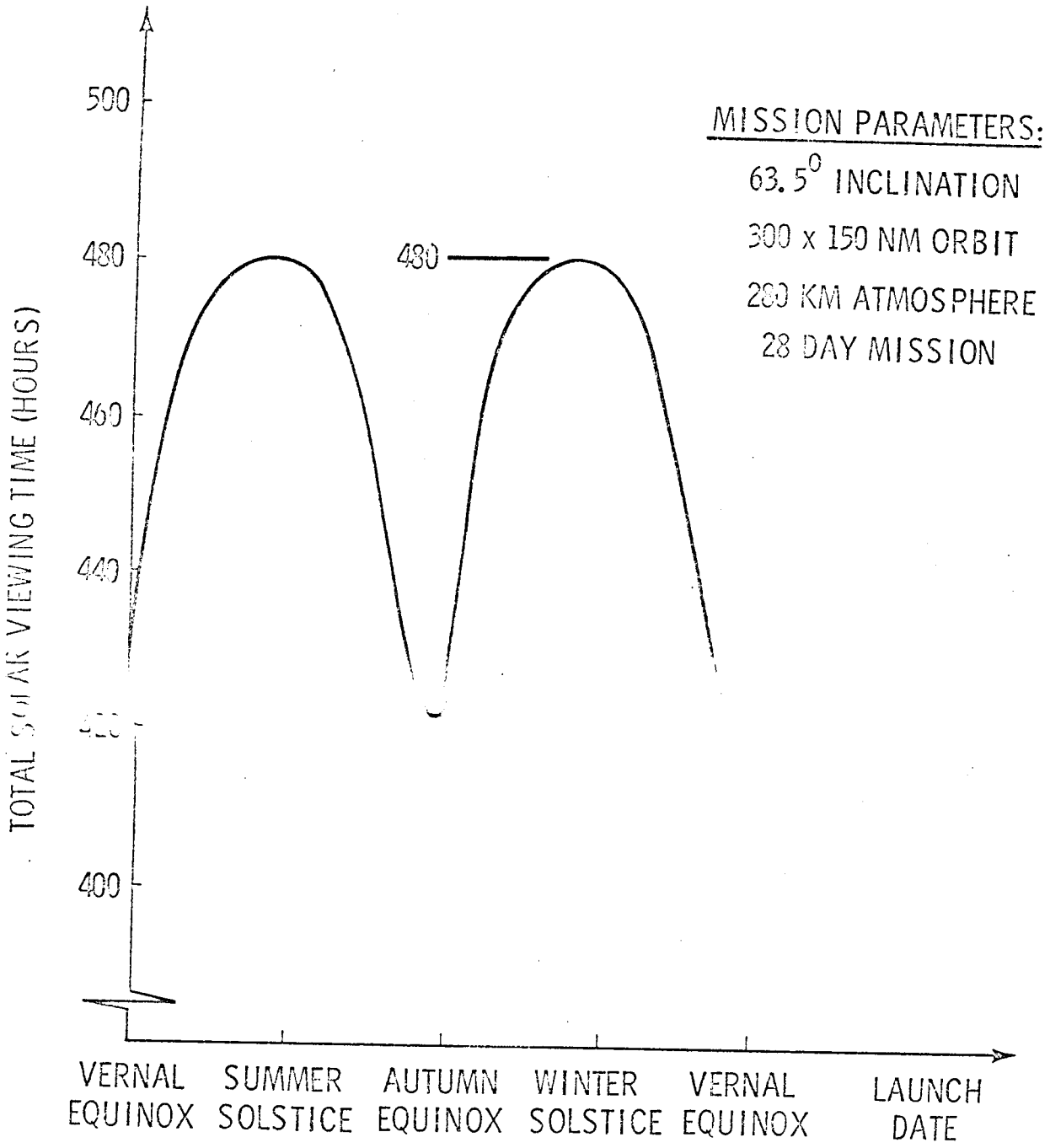


SYMBOLS:

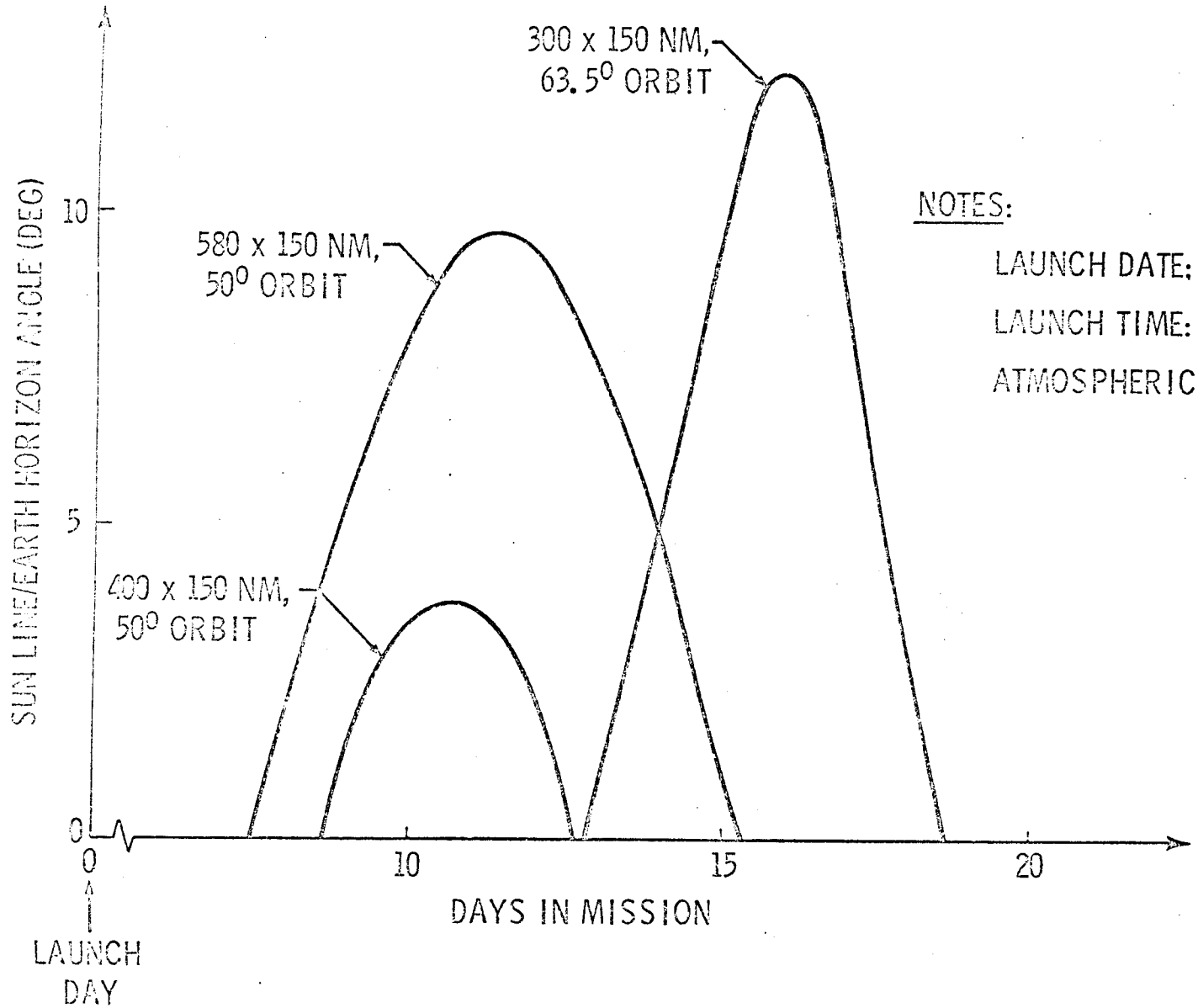
i	- ORBIT INCLINATION
e	- ANGLE BETWEEN EQUATORIAL AND ECLIPTIC PLANES ($e=23.45^0$)
$\overline{\Upsilon}$	- EARTH-SUN LINE AT VERNAL EQUINOX
$\overline{LON}$	- ORBIT/EQUATORIAL PLANE LINE-OF-NODES
Ω_r	- LOCATION OF LON WITH RESPECT TO $\overline{\Upsilon}$
Ω_p	- LOCATION OF PERIGEE WITH RESPECT TO $\overline{LON}$
ψ	- LOCATION OF ORBITAL NOON WITH RESPECT TO $\overline{LON}$
β	- MINIMUM ANGLE BETWEEN SUNLINE AND ORBITAL PLANE


MISSION PARAMETERS:
50° INCLINATION
580 x 150 NM ORBIT
280 KM ATMOSPHERE
28 DAY MISSION
TOTAL SOLAR VIEWING TIME (HOURS)
520
500
480
440
420
520
NO CONSTRAINT ON PERIGEE
PERIGEE CONSTRAINED TO SOUTHERN HEMISPHERE
VERNAL EQUINOX
SUMMER SOLSTICE
AUTUMN EQUINOX
WINTER SOLSTICE
VERNAL EQUINOX
LAUNCH DATE


MISSION PARAMETERS:
50° INCLINATION
400 x 150 NM ORBIT
280 KM ATMOSPHERE
28 DAY MISSION
TOTAL SOLAR VIEWING TIME (HOURS)
480
460
440
420
400
478
NO CONSTRAINT ON PERIGEE
PERIGEE CONSTRAINED TO SOUTHERN HEMISPHERE
VERNAL EQUINOX
SUMMER SOLSTICE
AUTUMN EQUINOX
WINTER SOLSTICE
VERNAL EQUINOX
LAUNCH DATE


MISSION PARAMETERS:
63.5° INCLINATION
300 x 150 NM ORBIT
200 KM ATMOSPHERE
28 DAY MISSION
TOTAL SOLAR VIEWING TIME (HOURS)
500
480
460
440
400
480
VERNAL EQUINOX
SUMMER SOLSTICE
AUTUMN EQUINOX
WINTER SOLSTICE
VERNAL EQUINOX
LAUNCH DATE

TYPICAL SUN LINE/EARTH HORIZON ANGLES
DURING CONTINUOUS SOLAR VIEWING PERIODS



NOTES:

LAUNCH DATE: JUNE 21

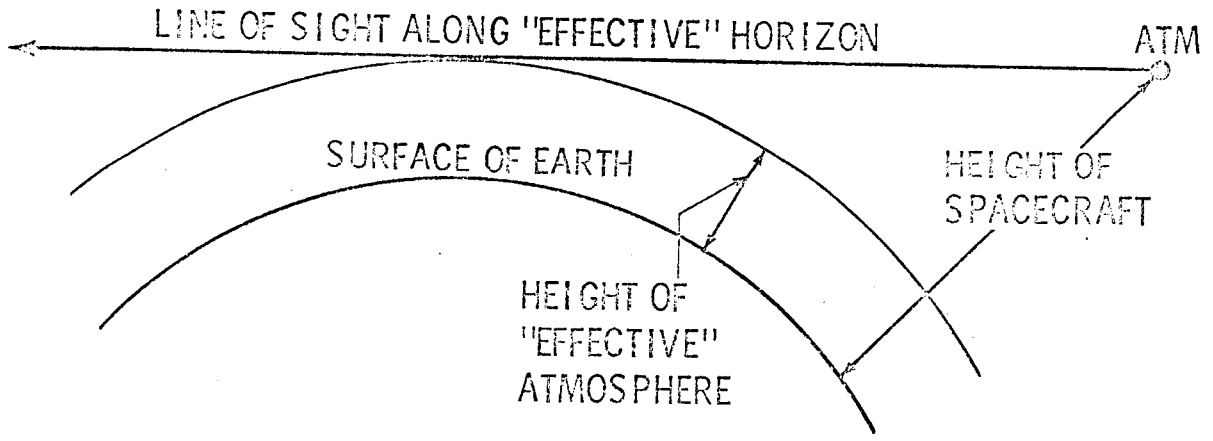
LAUNCH TIME: 12:00 AM

ATMOSPHERIC HEIGHT: 280 KM

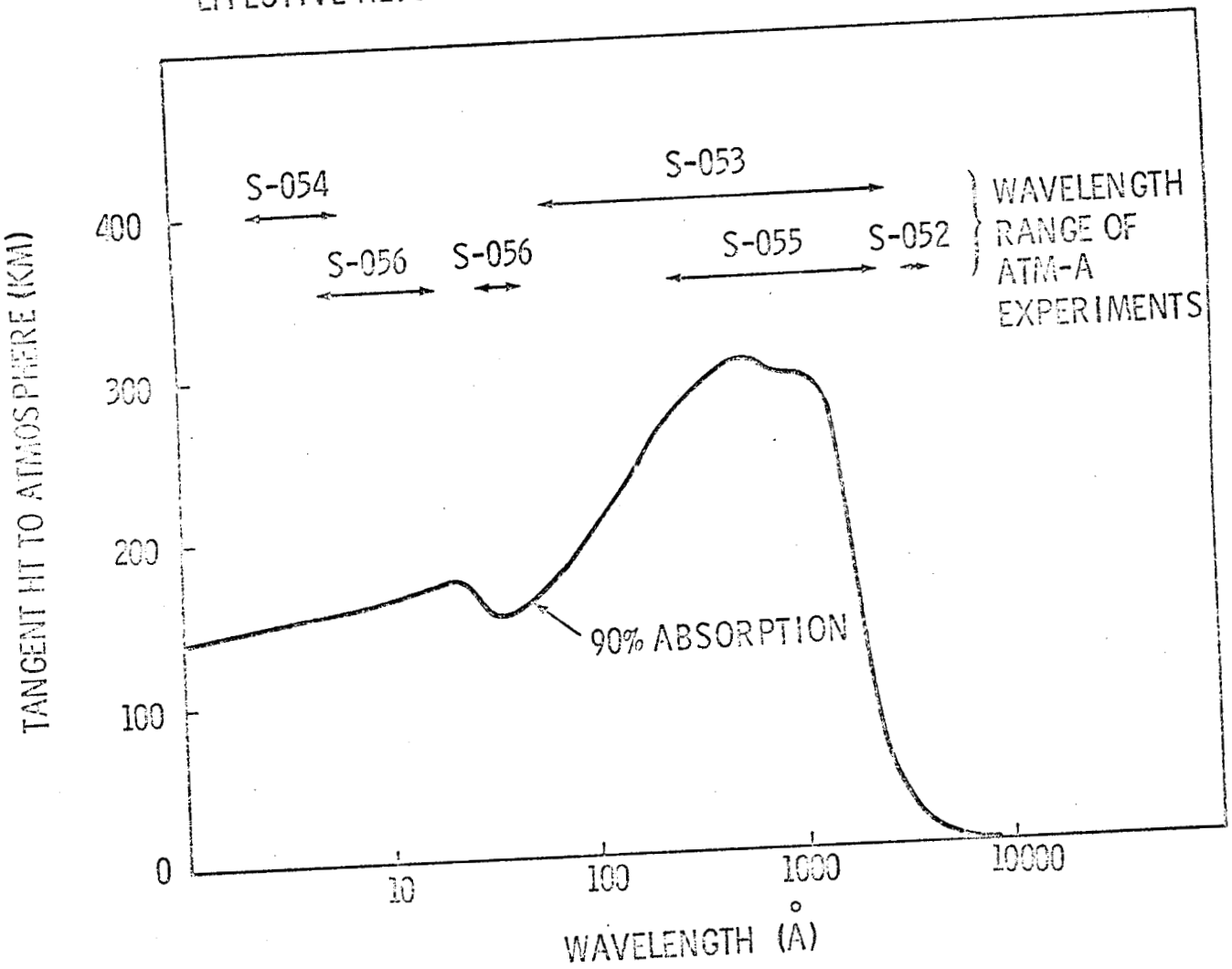
CONCLUSIONS ON SOLAR VIEWING

- A 12% INCREASE OVER TOTAL SOLAR VIEWING TIME AVAILABLE IN THE BASELINE MISSION CAN BE ACHIEVED WITH A 50^{0}, 400 x 150 NM ORBIT AND A 56 DAY MISSION, IF LAUNCHED NEAR THE SUMMER SOLSTICE.
- AVERAGE SOLAR VIEWING TIMES CAN BE 2-4.5 HOURS/DAY HIGHER THAN IN THE BASELINE MISSION
- CONTINUOUS SOLAR VIEWING DURATIONS OF 5-8 DAYS ARE ACHIEVABLE
- SUN LINE / EARTH HORIZON ANGLES IN BOTH 50^{0} AND 63.5^{0} ORBITS ARE ACCEPTABLE FOR ATM CORONOGRAPH EXPERIMENTS

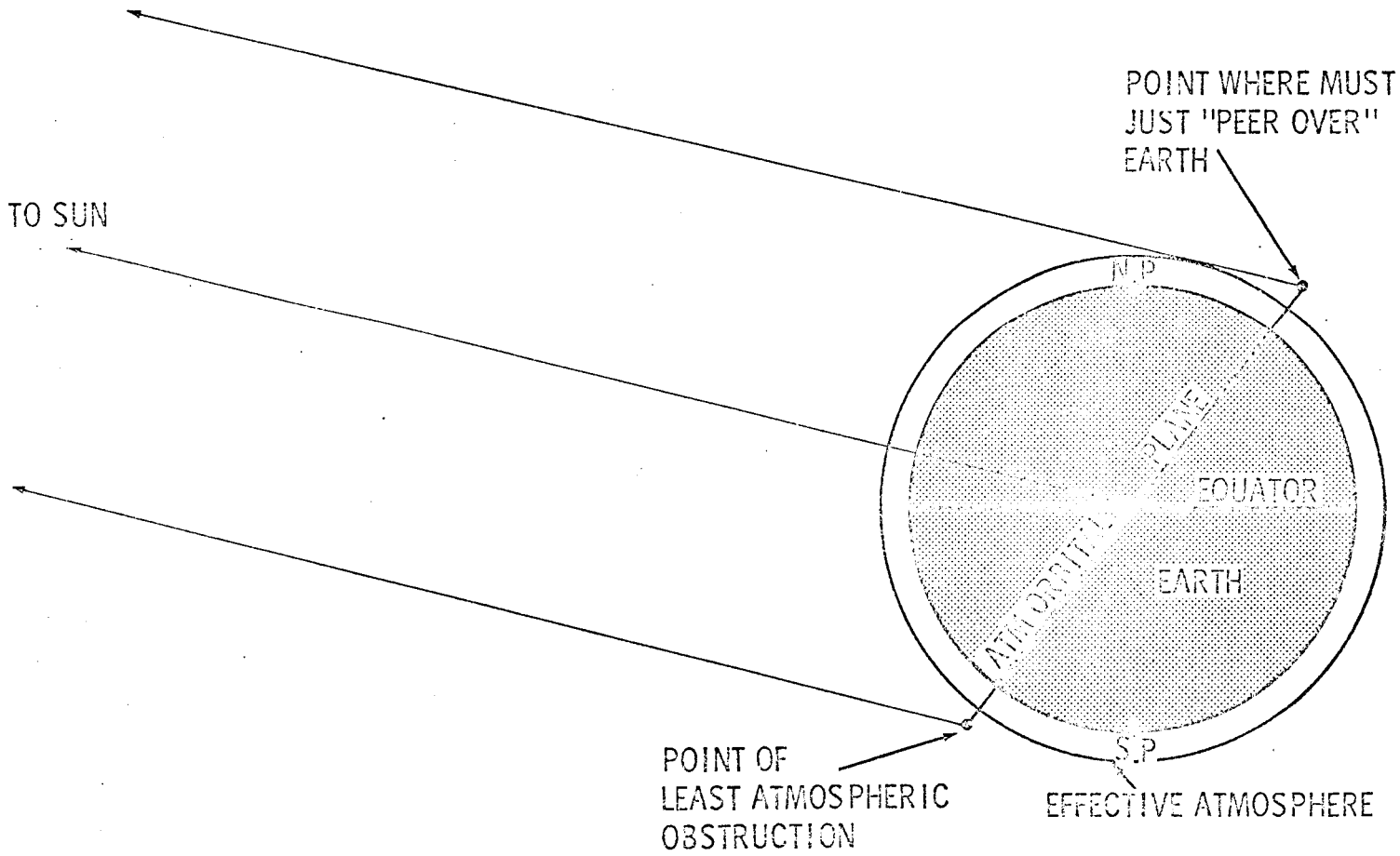
GEOMETRY OF LINE-OF SIGHT TANGENT TO "EFFECTIVE" EARTH ATMOSPHERE



EFFECTIVE HEIGHT OF ATMOSPHERE FOR MOLECULAR ABSORPTION



GEOMETRY OF JUST "PEERING OVER" EARTH, SHOWN FOR TIME NEAR SUMMER SOLSTICE



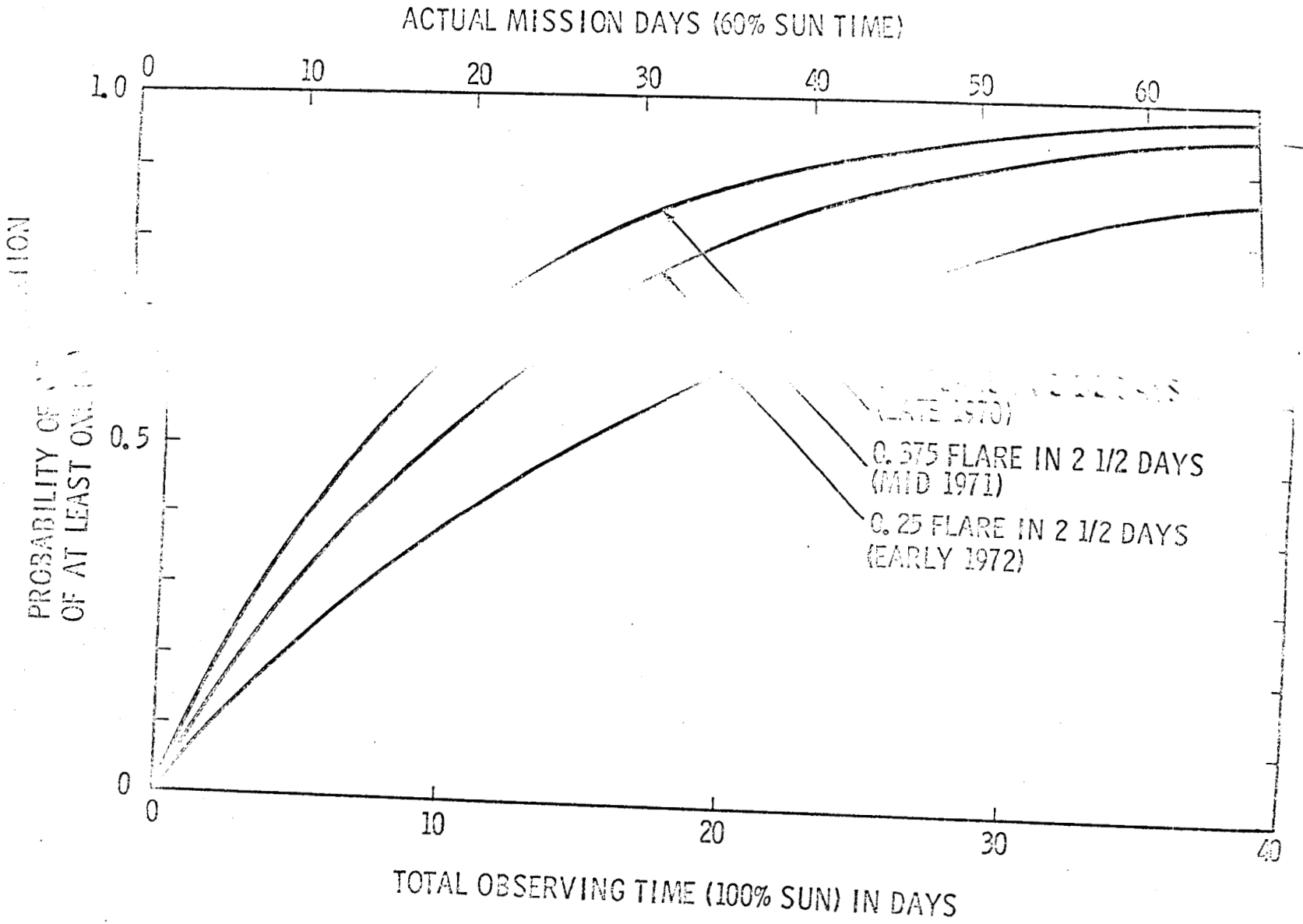
SUMMARY OF AIM SCIENTIFIC GOALS

- OBSERVE SUN WITH HIGHER SPATIAL RESOLUTION THAN POSSIBLE FROM OSO.
- OBSERVE AT LEAST ONE SOLAR ROTATION (28 DAYS).
- OBSERVE THE SUN AT THE HIGHEST POSSIBLE LEVEL OF ACTIVITY.
- OBSERVE THE SUN FOR THE LONGEST POSSIBLE INTEGRATED VIEWING TIME.

}

- MAXIMIZE PRODUCT
  SOLAR ACTIVITY X VIEWING TIME
  TO YIELD HIGHEST PROBABILITY OF FLARE DETECTION.

PROBABILITY OF OBSERVING AT LEAST ONE CLASS 2 FLARE

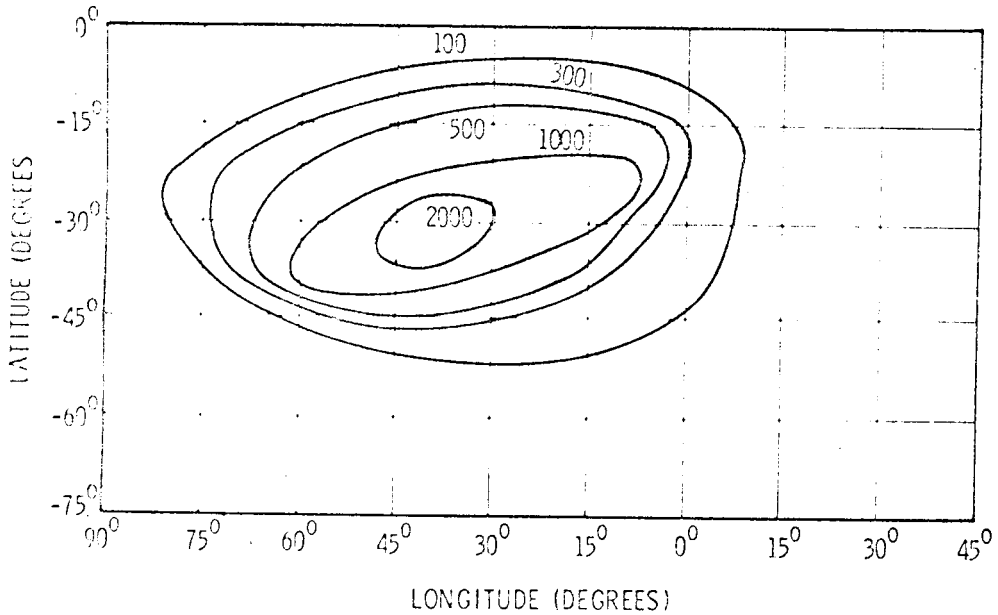


EVALUATION OF ALTERNATIVE MISSIONS

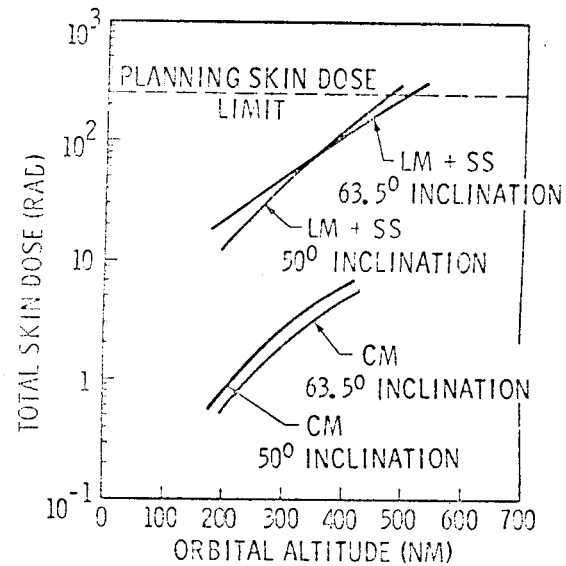
1 MISSION	2 DURATION (DAYS)	3 UNOCCULTED VIEWING (DAYS)	4 INTEGRATED VIEWING (DAYS)	5 INTEG. VIEWING X FLARE RATE (TOTAL FLARES)		6 FLARE PROBABILITY FOR TOTAL MISSION		7 PROB. OF FLARE DURING UNOCCULTED PERIOD	
				SUMMER '71	WINTER '71	SUMMER '71	WINTER '71	SUMMER '71	WINTER '71
A. WORKSHOP CLUSTER	56	0	32.4	4.86	3.64	.92	.84	0	0
B. 28.5° CIRCULAR	28	0	16.2	2.43	1.82	.71	.60	0	0
C. 50° HIGH ELLIPTICAL	28	8	21.7	3.26	-	.81	-	.45	-
D. 50° CIRCULAR	28	5	21.0	3.15	2.36	.80	.69	.31	.24
E. 50° LOW ELLIPTICAL	28	5	19.9	2.98	-	.78	-	.31	-
F. 63.5° ELLIPTICAL	28	6	20.0	3.00	2.25	.78	.67	.36	.28
G. 63.5° CIRCULAR	28	6	19.9	2.98	2.23	.78	.67	.36	.28

RADIATION TRAPPED IN EARTH MAGNETIC FIELD

ENERGETIC PROTONS AND ELECTRONS LOCATED IN "SOUTH ATLANTIC ANOMALY"



FLUX OF PROTONS WITH ENERGY ABOVE 34 MEV IN THE REGION OF THE SOUTH ATLANTIC ANOMALY AT 600 KM (323 NM) (FROM VETTE, API)



SKIN DOSES FOR CIRCULAR ORBIT, 28 DAY MISSION IN LUNAR MODULE PLUS SPACE SUIT (LM + SS) AND COMMAND MODULE (CM)

DOSE LIMITS

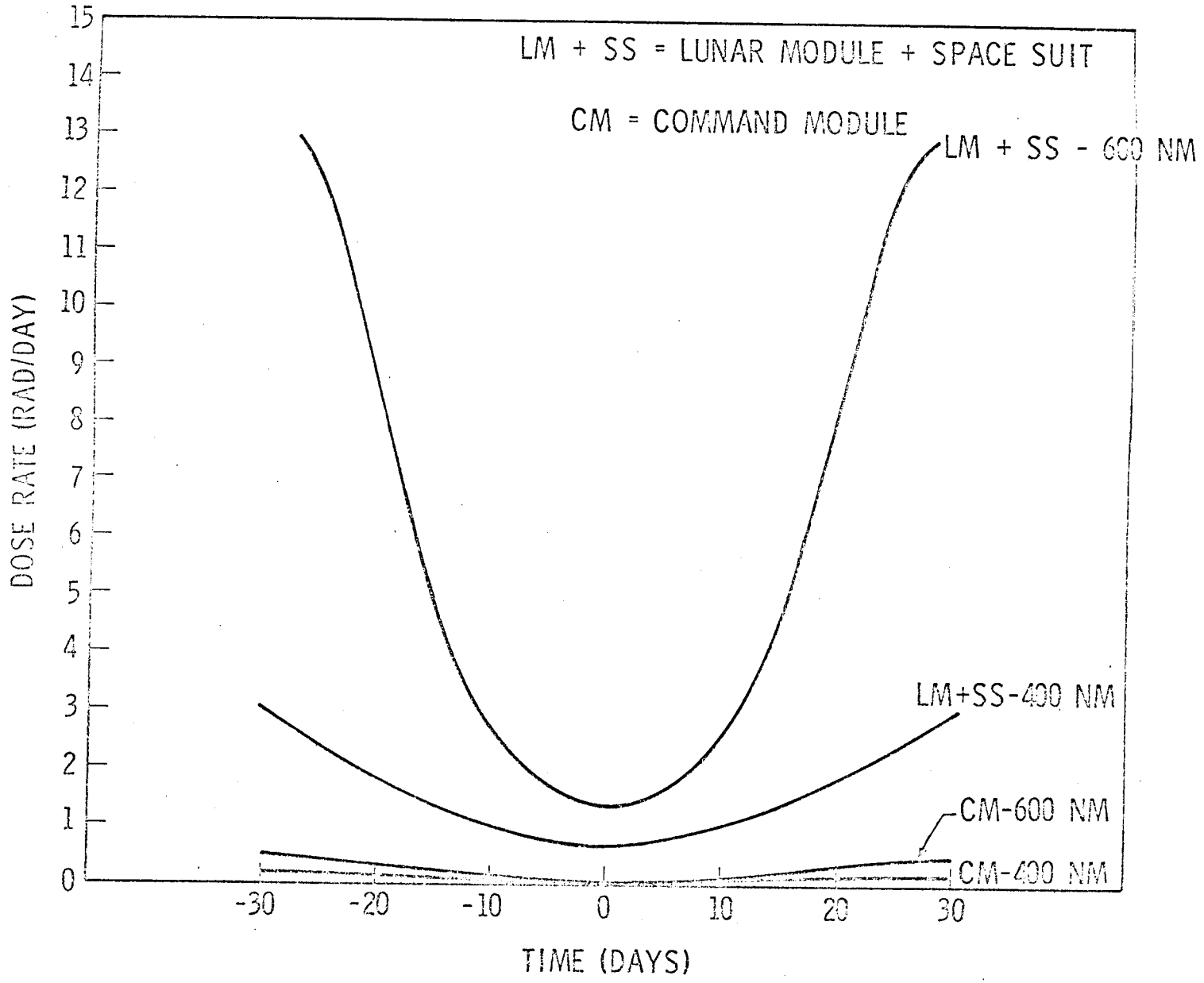
PLANNING

APOLLO E	DOSE LIMITS		
		SKIN	150 RADS (EVA) 250 RADS (CABIN)
		BONE MARROW	35 RADS
		GASTROINTESTINAL TRACT	25 RADS

ATM FILMS

EXPERIMENT	FILM TYPE	DOSE REQUIRED TO PRODUCE STATE FOGGING DENSITY (RAD)
S-052	PAN X	10 (d=0.2)
S-054	PAN X	10 (d=0.2)
S-056	PAN X	10 (d=0.2)
S-082	SWR	15 (d=0.2)
S-083	S0375	20 (d=0.1)
H-ALPHA 1	S0375	20 (d=0.1)

DOSE RATE AS A FUNCTION OF TIME FOR 50^0 INCLINATION ORBITS.
T = 0 CORRESPONDS TO PERIGEE BEING LOCATED AT THE
SOUTHERN MOST POINT OF THE ORBIT



MISSION DOSES

INCLINATION	ORBIT PARAMETERS PERIGEE (NM)	APOGEE (NM)	DURATION (DAYS)	DOSE CM	DOSE LM & SS
28 1/2°	230 - CIRCULAR		56	3	60
50°	150	600	28	3	60
	150	400	28	1	25
	150	400	56	4	90
	375 - CIRCULAR		28	5	100
63.5°	150	300	28	2	34
	225 - CIRCULAR		28	1	28

IMPACT OF COMPUTER SYSTEMS ON LM-ATM/CM-SM MISSION

- SPACEBORNE COMPUTERS
  - LAUNCH VEHICLE DIGITAL COMPUTER (LVDC)
  - COMMAND MODULE DIGITAL COMPUTER (CMC)
  - LM GUIDANCE COMPUTER (LGC)
  - ATM DIGITAL COMPUTER (ATMDC)
- MISSION CONTROL CENTER-HOUSTON SYSTEMS
  - REAL TIME COMPUTER COMPLEX (RTCC)
  - COMMUNICATIONS, COMMAND AND TELEMETRY SYSTEM (CCATS)
  - SIMULATION, CHECKOUT AND TRAINING SYSTEM (SCATS)
  - CONTROL ROOMS AND DISPLAYS

SPACEBORNE COMPUTERS

COMPUTER	MEMORY CAPACITY	CARRIED OVER FROM APOLLO	MARGIN
LVDC	12,000 DUPLEX WORDS	11,250 DUPLEX WORDS	750 DUPLEX WORDS (EXPANDABLE TO 5,000)
CMC	37,000 WORDS	33,000 WORDS	4,000 WORDS
LGC	37,000 WORDS	27,500 WORDS	9,500 WORDS
ATMDC	8K DESIRED (NO MACHINE PROCURED YET)		

COMMENTS-SPACEBORNE COMPUTERS

1. NO LARGE NEW PROGRAMS IDENTIFIED, EXCEPT "2-1/2 STAGES TO ORBIT"
2. CONSIDERABLE MARGINS EXIST BOTH IN MEMORY AND SPEED
3. MARGINS OF LGC WILL BE REDUCED (BUT POSITIVE) IF USED FOR ATMDC FUNCTIONS
4. LEAD TIME REQUIRED FOR DEVELOPING SPACECRAFT COMPUTER SOFTWARE IS 23 MONTHS (MSC)
5. LEAD TIME REQUIRED FOR DEVELOPING LAUNCH VEHICLE COMPUTER SOFTWARE IS 22 MONTHS (MSFC)
6. NO SIGNIFICANT PROBLEMS FOR LM-ATM/CM-SM MISSION THAT DO NOT EXIST FOR OTHER AAP MISSIONS AS WELL

MISSION CONTROL CENTER-HOUSTON

PLANNING CONSTRAINTS WITH PRESENT EQUIPMENT	LIMITING SYSTEMS
○ LIMIT DATA FLOW TO ALDS AND 12 HSD LINES	CCATS
○ PLAN LAUNCHES 10 DAYS APART (EXCEPT DUAL MISSION USING ONE CONTROL ROOM)	SCATS
○ PLAN NO MISSION MORE COMPLEX THAN APOLLO LUNAR LANDING (IN TERMS OF DISPLAYS, COMPUTER LOADING)	RTCC, DISPLAYS
○ PLAN NO MORE THAN TWO MISSIONS UP SIMULTANEOULSY (DUAL MISSION SUCH AS AAP 3-4 COUNTS AS ONE)	# OF CONTROL ROOMS
○ PLAN NO MORE THAN TWO MISSIONS IN 85 DAYS	# OF CONTROL ROOMS & THEIR TURNAROUND TIMES
○ AVOID WORST-CASE SUPPORT OVERLAP OF TWO MISSIONS IN PROGRESS	DISPLAYS

COMMENTS-MCC-H

1. MCC-H CONSTRAINTS ARE NOT PECULIAR TO LM-ATM/CM-SM MISSION

2. CONSTRAINTS WOULD RULE OUT FLYING THIS MISSION SIMULTANEOUSLY WITH INDEPENDENT OWS MISSION AND AN APOLLO MISSION

3. LEAD TIME REQUIRED FOR MCC-H SOFTWARE IS ABOUT ONE YEAR

CONCLUSION ON COMPUTER SYSTEMS

SPACEBORNE AND GROUND COMPUTER SYSTEMS SHOULD PRESENT NO SIGNIFICANT PROBLEMS ABOVE THOSE EXISTING FOR "BASELINE" AAP

STRUCTURE

- BASELINE PROGRAM PROVIDES LM-A CAPABILITY TO SUPPORT SPS BURN
- ATM DESIGN CAN ACCOMMODATE SPS INDUCED - X ACCELERATIONS, .37 g STATIC, + .75 g DYNAMIC. CAPABILITY IS 2.11 g
- ATM LATERAL LOADS WITH YAW STEERING ARE WITHIN SPECIFICATION

ATTITUDE CONTROL

- STUDY BASELINED 10 LBS RCS PROPELLANT PER DAY FOR CMG DESATURATION
- GRAVITY GRADIENT DESATURATION COULD SAVE 200 LBS
- PRELIMINARY ESTIMATE USING RIGID BODY MODEL INDICATES POINTING CONTROL SYSTEM CAN MEET ATM ACCURACY REQUIREMENTS IN PRESENCE OF CREW MOTION DISTURBANCES

SUMMARY OF COMMUNICATIONS & TRACKING SUPPORT
HIGH INCLINATION ATM MISSION

- LAUNCH COVERAGE FOR 50^0 & 63.5^0 INCLINED ORBITS WILL REQUIRE TWO TRACKING SHIPS
- ARIA OR SHIP SUPPORT APPEARS DESIRABLE TO ELIMINATE A 75 MINUTE GAP THAT OCCURS BETWEEN ORBIT INSERTION AND FIRST CONTACT WITH A STATION OF THE MSFN

TYPICAL NETWORK COVERAGE

ORBIT		% TIME IN CONTACT WITH MSFN		NUMBER OF GAPS IN CONTACTS EXCEEDING 90 MINUTES (28 DAYS)*	
		VHF SUPPORT	USB SUPPORT	VHF SUPPORT	USB SUPPORT
210 CIRCULAR	28.5^0	25.3%	28.5%	43	43
150/400	50^0	20.9%	27.4%	9	9
150/600	50^0	31.7%	32.0%	0	0
150/300	63.5^0	12.4%	15.9%	69	38

*90 MINUTES IS THE RECORD CAPABILITY OF ATM TAPE RECORDER

CONCLUSIONS
28 DAY MISSIONS

- SATISFACTORY ALTERNATIVE MISSIONS ARE AVAILABLE WITHOUT MAJOR SYSTEM MODIFICATIONS

  NO YAW STEERING DURING BOOST

  NO SUB-ORBITAL SPS BURN (2-1/2 STAGE CAPABILITY)

- ELLIPTICAL ORBIT 150 x 400 NM, $i = 50^0$ PROVIDES NEAR OPTIMUM SCIENTIFIC YIELD* AND 5 DAYS OF CONTINUOUS SOLAR VIEWING SUMMER SOLSTICE LAUNCH IS REQUIRED

- DEGRADED PERFORMANCE AT NON-OPTIMUM LAUNCH TIMES MEETS THE PRINCIPAL INVESTIGATORS MINIMUM REQUIREMENTS FOR TOTAL SOLAR VIEWING OF 330 HOURS*

- RADIATION IS NOT A PROBLEM FOR THE CREW. DOSEAGE LEVELS FOR FILM ARE LESS OF A PROBLEM THAN FOR THE CLUSTER MISSION - 25 RADS vs. 60 RADS IN THE LM

*FOR 28 DAY ALTERNATIVE MISSIONS.

**O.K. GARRIOTT, VERBAL COMMUNICATION. FROM MARTIN ANALYSIS OF ATM REQUIREMENTS FOR MSFC.

CONCLUSIONS

56 DAY MISSIONS

- PERFORMANCE AND CONSUMABLE LIMITS PERMIT A 56 DAY MISSION AT 150 x 400 NM, $i = 50^0$
- SPS SUBORBITAL BURN IS REQUIRED
- SCIENTIFIC YIELD POTENTIAL IS SUPERIOR TO CLUSTER MISSION
- RADIATION PROBLEM FOR FILM IS DISPROPORTIONATELY INCREASED OVER 28 DAY MISSION, 90 RADS vs. 28 RADS IN LM
- DURATION MAY BE CONSTRAINED BY:
  - LACK OF PRIOR MEDICAL EXPERIENCE BEYOND 28 DAYS
  - CREW VOLUME LIMITATIONS

RECOMMENDATION

- LM-ATM BACKUP MISSION PLANNING BE BASED ON:
  - 28 DAYS DURATION
  - $i = 50^0$
  - ELLIPTICAL ORBIT
  - NO SM SPS SUBORBITAL BURN