N79-76150

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(NASA-CR-104185) ADVANCED LUNAR TRANSPORTATION SYSTEM STUDIES PROGRESS REPORT (Lockheed Missiles and Space Co.) 39 p

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(CODE)
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ADVANCED LUNAR TRANSPORTATION

(UNCLASSIFIED TITLE)

SYSTEM STUDIES

CONTRACT NO. NAS 8-5020

PHASE I PROGRESS REPORT AUGUST 1, 1972

CLASSIFICATION CHANGE
To UNCLASSIFIED
By authority of GDS-GP-4 Date 12/75
Changed by L. Shirley
Classified Document Master Control Station, NASA
Scientific and Technical Information Facility

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Lockheed MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION SUNNYVALE, CALIFORNIA

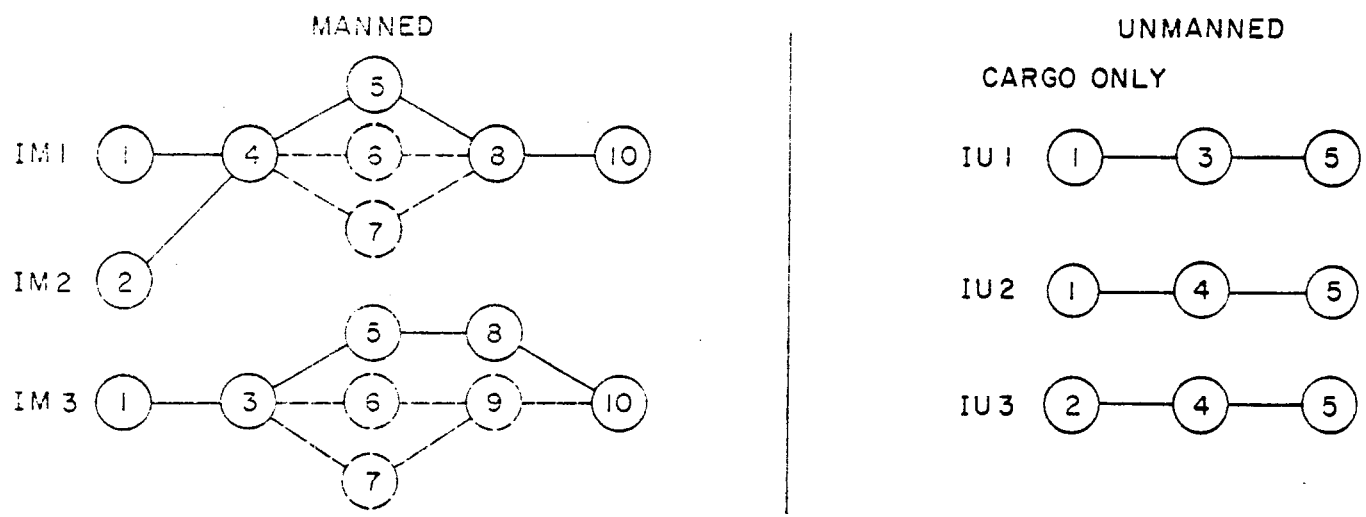
DOWNGRAD[illegible]T 3 [illegible]R INTERVALS;
DECLASSI[illegible]TER 12 YEARS.

[redacted]

C69-2715

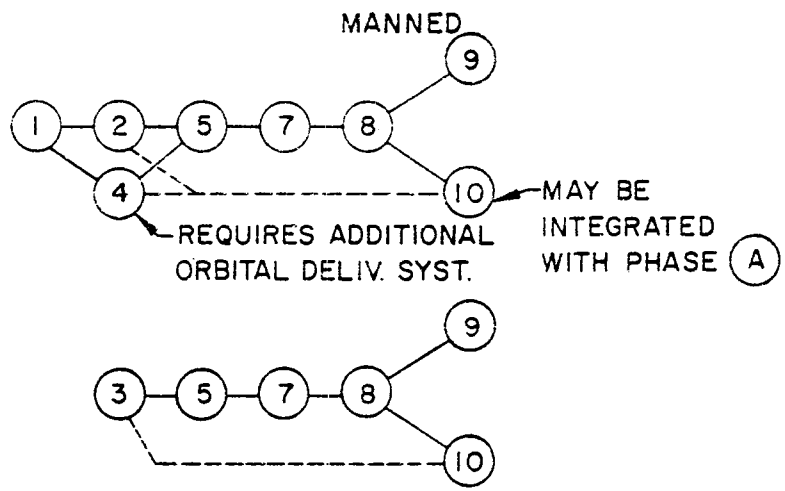
MODE I OPERATIONAL PHASES

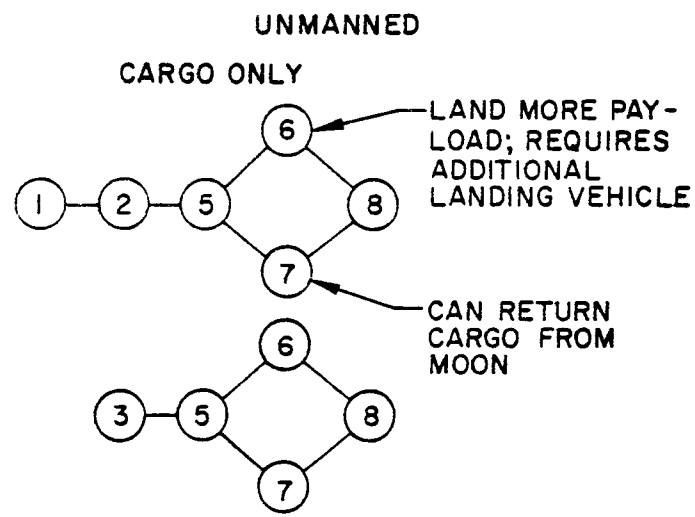
A	B	C	D	E
EARTH LAUNCH TO ORBIT	EARTH ORBIT TO LUNAR ORBIT	ORBIT TO LUNAR SURFACE	RETURN	RE-ENTRY
(1) 2-STAGE C-5 & SUBORBITAL NUCLEAR-STAGE START	(3) NUCLEAR-STAGE TO ORBIT	(5) DIRECT LANDING	(8) CHEMICAL	(10) AERO-DYNAMIC
		(6) RE-USABLE SHUTTLE	(9) NUCLEAR	
(2) 2-STAGE C-5 TO ORBIT	(4) NUCLEAR-STAGE TO INJ. ONLY	(7) "LEM"-TYPE SHUTTLE		



MODE II OPERATIONAL PHASES

A	B	C	D	E
LOAD FERRY IN EARTH ORBIT	EARTH ORBIT TO LUNAR ORBIT	ORBIT TO LUNAR SURFACE	RETURN TO EARTH ORBIT	LAND FROM ORBIT
(1) C-5 TANKER (2) C-5 PAYLOAD TRANSP. (3) C-5 COMBINATION (4) ORBITAL TRANSP. SYSTEM (TO BE STUDIED)	(5) NUCLEAR STAGE	(6) DIRECT (7) RE-USABLE SHUTTLE	(8) NUCLEAR STAGE	(9) FERRY-BORNE ENTRY STAGE (10) RENDEZVOUS WITH EARTH-LAUNCHED RE-ENTRY VEH.





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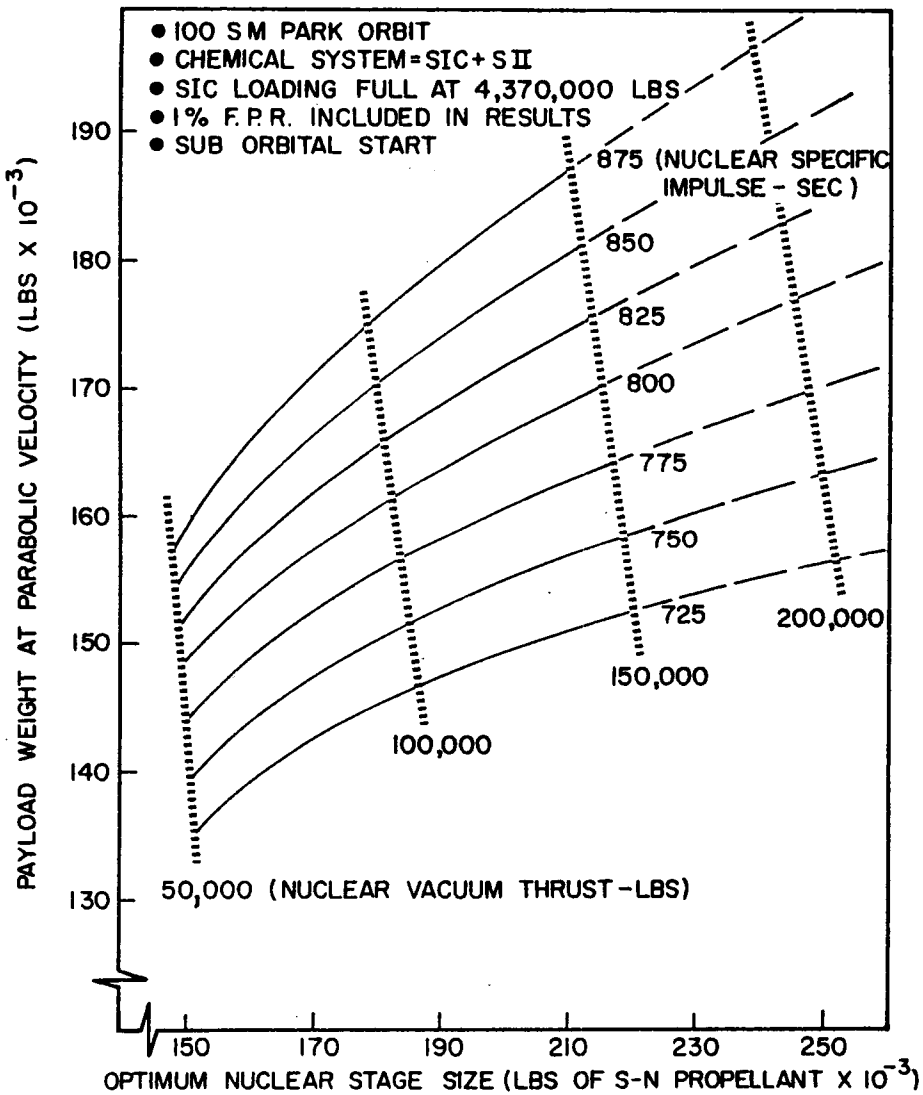
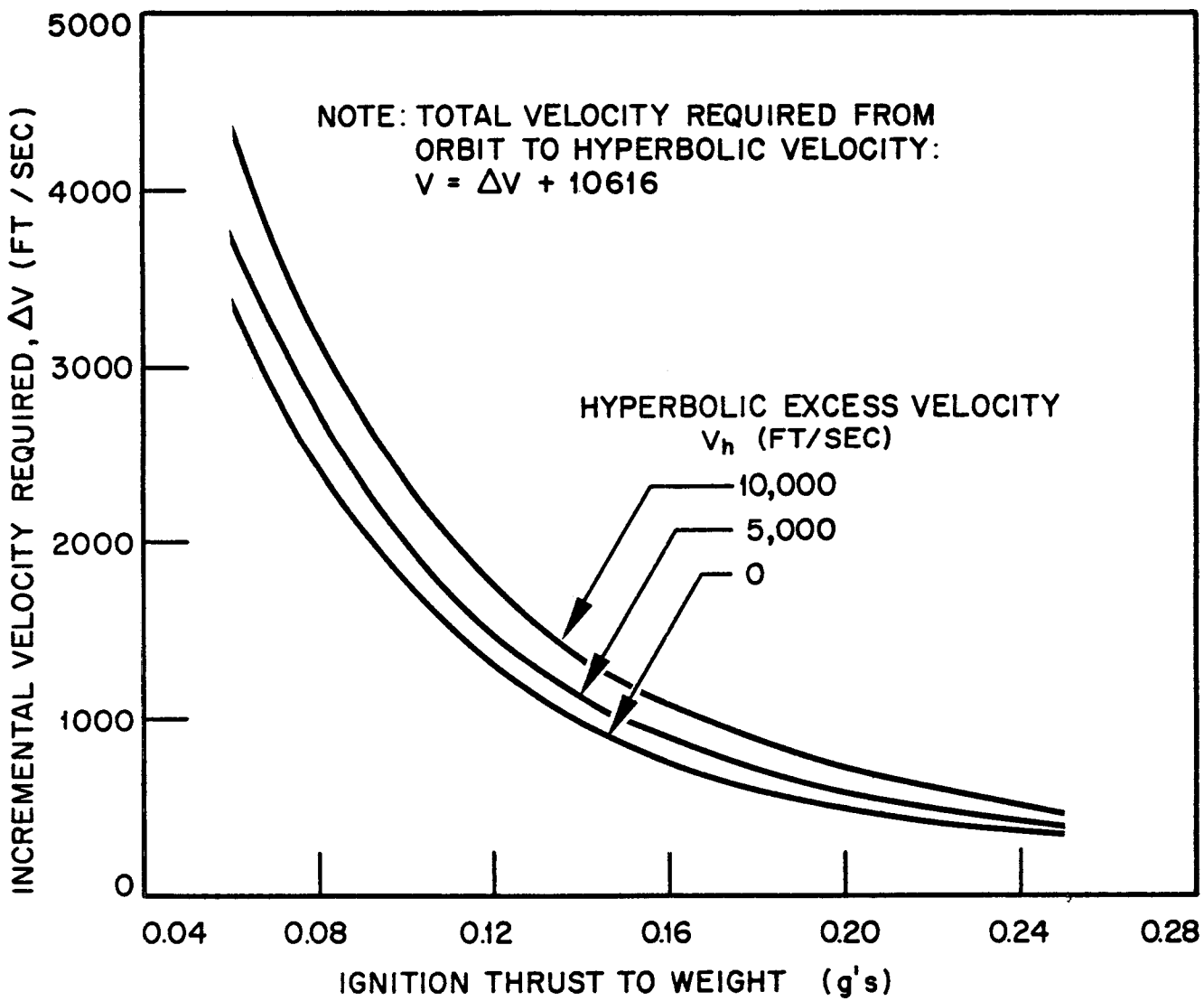


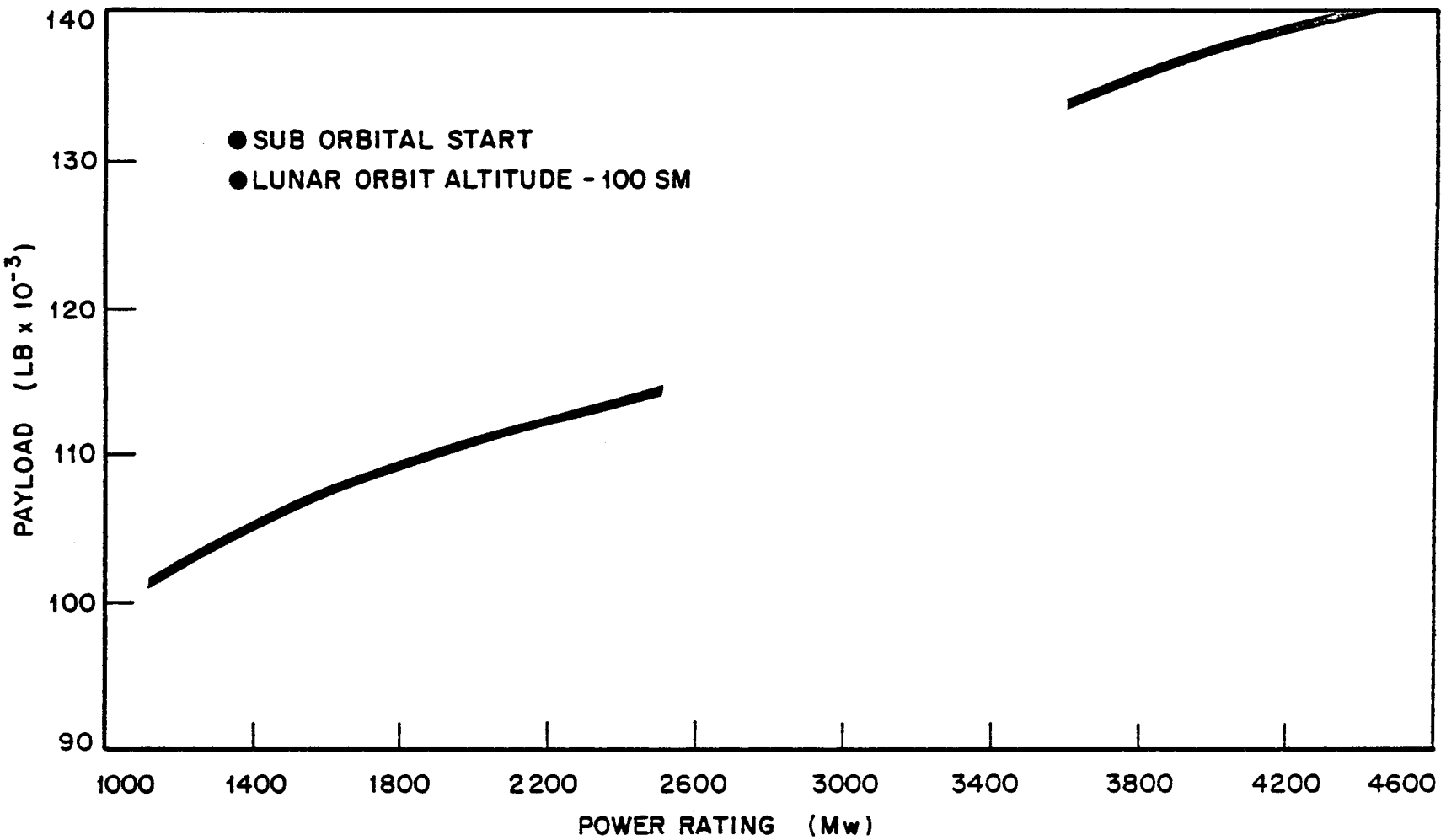
NUCLEAR STAGE ESCAPE PERFORMANCE

[redacted]



PERFORMANCE REQUIREMENTS TO ESCAPE FROM 100 S MILE ORBIT

~~CONFIDENTIAL~~



PAYLOAD IN LUNAR ORBIT

~~CONFIDENTIAL~~

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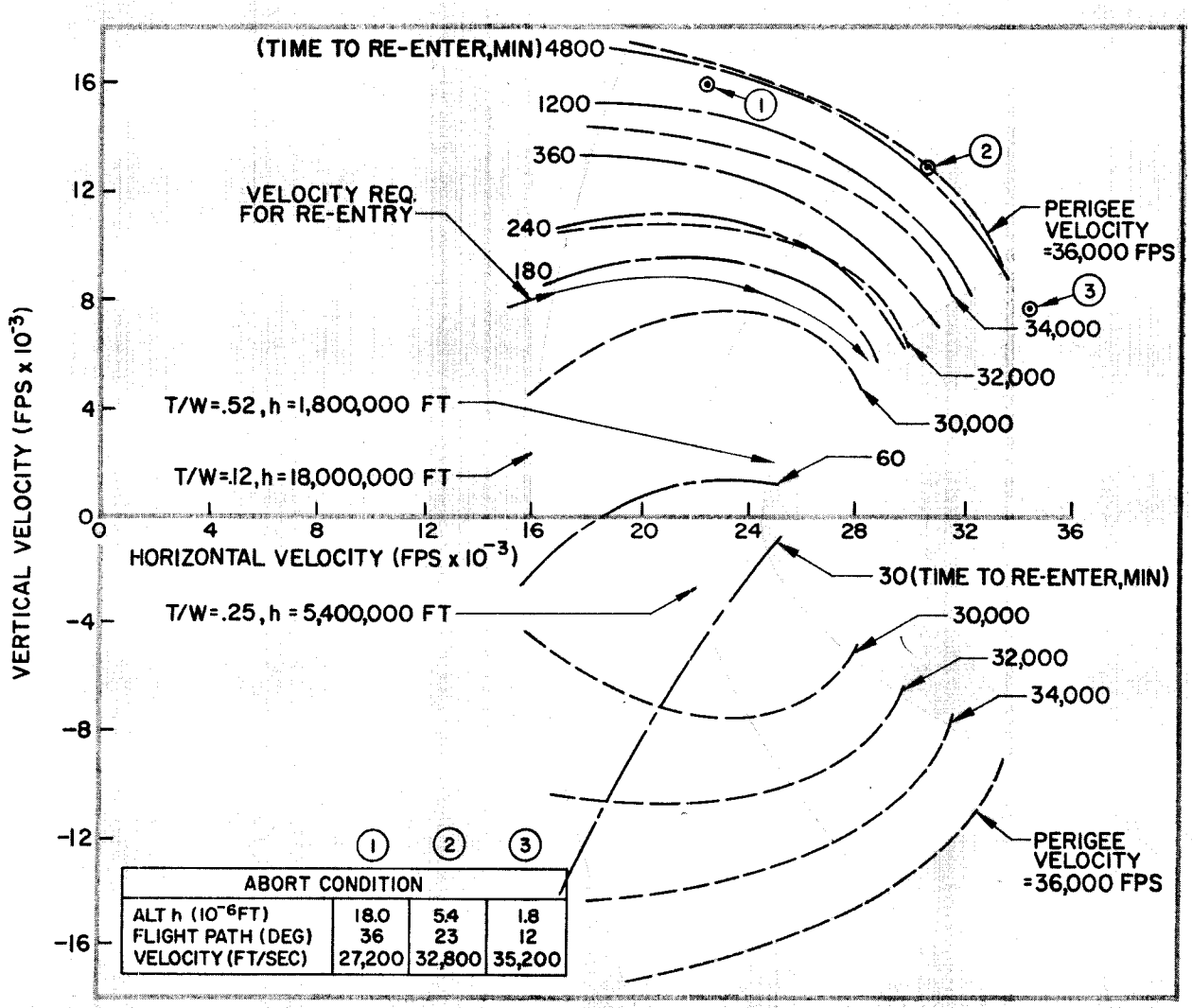
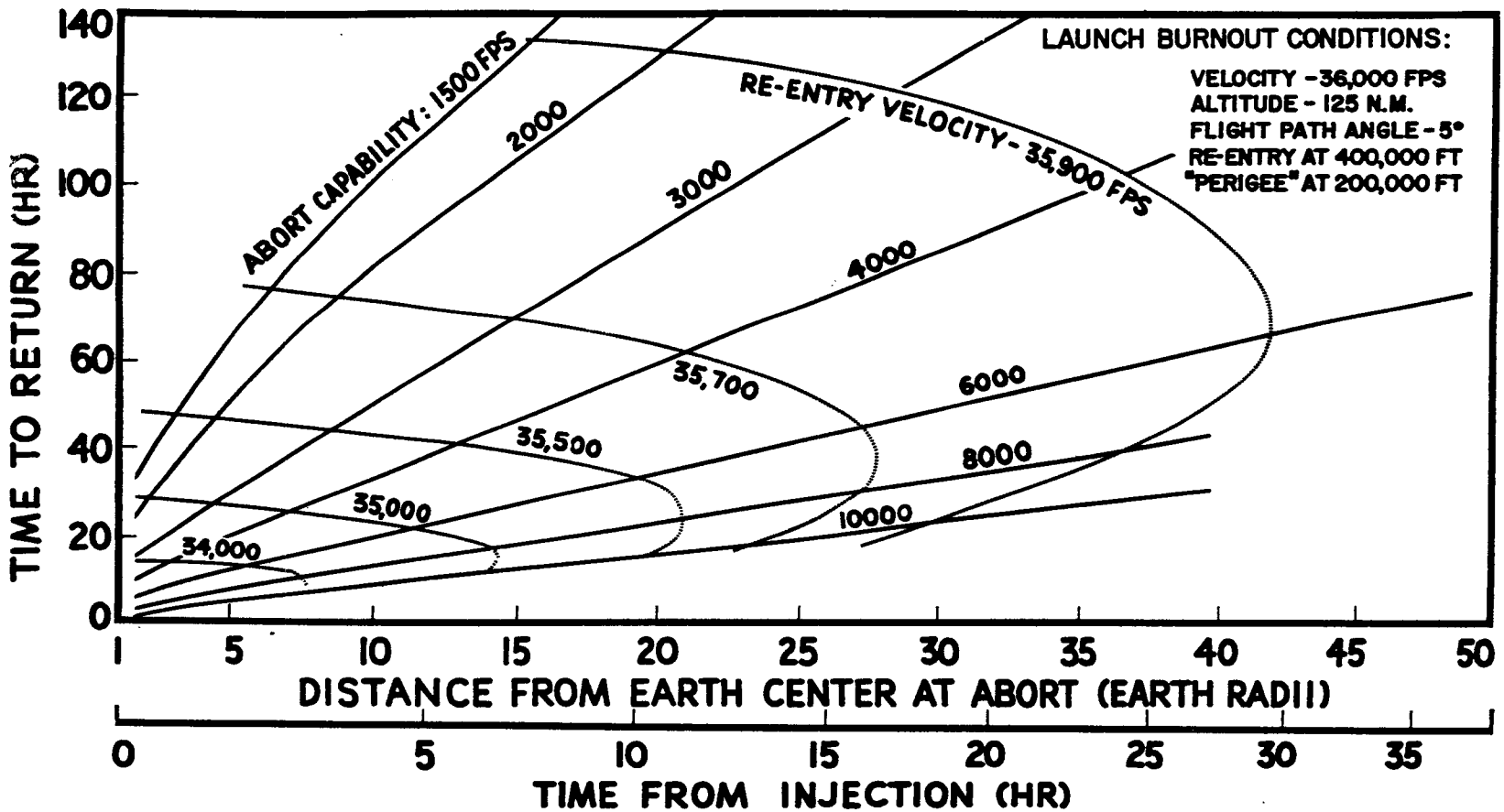


IMPULSIVE ABORT REQUIREMENTS DURING ESCAPE

UNCLASSIFIED

TRANSLUNAR ABORT CHARACTERISTICS



UNCLASSIFIED

VELOCITY REQUIREMENTS (FPS)

MODE I

	IM1		IM2		IM3		IM4	
PHASE OF MISSION	NUC	CHEM	NUC	CHEM	NUC	CHEM	NUC	CHEM
SUB-ORBITAL TO ESCAPE	19,000		11,000		19,000		19,000	
NUCLEAR STAGE DISPOSAL	200		200					
MID COURSE CORRECTION		230		230	230		230	
RETRO TO LUNAR ORBIT		3,500		3,500	3,500		3,500	
*DEORBIT TO 50,000 FT PERILUNE		460		460		460		460
*PLANE CHANGE		190		190		190		190
RETRO TO ZERO VELOCITY		5,900		5,900		5,900		5,900
HOVERING		700		700		700		700
TAKE-OFF TO LUNAR ORBIT		5,900		5,900		5,900		5,900
*CIRCULARIZATION		460		460		460		
*PLANE CHANGE		190		190		190		
*RENDEZVOUS & NAV. ALLOWANCE		500		500		500		
ESCAPE LUNAR ORBIT							2,700	
EARTH RETURN FROM LUNAR ORBIT		3,500		3,500	3,500*			3,500
MIDCOURSE CORRECTION		230		230		230		230
3% FPR	570		336		787		763	

*REQUIRED FOR LUNAR ORBIT RENDEZVOUS ONLY
(100 Mi ORBIT ALTITUDE)

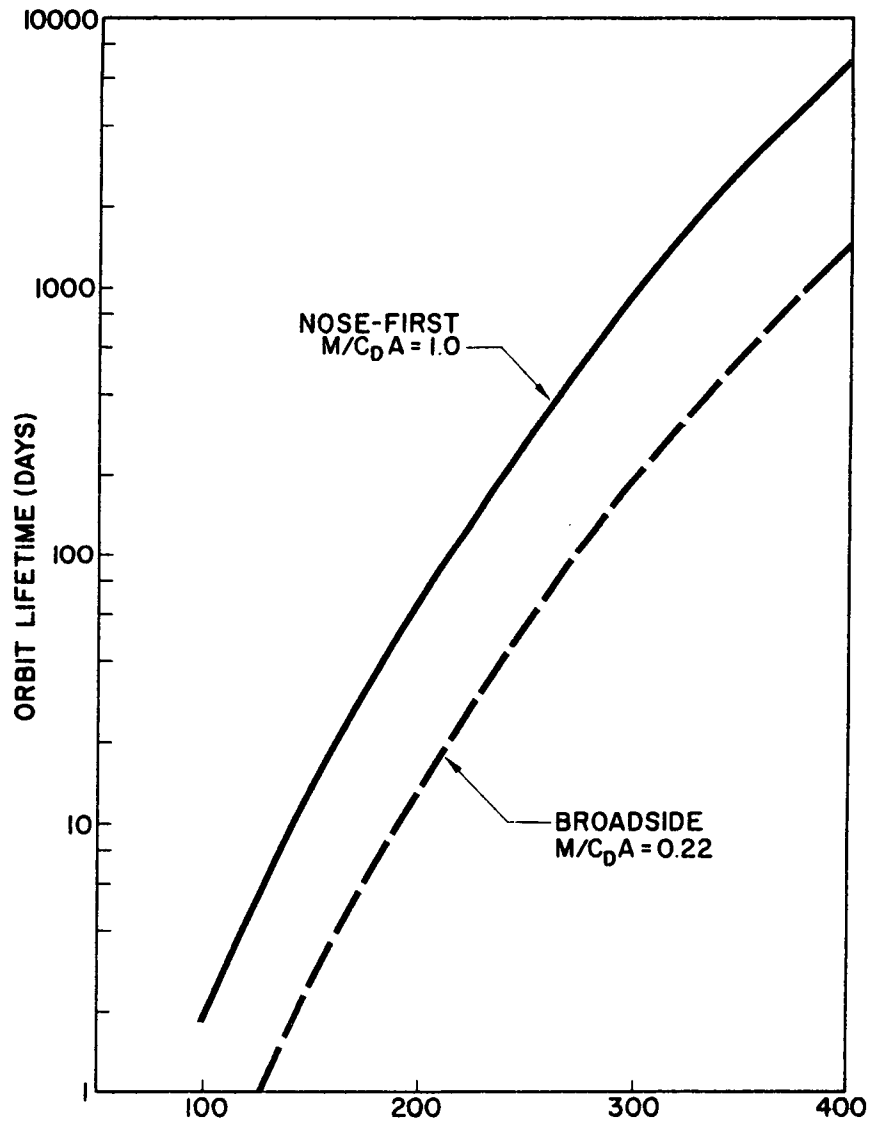
VELOCITY REQUIREMENTS (FPS)
MODE II

FERRY VEHICLE

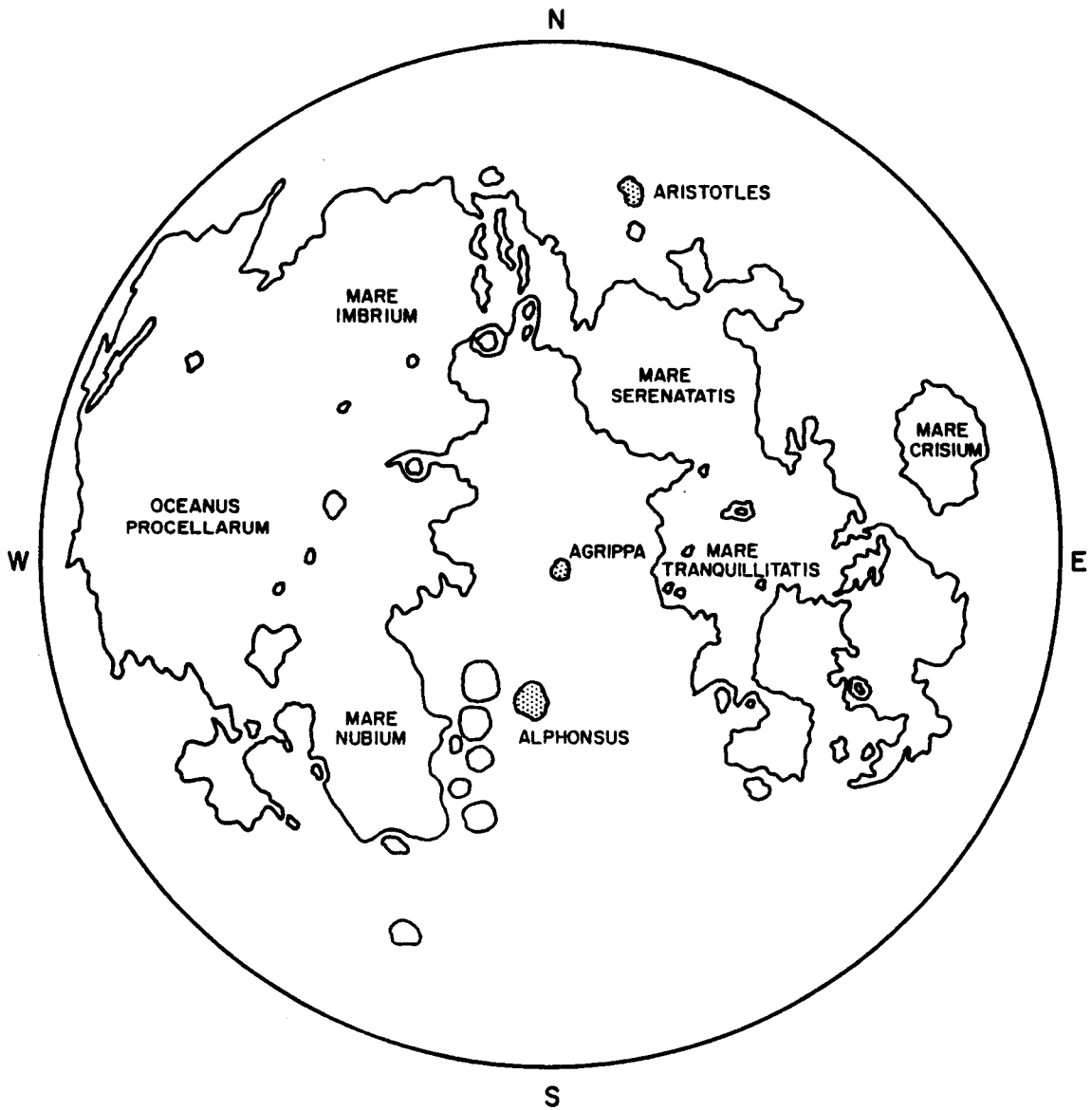
PHASE OF MISSION	NUCLEAR
EARTH ORBIT TO ESCAPE	11000
MIDCOURSE CORRECTION	230
RETRO TO LUNAR ORBIT	3500
PLANE CHANGE REQMTS (30°)	1700
EARTH RETURN FROM LUNAR ORBIT	3500
MIDCOURSE CORRECTION	230
RETRO TO EARTH ORBIT	11000
3% FPR	923

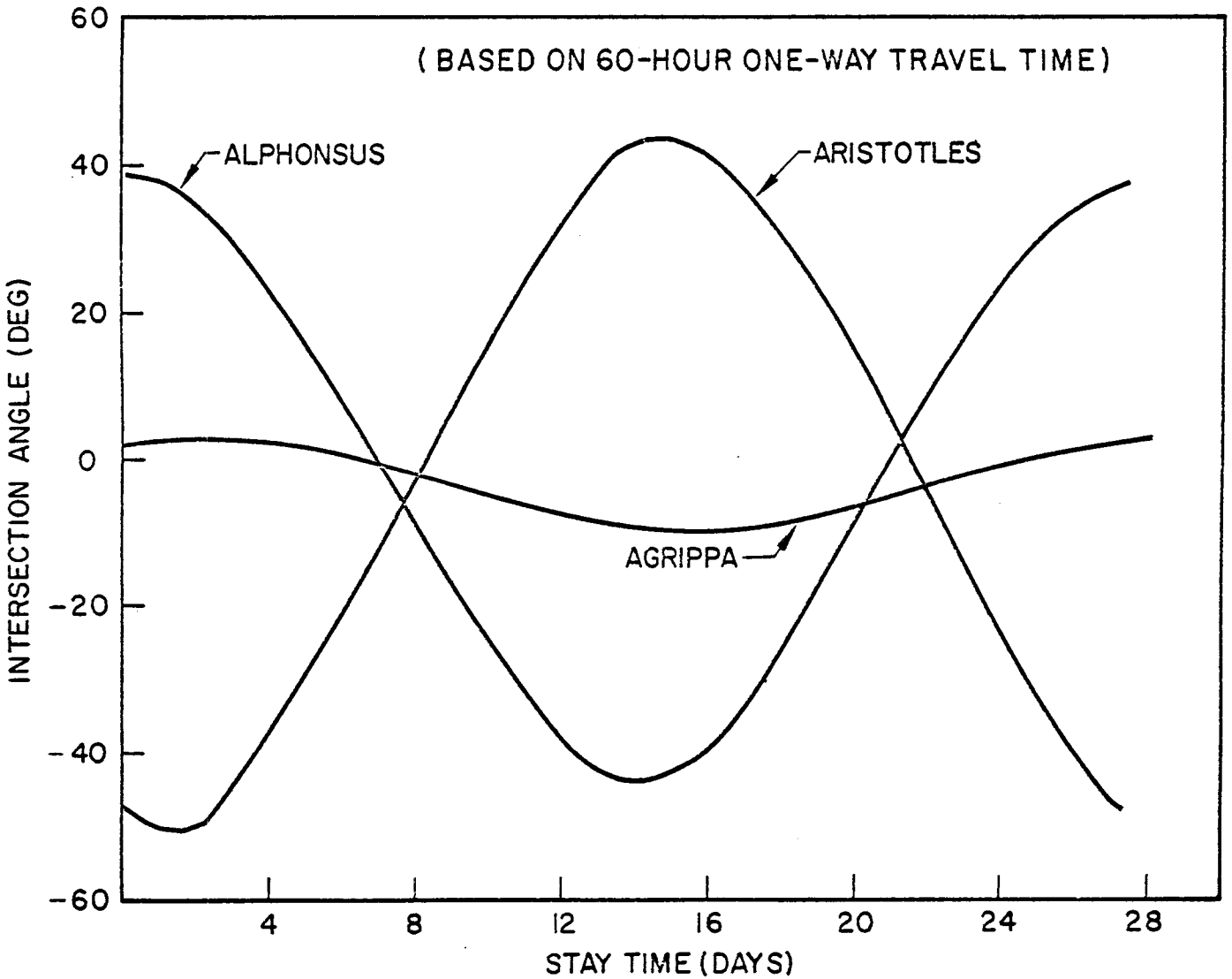
LUNAR SHUTTLE

PHASE OF MISSION	CHEMICAL
TAKE-OFF TO LUNAR ORBIT	5900
CIRCULARIZATION	460
PLANE CHANGE	190
RENDEZVOUS & NAV. ALLOWANCE	500
DE-ORBIT TO 50,000 FT PERILUNE	460
PLANE CHANGE	190
RETRO TO ZERO VELOCITY	5900
HOVERING	700
3% FPR	430

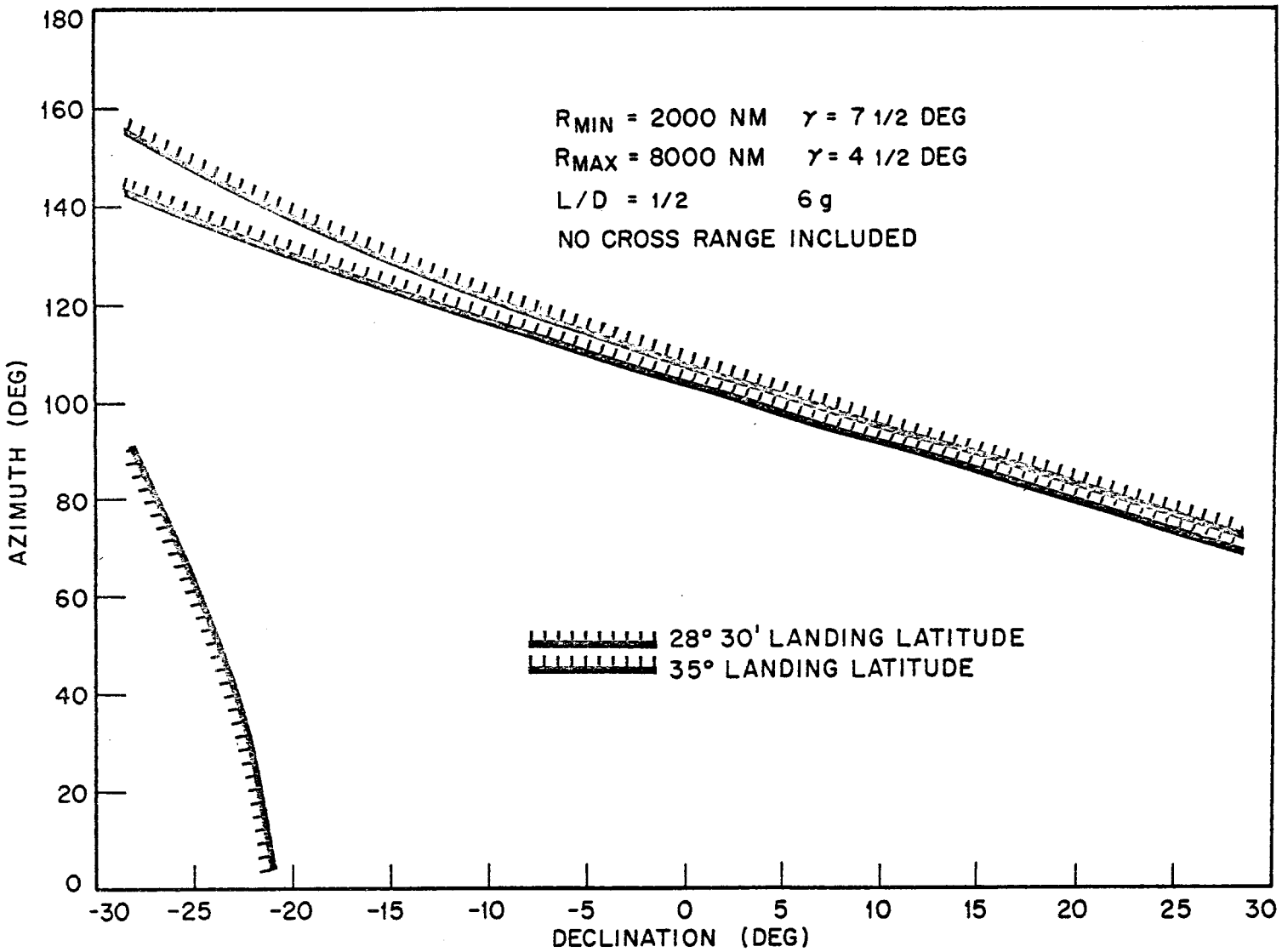


FERRY ORBIT LIFETIME, MODE II

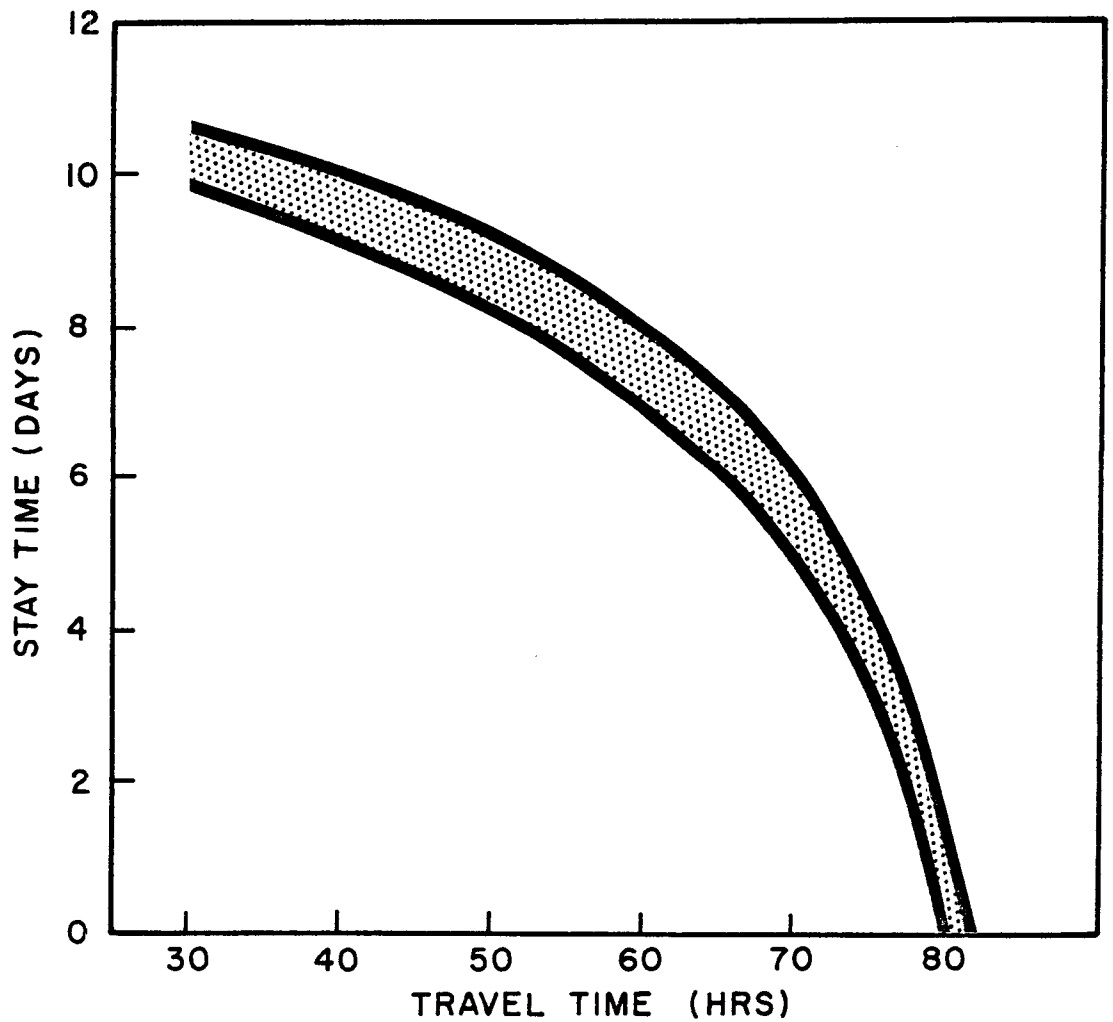

N
S
W
E
ARISTOTLES
MARE IMBRIUM
MARE SERENATATIS
MARE CRISIUM
OCEANUS PROCELLARUM
AGRIPPA
MARE TRANQUILLITATIS
MARE NUBIUM
ALPHONSUS



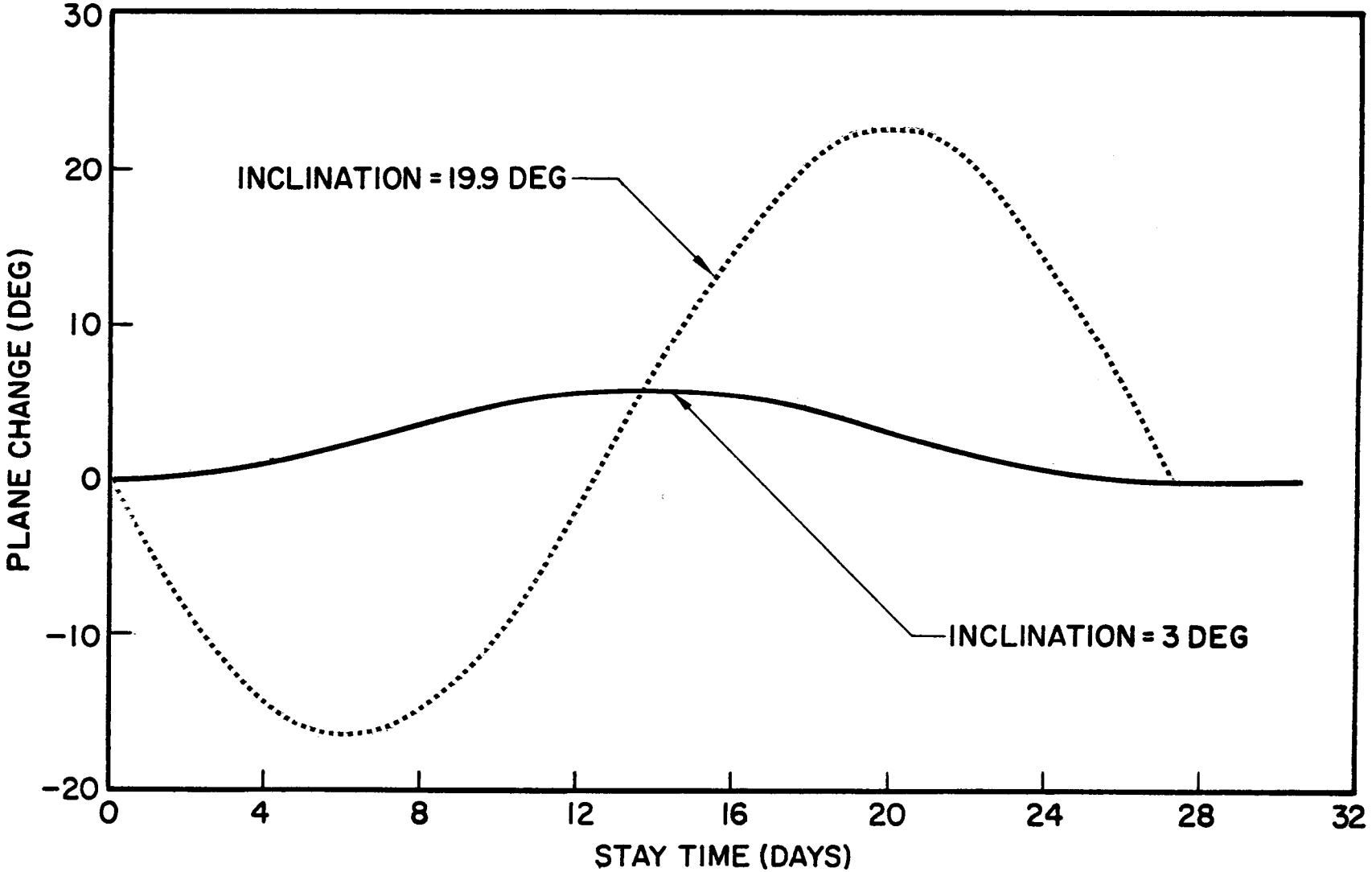
INTERSECTION ANGLE BETWEEN DEPARTURE ASYMPTOTE AND FERRY ORBIT PLANE



EARTH RETURN CONDITIONS FOR APOLLO TYPE REENTRY

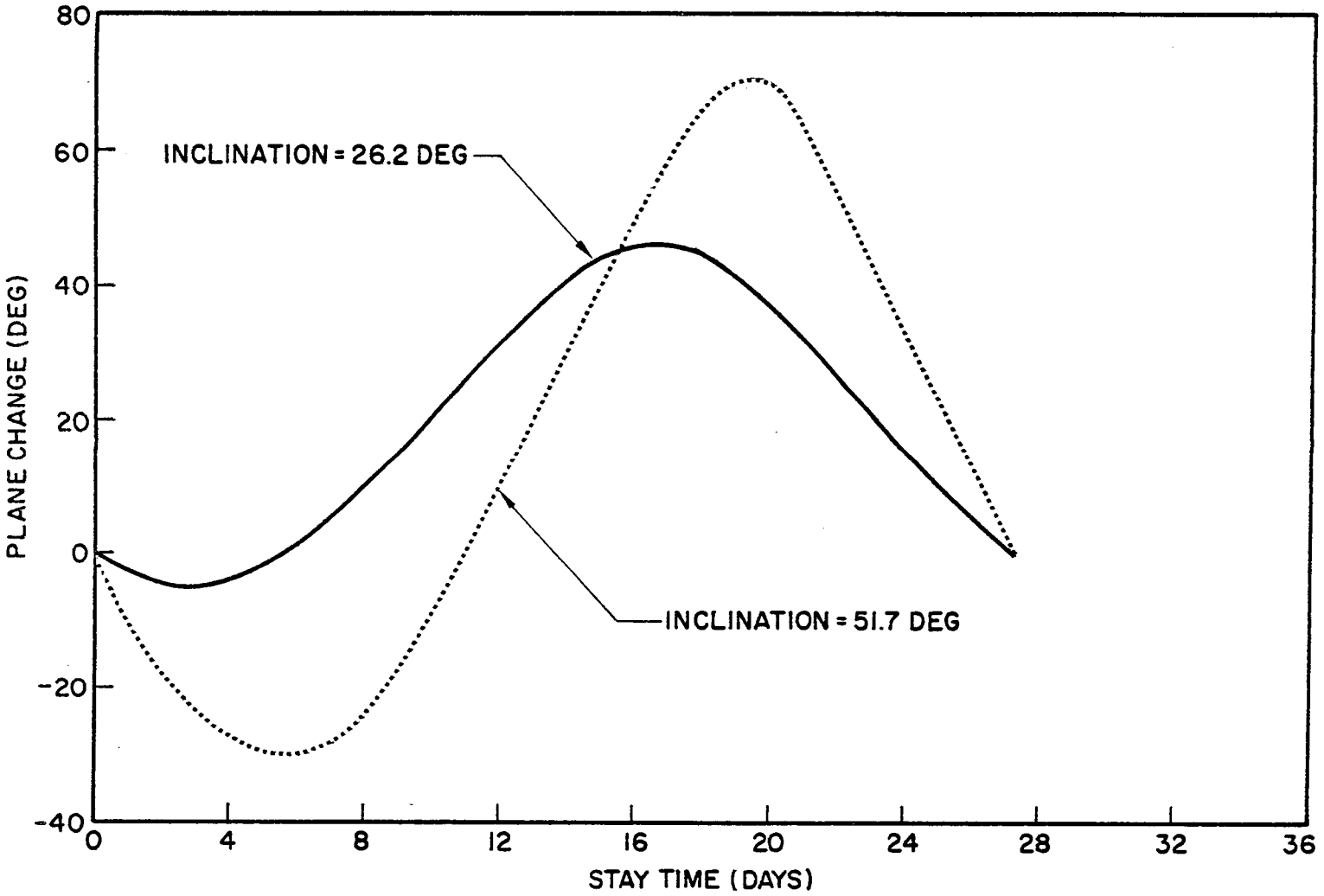


STAY TIME REQUIRED FOR FERRY ORBIT PLANE
TO CONTAIN DEPARTURE ASYMPTOTE



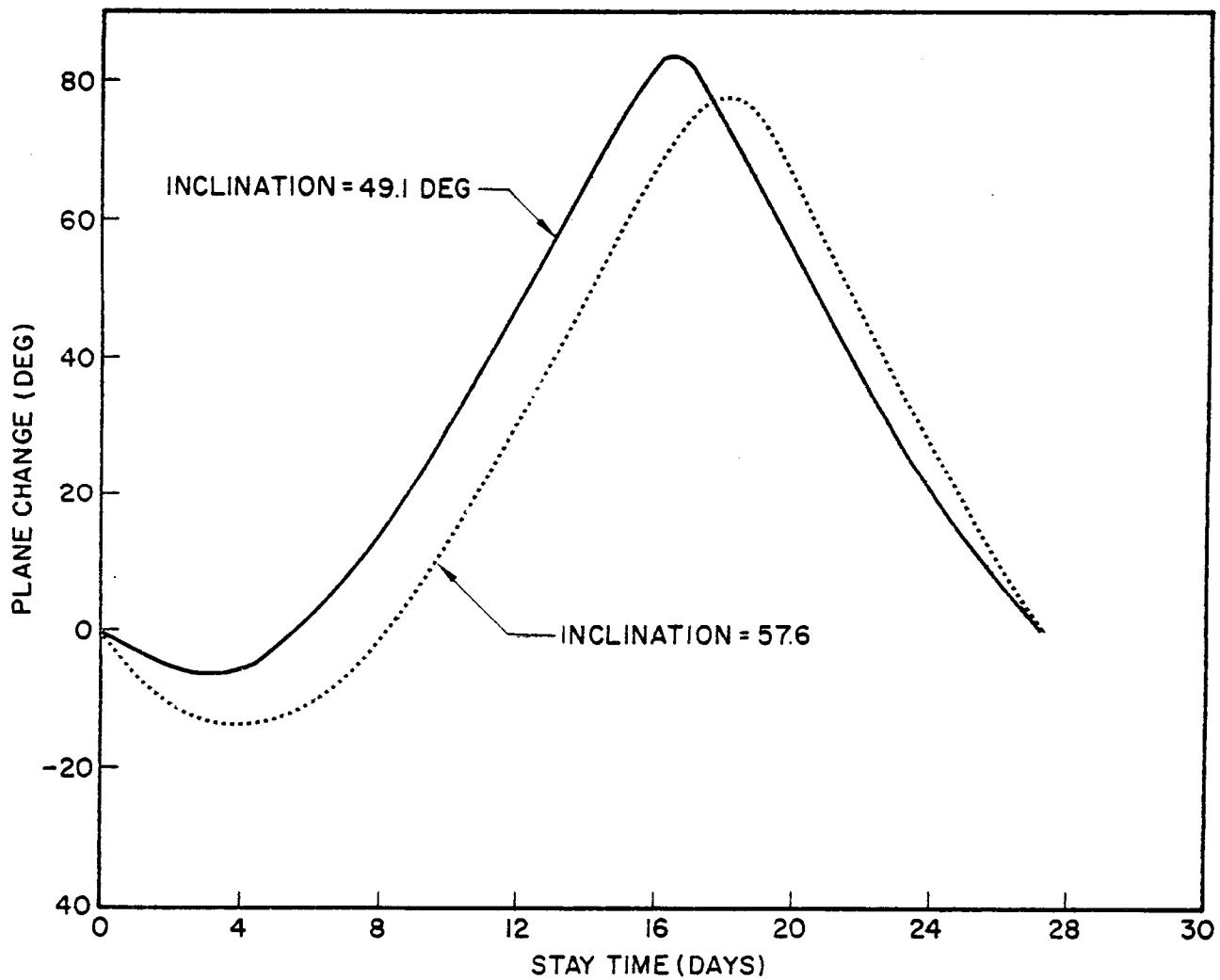
SHUTTLE PLANE CHANGE REQUIREMENT

AGRIPPA, 3 DEG S. LATITUDE



SHUTTLE PLANE CHANGE REQUIREMENT

ALPHONSUS, 21 DEG S. LATITUDE



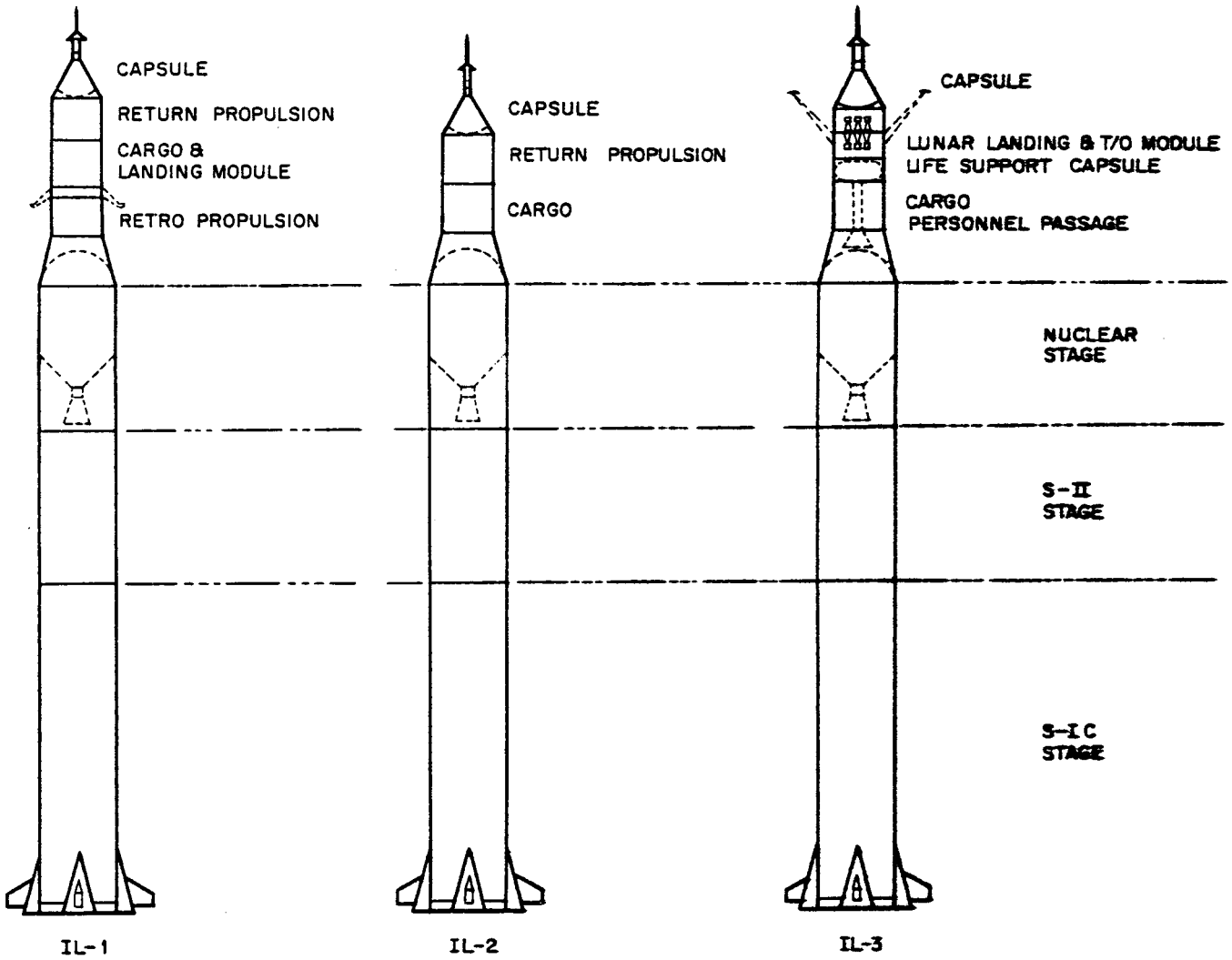
SHUTTLE PLANE CHANGE REQUIREMENT

ARISTOTLES, 43 DEG N. LATITUDE

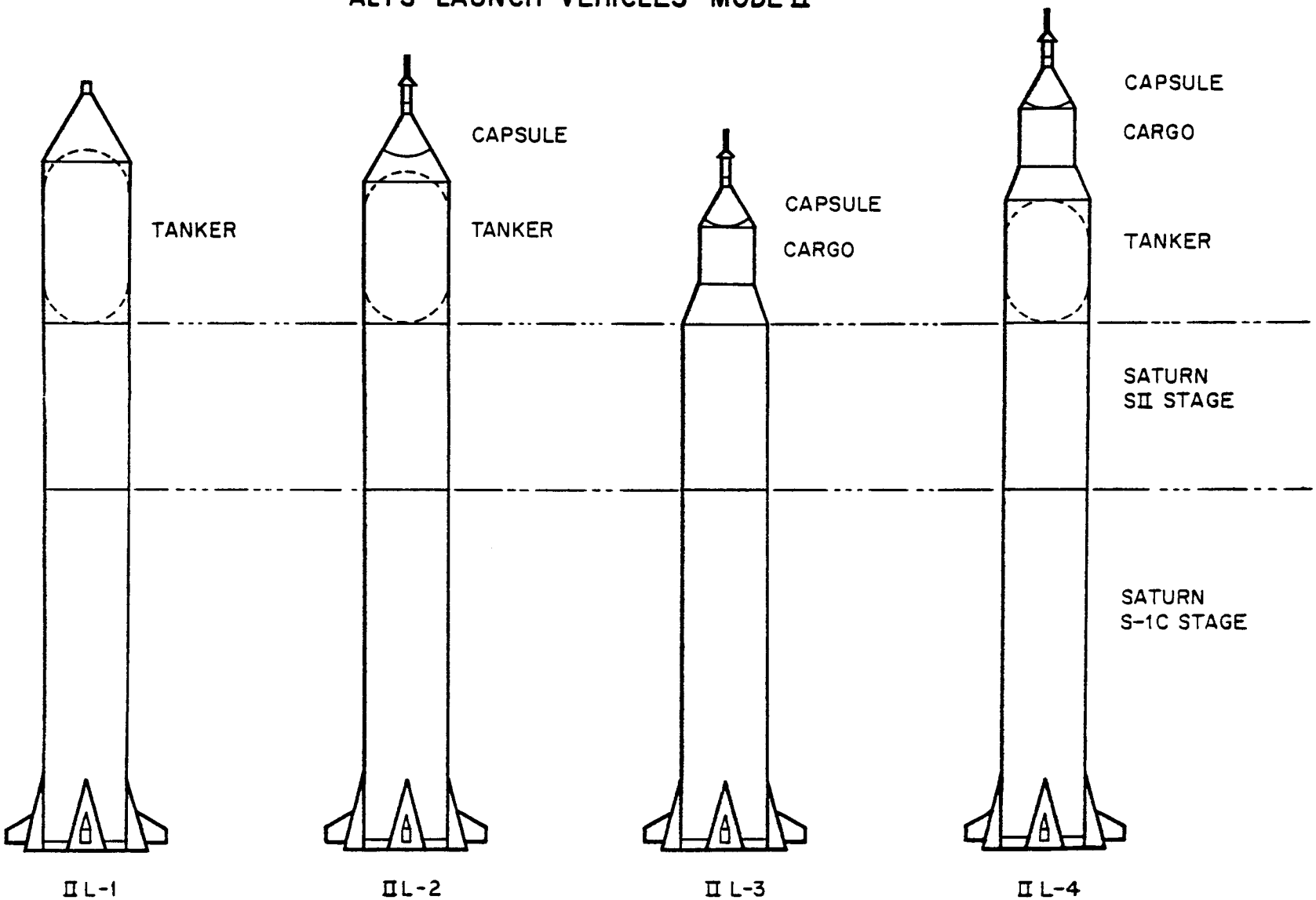
VEHICLE CONFIGURATION SUMMARY ALTS.

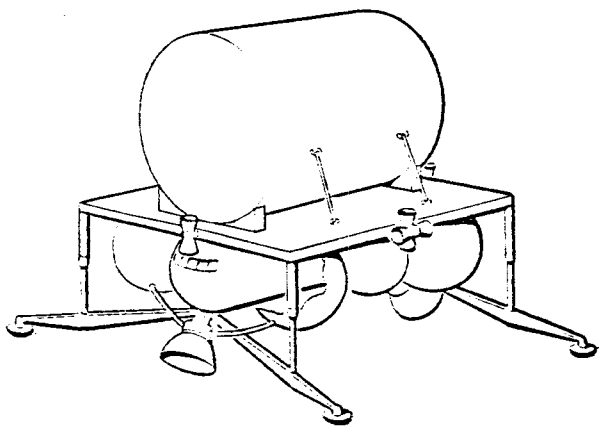
	CONFIG NUMBER	DESCRIPTION	FUNCTION	STAGES I	STAGES II	STAGES III	STAGES UPPER
LAUNCH VEHICLE	I L-1 I L-2 I L-3	Apollo Type With Direct Landing Approach. Apollo Type With LEM Type Landing Operation. Apollo Type With Lunar Based Shuttle Operation.	Mode I • Delivery of cargo & men to lunar surface. • Return of men from lunar base to earth.	S-IC	S-II	Nuclear	See Sketches
LAUNCH VEHICLE	II L-1 II L-2 II L-3 II L-4A II L-4B	Unmanned Tanker. Manned Tanker. Manned Cargo Vehicle. Combination Vehicle Tanker/Cargo/Man. Combination Vehicle Tanker/Cargo.	Mode II • Delivery of fuel, cargo, and men to orbiting ferry vehicle.	S-IC	S-II	None	See Sketches
FERRY	II F-1A II F-1B	"Life Boat" and Separate Command Capsule. Command Capsule Integrated in "Lifeboat".	• Navigates from earth orbit to lunar orbit with passengers and cargo. • Returns passengers from lunar orbit to earth orbit. • Carries provisions for abort whenever manned. • Has provisions for rendezvous and transfer of personnel and cargo to and from earth launched vehicles and lunar shuttle vehicles.	Nuclear Stage and Payloads			
FERRY	II F-2A II F-2B II F-2C	Permanent Command Capsule, Re-Entry Body of Orbital Delivery System Is Attached to Ferry Vehicle Variations in Geometry.					
FERRY	II F-3A II F-3B	No Command Capsule. All Ferry Vehicle Controls and Life Support Systems are Contained in Re-Entry Body.					
SHUTTLE	I S-1	Apollo Type Landing System.	• Land passengers and cargo from launch vehicle on lunar surface. • Return passengers to earth.	See Sketch I L-2			
SHUTTLE	I S-2	LEM Type Shuttle Vehicle.	• Land passengers and cargo from launch vehicle on lunar surface. • Return passengers to lunar orbit.	See Sketch I L-3			
SHUTTLE	II S-1 II S-2 II S-3	Square "Flat Bed" Configuration. Delta Configuration. Propulsion Package Rudimentary. Landing Gear.	• Shuttle from ferry vehicle to lunar surface with passengers and cargo.	Single Chemical Stage			

ALTS LAUNCH VEHICLES-MODE I

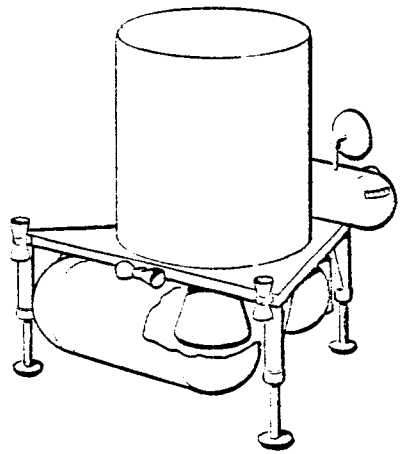


ALTS LAUNCH VEHICLES-MODE II

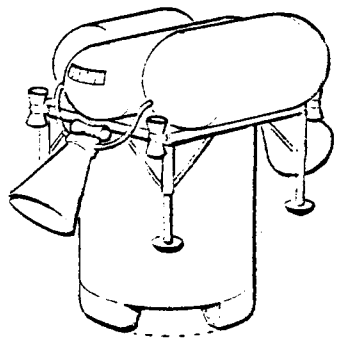




II S-1



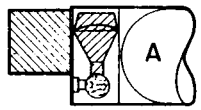
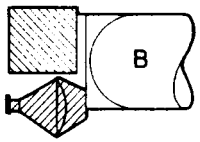
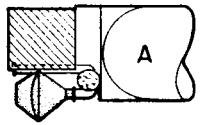
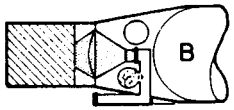
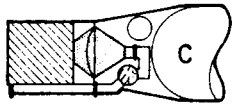
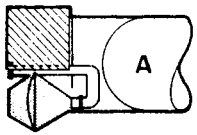
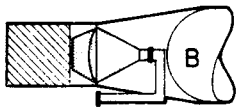
II S-2

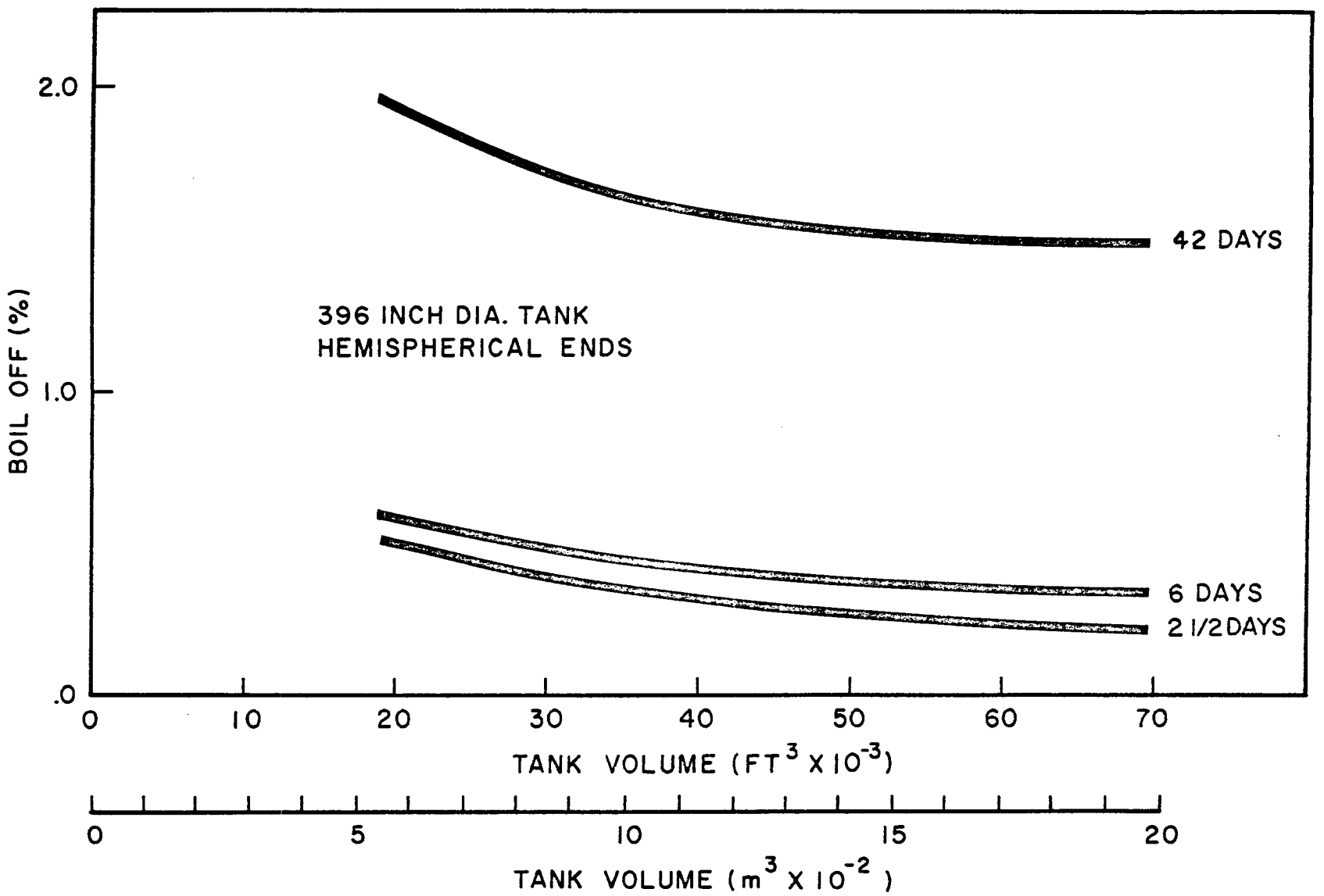


II S-3

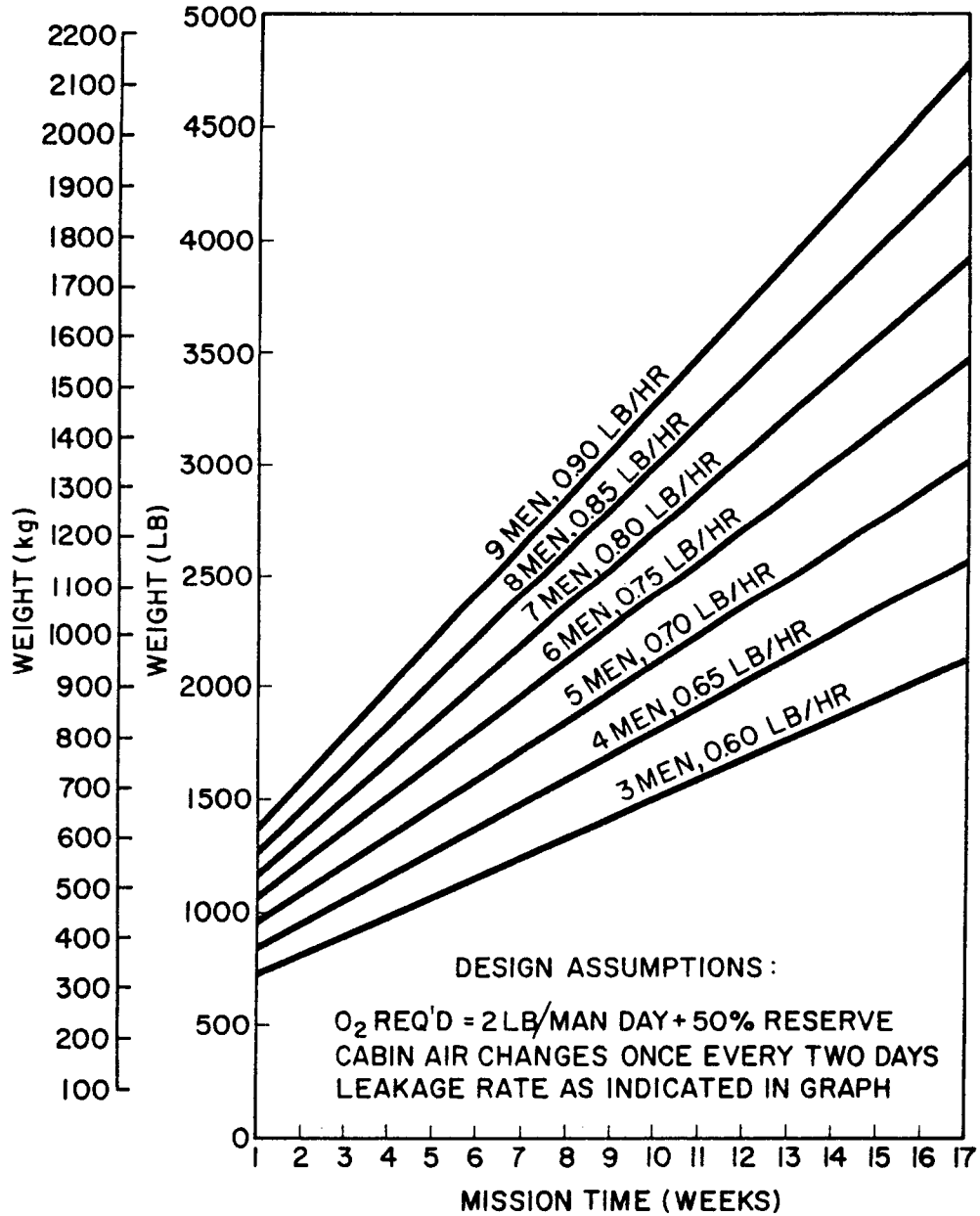
SHUTTLE VEHICLE CONFIGURATIONS

FERRY VEHICLE SUMMARY-ALTS

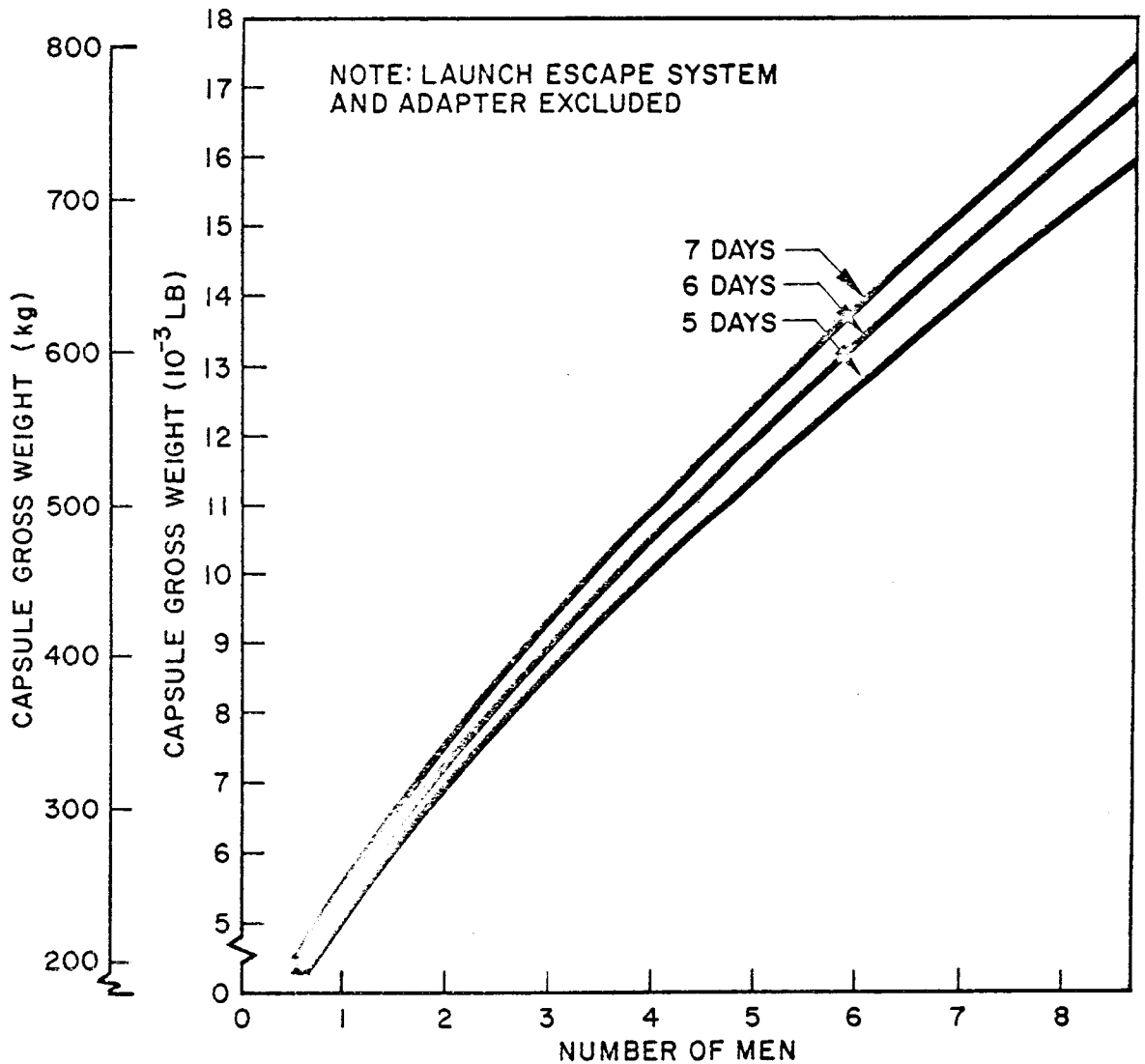
FERRY CONFIGURATION		CREW TRANSFER IN EARTH ORBIT	PERMANENT COMMAND CAPSULE	COMPATIBLE SHUTTLE VEHICLE
IIF-1		YES	YES	IIS-1 IIS-2
			NO	IIS-1
IIF-2		NO	YES	IIS-1
				IIS-1 IIS-2
				IIS-3
IIF-3		NO	NO	IIS-1
				IIS-1 IIS-2



LIQUID HYDROGEN BOIL-OFF
AS A FUNCTION OF TANK VOLUME AND STORAGE TIME



ENVIRONMENTAL CONTROL SYSTEM WT
AS FUNCTION OF TIME AND NO. OF MEN



CAPSULE WEIGHT VS NUMBER OF MEN
FOR MISSION TIME OF 5, 6, AND 7 DAYS

MODE I – ASSUMPTIONS FOR PRELIMINARY BASE SIZING

MAINTENANCE PHASE

MIXTURE OF MANNED AND UNMANNED FLIGHTS

N – NO. MEN AT BASE n – MEN/FLIGHT

L – NO. FLIGHTS/YEAR w_c – CARGO/MAN-YEAR

BUILD-UP PHASE

L_m – NO. MANNED FLIGHTS REQUIRED

L_u – NO. UNMANNED FLIGHTS REQUIRED

10 TONS/MAN FACILITIES

1 TON/MAN DELIVERED WITH MEN FOR 6-MO. LIFE SUPPORT

NO BASE IMPROVEMENT DURING BUILD-UP

DESIRE SAME RETURN VEHICLE (n) FOR BUILD-UP AND MAINTENANCE

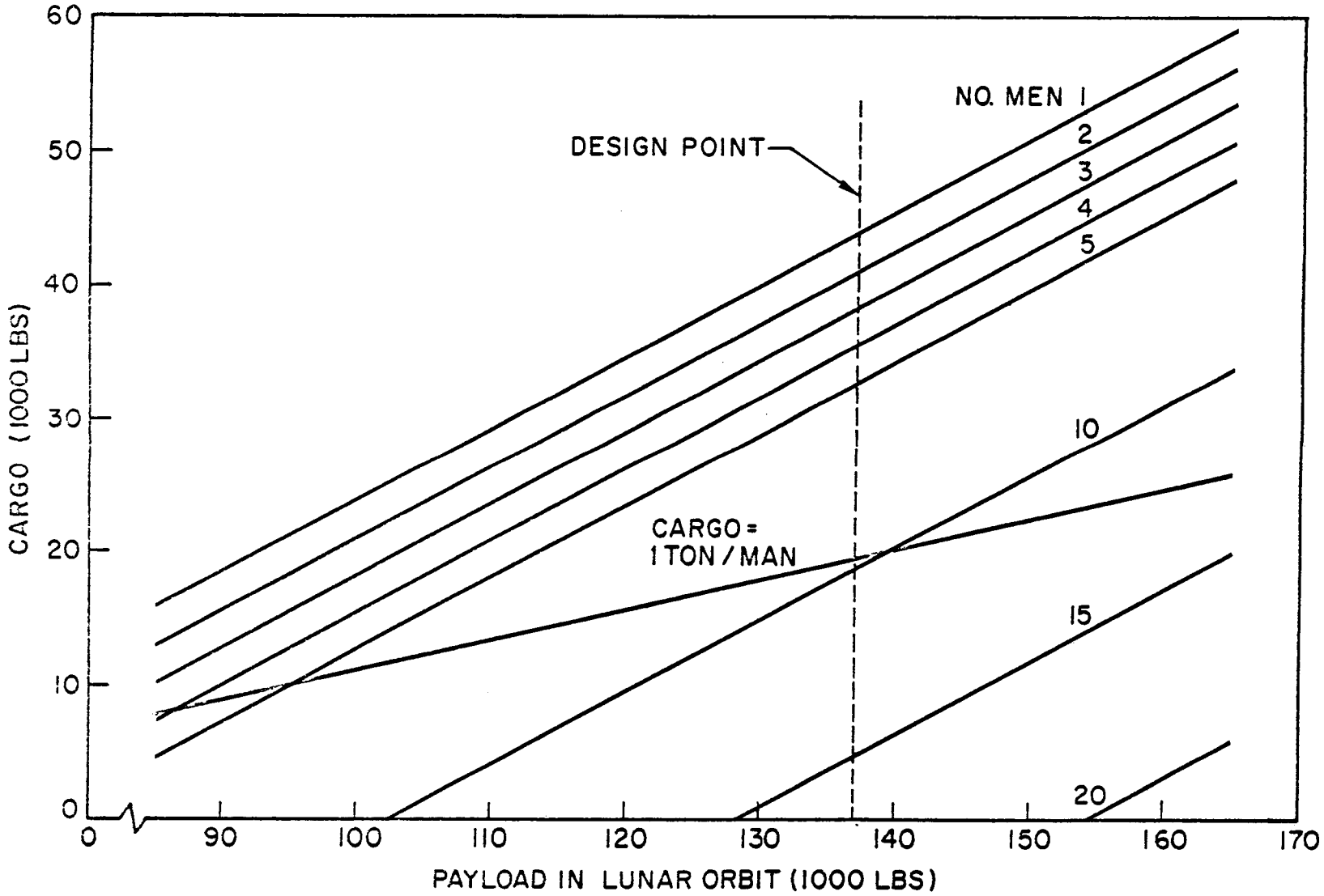
VEHICLE PARAMETERS

W_o – PAYLOAD IN LUNAR ORBIT

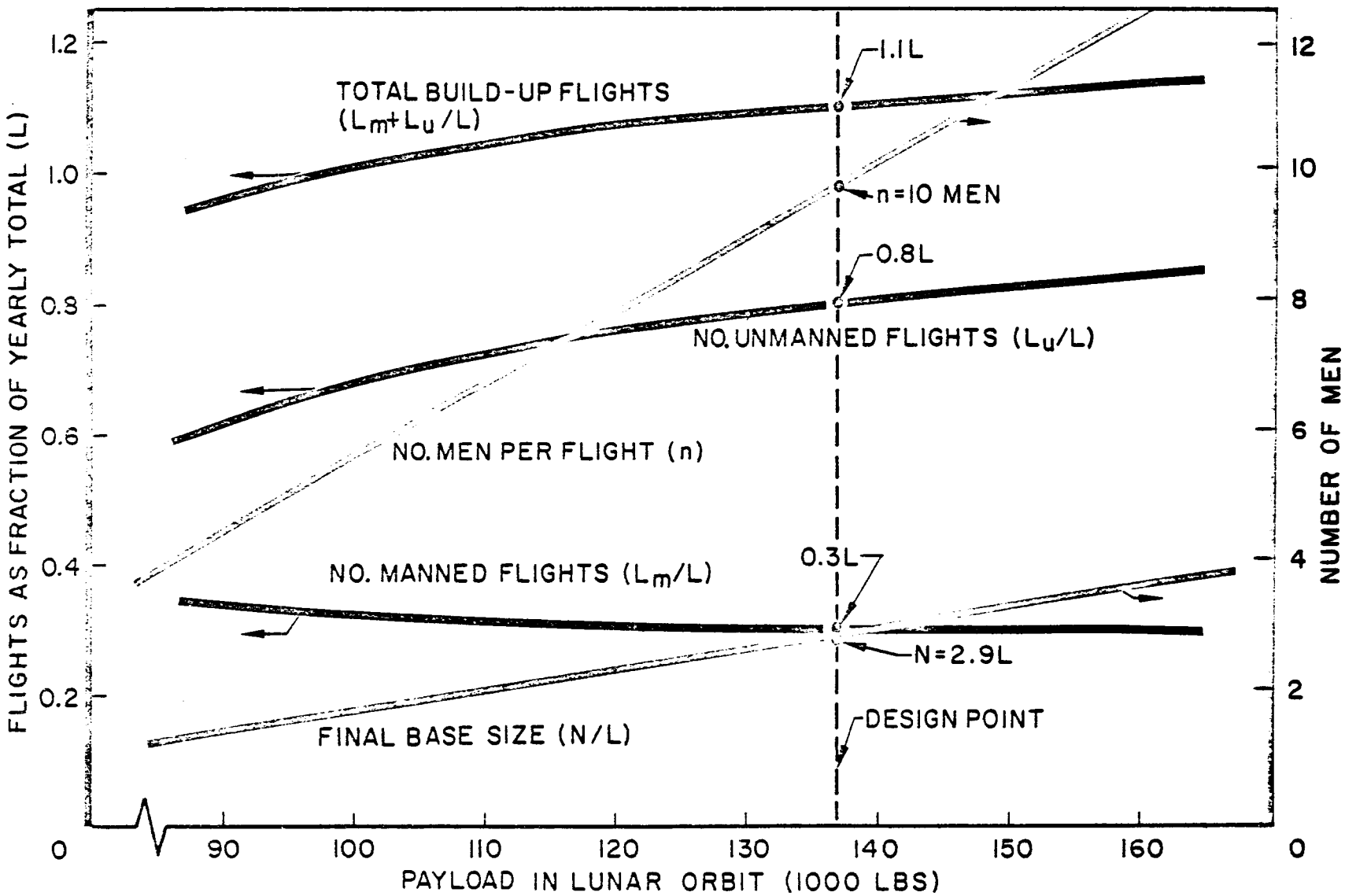
STAGE INERT = 15% PROPELLANT WEIGHT I_{SP} = 420 SEC

ΔV LANDING – 7000 fps ΔV LAUNCH – 11000 fps

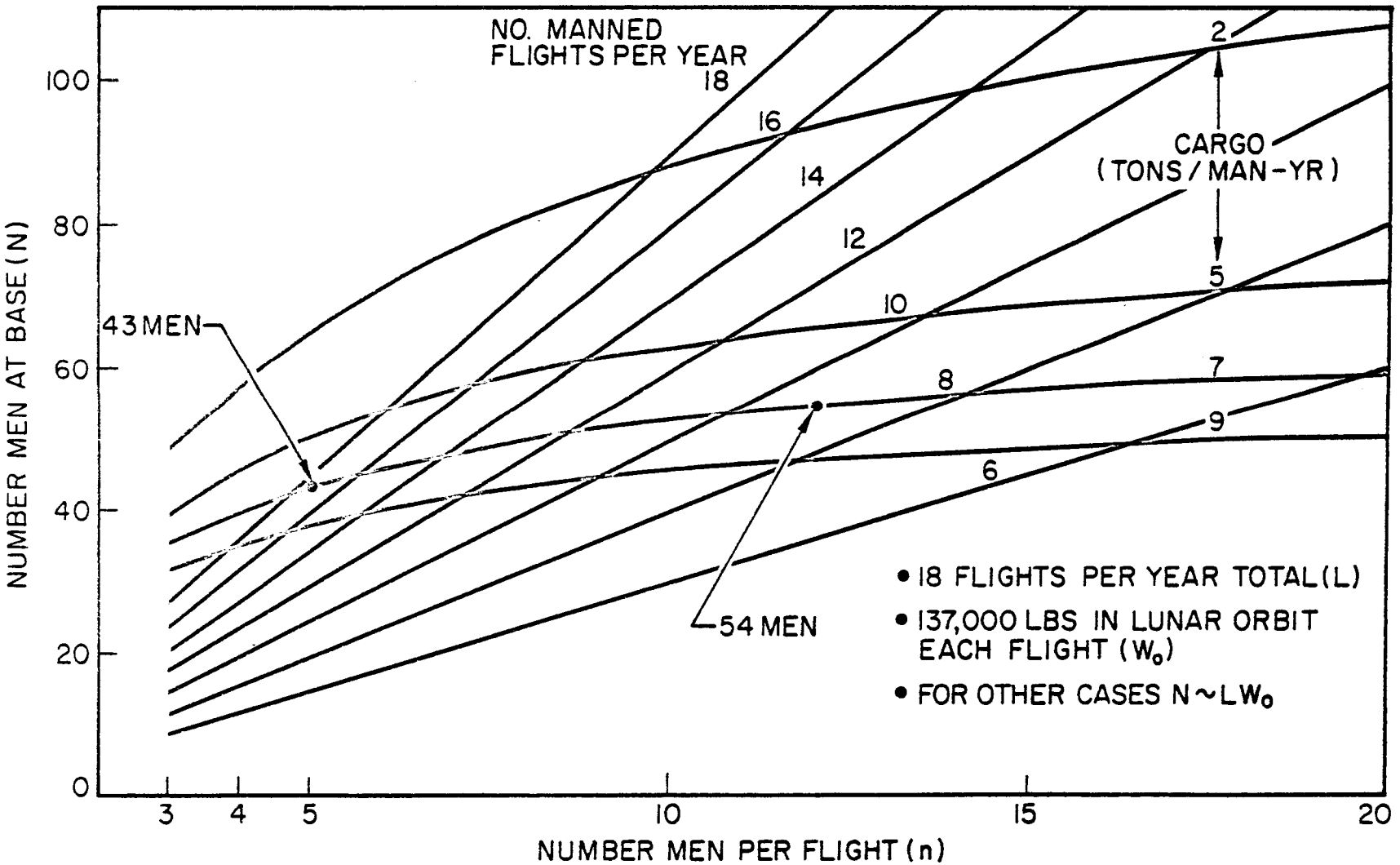
RETURN PAYLOAD REQUIRED = 9500 + 1000 n lbs



MODE I DIRECT MANNED LANDING PAYLOADS



MODE I BASE BUILD-UP OPERATIONS



MODEI PERFORMANCE FOR BASE MAINTENANCE AND IMPROVEMENT

MODE II PARAMETRIC STUDY – ASSUMPTIONS

- MANNED COMPARTMENT/REV PUT ON FERRY EACH TRIP
- MAINTENANCE MODE ONLY WITH SEQUENCE OF IDENTICAL FLIGHTS
- NO BACK-UP LAUNCHES
- MISSION VELOCITIES:
  - FERRY OUTBOUND OR RETURN – 14500 FPS
  - SHUTTLE LAUNCH OR LANDING – 7000 FPS
- SHUTTLE PROPELLANT CAPACITY BASED ON DESCENT LOADED + ASCENT EMPTY + DESCENT EMPTY TO PROVIDE FOR MISSED RENDEZVOUS
- PARAMETERS WITH NOMINAL VALUES WHERE APPLICABLE:

N = NO. MEN AT BASE, EXCLUSIVE OF CREW

R = NO. ROTATIONS PER YEAR (2)

w_1 = LIFE SUPPORT REQ. (2TONS/MAN YEAR); w_b = BASE IMPROVEMENT REQ (5 TON/MAN YEAR)

L = NO. C-5 LAUNCHES AVAILABLE PER YEAR (18)

P_o = PAYLOAD SUPPLIED TO FERRY BY ONE C-5 LAUNCH (200,000 LB)

M = NO. C-5 LAUNCHES PER FERRY TRIP; m = NO. SHUTTLE LAUNCHES PER FERRY TRIP

C_f = NO. FERRY CREW (2) ; C_s = NO. SHUTTLE CREW (2)

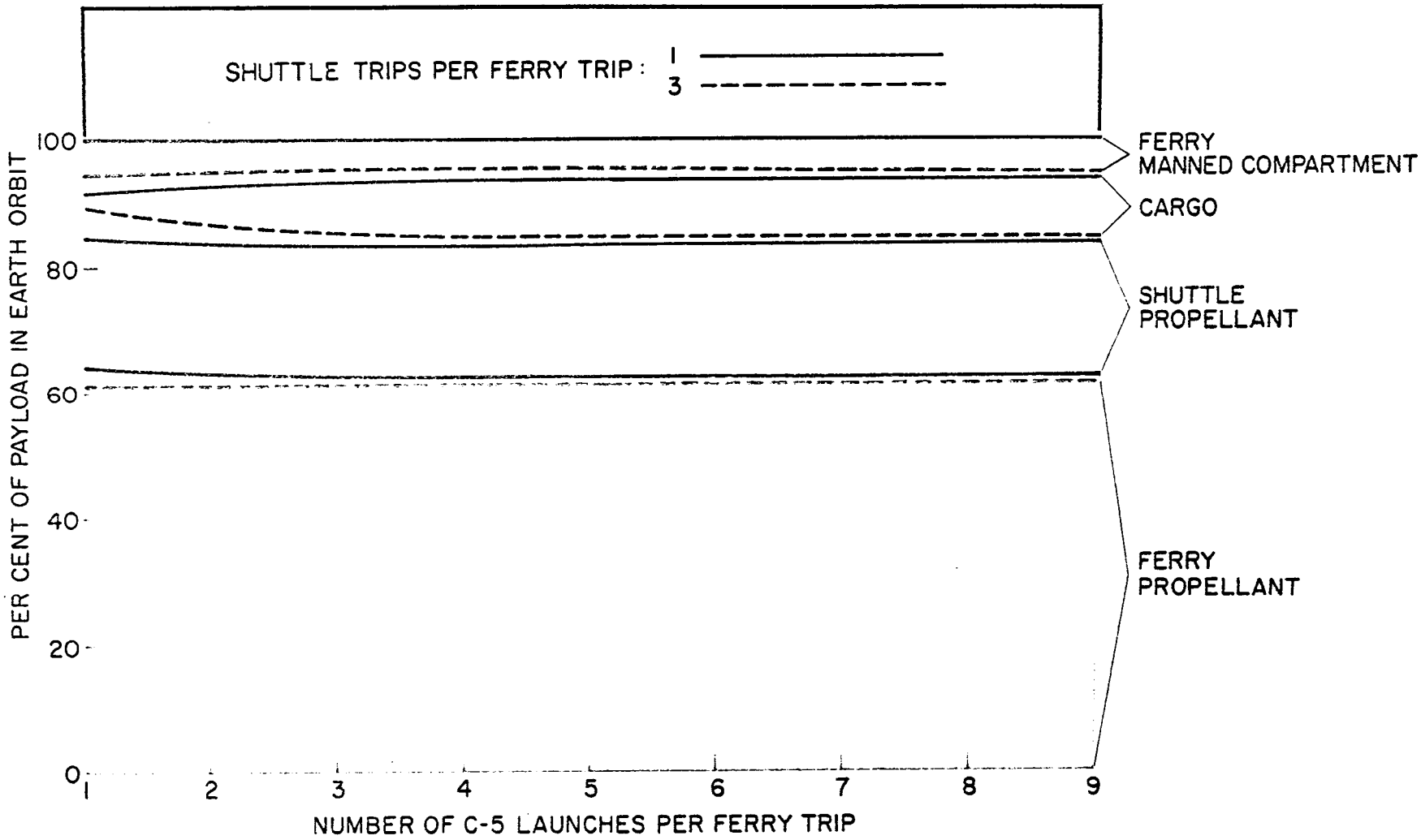
W_{mf} = FERRY MANNED COMPARTMENT MASS = $k_f \left(\frac{RNM}{L} + C_f\right)$; k_f = 3500 lb/MAN

W_{ms} = SHUTTLE MANNED COMPARTMENT MASS = $k_s \left(\frac{RNM}{mL} + C_s\right)$; k_s = 1000 lb/MAN

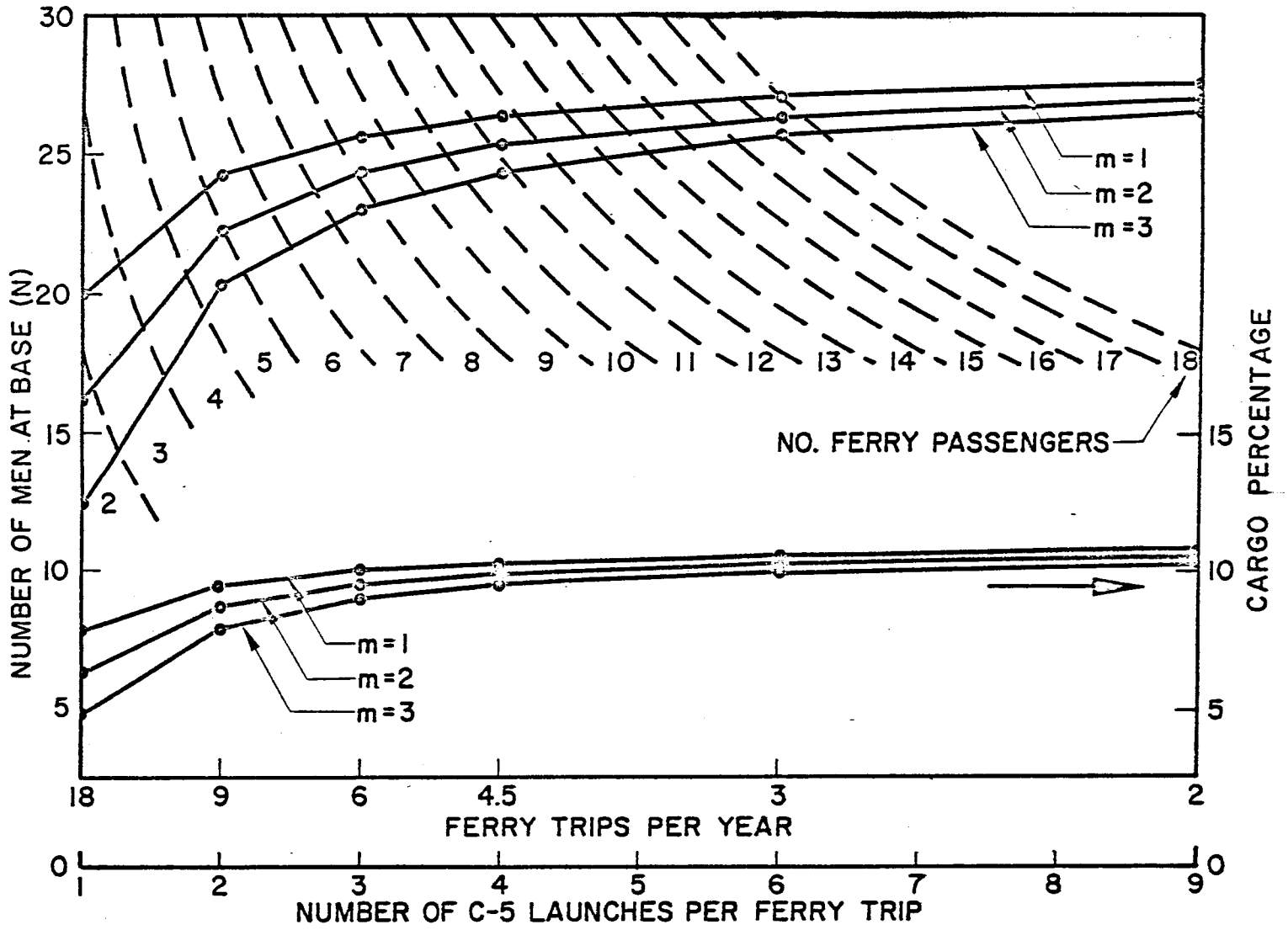
W_{if} = FERRY INERT = $W_{mf} + \eta_f W_{pf}$; $\eta_f = .20$; W_{pf} = FERRY PROPELLANT CAPACITY

W_{is} = SHUTTLE INERT = $W_{ms} + \eta_s W_{ps}$; $\eta_s = .10$; W_{ps} = SHUTTLE PROPELLANT FOR ONE TRIP

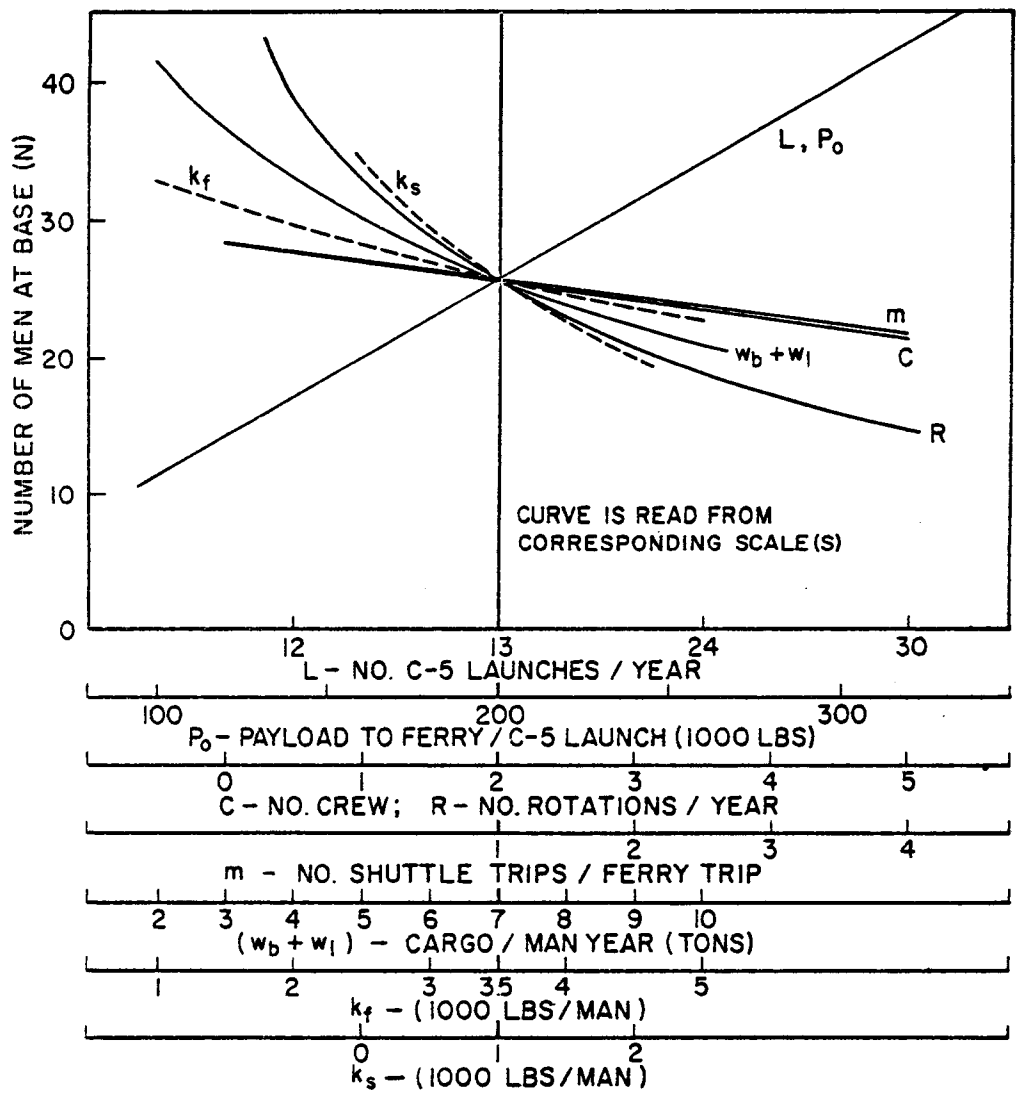
I_{SP} – FERRY 820/SHUTTLE 420



MODE II PARAMETRIC STUDY-FERRY WEIGHT ALLOCATIONS



MODE II PARAMETRIC STUDY, MEN AND CARGO DELIVERED



MODE II SYSTEM SENSITIVITIES

PREDICTION OF SUBSYSTEM RELIABILITIES

PROPULSION	
SATURN C-5	MSFC ESTIMATES AND APOLLO REQUIREMENTS
CHEMICAL	FLIGHT TESTS OF PRESENT SYSTEMS MANUFACTURERS' DATA
NUCLEAR	RIFT PROGRAM ESTIMATES
ELECTRONICS	
COMMUNICATION GUIDANCE & CONTROL	ANALYSIS BY ACTIVE ELEMENT GROUPS, MTF, MISSION DURATION
OTHER SUBSYSTEMS	
MECHANICAL STRUCTURAL AND LIFE SUPPORT	POOR BASIS FOR PREDICTION EXPECT HIGH RELIABILITY ATTAINABLE

DEVELOPMENT COST MODEL

Major Breakdown	Governing Parameters
Vehicle Design and Development	Engineering Manhours
Engine Development	Engine Manufacturers' Estimates
Test Hardware*	Subsystem Weights Engines No. of launch attempts
C-5*	($35M) (No. required to test upper stages)
Tooling	Tooling manhours Production Rate
Facilities	Square Feet Special Equipment
Facilities Maintenance	% of facilities cost
Crew Training	No. of Pilots
Spares	% of hardware cost
Transportation	% of hardware cost
Propellant	No. of launch attempts
Flight test operating costs	($5M + Upper Stages) (No. of attempts)

* 90% Learning Curve

OPERATIONAL PROGRAM COST MODEL

Major Breakdown	Governing Parameters
Sustaining Engineering	Engineering Manhours
Hardware*	
C-5	($35M) (No. required)
Other	Subsystem weights Engines No. of launch attempts
Spares	% of hardware cost
Transportation	% of hardware cost
Propellant	No. of launch attempts
Launch Operations	($5M + Upper stages)(No. of attempts)
Facilities Maintenance	% of facilities cost
Crew Allowance	No. of pilots
Replacement training	Reliability
Refurbishment cost of reusable vehicles	% of subsystem deterioration

* 90% Learning Curve

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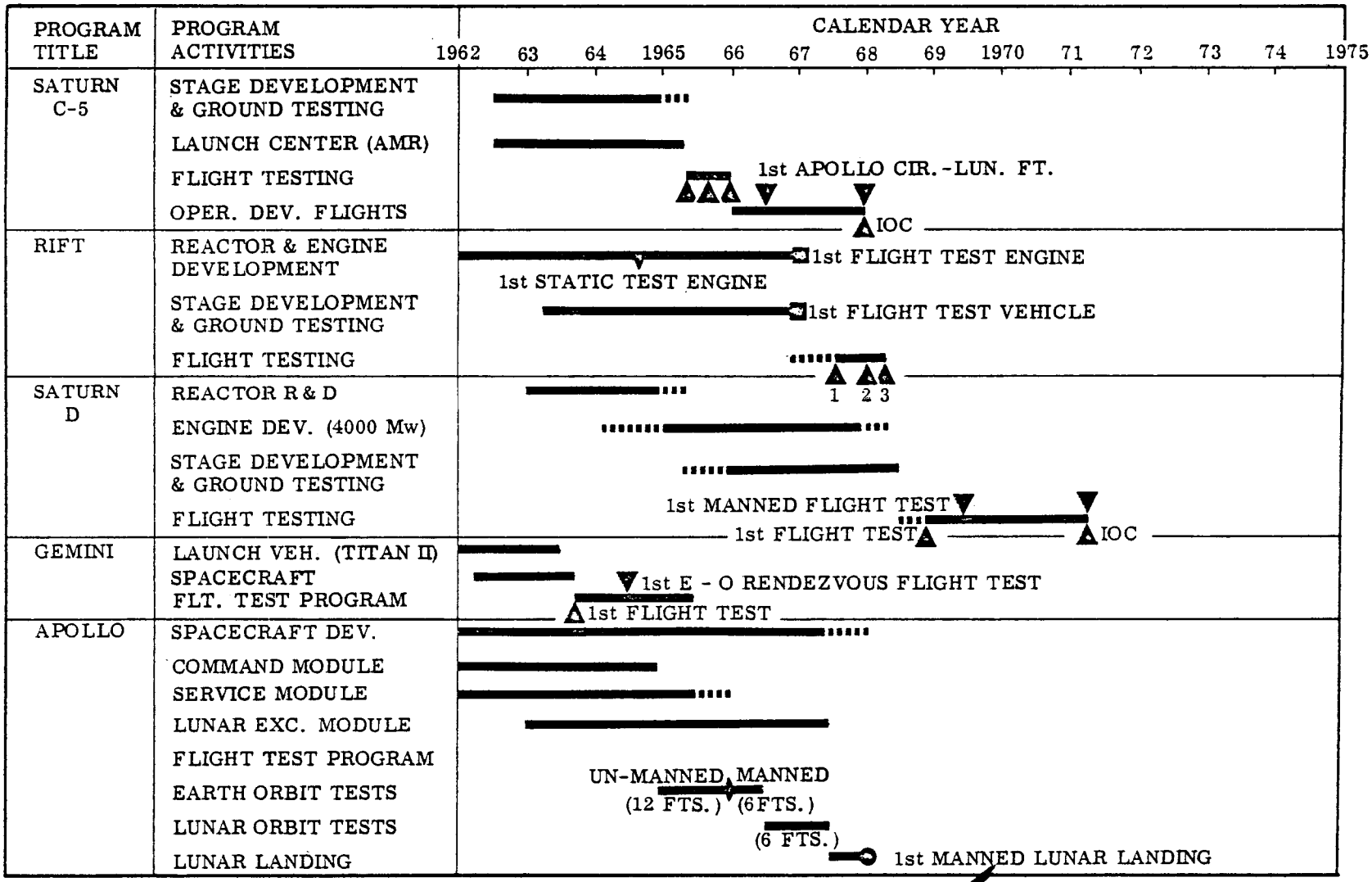
SUMMARY OF RELATED NATIONAL SPACE PROGRAMS

PROGRAM MILESTONES & DEVELOPMENT AREAS



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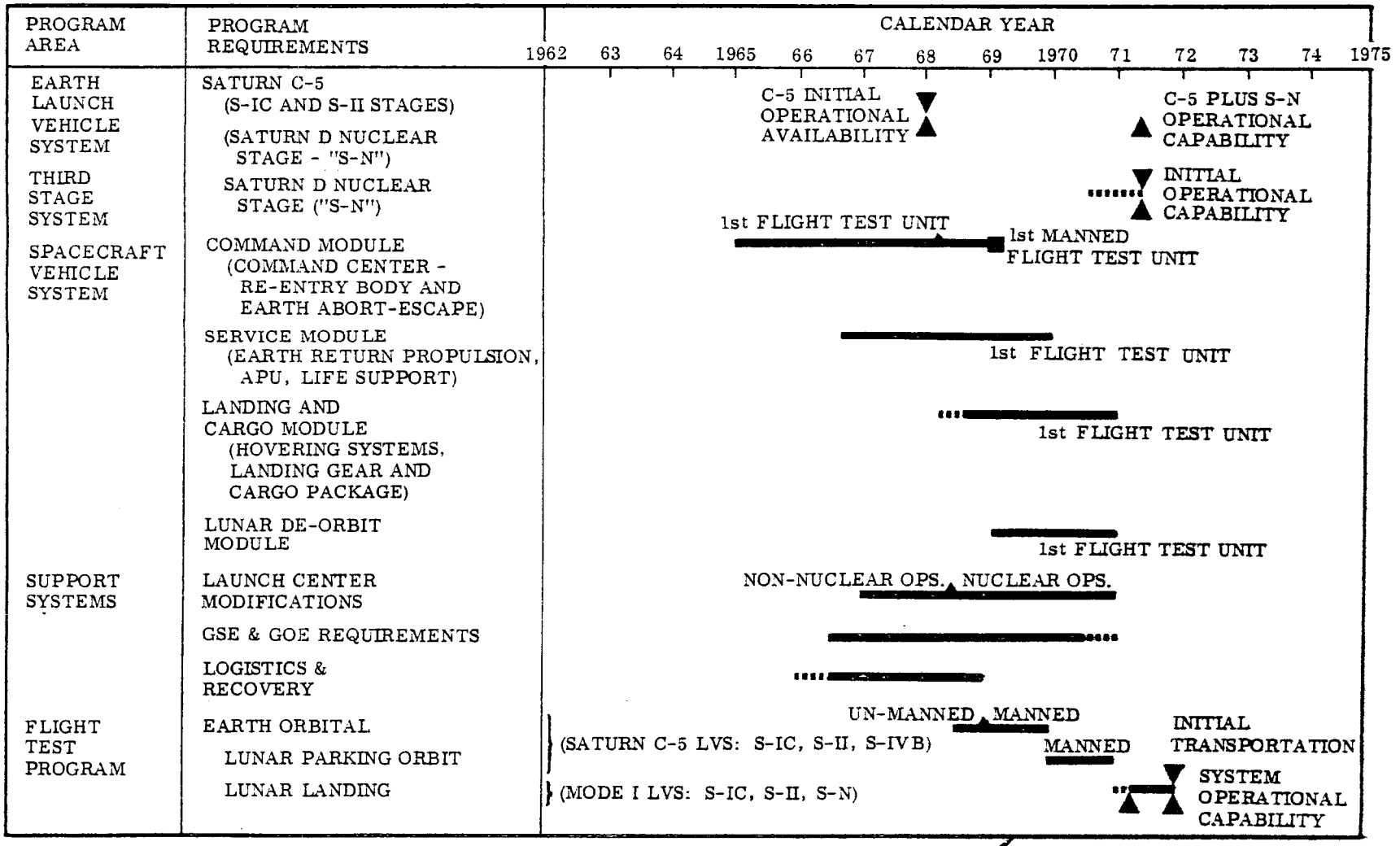
SELECTED MODE I INTEGRATED PROGRAM PLAN

(MANNED SYSTEM – COMPOSITE PERSONNEL & CARGO

CAPABILITY – VEHICLE CONFIGURATION I L-1)



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MAJOR PROGRAM CONSIDERATIONS IN SELECTED MODE I SYSTEM

CURRENT PROGRAM CONTRIBUTIONS		NEW PROGRAM REQUIREMENTS		CRITICAL PROGRAM PACING EVENTS
LAUNCH VEHICLE SYSTEM	SATURN C-5 (S-IC, S-II & S-IV B)			1. OPERATIONAL CAPABILITY FOR NUCLEAR STAGE 2. MANNED EARTH ORBITAL FLIGHT TEST OF COMMAND & RE-ENTRY MODULE 3. MANNED LUNAR CARGO LANDINGS AND EARTH RETURN (DEVELOPMENT OPERATIONS FLIGHT TESTS)
THIRD STAGE VEHICLE	RIFT VEHICLE & FLIGHT TESTS NERVA NUCLEAR ENGINE	THIRD STAGE VEHICLE	SATURN D (4000 Mw) NUCLEAR THIRD STAGE NUCLEAR ENGINE – 4000 Mw	
SPACE-CRAFT SYSTEM	APOLLO TECHNOLOGY COMMAND MODULE SERVICE MODULE LUNAR ORBITAL RENDEZVOUS	SPACE-CRAFT SYSTEM	COMMAND & RE-ENTRY MODULE (6–8 MAN) SERVICE MODULE (AUXILIARY EQUIPMENT & LUNAR ESCAPE TO EARTH) LANDING – CARGO MODULE LUNAR DE-ORBIT MODULE	
LAUNCH CENTER	AMR SATURN C-5 AMR RIFT	LAUNCH CENTER	LAUNCH PADS FOR VEHICLES WITH SATURN D & SPACECRAFT SYSTEM ASSEMBLY AND CHECK-OUT WITH NEW SPACECRAFT CONTROL CENTER MODIFICATIONS	
SUPPORT SYSTEMS	MERCURY, GEMINI & APOLLO RECOVERY COMMAND AND CONTROL MERCURY, GEMINI DSIF	SUPPORT SYSTEMS	ADVANCED RECOVERY FORCE C&C MODIFICATIONS FOR LUNAR BASING OPERATIONS	