WHS-311
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Page 1
C. L. Olson

PLANNING BRIEFING

4-12-67

MOL SYSTEM PLANNING OBJECTIVES

- **VIABLE INITIAL PROGRAM**
- **FOLLOW-ON GROWTH THROUGH IMPROVED:**
  - O SYSTEM ECONOMICS
  - O OPERATIONS FLEXIBILITY
  - O MISSION PERFORMANCE
  - O ADDITIONAL APPLICATIONS (NATIONAL SPACE GOALS)

MOL PLANNING GUIDELINES

- EVOLUTIONARY (NOT REVOLUTIONARY) SYSTEM CAPABILITY GROWTH.
- PRIMARY MISSION IS HIGH RESOLUTION RECONNAISSANCE.
- CONTINUAL EXAMINATION OF FUTURE ALTERNATIVES, TO GUIDE PRESERVATION OF OPTIONS IN ONGOING PROGRAM.

MOL PLANNING ELEMENTS

- **MAJOR MOL SYSTEM SEGMENTS**
  - ✓ LAUNCH VEHICLE
  - ✓ LABORATORY VEHICLE
  - ✓ PAYLOAD
  - ✓ RE-ENTRY VEHICLE
  - ✓ SUPPORT MODULE
  - ✓ FACILITIES
  - ✓ FLIGHT CREW
  - ✓ TRAINING SIMULATORS
  - ✓ SUPPORT FORCES

- **TYPICAL PLANNING STUDY CONSIDERATIONS**
  - ✓ PRELIMINARY SYSTEM DESIGN
  - ✓ CONFIGURATION ANALYSIS
  - ✓ PERFORMANCE ANALYSIS
  - ✓ OPERATIONS SCENARIO
  - ✓ CREW FUNCTIONS
  - ✓ RELIABILITY ESTIMATES
  - ✓ COST ESTIMATES
  - ✓ SCHEDULE CONSTRAINTS
  - ✓ EFFECTIVENESS COMPARISONS

REVIEW OF MOL PLANNING ACTIVITIES

ORGANIZATION AND SCOPE OF BRIEFING

- EARLY SYSTEM DEFINITION STUDIES (1963 - 1965)
- RECENT SYSTEM IMPROVEMENTS AND GROWTH STUDIES (1965 - 1967)
- CURRENT MOL PLANNING FRAMEWORK (1967 - 1968)

6

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TYPICAL MOL PLANNING STUDIES - EARLY SYSTEM DEFINITION PERIOD

LABORATORY VEHICLE

1. 10 FT. VS 13 FT. DIAMETER
2. AMOUNTS OF PRESSURIZED AND UNPRESSURIZED VOLUMES
3. SINGLE VS DUAL PRESSURIZED COMPARTMENTS
4. FORWARD VS AFT LOCATION OF TEST SECTION
5. LONGITUDINAL VS TRANSVERSE CREW ORIENTATION
6. SIDE-BY-SIDE VS END-TO-END DOCKING MODES
7. INTERNAL VS EXTERNAL ARTIFICIAL GRAVITY PROVISIONS
8. SOLAR ARRAY VS FUEL CELL ELECTRICAL POWER
9. "PROVISION FOR" VS "ADD-ON" VS "BUILT-IN" APPROACH FOR RENDEZVOUS AND DOCKING
10. MAINTENANCE VS REDUNDANCY FOR SYSTEM EFFECTIVENESS
11. SINGLE VS MULTI-LEVEL ATTITUDE CONTROL THRUSTERS
12. GEMINI VS APOLLO ATTITUDE CONTROL ELECTRONICS APPLICATION
13. REACTION JET VS COMBINED REACTION JET/MOMENTUM STORAGE ATTITUDE CONTROL SYSTEM.
14. RADIATIVE VS ABLATIVE ATTITUDE CONTROL THRUSTERS
15. OPTIMAL ATTITUDE CONTROL JET CONFIGURATION
16. COMBINED VS INDIVIDUAL ELECTRICAL INVERTERS/CONVERTERS/REGULATORS
17. SEPARATE VS INTEGRAL HEAT REJECTION SYSTEM FOR ELECTRICAL POWER

TYPICAL MOL PLANNING STUDIES - EARLY SYSTEM DEFINITION PERIOD

LABORATORY VEHICLE (CONTINUED)

18. FUEL CELL SELECTION FOR ELECTRICAL POWER
19. USE OF AUXILIARY BATTERIES VS USE OF THE LABORATORY CENTRAL POWER SYSTEM FOR SPECIAL PURPOSE ELECTRICAL LOADS AND/OR EMERGENCIES
20. SINGLE VS DUAL GAS ENVIRONMENTAL CONTROL SYSTEM
21. GASEOUS VS SUPERCRITICAL OR SUBCRITICAL CRYOGENIC FLUID STORAGE
22. WICK ABSORBERS VS CENTRIFUGAL ROTATORS FOR HUMIDITY CONTROL
23. LITHIUM HYDROXIDE VS MOLECULAR SIEVES FOR CO_2 CONTROL
24. RADIATOR VS WATER BOILER FOR PEAK THERMAL LOAD CONTROL
25. ALUMINUM VS MAG-LITHIUM STRUCTURAL MATERIALS
26. SINGLE VS MULTI-WALL STRUCTURAL CONFIGURATION
27. CURVED VS FLAT PRESSURE BULKHEADS
28. INTEGRATED VS INDIVIDUAL COMPONENT TM/TRACK AND COMMAND
29. COMBINED VS SEPARATE DATA MANAGEMENT FOR LABORATORY AND EXPERIMENTS

GEMINI B

1. HOLE IN THE HEAT SHIELD VS INFLATABLE TUNNEL VS ROTATED GEMINI FOR ASTRONAUT TRANSFER
2. ABORT TOWER VS SEAT IMPROVEMENT, ADDITIONAL REDUNDANCY, AND ADDITIONAL PROPULSION FOR CREW ESCAPE
3. RE-ENTRY GUIDANCE SYSTEMS VS PILOT CONTROL

TYPICAL MOL PLANNING STUDIES - EARLY SYSTEM DEFINITION PERIOD

GEMINI B (CONTINUED)

4. AUTONOMOUS BATTERY OR FUEL CELL POWER VS UTILIZATION OF LABORATORY POWER
5. USE OF A GEMINI-A ADAPTER VS ALTERNATIVE NEW ADAPTERS

TITAN III C

1. ACTIVE VS PASSIVE ON-ORBIT TRANSTAGE TEMPERATURE CONTROL
2. ALTERNATIVE DEGREES OF REDUNDANCY FOR RELIABILITY AND SAFETY IMPROVEMENT
3. TRANSTAGE VS NO TRANSTAGE STUDY

OPERATIONS/PERFORMANCE

1. ORBIT DECAY VS CONTROLLED RE-ENTRY VS EXPLOSIVE DESTRUCTION FOR LABORATORY DISPOSAL
2. OPTIMAL DISTRIBUTION OF EXPERIMENTS PER FLIGHT AND THE SEQUENCE OF EXPERIMENTS CONDUCT WITHIN EACH FLIGHT
3. INCREASED ON-ORBIT LOITER CAPABILITY FOR GEMINI B VS INCREASED RECOVERY FORCES
4. QUALIFICATION OF EQUIPMENT FOR STORAGE ENVIRONMENT VS ALTERNATIVE METHODS OF PROVIDING AN ENVIRONMENT COMPATIBLE WITH EXISTING QUALIFICATIONS
5. ORBIT ALTITUDE SELECTION FOR RENDEZVOUS MISSION
6. FIXED VS VARIABLE LAUNCH-AZIMUTH CAPABILITY FOR RENDEZVOUS MISSIONS
7. ALTERNATIVE PERFORMANCE IMPROVEMENTS FOR TITAN III C VS PROGRAM COST EFFECTIVENESS

TYPICAL MOL PLANNING STUDIES - EARLY SYSTEM DEFINITION PERIOD

OPERATIONS/PERFORMANCE (CONTINUED)

8. TARGET DECK SIZING
9. WEATHER ANALYSIS - ALTERNATIVE RETARGETING
10. DETERMINATION OF MAN'S IMC PERFORMANCE
11. SENSOR SIZING SYSTEM STUDIES - ALT/OPTICS/DRAG
12. OPTICAL SYSTEM STUDIES - BAKER-GREY
13. TRACKING MIRROR VS DUMP TRUCK ANALYSIS
14. AUTONOMOUS NAVIGATION STUDIES

TYPICAL GROWTH-ORIENTED STUDIES

EARLY SYSTEM DEFINITION PERIOD

(LABORATORY VEHICLE)

- **PRESSURIZED VOLUME AND COMPARTMENTATION**

  TRADES IN VOLUME UTILIZATION, DUAL VS SINGLE COMPARTMENTS, RELATIVE CREW SAFETY

- **ENVIRONMENTAL CONTROL SYSTEM**

  APPLICABLE EXISTING EQUIPMENT, SINGLE OR DUAL GAS ATMOS., CO_2 REMOVAL APPROACH DEFINED

- **ELECTRICAL POWER**

  DETERMINED POWER PROFILES, FUEL CELL VS SOLAR CELL TRADES, 1000 HR FUEL CELL AVAILABILITY

- **STRUCTURAL CONFIGURATION**

  ARRANGEMENT OF STRUCTURALLY AND THERMALLY REQUIRED MATERIAL TO MAXIMIZE METEOROID PROTECTION

- **ARTIFICIAL GRAVITY CONCEPTS**

  EVALUATION OF SYSTEM COMPLEXITY, WEIGHT PENALTIES, DYNAMIC PROBLEMS, OPERATIONAL FLEXIBILITY

- **DOCKING MODES**

  STUDY OF APPROACH MANEUVERS, MISALIGNMENT CONSTRAINTS, CREW/CARGO TRANSFER, DRAG EFFECTS

- **EXTENDED MISSION DURATION**

  EVALUATION OF RENDEZVOUS OPERATIONS AND DISCRETIONARY PAYLOAD CAPABILITY

- **MAINTENANCE/REDUNDANCY OPTIMIZATION**

  FAILURE MODE AND EFFECTS ANALYSIS, IN-SPACE MAINTENANCE CONSIDERATIONS, REDUNDANCY VS SPARES TRADES, 60 DAY MISSION CAPABILITY

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TYPICAL RECENT - PLANNING STUDIES
SYSTEM ECONOMICS

- **LAUNCH VEHICLES & SPACECRAFT APPLICABLE TO MOL**

  SATURN I AND TITAN III BOOSTERS, APOLLO, GEMINI AND MOL SPACECRAFT, ETR & WTR OPERATIONS (60 MIN)

- **EVALUATION OF ETR & WTR OPERATIONS FOR MOL**

  UPRATED SATURN I AND TITAN III BOOSTERS, ETR AND WTR OPERATIONS (60 MIN)

- **RENDEZVOUS/RESUPPLY SYSTEMS GROWTH**

  CONFIGURATION DEVELOPMENT, RENDEZVOUS AND DOCKING MECHANICS, OPERATING MODES, RELIABILITY CONCEPTS, COST BENEFIT COMPARISONS (120 MIN)

- **EXTENDED DURATION INTEGRAL LAUNCH SYSTEMS GROWTH**

  50-90 DAY MISSION CAPABILITY FOR BASELINE MOL DERIVATIVES (30 MIN)

- **SUBSYSTEM LIFE EXTENSION CONCEPTS**

  TRADES BETWEEN MAINTENANCE, REPLACEMENT, REPAIR, BLOCK AND FUNCTIONAL REDUNDANCY - MEAN MISSION LIFE & SYSTEM AVAILABILITY (60 MIN)

- **MAXIMUM DURATION AUTOMATIC MODE VEHICLE**

  60 DAY DESIGN LIFE AUTO MODE VEHICLE DEVELOPMENT GUIDELINES DEFINED (30 MIN)

- **WHOLLY UNMANNED SYSTEM EVALUATIONS**

  COST BENEFIT COMPARISONS BETWEEN OPTIMIZED WHOLLY UN-MANNED (WUM) SYSTEM, AND MOL FOR DORIAN MISSION (90 MIN)

14

TYPICAL RECENT PLANNING STUDIES

OPERATIONS FLEXIBILITY

- **EVALUATION OF SV-5 MANEUVERING RE-ENTRY VEHICLE FOR MOL**
  MARTIN CO. PROPOSAL FOR MEDIUM HYPERSONIC L/D VEHICLE TO BE DEVELOPED FROM PRIME CONFIGURATION (15 MIN)

- **MANEUVERING RE-ENTRY VEHICLE TEST ON MOL AUTO-MODE FLIGHTS**
  FEASIBILITY INVESTIGATION OF FULL SCALE, UNMANNED PROTOTYPE LIFTING BODY FLIGHT TEST ON MOL DEVELOPMENT FLIGHTS 6 & 7 (20 MIN)

- **MAN'S CONTRIBUTION TO MOL MISSION EFFECTIVENESS**
  ACTIVE TARGET INDICATORS, WEATHER AVOIDANCE, WEATHER VERIFICATION, PRECISION NAVIGATION FOR TARGET ACQUISITION, IMPROVEMENT BY MAINTENANCE/REPLACEMENT/REPAIR (120 MIN)

- **ORBITAL RESCUE AND ESCAPE**
  ESTIMATE OF RISK THAT CREW BE STRANDED IN ORBIT, AND EVALUATION OF VARIOUS MEANS TO REDUCE HAZARD (30 MIN)

- **CONTINGENCY PLANNING ALTERNATIVES**
  ANALYSIS OF BACK-UP HARDWARE COSTS AND LEAD TIMES FOR FLIGHTS 1 AND 2, AND FOR OPTIONAL USE OF M/AM OR AM CONFIGURATIONS FOR FLIGHTS 6 AND 7 (10 MIN)

- **POSSIBLE FOLLOW-ON VEHICLE MIX**
  FISCAL FUNDING ANALYSIS OF LEAD TIMES AND COSTS FOR A RANGE OF "CARBON COPY" FOLLOW-ON BUYS. (10 MIN)

- **"CONVERSION" VS "SUBSTITUTION" M/AM -- AM**
  STUDY OF DECISION LEAD TIME AND COSTS FOR VARIOUS APPROACHES TO OPTIONAL CHOICE OF M/AM OR AM FLIGHT CONFIGURATIONS (15 MIN)

TYPICAL RECENT PLANNING STUDIES
MISSION PERFORMANCE

- O **ADVANCED (GROWTH) PAYLOAD** (30 MIN)

  FEASIBILITY AND CHARACTERISTICS OF ADVANCED OPTICAL SYSTEM [redacted] RESOLUTION)

  - o SYSTEM ROUGH SIZING: FOCAL LENGTH, APERTURE
  - o CONFIGURATIONS: TRACKING MIRROR, POINTING TELESCOPE, FOLDED OPTICS
    - √ DEVELOPMENT/FABRICATION OF LARGE [redacted] MIRRORS
    - √ LARGE CONTROL MOMENT GYROS
  - o FLIGHT VEHICLE CONFIGURATION ANALYSIS

- O **COMPLIMENTARY PAYLOAD ELEMENTS** (20 MIN)

  POSSIBLE ENHANCEMENT OF BASELINE HIGH RESOLUTION OPTICS SYSTEM BY "ADD-ON" DETECTION/ACQUISTION SENSORS. SENSOR EQUIPMENT AND VEHICLE INTEGRATION REQUIREMENTS

  - o ELECTRONIC POINTING SYSTEM (ELINT)
  - o FORWARD LOOKING RADAR

- O **BASELINE PAYLOAD ENHANCEMENT** (20 MIN)

  - o POINTING AND TRACKING SCOPE ALTERNATIVES
  - o EXTENSION OF CAPABILITY FOR AUTOMATIC IMC
  - o SINGLE VERSUS DUAL CAMERA/FILM LOADING STUDIES

TYPICAL RECENT PLANNING STUDIES

ADDITIONAL APPLICATIONS

- **NAV-MOL SYSTEM**

  MOL VEHICLE SYSTEM + NAVY PAYLOADS FOR OCEAN SURVEILLANCE (15 MIN)

- **SAA 209/MOL EXPERIMENTS PLANNING**

  MAN-EQUIPMENT EXPERIMENTS UNIQUE TO MOL, FLOWN ON NASA S-IV B "ORBITAL WORKSHOP." EVALUATE PROCEDURES, MAINTENANCE, TOOLS, CREW RESTRAINTS. (20 MIN)

- **SELECTED MOL/GEMINI-B DATA FOR AAP**

  PERFORMANCE, CONFIGURATION, SUBSYSTEMS DATA, INCLUDING GROWTH POTENTIAL FOR INTEGRAL LAUNCH AND RENDEZVOUS. REQUESTED BY NASA. (TOR REPORT)

- [redacted] (20 MIN)

- **ASTRONOMY**

  POTENTIAL FOR BASELINE SENSOR TO PHOTOGRAPH NEAR PLANETS: MODIFICATIONS FOR STELLAR PHOTOGRAPHY (30 MIN)

- **BIO-MOL CONCEPT (PSAC)**

  MOL VEHICLES FOR PROLONGED BIO-MED TEST, COMBINED WITH DOD MISSION OR SEPARATE FLIGHTS. (60 MIN)

- **MOL VARIANTS FOR NASA APPLICATIONS "A" + BIO-TEST MISSION**

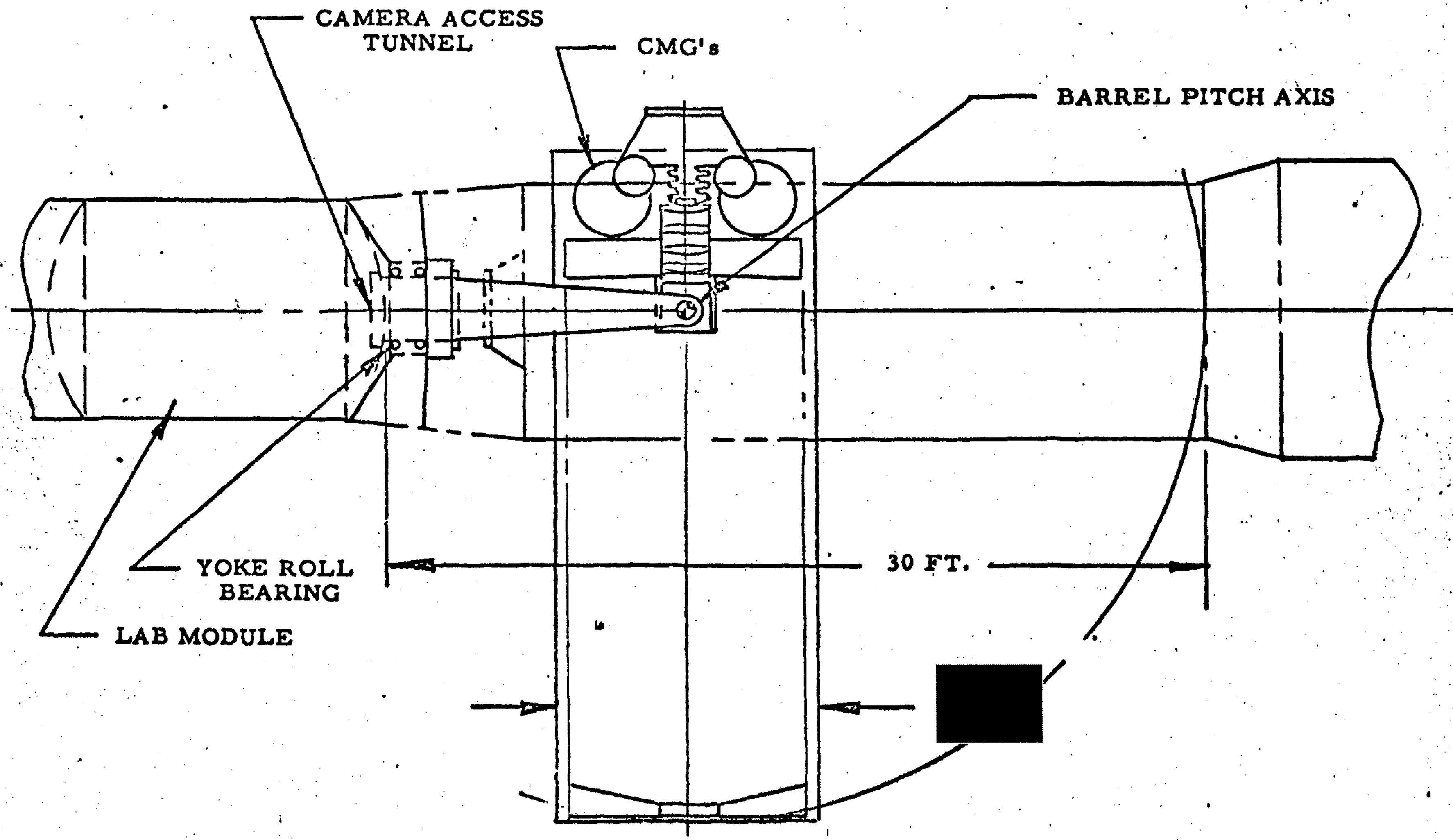
  ACCOMMODATE 14 METEOROLOGICAL EXPERIMENTS ON SEPARATE FLIGHT OR PIGGYBACK ON BASELINE VEHICLES. (60 MIN)

17

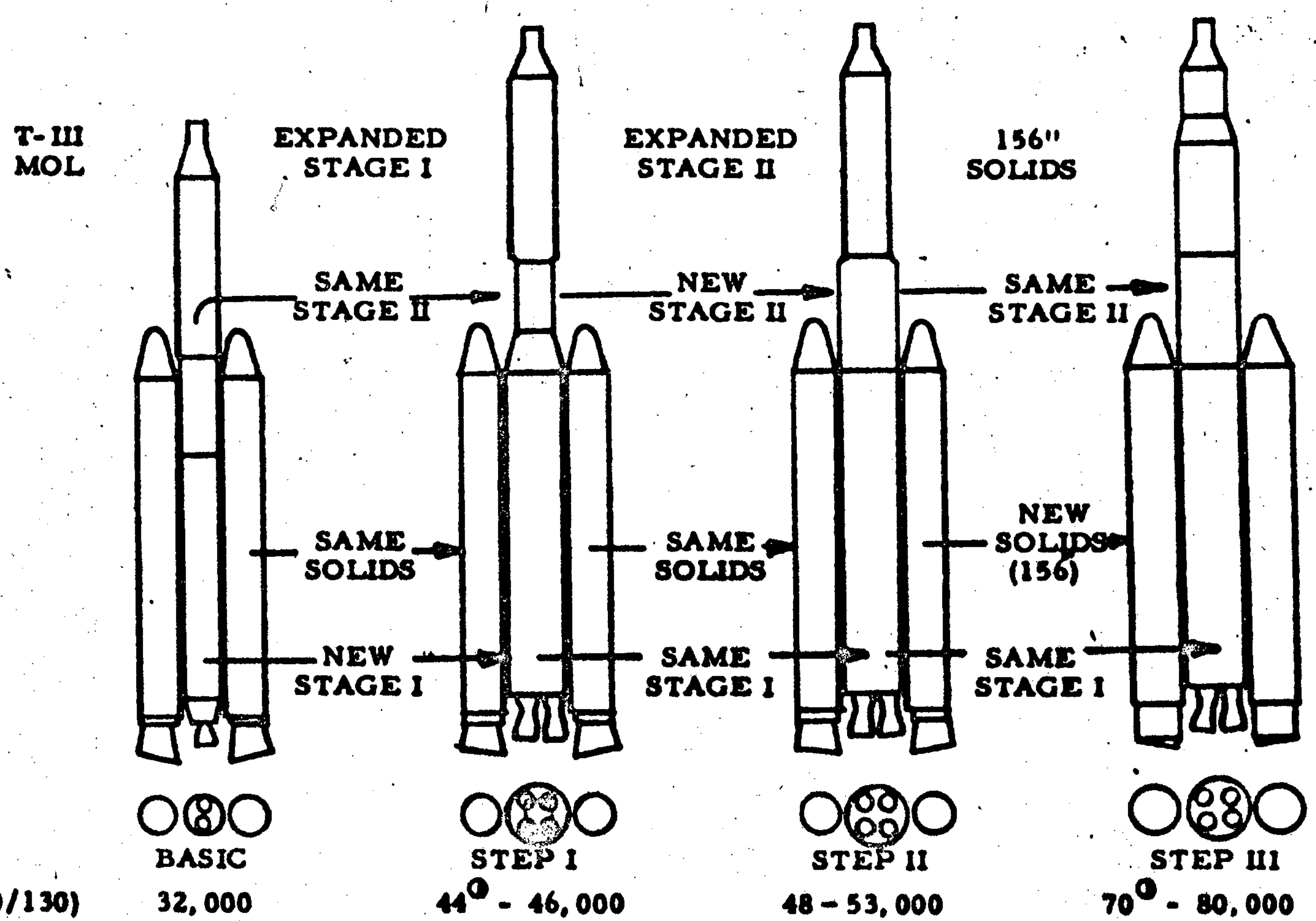
A MOL SHORT RANGE PLANNING STUDY EXAMPLE

"FOLLOW-ON SYSTEM ANALYSIS"

[redacted] POINTING CASSEGRAIN CONFIGURATION

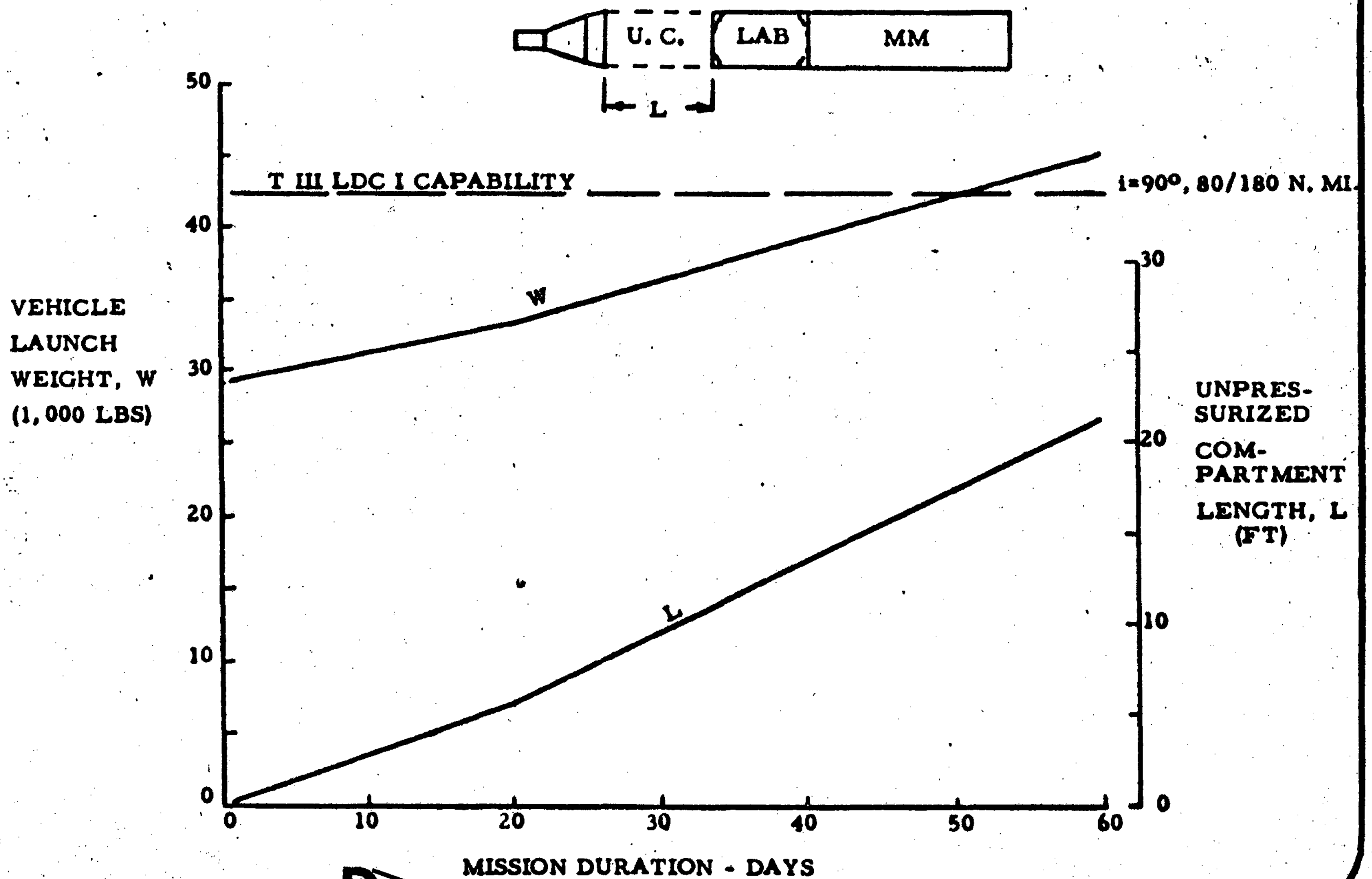


POSSIBLE MOL LAUNCH VEHICLE EVOLUTION



EXTENDED DURATION INTEGRAL LAUNCH

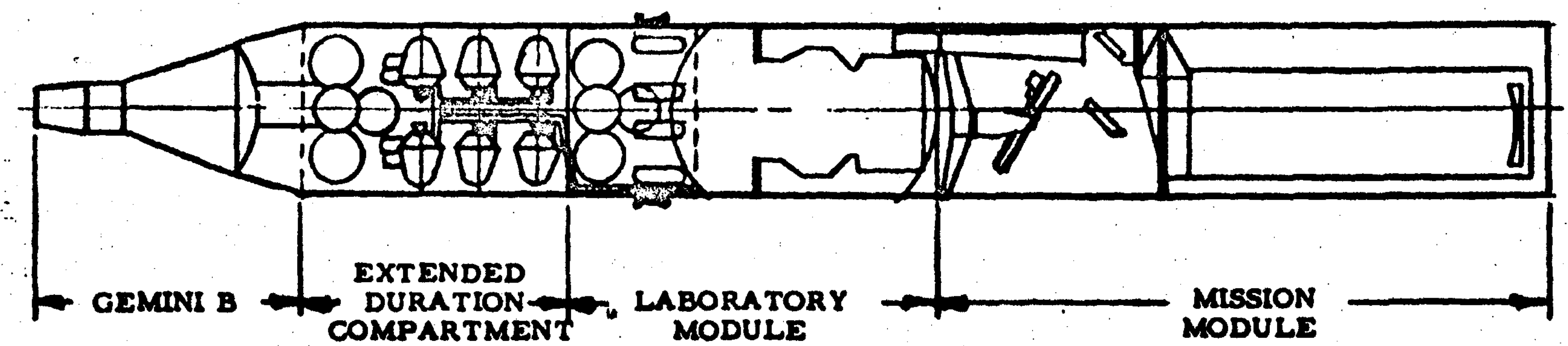
ORBITING VEHICLE



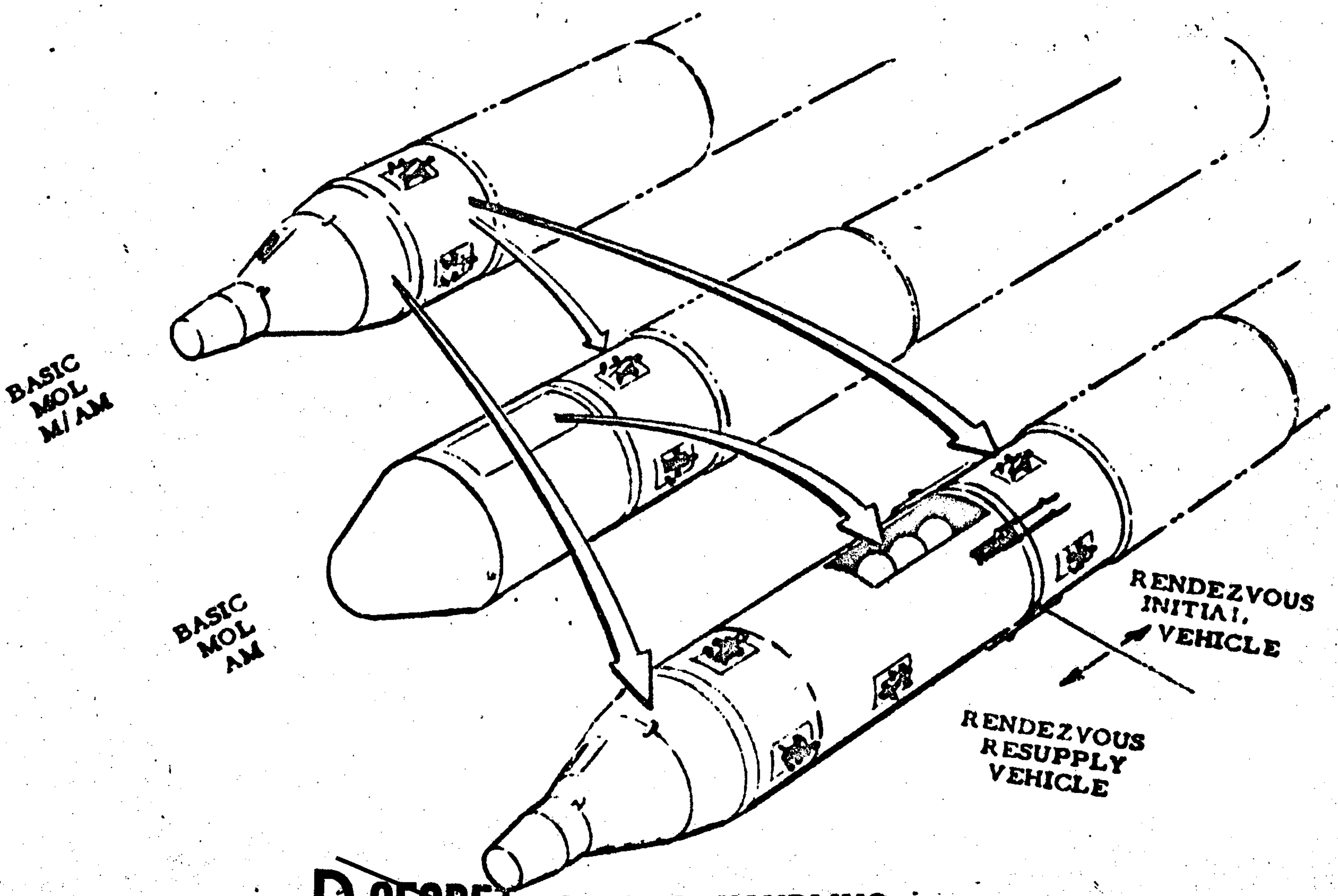
EXTENDED DURATION INTEGRAL LAUNCH

ORBITING VEHICLE

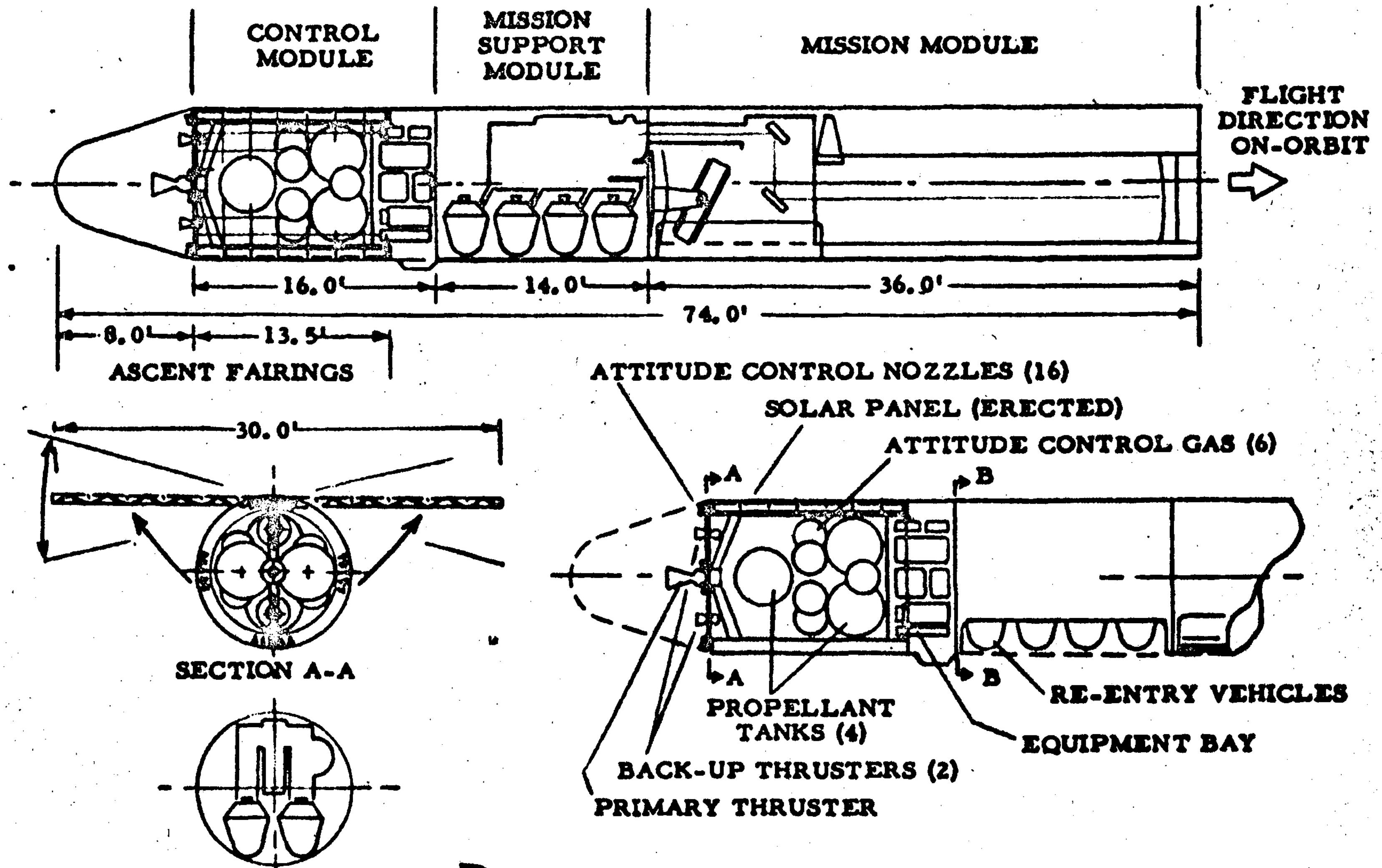
(50 DAY MISSION DURATION)



RESUPPLY SYSTEM CONCEPT

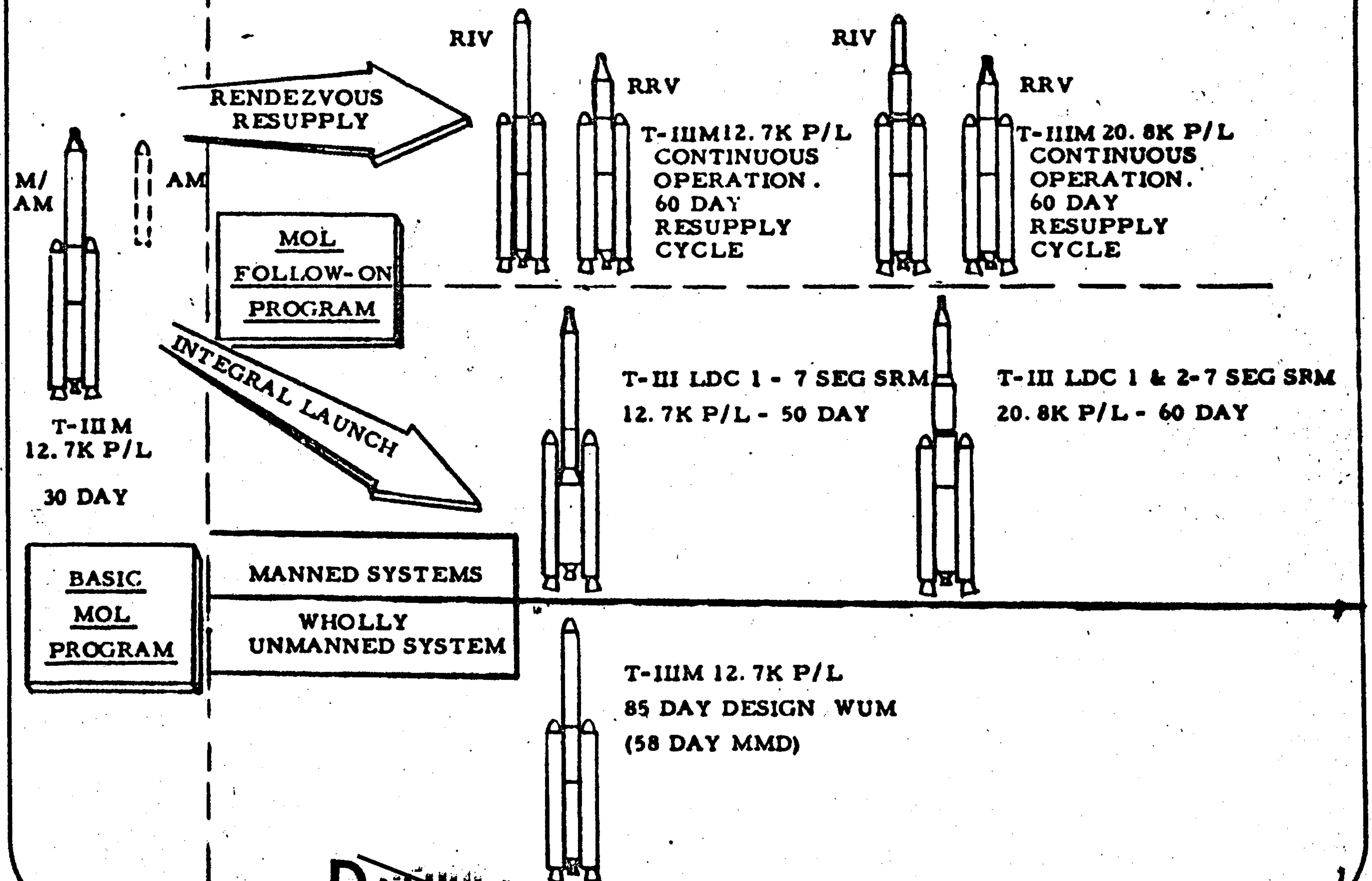


WHOLLY UNMANNED VEHICLE - TIII 7 SEG BOOSTER



GROWTH AVENUES

D SECRET SPECIAL HANDLING

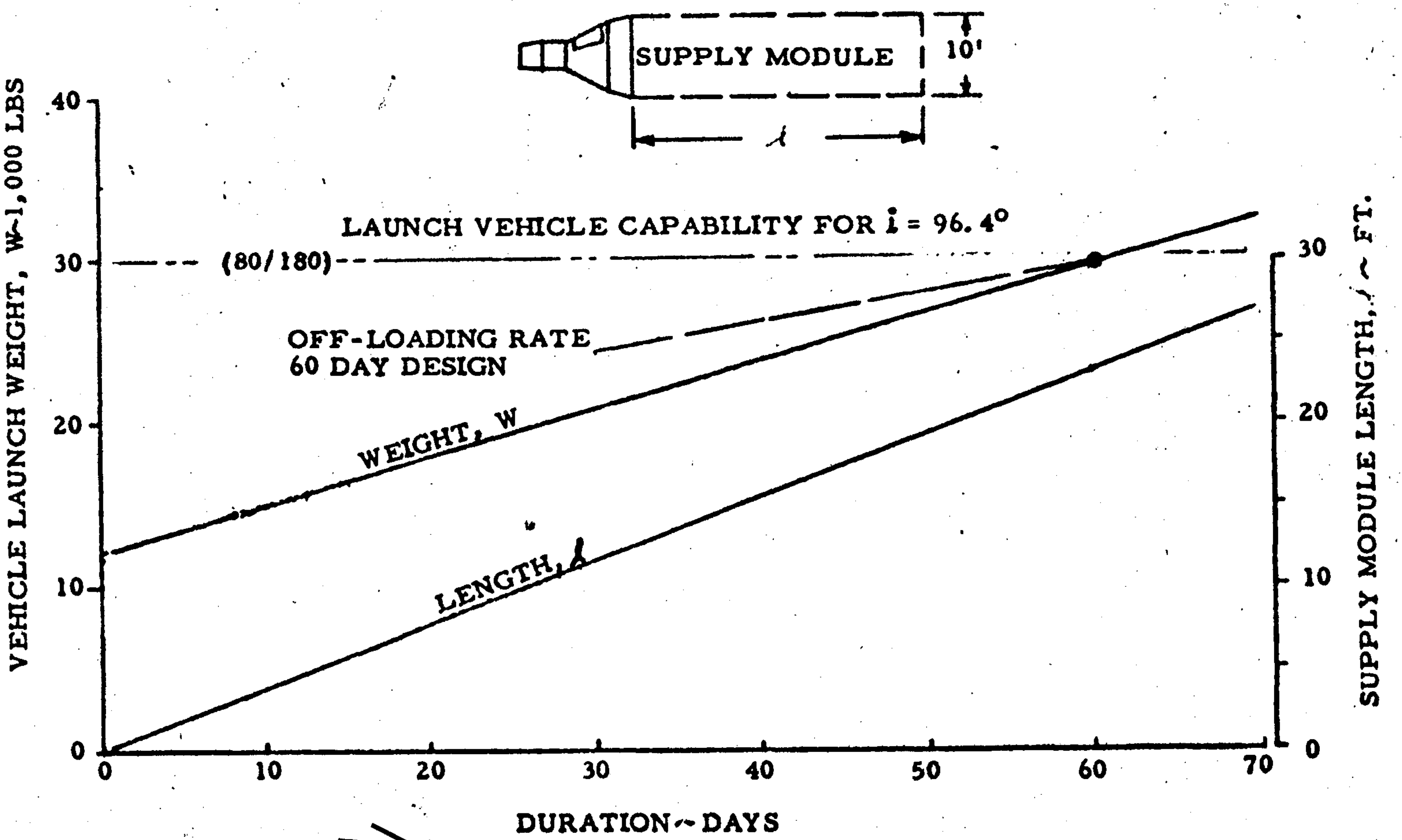


D SECRET SPECIAL HANDLING

RESUPPLY SYSTEM STUDIES

- RENDEZVOUS OPERATING MODES
- RENDEZVOUS MECHANICS
- VEHICLE SIZING ANALYSIS
- VEHICLE CONFIGURATION DEVELOPMENT
- DOCKING MECHANICS
- PERFORMANCE ESTIMATES
- ATTAINMENT OF EXTENDED DURATION
- BASELINE HARDWARE IMPLICATIONS
- OPERATIONS ASPECTS
- GROUND OPERATIONS IMPLICATIONS
- POSSIBLE RENDEZVOUS GROWTH WITH MINIMUM BASELINE IMPACT
- SYSTEM COST AND BENEFIT COMPARISONS

VEHICLE SIZING SUMMARY
(RRV)



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RENDEZVOUS/RESUPPLY VEHICLE SIZING APPROACH

- o FIXED VEHICLE ELEMENTS
  - √ GEMINI B
  - √ RENDEZVOUS PROPELLANT AND TANKAGE
  - √ THRUSTERS + Δ STRUCTURE
  - √ DOCKING HARDWARE
- o TIME DEPENDENT VEHICLE ELEMENTS
  - √ CRYOGENIC STORAGE
  - √ PROPELLANT STORAGE AND PRESSURIZATION
  - √ FUEL CELLS AND POWER DISTRIBUTION
  - √ PERSONNEL (FOOD, CLOTHING, MEDICAL, ETC.)
  - √ ENVIRONMENTAL CONTROL (ATMOSPHERE)
  - √ SPARES
  - √ DATA RETURN VEHICLES AND FILM
  - √ UNPRESSURIZED HOUSING STRUCTURE AND CREW TUNNEL EXTENSION

VEHICLE GROWTH EQUATION
(RRV)

- **VARIABLE VEHICLE ITEMS**

$$\dot{W}_v = \dot{W}_{Prop.\,Sys.} + \dot{W}_{EPS} + \dot{W}_{EC/LS} + \dot{W}_{Personnel} + \dot{W}_{Data} + \dot{W}_{Spares} + \dot{W}_{Crew\ Tunnel}$$

$$= 17.2 + (1.46 \times 10^{-4})\ W_v\, \Delta V + (24 + 40.3\ \text{LB/KW-DAY}) + 15.87 + 5.7 + 63.8 + 6.0 + 6.2$$

$$= \boxed{139 + 40.3\ \text{LB/KW-DAY} + (1.46 \times 10^{-4})\ W_{VEH}\ \Delta V}$$

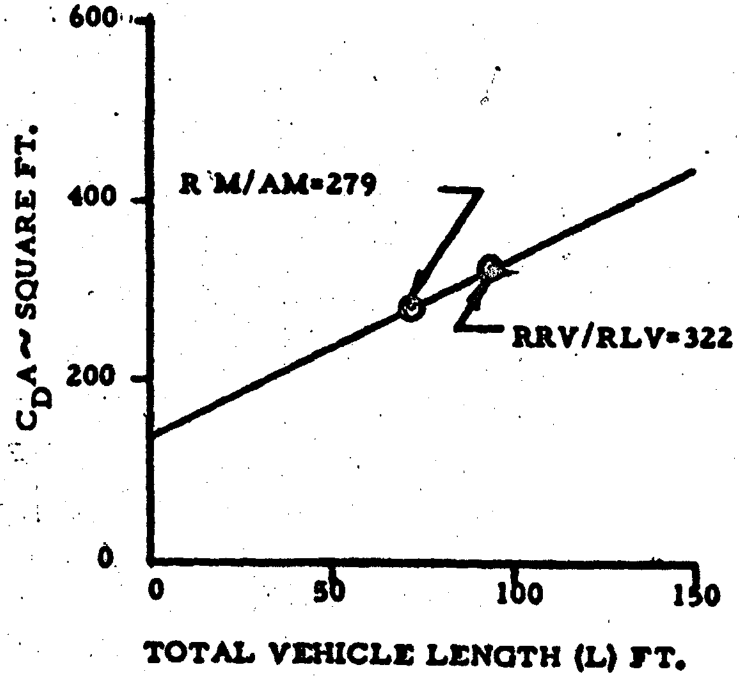
NOTE: HOUSING STRUCTURE INCLUDED WERE APPLICABLE

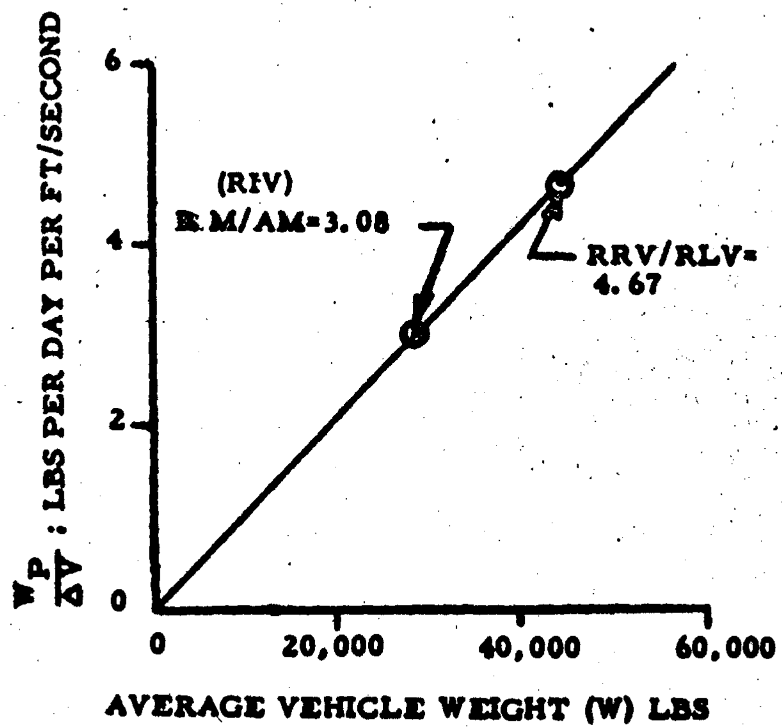
RESUPPLY VEHICLE DESIGN

● GEMINI B + CREW & EQUIP.	6,450
● SUPPLY MODULE (ZERO DAY)	
ACTS (THRUSTERS, TANKS, SUPPORTS)	1,850
DOCKING HARDWARE	230
FUEL CELL (1) + DISTRIBUTION	290
RENDEZVOUS RADAR (GEMINI B)	90
HOUSING STRUCTURE (~1.5')	75
PROPELLANTS (RENDEZVOUS)	2,300
CONTINGENCY (DRY WGT 20%)	970
TOTAL	12,225 LBS
● 60 DAY GROWTH @ 293 LBS/DAY	17,580
TOTAL VEHICLE WEIGHT	29,805 LBS

OFF-LOADING RATE	
PROPELLANT (O.K. + LIMIT CYC.)	75
EPS (1.63 KW-AVG.)	35
DATA	55
EC/LS + PERSONNEL	13
SPARES	6
TOTAL	184 LBS/DAY

VEHICLE DRAG CHARACTERISTICS AND PERFORMANCE REQUIREMENTS

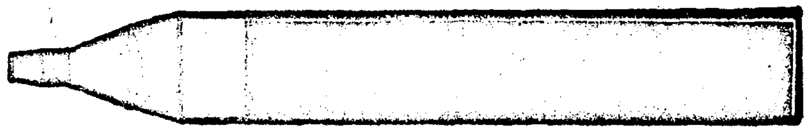




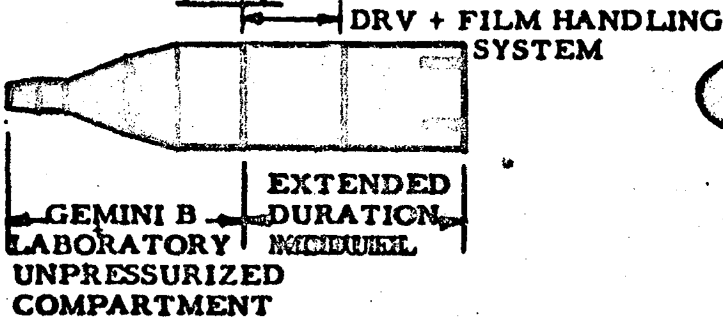
RESUPPLY SYSTEM DERIVATION FROM MOL HARDWARE

BASELINE AM VEHICLE

BASELINE M/AM VEHICLE

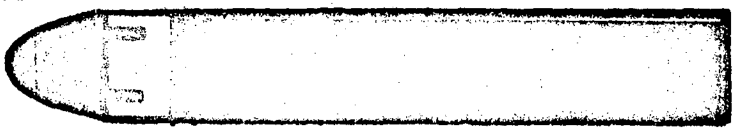


RENDEZVOUS RESUPPLY VEHICLE (RRV)



- ADD BASELINE SUBSYSTEM COMPONENTS
- ADD DOCKING SYSTEM AND INTERFACE

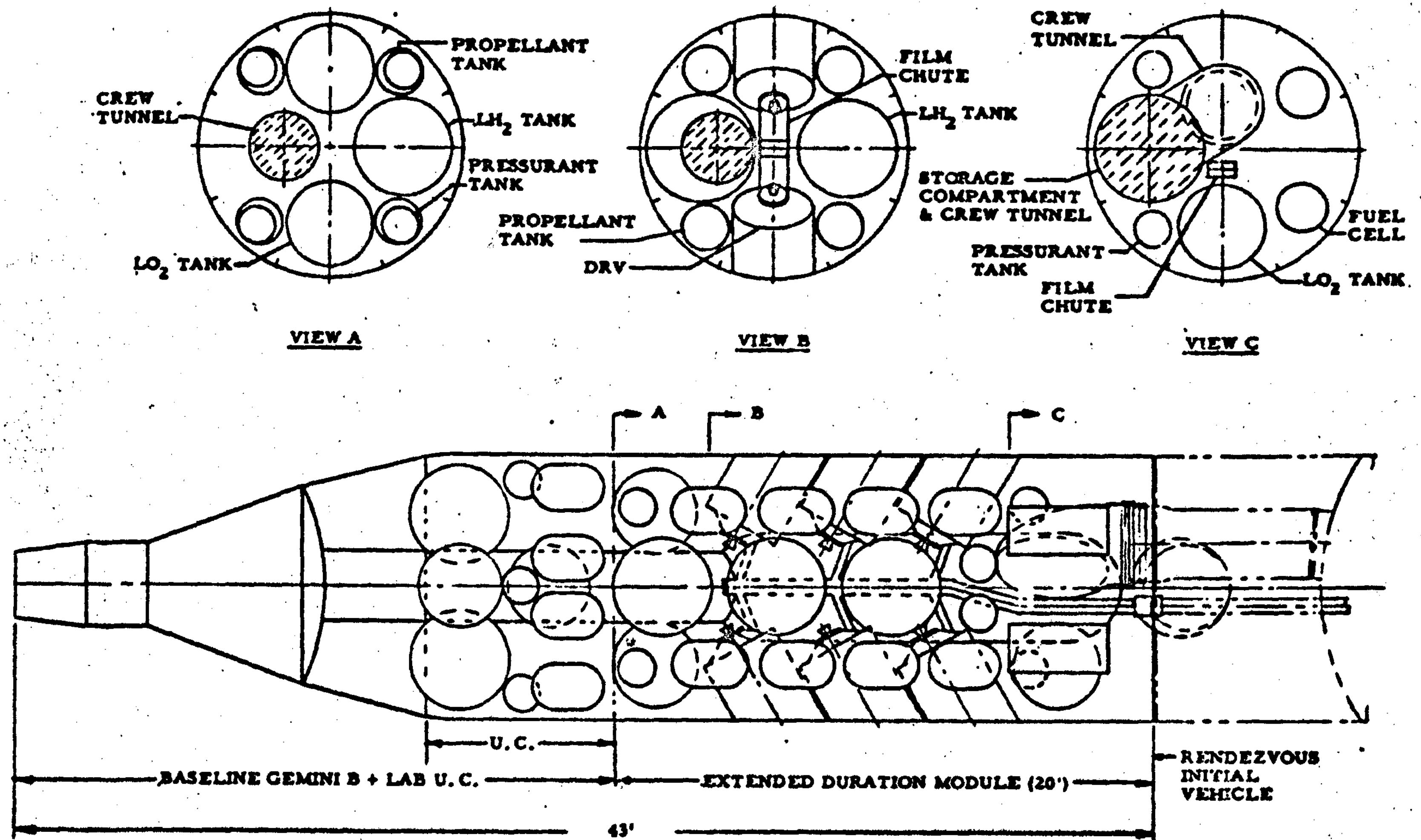
RENDEZVOUS INITIAL VEHICLE (RIV)



- DELETE GEMINI B
- ADD EXTENDED DURATION PROVISIONS
- ADD DOCKING SYSTEM AND INTERFACE
- ADD ASCENT FAIRING

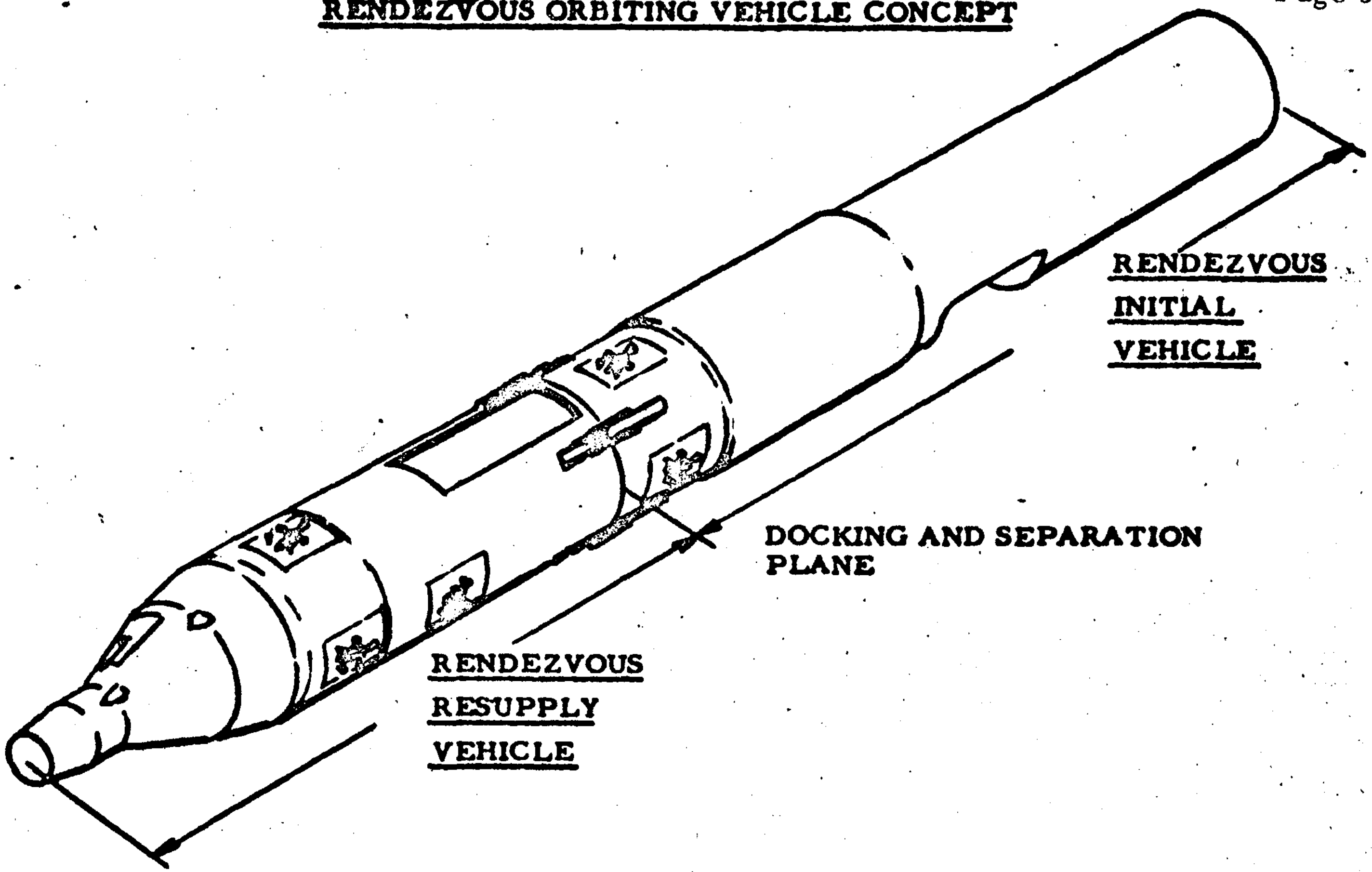
D ~~SECRET~~ SPECIAL HANDLING

RENDEZVOUS/RESUPPLY VEHICLE - "VERTICAL" DRV ARRANGEMENT



D ~~SECRET~~ SPECIAL HANDLING

RENDEZVOUS ORBITING VEHICLE CONCEPT



RRV FUNCTIONS

- CREW TRANSPORT VEHICLE
- ACTS PROPULSION
- PRIME POWER SYSTEM
- LIFE SUPPORT EXPENDABLES
- DATA RETURN SYSTEM
- SUBSYSTEM SPARES/REPLACEMENTS

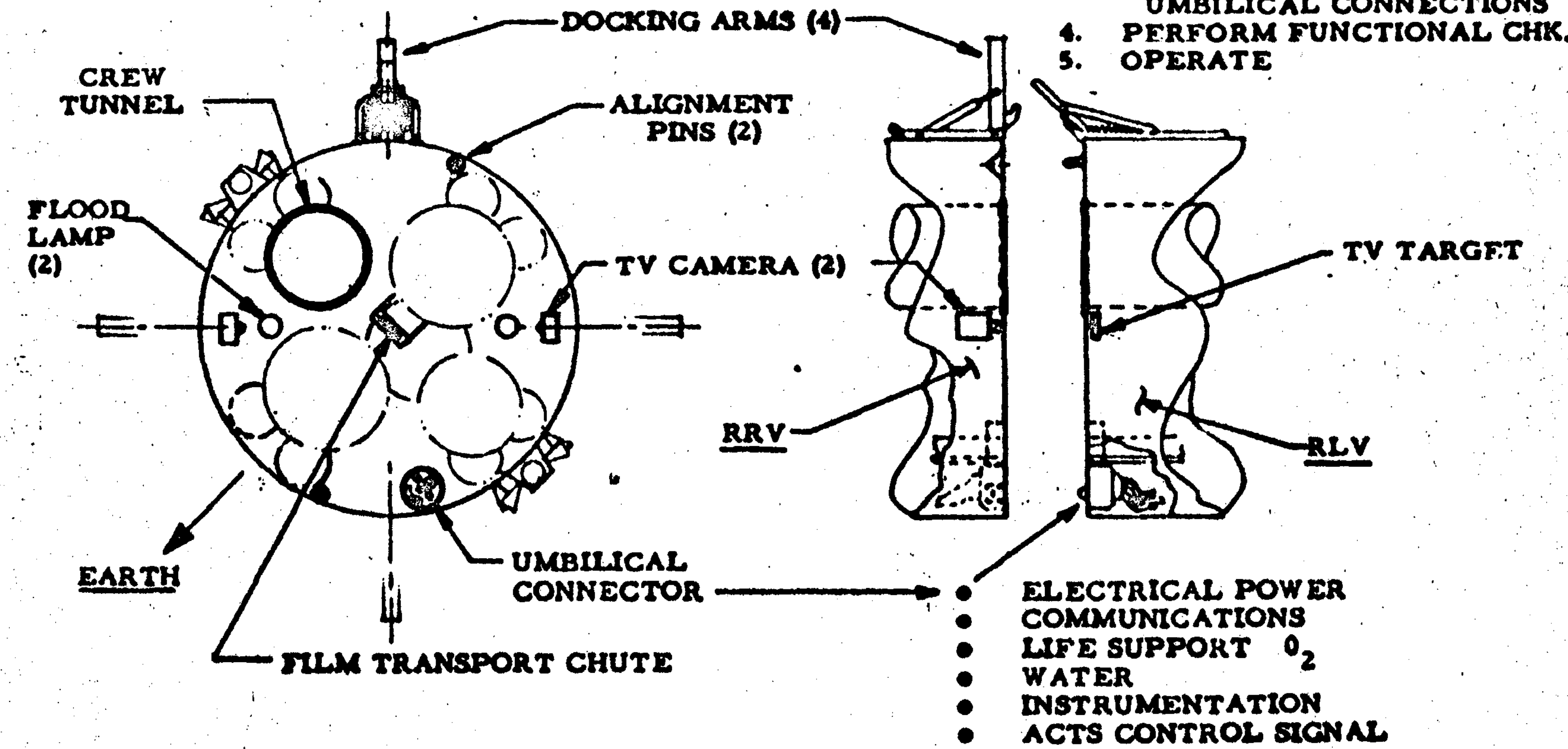
RIV FUNCTIONS

- LIFE SUPPORT SYSTEM
- ATTITUDE CONTROL REFERENCE/ ELECTRONICS
- COMMUNICATIONS AND DATA HANDLING
- ENVIRONMENTAL CONTROL
- HRO SYSTEM

DOCKING SYSTEM/INTERFACE CONCEPT

MATING SEQUENCE:

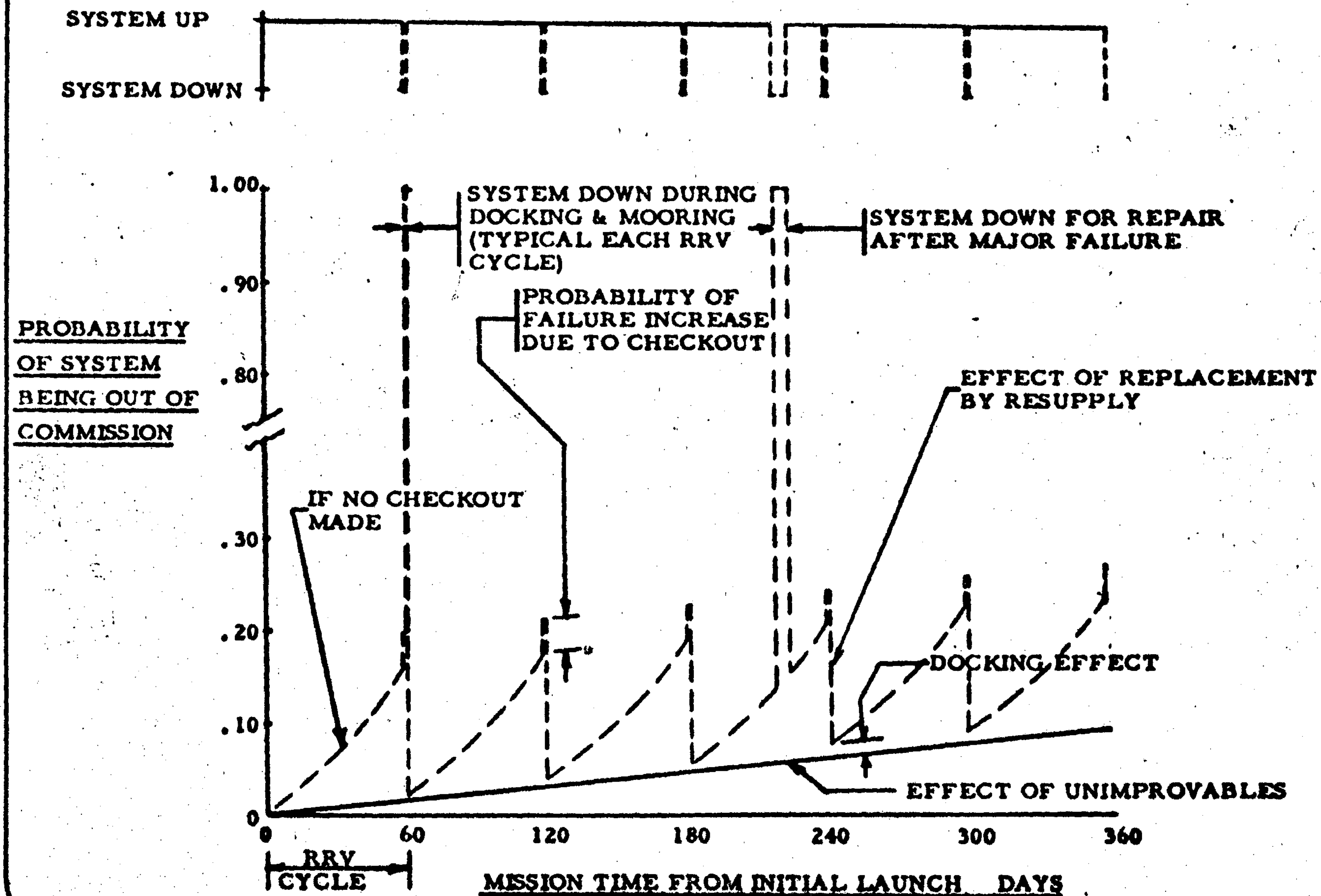
1. DISSIPATE DOCKING ENERGY & STABILIZE STRUCTURE
2. INDEX & LOCK STRUCTURE; TUNNEL
3. MATE MECHANIZFD UMBILICAL CONNECTIONS
4. PERFORM FUNCTIONAL CHK.
5. OPERATE



CONCEPT OF EXTENDED LIFE SYSTEMS

- COMPLETE REPLACEMENT EACH RESUPPLY CYCLE
  - ✓ FUEL CELLS
  - ✓ CRYOGENIC TANKAGE
  - ✓ THRUST CHAMBER ASSY.
  - ✓ PROPELLANT TANKS/FUEL SYSTEMS
- INTENSE APPLICATION OF SPARES FOR MANNED MAINTENANCE/REPAIRS/REPLACEMENT.
- UTILIZATION OF MAN IN TROUBLE-SHOOTER ROLE
- ELIMINATION OF MAJOR EQUIPMENT PROBLEMS DURING INITIAL MOL DEVELOPMENT PROGRAM.

RENDEZVOUS ORBITING VEHICLE AVAILABILITY FOR LONG DURATION



EARLY RESUPPLY FOLLOW-ON PROGRAM ESTIMATED COSTS

NON-RECURRING

• RRV DEV.		67.5
√ DESIGN/INTEGRATION	50.0	
√ HARDWARE	17.5	
• DOCKING SYSTEM DEVELOPMENT		18.5
• RIV DESIGN/INTEGRATION		18.0
• ROV INTEGRATION/TEST		12.0
• LAUNCH SITE REQUIREMENTS		142.5
• ADDITIONAL PRODUCTION FACILITY AND FACTORY AGE (RRV)		10.0
• MISSION SIMULATOR MODS		5.0
	TOTAL M$	273.5

RRV DESIGN AND INTEGRATION

			ESTIMATED COST IN $1000		
	MEN	MAN-MON	ENG'R DESIGN $ 3000/MM FOR 18 MON	DEV. TEST	QUAL. TEST
• EXTENDED DURATION MODULE STRUCTURE	20	360	1,080	1,500	1,500
• PROPULSION SYSTEM INSTALLATION	15	270	810	1,000	1,500
• POWER SYSTEM INSTALLATION	15	270	810	1,000	1,500
• CRYOGENIC TANKAGE INSTALLATION	15	270	810	1,000	1,500
• CARGO COMPARTMENT & CREW TUNNEL	10	180	540	800	1,000
• DOCKING SYSTEM INSTALLATION	10	180	540	---	---
• ACQUISITION AIDS INSTALLATION	20	360	1,080	1,000	1,500
• DATA SYS. INSTALLATION	20	360	1,080	1,500	2,000
• DOCKING PLANE INTER CONNECTIONS	20	360	1,080	1,500	2,000
• GEMINI B INTEGRATION & LIFE EXT.	45	810	2,500	4,000	5,500
• UNPRESSURIZED COMPARTMENT DESIGN/INTEGRATION	15	270	810	1,000	1,500
• SYSTEMS INTEGRATION	30	540	1,620	---	---
• SIMULATION & TRAINING	20	360	1,080	2,000	---
	255	4,590	13,840	16,300	19,500

TOTAL 49,640

RRV GROUND TEST HARDWARE

(RESUPPLY MODULE)

		M$
● / QUALIFICATION TEST UNIT (COMPLETE SET)		11.8
● / STRUCTURAL TEST UNIT		5.7
- STRUCTURE & CREW TUNNEL	1.0	
- PROPELLANT TANKS/FEED	1.4	
- CRYOGENIC TANKS	.9	
- FUEL CELLS (SIMULATED)	.3	
- DATA SYSTEM (SIMULATED UNITS)	.7	
- DOCKING SYSTEM	.4	
- VEHICLE ASSEMBLY & CHECK OUT	1.0	
TOTAL HRDWR COST		17.5

RENDEZVOUS/RESUPPLY MODULE RECURRING COST ESTIMATE

MILLIONS OF DOLLARS

STRUCTURE SHELL -		1.0
√ SHELL	0.8	
√ INTERIOR SUPPORT	0.2	
ACTS		2.2
√ TCA/LOGIC	1.0	
/ PROPELLANT TANKS/ MANIFOLDS, VALVES, ETC.	1.2	
EPS		3.4
√ CRYOGENIC TANKAGE	1.6	
√ FUEL CELLS (5)	1.5	
√ CONTROLS/DISTRIBUTION	0.3	
THERMAL CONTROL		0.2
COMMUNICATIONS/TRACKING		0.2
INSTRUMENTATION		0.2
DATA RETURN SYSTEM		1.8
√ FILM TRANSPORT & DRV SUPPORT	0.3	
√ DRV'S (6)	1.5	
DOCKING SYSTEM		0.4
SPARES COMPLIMENT (60 DAY)		1.0
VEHICLE ASSEMBLY/CHECKOUT		1.4
TOTAL		11.8

32 BJE

D SECRET SPECIAL HANDLING

DOCKING SUBSYSTEM DEVELOPMENT

		ESTIMATED COST IN $1000			
		DESIGN	DEVEL. TEST	QUAL. TEST	TOTALS
● RRV MECHANISM (ACTIVE)		2,500	2,500	2,500	7,500
ENGAGEMENT & CAPTURE DEVICE ACTUATING SYS., CONTROLS, SENSORS ALIGNMENT DEVICE					
● RIV MECHANISM (PASSIVE)		2,000	2,000	2,000	6,000
ENGAGEMENT & CAPTURE DEVICE ACTUATING SYS., CONTROLS, SENSORS ALIGNMENT DEVICE					
● SYSTEM INTEGRATION		1,000	---	---	1,000
● SIMULATION		500	---	---	500
DISPLAY (CRT) EQUIP FOR DOCKING	500				
MODIFY NASA SIMULATOR	1,600				1,500
● MISSION CONTROL	2,000				2,000
	3,500	6,000	4,500	4,500	18,500

REFERENCE:

- AGENA TARGET DOCKING ADAPTER (TOTAL PROGRAM COST: INCLUDES STRUCTURE, ELECTRICAL, ELECTRONICS: AND 7 SETS OF FLIGHT HARDWARE) ~ 10 MS
- PASSIVE TARGET VEHICLE (TOTAL COST: INCLUDES ALL HARDWARE DEV. PLUS 2 FLIGHT ARTICLES) $ 427,000

D SECRET SPECIAL HANDLING

32 BUF

RENDEZVOUS INITIAL VEHICLE

(NON-RECURRING COST ESTIMATE)

	DESIGN	1,000/$ D. T.	Q. T.
● DOCKING SYSTEM INSTALLATION	200	0	0
● INTERCONNECTION INSTALLATION (DESIGN + FLUID & ELECT. DEV.)	1,000	1,500	600
● TUNNEL HOOKUP (DESIGN & INSTALL - DEV.)	200	300	400
● DATA HANDLING (DESIGN & INSTAL - DEV.)	1,000	300	600
● INTERDOCK SYSTEM			
- ATTITUDE CONTROL ("MINIMUM" TYPE)	1,500	1,000	1,500
- POWER SYSTEM	200	300	400
● AUTOMATIC SYSTEM (INITIAL & INTERDOCK REQ.)	200	200	600
● NOSE CONE (DESIGN & INSTALL - DEV.)	200	400	300
TOTAL COST (INCLUDING HARDWARE)	4,500	4,000	4,500
● LAB EXTENDED LIFE TEST		5,000	
TOTAL		18,000 K, $	

EARLY RESUPPLY FOLLOW-ON PROGRAM ESTIMATED COSTS

LAUNCH SITE REQUIREMENTS *

		TOTALS M$
FACILITIES		
• LCC MODS	0.5	
• PAD #1 MODS	0.5	
• PAD #2 - NEW	15.5	
• SUPPORT AREAS MODS	4.0	20.5
AGE		
• LCC	58.0	
• PAD #1	5.0	
• PAD #2	56.0	119.0
OTHER		
• TV/COMM	2.0	
• SYSTEMS ENG/INTEG.	1.0	3.0
TOTAL COST		142.5

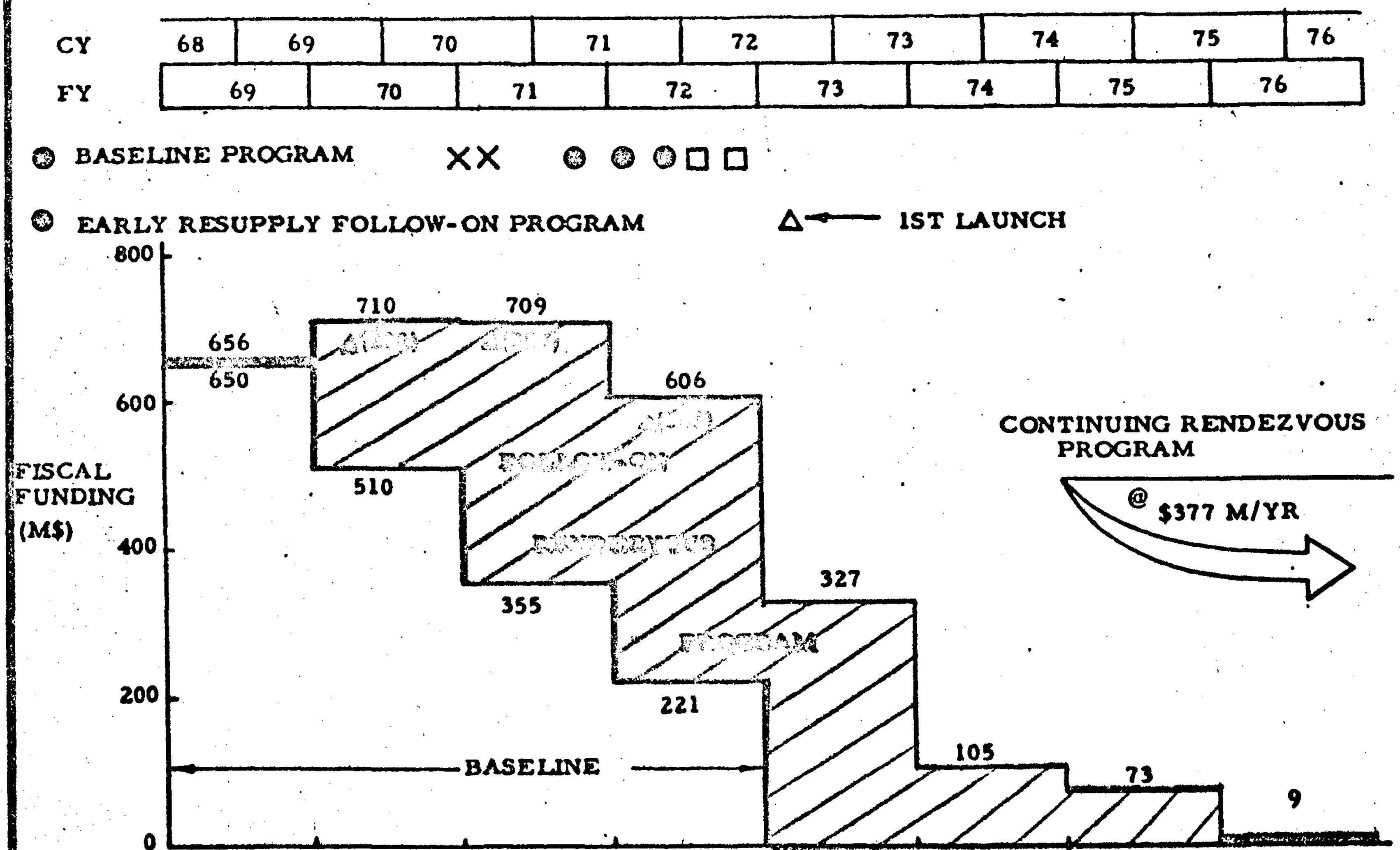
* SAME RATIONAL AND COSTING AS "MOL LAUNCH FACILITIES OPTIONS" STUDY (PLAN #1), DATED 15 FEBRUARY 1967

EARLY RESUPPLY FOLLOW-ON PROGRAM ESTIMATED COSTS

RECURRING

	UNIT (M$)	TOTAL/LAUNCH (M$)
• RIV		69.4
√ HARDWARE	(62.3)	
o T-IIIM	14.5	
o LAB VEHICLE	23.3	
o MISSION PAYLOAD	22.0	
o MISC. - NOSECONE		
- AUX. ACTS	2.5	
- DOCKING & INTERFACE		
√ O & M	(7.1)	
o LAUNCH SERVICES	5.1	
o TRACKING	1.0	
o FLIGHT OPS & SUPPORT	1.0	
• RRV		56.5
√ HARDWARE	(41.3)	
o T-IIIM	14.5	
o RRV MODULE	11.8	
o GEMINI	14.0	
o PRESS. SUITS, ETC.	1.0	
√ O & M	(9.0)	
o LAUNCH SERVICES - PRIMARY	3.1	
o - BACK-UP	1.3	
o RECOVERY/TRACKING	1.8	
o FLIGHT OPS. & SUPPORT	1.8	
o CREW TRAINING	1.0	

FISCAL FUNDING ESTIMATE FOR A RESUPPLY FOLLOW-ON OPTION



EARLY RESUPPLY FOLLOW-ON PROGRAM ESTIMATED COSTS

FISCAL FUNDING (MILLIONS OF $)

FY	69	70	71	72	73	74	75	76
STUDIES	6.0							
NON-RECURRING		111.0	85.0	69.0	9.5			
RECURRING		88.0	265.0	311.0	313.9	101.8	71.3	8.2
GSE/TD		1.0	4.0	5.0	4.0	3.0	2.0	1.0
YEARLY TOTAL	6.0	200.0	354.0	385.0	327.4	104.8	73.3	9.2

REVIEW OF MOL PLANNING ACTIVITIES

ORGANIZATION AND SCOPE OF BRIEFING

- EARLY SYSTEM DEFINITION STUDIES (1963 - 1965)

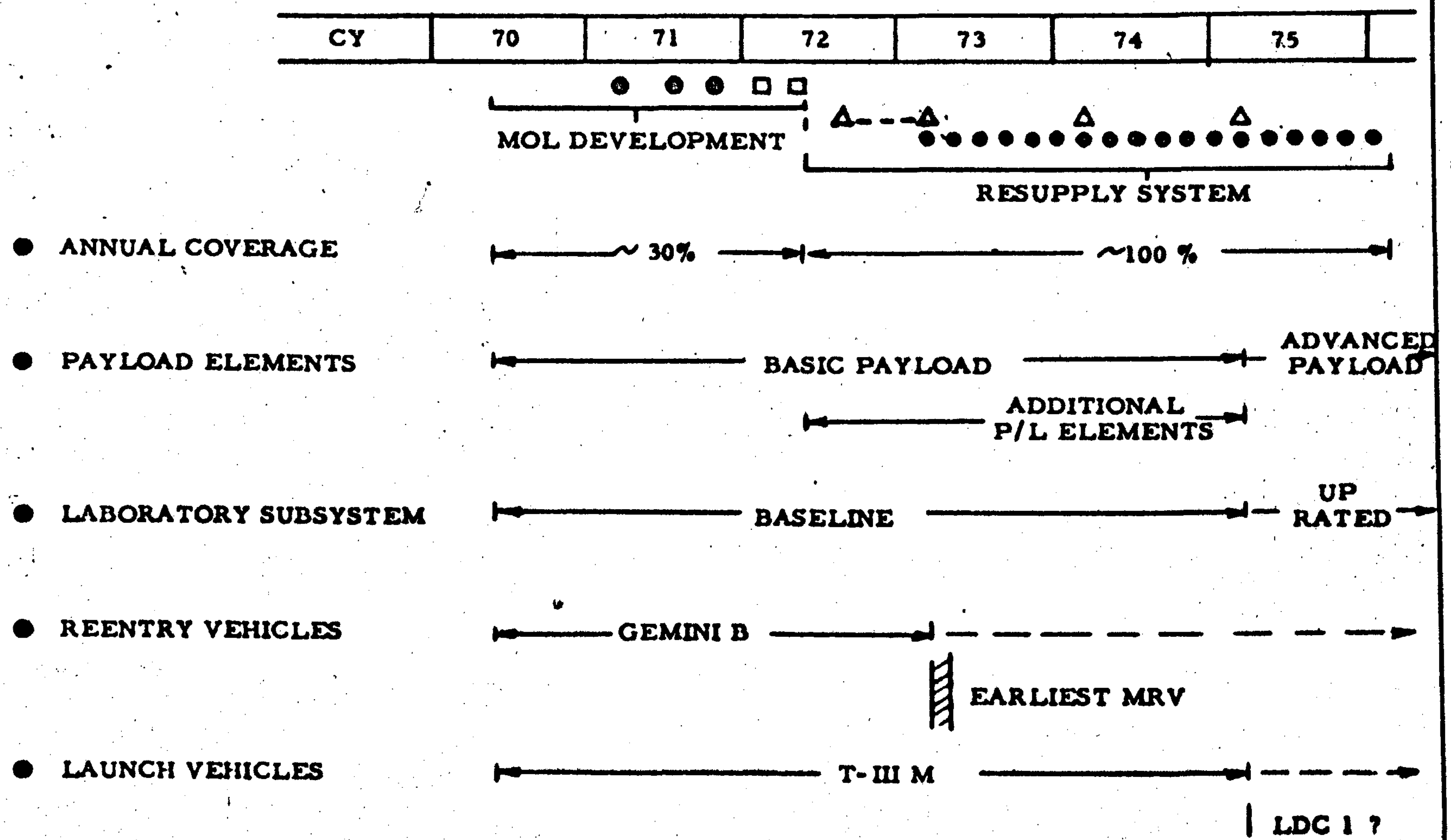
- RECENT SYSTEM IMPROVEMENTS AND GROWTH STUDIES (1965 - 1967)

- CURRENT MOL PLANNING FRAMEWORK (1967 - 1968)

MOL GROWTH OBJECTIVES

- IMPROVED SYSTEM ECONOMICS
  - ✓ INCREASED MISSION DURATION
  - ✓ EXTENDED UTILIZATION OF SYSTEM SEGMENTS
- IMPROVED OPERATIONAL FLEXIBILITY
  - ✓ RECALL/REPEATER CAPABILITY
  - ✓ CREW NUMBER INCREASE
  - ✓ ORBITAL ASSEMBLY
  - ✓ ORBITAL STORAGE
  - ✓ VULNERABILITY COUNTERMEASURES
- IMPROVED MISSION PERFORMANCE
  - ✓ BASELINE P/L CAPABILITY
  - ✓ HIGHER RESOLUTION P/L
  - / ADDITIONAL/COMPLIMENTARY P/L ELEMENTS
  - ✓ DATA RECOVERY TECHNIQUES
- ADDITIONAL APPLICATIONS OF MOL HARDWARE TO DOD/NASA NATIONAL SPACE GOALS

POSSIBLE MOL PLANNING FRAMEWORK



MOL SYSTEM SHORT RANGE PLANNING ACTIVITIES

IN HOUSE STUDIES FY-68

INITIAL FOLLOW-ON MIX

- FLT. FREQUENCY ALTERNATIVES
- MANNED & AUTO FLIGHTS
- FOLLOW ON PROGRAM TIMING
- COST ESTIMATES
- LEAD TIME & FUNDING REQMTS.

RENDEZVOUS/RESUPPLY

- DAC CONTRACT (5 MOS. STUDY)
- OPERATIONS MECHANICS (ALTERNATIVES)
- DOCKING DYNAMICS
- DESIGN EVALUATION

SYSTEM LIFE EXTENSION

- MAN'S ROLE IN REPAIR/DIAGNOSIS
- EFFECTIVENESS MODEL EXTENSION
- ACCESSIBILITY STUDIES

DATA MANAGEMENT/RECOVERY VEHICLES

(FOLLOW-ON APPLICATIONS)

- MULTI DATA-RECOVERY-VEHICLE
- WIDE-BAND LINK
- VEHICLE SYSTEM IMPACT

COMPLIMENTARY PAYLOADS

(FOLLOW-ON)

- ELINT, IR, FWD. & SIDE LOOK RADAR, LASER

ADVANCED PAYLOAD & TECHNOLOGY

- MIRROR MATERIAL & FABRICATION
- NAVIGATION ACCURACY REQMTS.
- MAN VS AUTOMATED FUNCTIONS
- CONTROL MOMENT GYRO DEVELOPMENT
- FORMAT SIZE AND CAMERA REQMTS
- FILM TRANSPORT & HANDLING

IMPACT OF ADVANCED P/L ON MOL SYSTEM DESIGN/PERFORMANCE

- STRUCTURAL DESIGN
- SYSTEM DYNAMICS
- NAVIGATION SYSTEM REQMTS
- ATTITUDE CONTROL REQMTS
- ELECTRICAL POWER SYSTEM
- LABORATORY CONFIGURATION CHANGES
- SYSTEM PERFORMANCE
- LAUNCH VEHICLE REQMTS
- OPERATIONS (ALTERNATIVES, MAN'S CONTRIBUTION)
- PRODUCTION FLOW
- P/L-LABORATORY INTEGRATION

VULNERABILITY/SURVIVABILITY

MOL SYSTEM SHORT RANGE PLANNING ACTIVITIES

IN-HOUSE STUDIES FY-68 (CONT.)

GEMINI B IMPROVEMENTS STUDIES

- LAND LANDING
- REFURBISHMENT/RE-USE
- STRANDING HAZARD REDUCTION
- ORBIT STORAGE LIFE EXTENSION
- CREW SIZE INCREASE

MANEUVERING RE-ENTRY VEHICLE APPLICATIONS

- SYSTEM REQUIREMENTS (MISSION)
- CONFIGURATION DEVELOPMENT
- FLIGHT SYSTEM INTEGRATION
- PERFORMANCE ANALYSIS
- DEVELOPMENT CYCLE (TEST FLOW)
- OPERATIONS

FUTURE MOL VEHICLE SYS. PLANNING

"60 DAY" AUTO MODE VEHICLE IMPLEMENTATION

- SCHEDULE & COST ESTIMATE
- TEST REQUIREMENTS

OTHER DOD/NASA APPLICATIONS

- EXTENDED BIO-TEST
- EARTH SENSOR COMPLEX
- ASTRONOMY/SPACE PHYSICS
- ORBITAL ASSEMBLY
- DOD P/S EXPERIMENTS

STATUS REVIEW - ADVANCED SUBSYSTEMS TECHNOLOGY

- ELECTRICAL POWER
- PROPULSION
- GUIDANCE & ATTITUDE CONTROL
- NAVIGATION
- LIFE SUPPORT
- THERMAL CONTROL

MOL SHORT RANGE PLANNING REVIEW

SUMMARY/CONCLUSIONS

- PLANNING EFFORTS HAVE CONTRIBUTED TO ESTABLISHING A VIABLE PROGRAM
- LOGICAL AVENUES OF SYSTEM GROWTH HAVE BEEN DEFINED AND PROTECTED
- A PLANNING BASELINE HAS BEEN ESTABLISHED
- SHORT TERM PLANNING TASKS HAVE BEEN IDENTIFIED

POSSIBLE UTILIZATION OF MOL HARDWARE

FOR LONG DURATION BIOASTRONAUTICS TEST MISSIONS

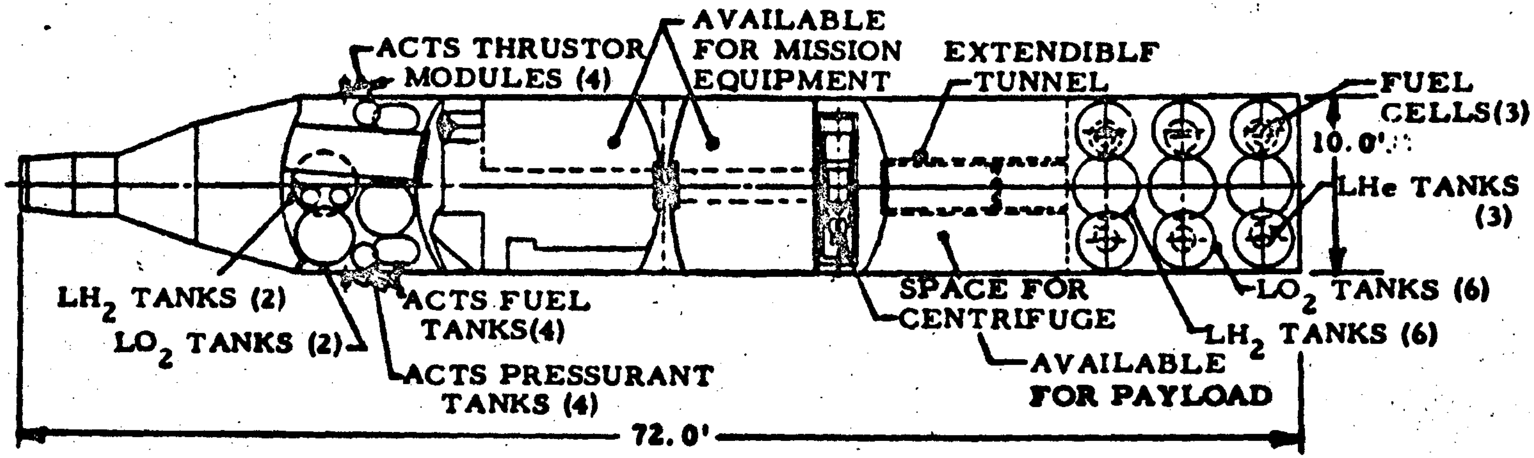
POTENTIAL APPROACHES FOR BIOASTRONAUTIC TESTING

- 60 TO 90 DAY DURATION
  - ✓ INTEGRAL LAUNCH MODE - SINGLE OR DUAL COMPARTMENT MODULE
- DURATIONS EXCEEDING 90 DAYS
  - ✓ RENDEZVOUS MODE - 4 MAN DUAL COMPARTMENT LABORATORY CONFIGURATION
  - ✓ 2 MAN DUAL COMPARTMENT LABORATORY CONFIGURATION (COMBINED MISSION)

INTEGRAL LAUNCH DUAL COMPARTMENT LABORATORY

(CONFIGURATION AND PERFORMANCE)

o **CONFIGURATION**



o **PERFORMANCE**

TOTAL PRESSURIZED VOLUME (SHIRT SLEEVE ENVIRONMENT)		2,000 FT^3
AVAILABLE PRESSURIZED VOLUME FOR CREW		1,200 FT^3
AVAILABLE PRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT		400 FT^3
AVAILABLE UNPRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT		~ 700 FT^3
EXPERIMENT PAYLOAD CAPACITY	(ETR, i = 28.5°, 180 N M CIR)	~5,800 LB
	(WTR, i = 80°, 180 N M CIR)	~1,000 LB
ELECTRICAL POWER (AVERAGE)		1,650 WATTS*
MISSION DURATION		90 DAYS

*INCLUDES 200 WATTS FOR EXPERIMENTS

APPROACH TO INTEGRAL LAUNCH EXTENDED DURATION

	30 DAY MOL BASELINE (80/180 N MI ORBIT, i=80°)	90 DAY EXTENDED DURATION VEHICLE* (180 N MI CIR. ORBIT, i=80°)
● **PROPULSION**		
PROPELLANTS	2,000 LBS	1,450 LBS
TANKAGE	4 FUEL + 4 OXID.	4 FUEL + 4 OXID.
● **PRIME POWER**	3 FUEL CELLS 1,650 WATTS	6 FUEL CELLS 1,650 WATTS
● **CRYOGENICS**		
FLUID (LO_2, LH_2, LH_e)	1,330 LBS	5,320 LBS
TANKAGE	2 LO_2 + 2 LH_2 + 1 H_e	8 LO_2 + 8 LH_2 + 4 H_e
● **PERSONNEL PROVISIONS**		
FOOD & PERSONAL GEAR	148 LBS	445 LBS
● **SUBSYSTEM SPARES**	160 LBS	410 LBS

*DUAL COMPARTMENT LABORATORY

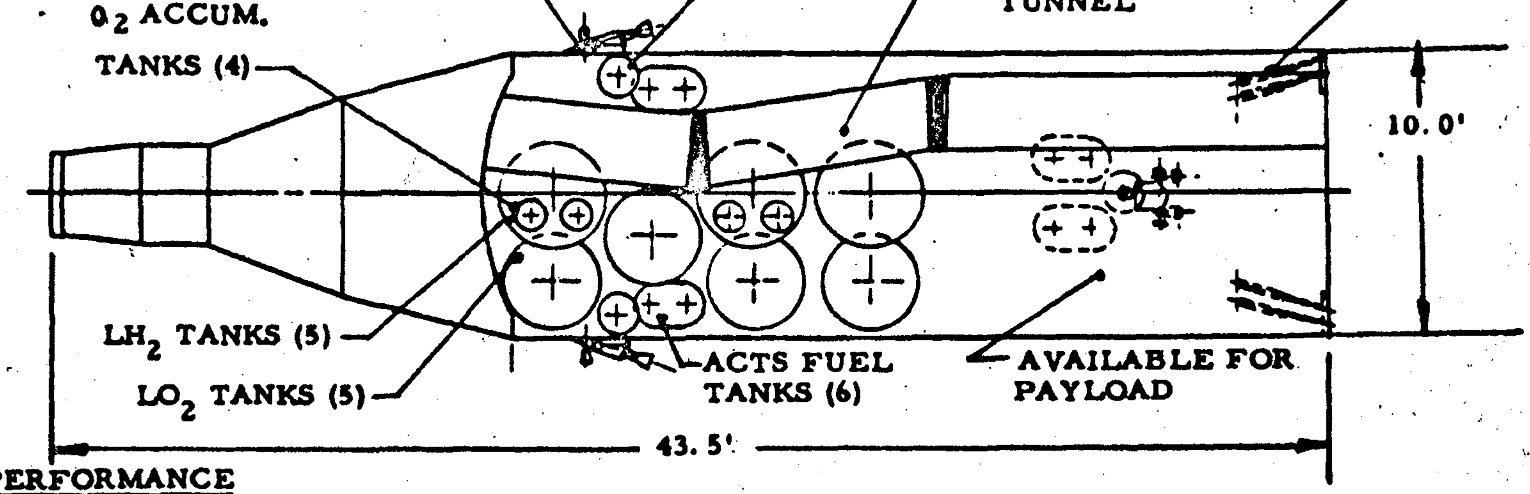
MISSION DURATIONS EXCEEDING 90 DAYS

(RENDEZVOUS)

RENDEZVOUS RESUPPLY VEHICLE

(CONFIGURATION AND PERFORMANCE)

o CONFIGURATION



o PERFORMANCE

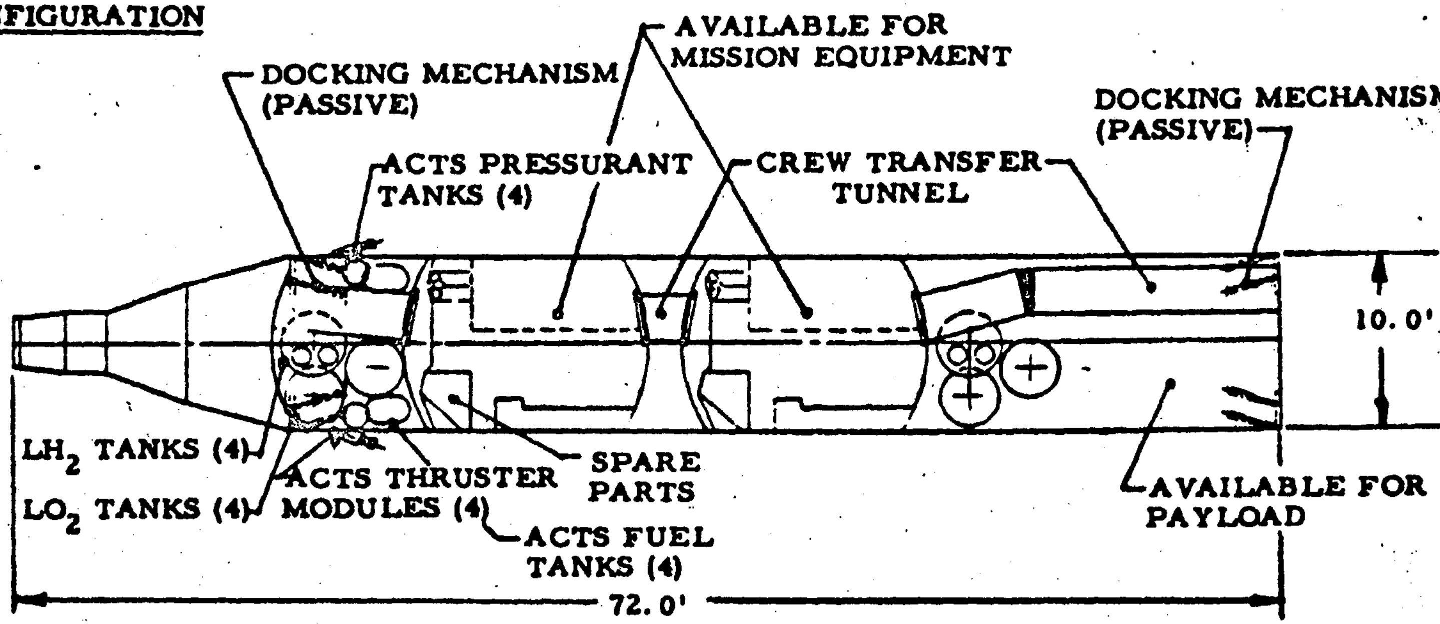
UNPRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT	2,000 FT^3
EXPERIMENT PAYLOAD CAPACITY (WTR, $i = 80^\circ$, 180 N M CIR)	10,000 LBS
ELECTRICAL POWER (AVERAGE)	2,000 WATTS*
RESUPPLY CYCLE (TO SUPPLY 4 MAN CREW)	60 DAYS

*200 WATTS AVAILABLE FOR EXPERIMENTS

4 MAN DUAL COMPARTMENT LABORATORY

(CONFIGURATION AND PERFORMANCE)

- **CONFIGURATION**

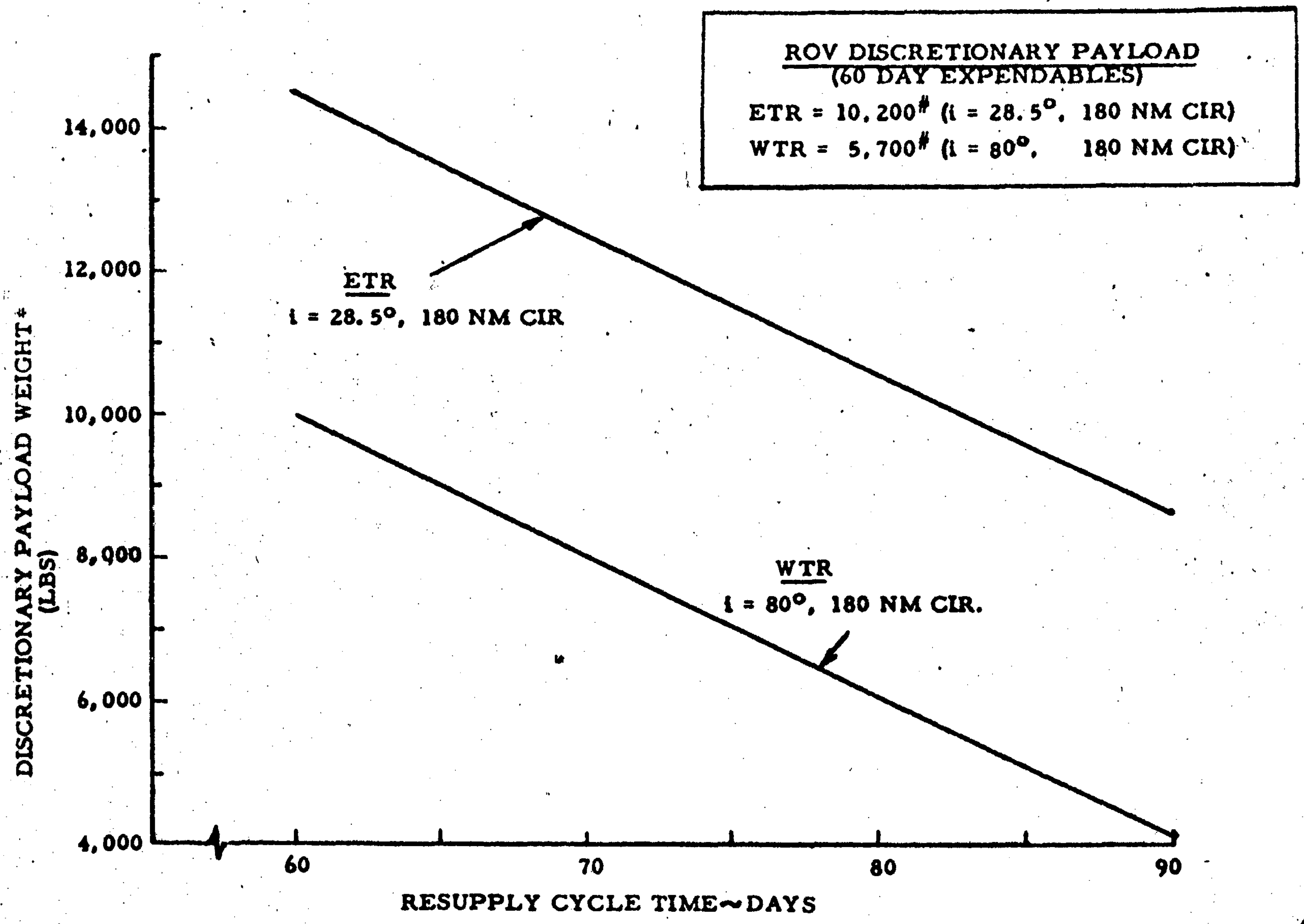


- **PERFORMANCE**

TOTAL PRESSURIZED VOLUME (SHIRT SLEEVE ENVIRONMENT)	2,000 FT^3
AVAILABLE PRESSURIZED VOLUME FOR CREW	1,200 FT^3
AVAILABLE PRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT	600 FT^3
AVAILABLE UNPRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT	950 FT^3
EXPERIMENT PAYLOAD CAPACITY (WTR, $i = 80^\circ$, 180 N M CIR)	5,700 LBS
ELECTRICAL POWER (AVERAGE)	2,000 WATTS*
RESUPPLY CYCLE	60 DAYS

* 200 WATTS AVAILABLE FOR EXPERIMENTS

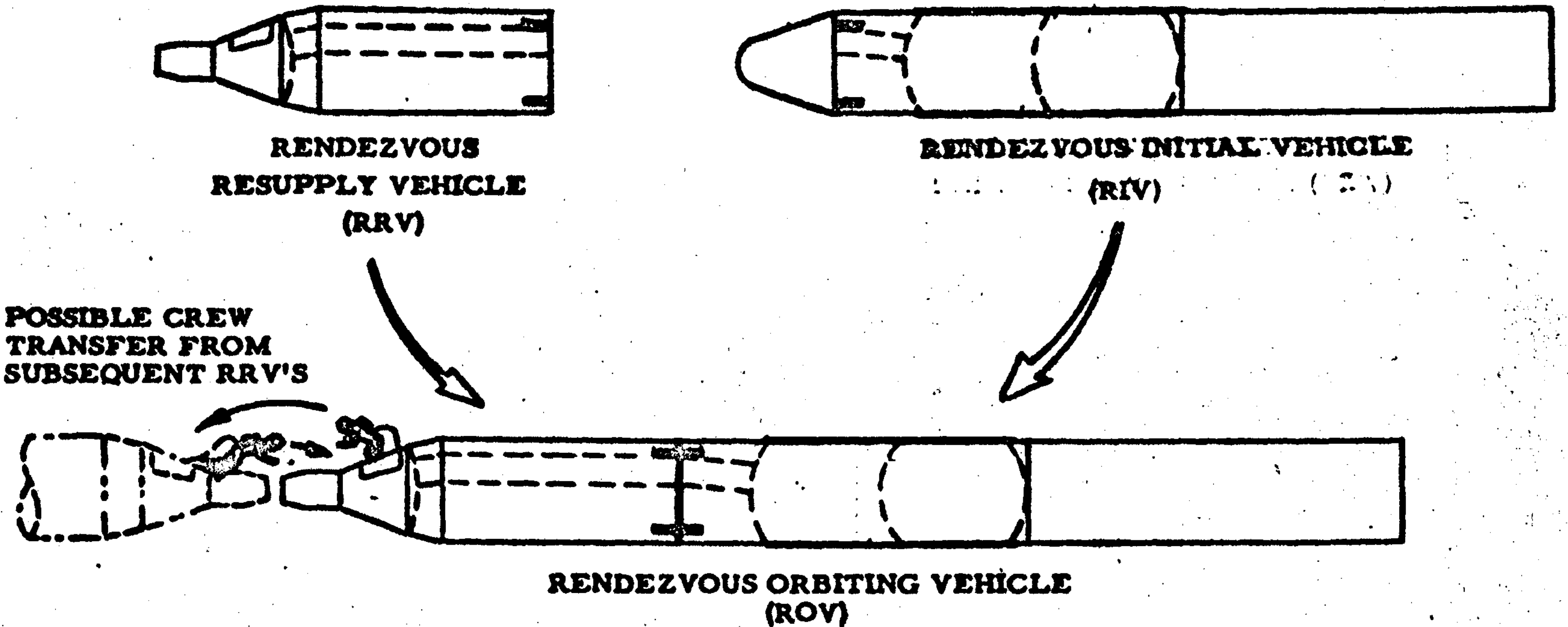
RESUPPLY VEHICLE DISCRETIONARY PAYLOAD



*DISCRETIONARY PAYLOAD = BOOSTER CAPABILITY LESS WEIGHT OF LOADED RRV

FIGURE 6
2 MAN DUAL COMPARTMENT LABORATORY CONFIGURATION

(COMBINED MISSION)



RRV FUNCTIONS

- CREW TRANSPORT VEHICLE
- ACTS PROPULSION
- PRIME POWER
- LIFE SUPPORT EXPENDABLES
- DATA RETURN SYSTEM
- SUBSYSTEM SPARES/REPLACEMENTS

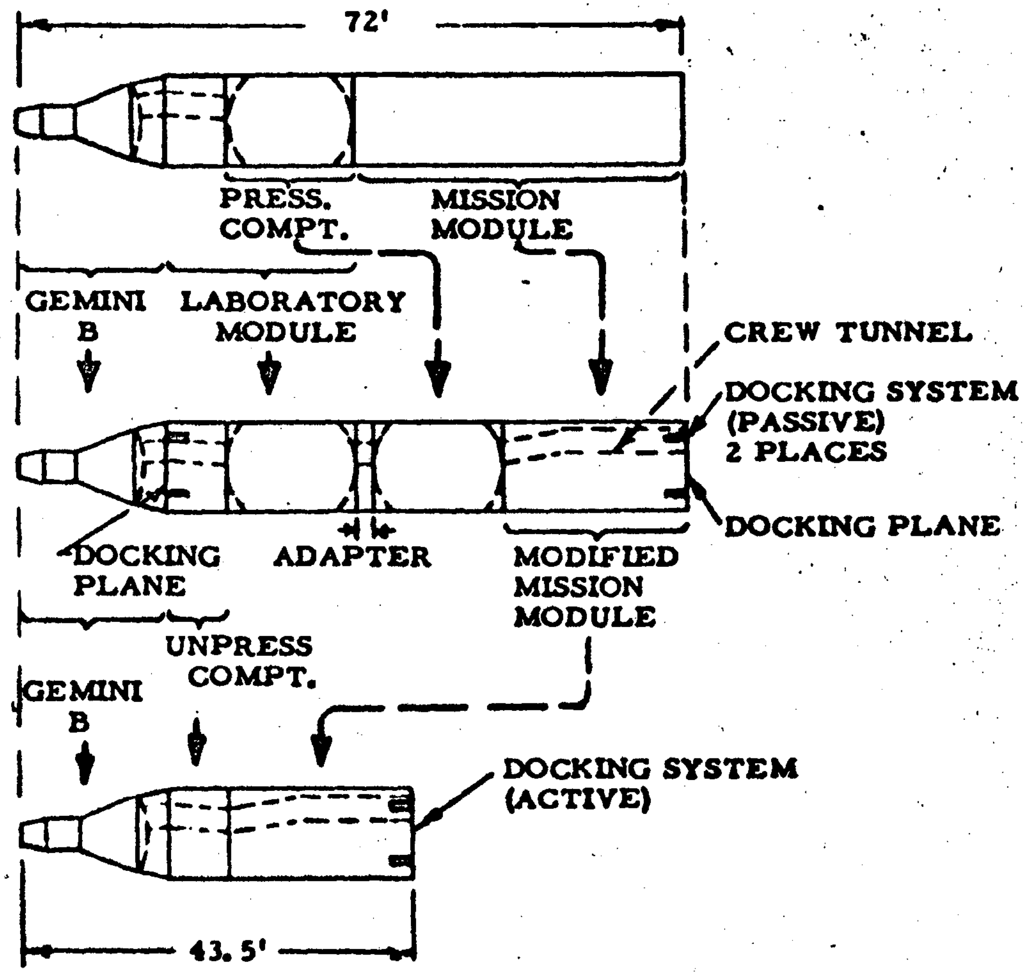
RIV FUNCTIONS

- LIFE SUPPORT SYSTEM
- ATTITUDE CONTROL REF. ELECTRONICS
- COMMUNICATIONS AND DATA HANDLING
- ENVIRONMENTAL CONTROL
- PERFORMANCE DATA

SECRET SPECIAL HANDLING

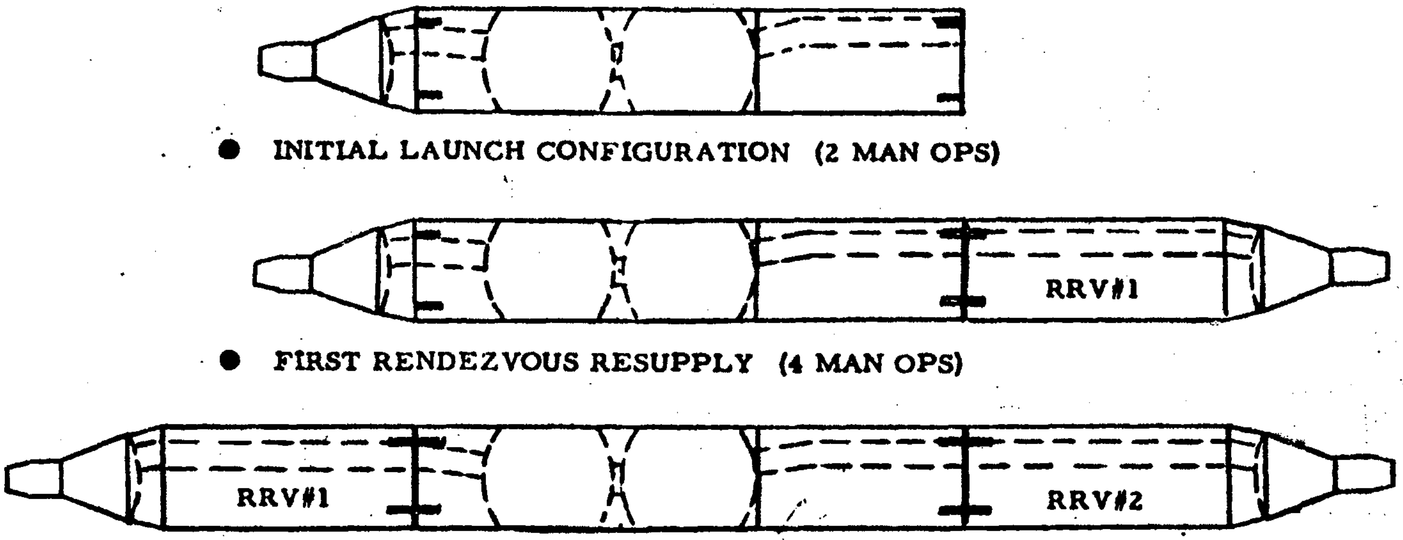
UTILIZATION OF MOL HARDWARE FOR
4 MAN DUAL COMPARTMENT LABORATORY CONFIGURATION

- O MOL BASELINE VEHICLE
- O RENDEZVOUS INITIAL VEHICLE (RIV)
- O RENDEZVOUS RESUPPLY VEHICLE (RRV)



SECRET SPECIAL HANDLING

4 MAN DUAL COMPARTMENT LABORATORY



- INITIAL LAUNCH CONFIGURATION (2 MAN OPS)
- FIRST RENDEZVOUS RESUPPLY (4 MAN OPS)
- ON-ORBIT CONFIGURATION (4 MAN OPS)

RRV FUNCTIONS

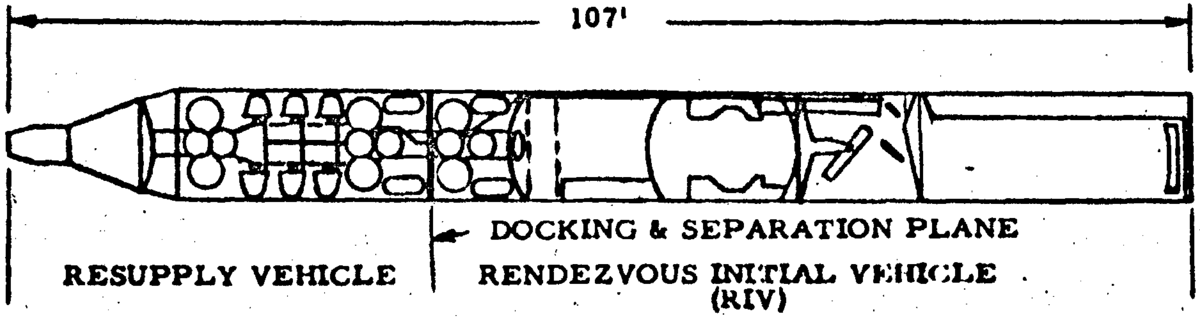
- ACTS PROPULSION
- PRIME ELECTRICAL POWER
- LIFE SUPPORT EXPENDABLES
- EXPERIMENTS
- SPARE EQUIPMENT

LABORATORY FUNCTIONS

- LIFE SUPPORT/ENVIRONMENTAL CONTROL
- ACTS - REFERENCE
- COMMUNICATIONS/DATA
- BIO-MEDICAL EQUIPMENT
- EXPERIMENTS

2 MAN DUAL COMPARTMENT LABORATORY
CONFIGURATION AND PERFORMANCE SUMMARY
(COMBINED MISSION)

- **CONFIGURATION**

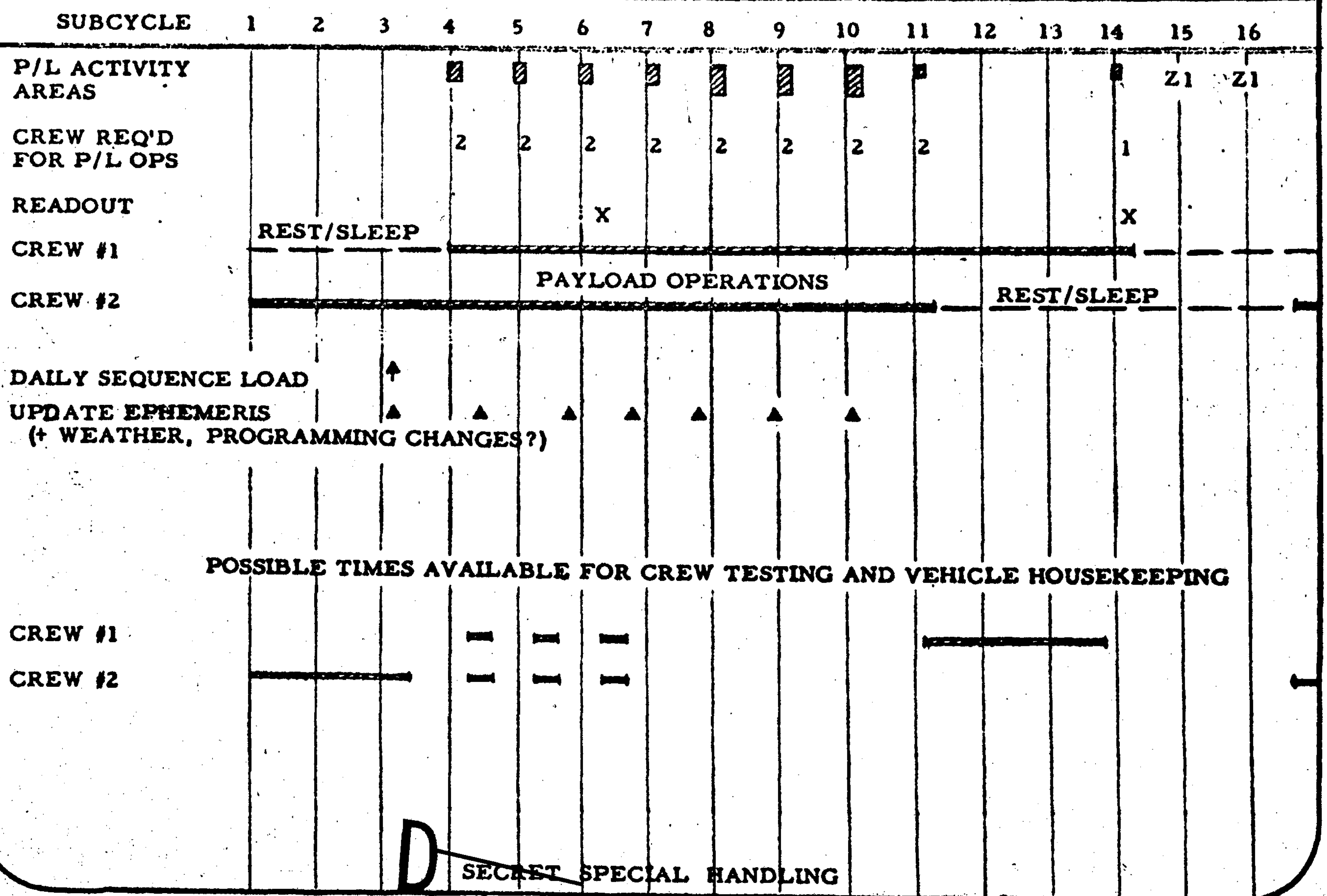


- **PERFORMANCE DATA**

TOTAL PRESSURIZED VOLUME (SHIRT SLEEVE ENVIRONMENT)	2,060 FT^3
AVAILABLE PRESSURIZED VOLUME FOR CREW	1,200 FT^3
AVAILABLE PRESSURIZED VOLUME FOR EXPERIMENT EQUIPMENT	210 FT^3
R.I.V. EXP. PAYLOAD CAPACITY ($i = 96.4^\circ$, 80/180 NM)	3,000 LBS
ELECTRICAL POWER (AVERAGE)	1,960 WATTS
RESUPPLY CYCLE	60 DAYS

COMBINED MISSION OPERATIONS

TYPICAL WORKCYCLE FOR A NORMAL DAY



POTENTIAL BIOASTRONAUTICS TEST PROGRAMS

4 MAN - DUAL COMPARTMENT LAB

LAUNCH	DURATION (MONTHS)	ON-ORBIT	TEST DATA
1 & 2	2	2, 2, 2, 0	2
3	4	4, 4, 0, 2	4
4	6	6, 0, 2, 4	6
5	8	8, 2, 4, 6	-
6	10	10, 4, 6, 8	-
7	12	12, 6, 8, 10	12, 6, 8, 10

TEST DATA TOTALS

1 MAN X 2 MO.
1 MAN X 4 MO.
2 MEN X 6 MO.
1 MAN X 8 MO.
1 MAN X 10 MO.
1 MAN X 12 MO.

2 MAN - DUAL COMPARTMENT LAB

LAUNCH	DURATION (MONTHS)	ON-ORBIT	TEST DATA
1 & 2	2	2, 0	2
3	4	0, 2	4
4	6	0, 4	2
5	8	2, 0	6
6	10	4, 0	2
7	12	6, 2	-
8 & 9	14	0, 2	8
10	16	0, 4	2
11	18	2, 6	-
12	20	0, 10	4
13	22	2, 12	2, 12

TEST DATA TOTALS

5 MEN X 2 MO.
2 MEN X 4 MO.
1 MAN X 6 MO.
1 MAN X 8 MO.
1 MAN X 12 MO.

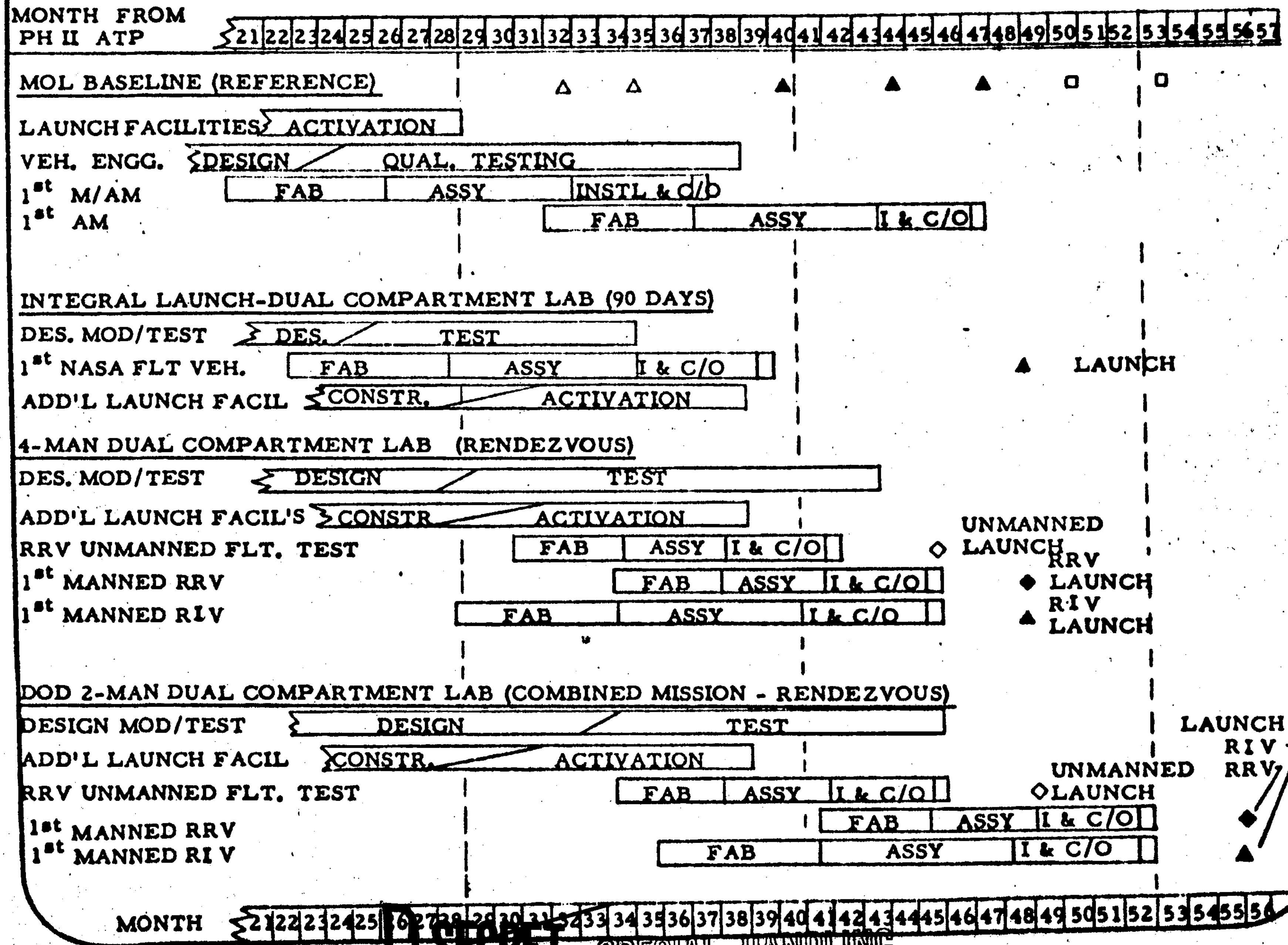
COST RANGE SUMMARY - WTR
INCREMENTS ABOVE MOL BASELINE*

PROGRAM	NONRECURRING COST, M$	RECURRING COST, M$	TOTAL** COST, M$
● 60 TO 90 DAY BIOASTRONAUTICS TESTING			
• 2 MAN - DUAL COMPARTMENT LAB (INTEGRAL LAUNCH)	285	332	562
● 1 YEAR BIOASTRONAUTICS TESTING			
• 1 YEAR PROGRAM 4 MAN - DUAL COMPARTMENT LAB (INTEGRAL LAUNCH)	515	466	981
• 2 YEAR COMBINED MISSION PROGRAM 2 MAN - DUAL COMPARTMENT LAB (RENDEZVOUS)	299	97	396

* 2 MANNED AND 3 UNMANNED LAUNCHES PER YEAR ASSUMED FOR BASELINE FOLLOW-ON PROGRAM

** NOT INCLUDING NASA PAYLOAD ELEMENTS

AVAILABILITY OF ALTERNATE SYSTEMS-WTR



CONCLUSION

- TEST DURATIONS UP TO 90 DAYS APPEAR POSSIBLE WITH MOL INTEGRALLAUNCH APPROACH
- MOL RENDEZVOUS APPROACHES PROVIDE FLEXIBILITY FOR LONGER DURATION TESTING
- COMBINED MISSION APPROACH APPEARS PROMISING BASED ON PRELIMINARY ANALYSIS

REVIEW

SHORT RANGE PLANNING ACTIVITIES

M. O. L. S. E. O.

12 APRIL 1967

GROUND RULES FOR MOL AM - 7 SEGMENT WUM COMPARISON

- ESTIMATE COSTS FOR 30 DAY DESIGNS AT ACCEPTABLE RELIABILITY
- PROVIDE EXPENDABLES FOR 65 DAYS (AM) AND 85 DAYS (WUM)
- IDENTIFY WEAR-OUT PRONE COMPONENTS
- DETERMINE APPLICABILITY OF STAND-BY REDUNDANCY OR EXTEND LIFE TESTING TO IDENTIFIED WEAR-OUT ITEMS
- ESTIMATE RECURRING AND NON-RECURRING COSTS, AND MEAN MISSION DURATION OF THE EXTENDED LIFE SYSTEMS.

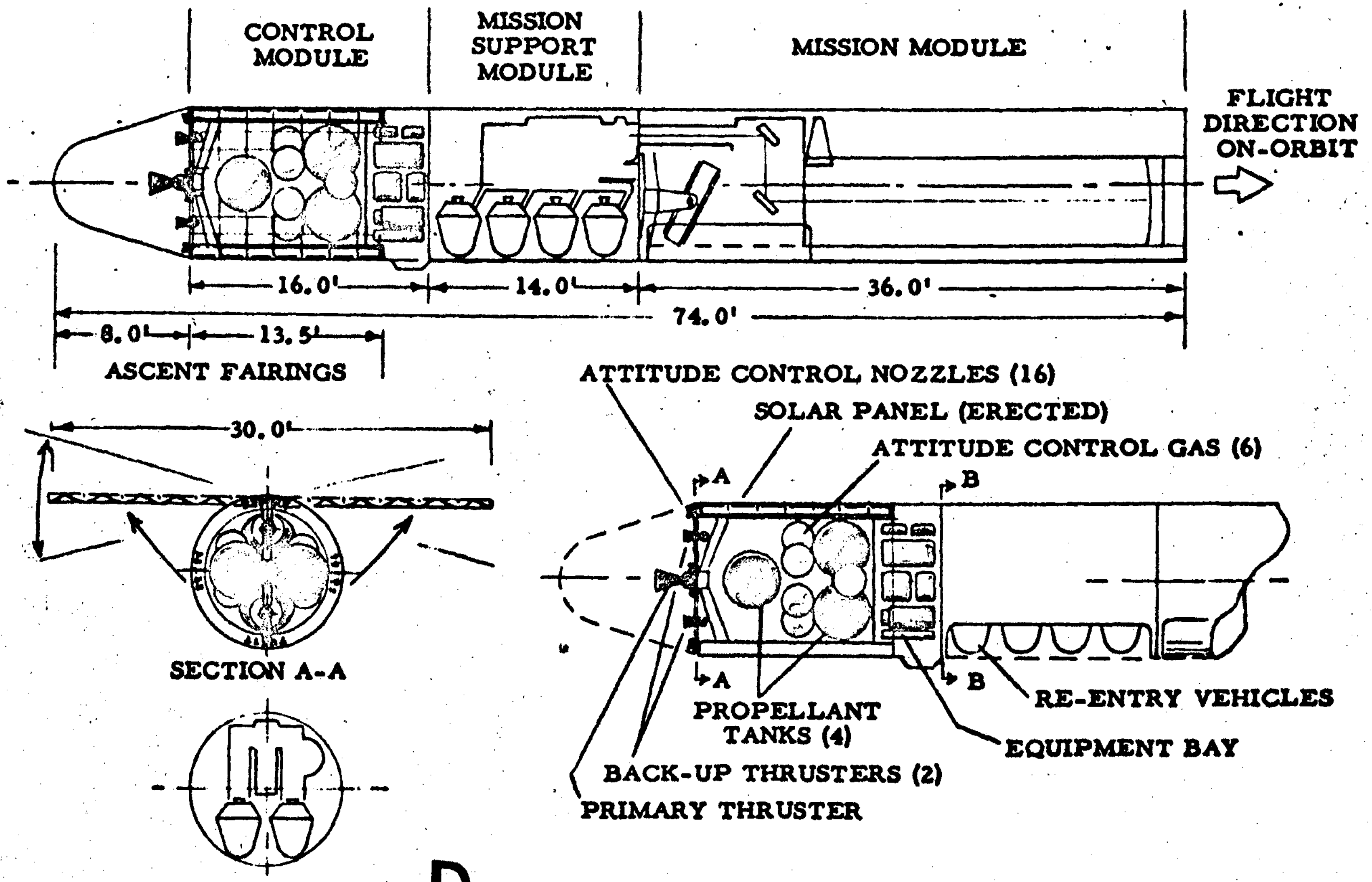
(1 of 25) 1

WHOLLY UNMANNED VEHICLE

(7-SEGMENT T-IIIC)

- CONFIGURATION
- SUBSYSTEMS
- WEIGHTS
- PERFORMANCE
- RELIABILITY
- MEAN MISSION DURATION
- COSTS
- COST - BENEFIT COMPARISONS

WHOLLY UNMANNED VEHICLE - TIII 7 SEG BOOSTER

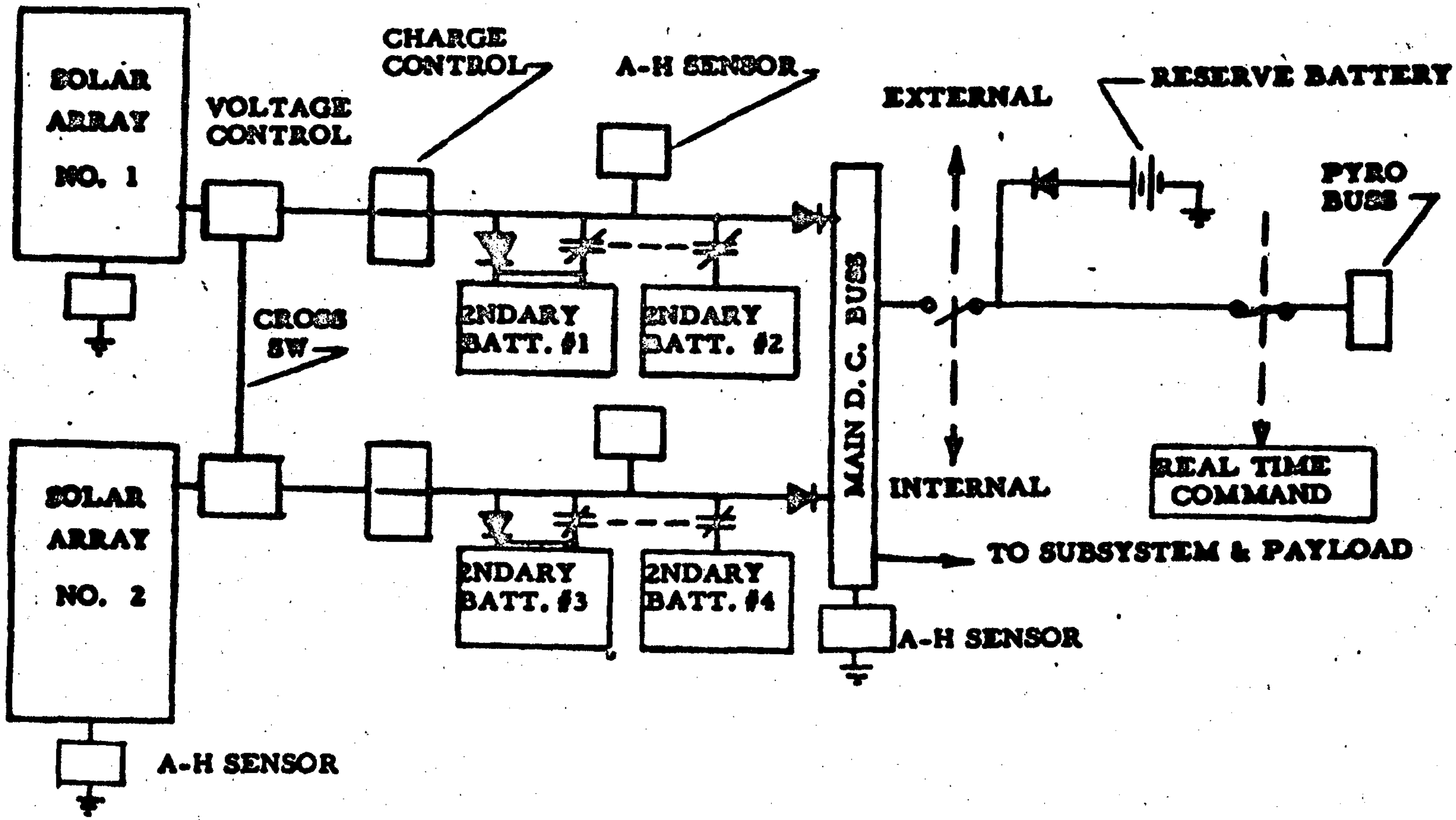


SUBSYSTEMS

7 SEG. WUM VEHICLE
SUBSYSTEM SUMMARY

• STRUCTURE	CONVENTIONAL ALUMINUM
• ENVIRONMENTAL CONTROL	PASSIVE, HEAT SINK PLUS INSULATION
• ORBIT KEEPING PROPULSION	BIPROPELLANT, PASSIVE CONTAINMENT, B THRUST CHAMBER. APOLLO THRUST CHAMBERS BACK-UP.
• ATTITUDE CONTROL	DIGITAL ELECTRONICS, ANALOGUE BACK-UP. REDUNDANT HEAD HORIZON SCANNER.
	REDUNDANT 3 X 2 DEGREE FREEDOM STRAP DOWN INERTIAL REFERENCE.
	COLD GAS STABILIZATION SYSTEM. REDUNDANT THRUSTERS AND PROPELLANT VALVES.
• ELECTRICAL POWER	ROLL-ORIENTED SOLAR PANELS PLUS BATTERIES 1000 WATT AVERAGE POWER OUTPUT.
• COMMUNICATIONS/ DATA MANAGEMENT	SGLS, WITH FUNCTIONAL AND BLOCK REDUNDANCY
• MISSION SUPPORT	8 DRV, 560# FILM
• MISSION MODULE	MOL AM SYSTEM

ELECTRICAL POWER SUBSYSTEM



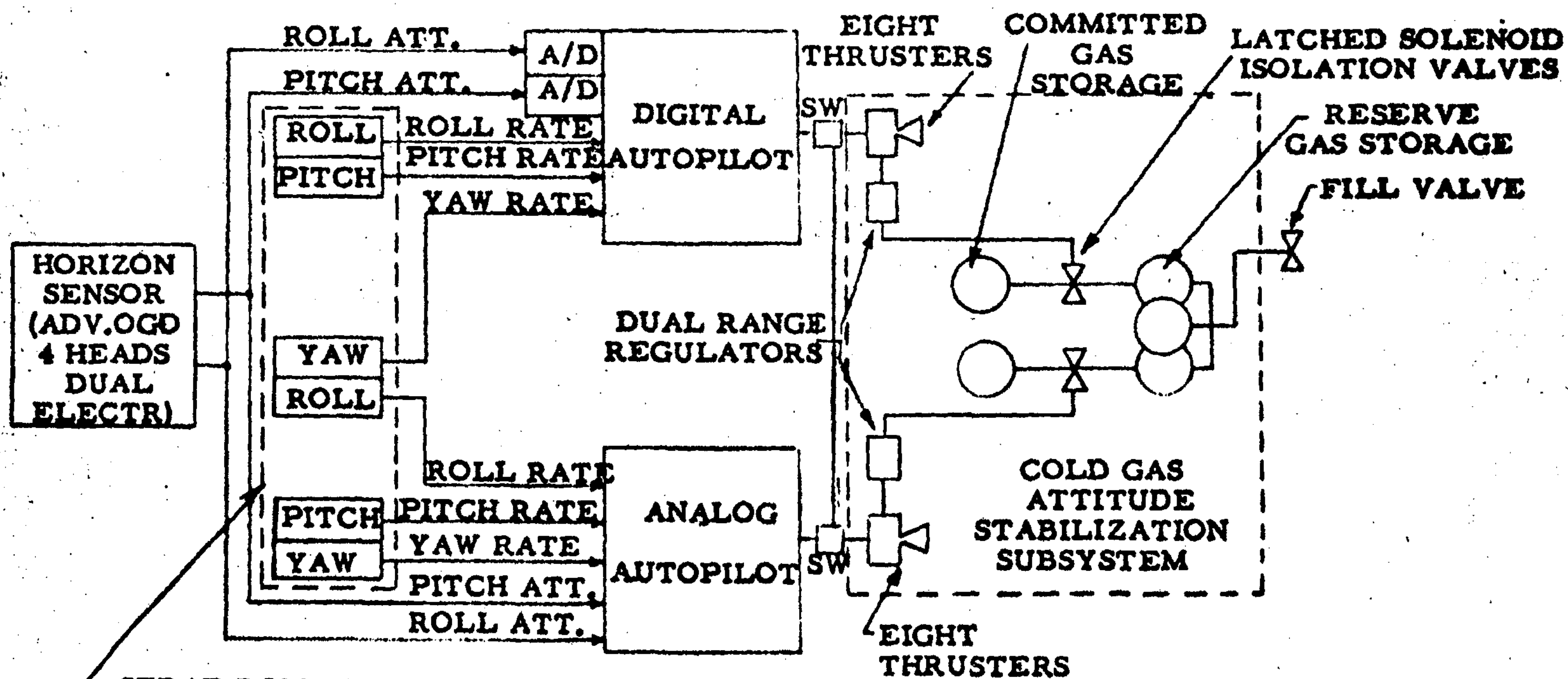
SOLAR ARRAY CHARACTERISTICS

380 FT^2 TOTAL AREA
1000 WATTS AVERAGE POWER

ELECTRICAL POWER SUMMARY

SUBSYSTEM	AVE. POWER - WATTS	
ATTITUDE CONTROL AND TRANSLATION		
ELECTRONICS	130	
PROPULSION	50	
ENVIRONMENTAL CONTROL	30	
COMMUNICATIONS/TRACK/COMMAND	12	
INSTRUMENTATION	85	
DATA MANAGEMENT	48	
ELECTRICAL POWER CONTROL/DISTRIBUTION	50	
SUBTOTAL CONTROL MODULE		405
MISSION MODULE AND COMPUTATION	567	
MISSION/SUPPORT MODULE	25	
SUBTOTAL MISSION PAYLOAD		592
TOTAL ORBITING VEHICLE		997

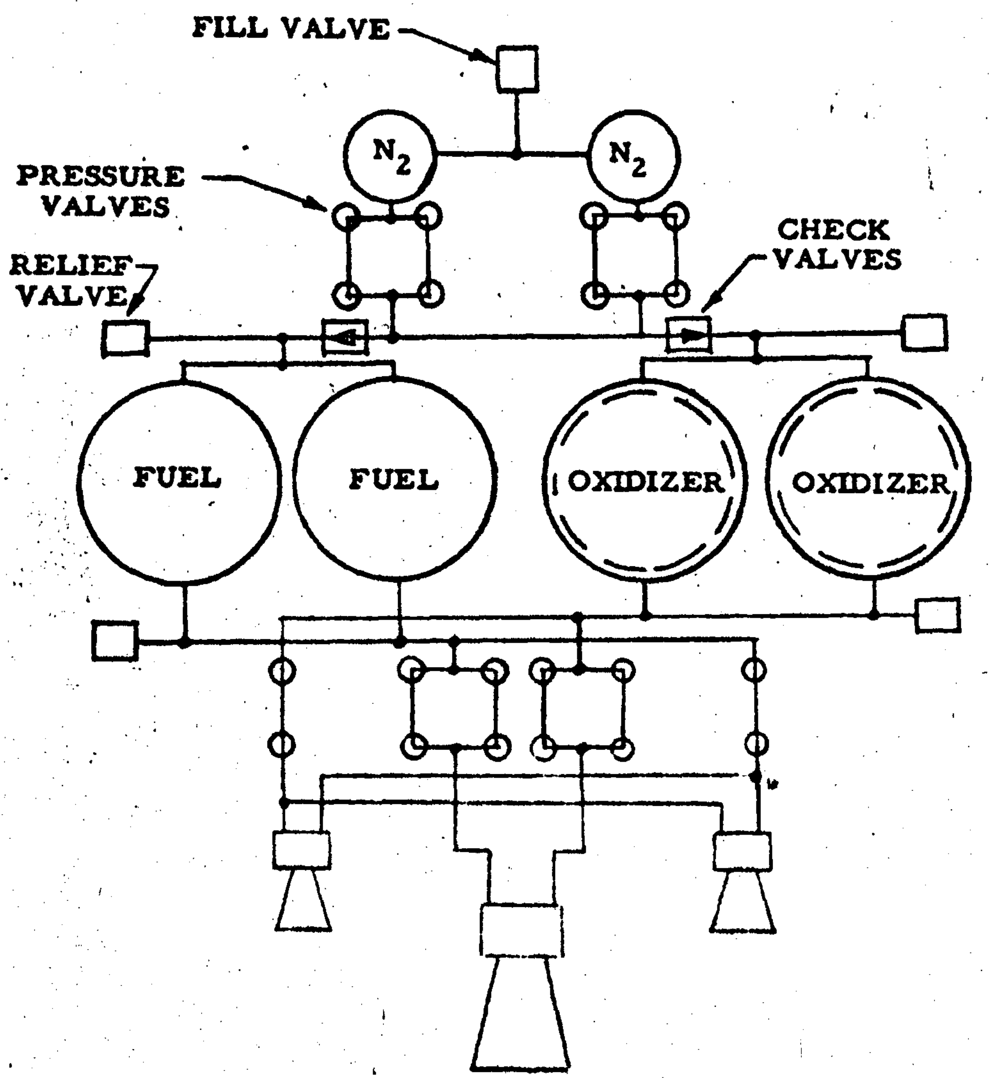
ACTS ELECTRONICS AND STABILIZATION SUBSYSTEM



STRAP DOWN INERTIAL REFERENCE ASSY.
(3) TWO-DEGREE OF FREEDOM GYROS

BACK-UP UNIT CARRIED IN STAND-BY MODE
SWITCH COMPLETE UNIT BY GROUND
COMMAND IF NECESSARY

PROPULSION SUBSYSTEM



CHARACTERISTICS

- BIPROPELLANT
- 280 SEC ISP MINIMUM
- 1,114 LB DRY WEIGHT
- 7,464 LB LOADED WEIGHT

PROPELLANT TANKS

- EQUAL VOLUME - 44" DIA. TITANIUM-
- PASSIVE CONTAINMENT

VALVES

- QUAD REDUNDANT, OX, FUEL + N_2 (PRIMARY ENGINE)
- DUAL REDUNDANT, OX, FUEL + N_2 (BACKUP ENGINES)

PRIMARY THRUST CHAMBERS

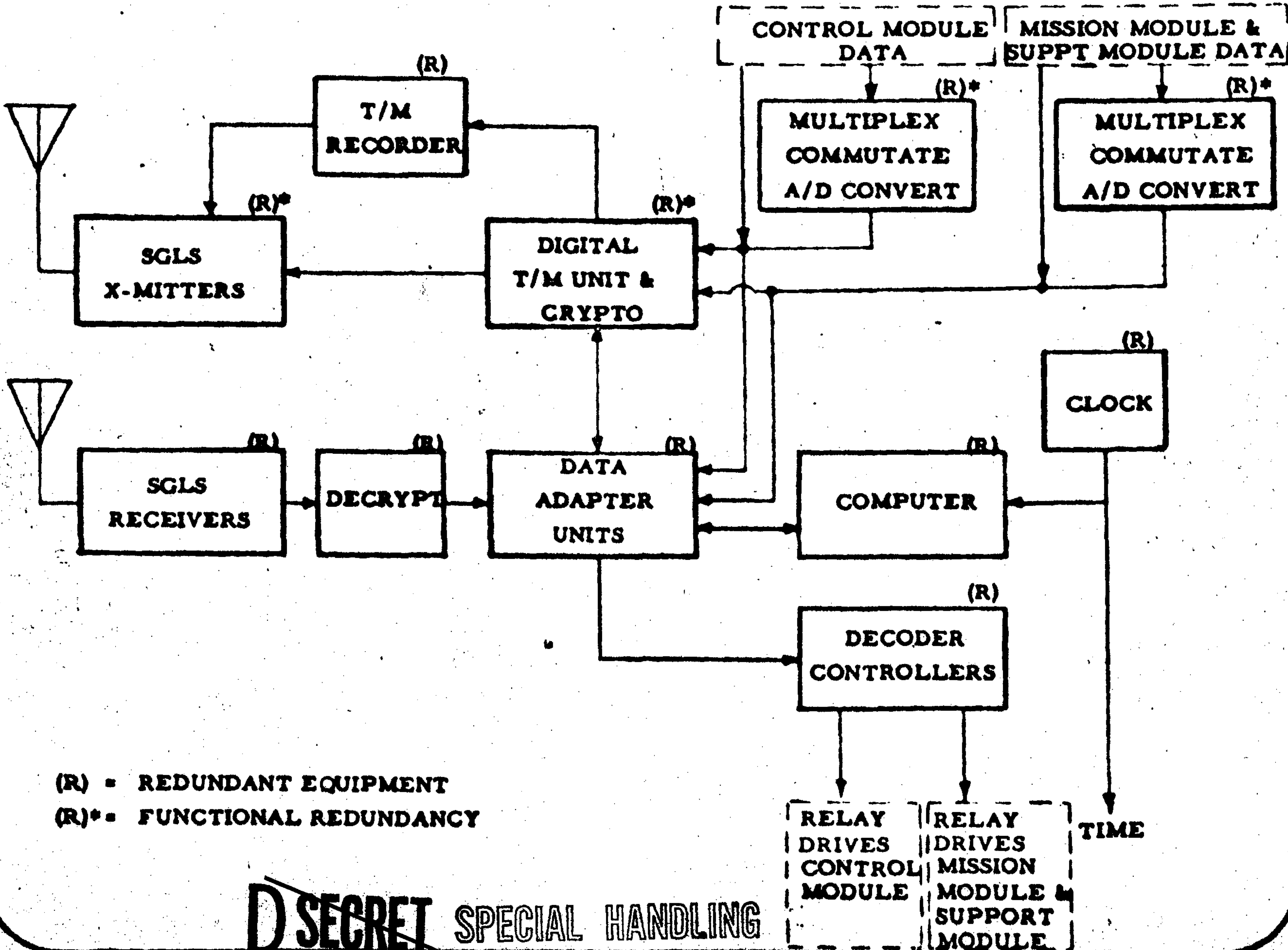
- * BELL AERO RE-ENTRY PROPULSION SYSTEM, MINUTEMAN III (1 YR QUAL)
- * COLUMBIUM-RADIATION COOLED
- 300 LB THRUST
- 10" DIA X 23" LENGTH

BACK-UP

- TWO 100# APOLLO ENGINES

* (A) → B. T. C. A.

COMMUNICATIONS/DATA MANAGEMENT SUBSYSTEM (TT&C)



(R) = REDUNDANT EQUIPMENT

(R)* = FUNCTIONAL REDUNDANCY

WEIGHTS

9

WEIGHT SUMMARY

85 DAY DESIGN LIFE, 8 DRV
7 SEG. WUM VEHICLE
80 NM, 90° i

ITEM	SUPPORT MODULE	CONTROL MODULE	MISSION MODULE	TOTAL VEHICLE
DRY WEIGHT (NO CONTINGENCY)	4,574	4,711	8,380	17,665
CONTINGENCY	592	1,413	1,680	3,685
DRY WEIGHT WITH CONTINGENCY	4,366	6,124	10,060	20,550
RESIDUALS		762		762
PROPELLANT		400		400
PRESSURANT		252		252
ATTITUDE CONTROL GAS		110		110
EMPTY WEIGHT	4,366	6,886	10,060	21,312
EXPENDABLES	88	8,883		8,883
ORBIT KEEPING PROPELLANT		6.350		6,350
ATTITUDE CONTROL GAS		1,970		1,970
DE-ORBIT PROPELLANT		475		475
CAMERA PRESSURIZING GAS	88	88		88
TOTAL	5,254	15,681	10,060	30,995

WEIGHT SUMMARY

85 DAY DESIGN LIFE, 8 DRV
7 SEG. WUM VEHICLE
80 NM, 90° i

ITEM	WEIGHT - POUNDS
SUPPORT MODULE	5,254
DRY WEIGHT	4,574
STRUCTURE	720
ENVIRONMENTAL CONTROL	80
MISSION SUPPORT COMPONENTS (560 LB. RECORD)	1,193
CAMERA PRESSURIZATION SYSTEM	46
FILM CHUTES AND CUTTERS	85
DATA RECOVERY VEHICLE LAUNCH SYSTEM	50
DATA RECOVERY VEHICLES (8)	2,400
CONTINGENCY	592
CAMERA PRESSURIZING GAS	88
CONTROL MODULE	15,681
DRY WEIGHT	4,711
PRIMARY STRUCTURE	800
PROPULSION	1,114
ATTITUDE CONTROL	942
TELEMETRY AND TRACKING	400
COMMAND AND CONTROL	145
ELECTRICAL POWER SOURCE (1,000 W. AVG.)	1,030
ELECTRICAL POWER CONVERSION & DISTRIBUTION	210
ENVIRONMENTAL CONTROL	70
CONTINGENCY	1,413
RESIDUALS	762
PROPELLANT	400
PRESSURANT	252
ATTITUDE CONTROL GAS	110
EXPENDABLES	8,795
ORBIT KEEPING PROPELLANT	6,350
ATTITUDE CONTROL GAS	1,970
DE-ORBIT PROPELLANT	475
MISSION MODULE	10,060
SPECIFIED MODULE DRY WEIGHT	8,380
CONTINGENCY	1,680
TOTAL VEHICLE, LESS FAIRING AND THERMAL SHROUD	30,995

WEIGHT STATEMENT
SUPPORT MODULE

ITEM	WEIGHT - POUNDS			
	30% 72 DAYS	10% 85 DAYS	30% 72 DAYS	10% 85 DAYS
STRUCTURE			720	
ENVIRONMENTAL CONTROL			80	
MISSION SUPPORT COMPONENTS			1,193	
CAMERA & FILM HANDLING (INCL. LOOPERS)	276			
FILM	560			
COMPUTERS	140			
DATA ADAPTERS	60			
STAR TRACKER ELECTRONICS	22			
V/R SENSORS (2)	45			
ELECTRICAL AND MISC.	90			
CAMERA PRESSURIZATION SYSTEM			40	46
GAS BOTTLES	28	34		
REGULATOR AND PLUMBING	12			
FILM CHUTES AND CUTTERS			85	
DRV LAUNCH & SEPARATION SYSTEM			50	
DATA RECOVERY VEHICLES (6)			2,400	
SUPPORT MODULE DRY WEIGHT LESS CONTINGENCY			4,568	4,574
CAMERA PRESSURIZATION GAS			72	88
CONTINGENCY			590	592
TOTAL SUPPORT MODULE (INCL. CONTINGENCY)			5,230	5,254

WEIGHT STATEMENT
CONTROL MODULE

ITEM	WEIGHT - POUNDS 30% 72 DAYS	10% 85 DAYS	30% 72 DAYS	10% 85 DAYS
PRIMARY STRUCTURE			800	
PROPULSION			1,080	1,114
MAIN ENGINE	120			
GIMBAL POWER	50			
100 LB. THRUSTERS (2)	12			
PROPELLANT TANKS	168	175		
PLUMBING	20			
PRESSURANT TANKS	60	62		
PRESSURANT SYSTEM	45			
WIRING	10			
MOUNTS AND SUPPORTS	595	620		
ATTITUDE CONTROL SYSTEM			920	942
THRUSTERS	33			
TANKS	480	495		
PLUMBING AND VALVES	60			
HORIZON SENSORS	24			
GYROS & FLIGHT CONTROL ELECTRONICS	64			
WIRING	9			
MOUNTS AND SUPPORTS	250	257		
TELEMETRY AND TRACKING			400	
PROPELLANT GAUGING SYSTEM	26			
WIRING AND PLUGS	70			
TAPE RECORDERS (2)	60			
MULTIPLENERS & END INSTRUMENTS	60			
A/D CONVERTERS (2)	20			
TIME REFERENCE UNITS (2)	24			
SIGNAL CONDITIONING	40			
DTU (2)	100			
COMMAND AND CONTROL			145	
COMMAND CONTROLLERS AND DECODERS (2)	40			
DECRYPTOR	5			
SGLS (2)	58			
WIRING	25			
ANTENNAS	7			
MISC.	10			
ELECTRICAL POWER SOURCE			1,030	

WEIGHT STATEMENT - CONTINUED

CONTROL MODULE - CONTINUED

ITEM	WEIGHT - POUNDS 30% 72 DAYS	10% 85 DAYS	30% 72 DAYS	10% 85 DAYS
SOLAR PANELS (INCL. DRIVE & LOCK) (379 SQ. FT.)	570			
BATTERIES	340			
POWER REGULATION	40			
SUPPORTS	80			
ELECTRICAL POWER CONVERSION & DISTRIBUTION			210	
"J" BOXES AND PANELS	55			
WIRING AND CONNECTORS	100			
POWER CONVERSION	55			
ENVIRONMENTAL CONTROL			70	
CONTROL MODULE DRY WEIGHT LESS CONTINGENCY			4,655	4,711
CONTINGENCY			1,395	1,413
CONTROL MODULE DRY WEIGHT WITH CONTINGENCY			6,050	6,124
ORBIT KEEPING PROPELLANTS			6,560	6,750
DE-ORBIT PROPELLANTS			475	475
ATTITUDE CONTROL GAS			2,020	2,080
PRESSURANT GAS			245	252
TOTAL CONTROL MODULE (INCL. CONT. & EXPENDABLES)			15,350	15,681

14

VEHICLE WEIGHT COMPARISON

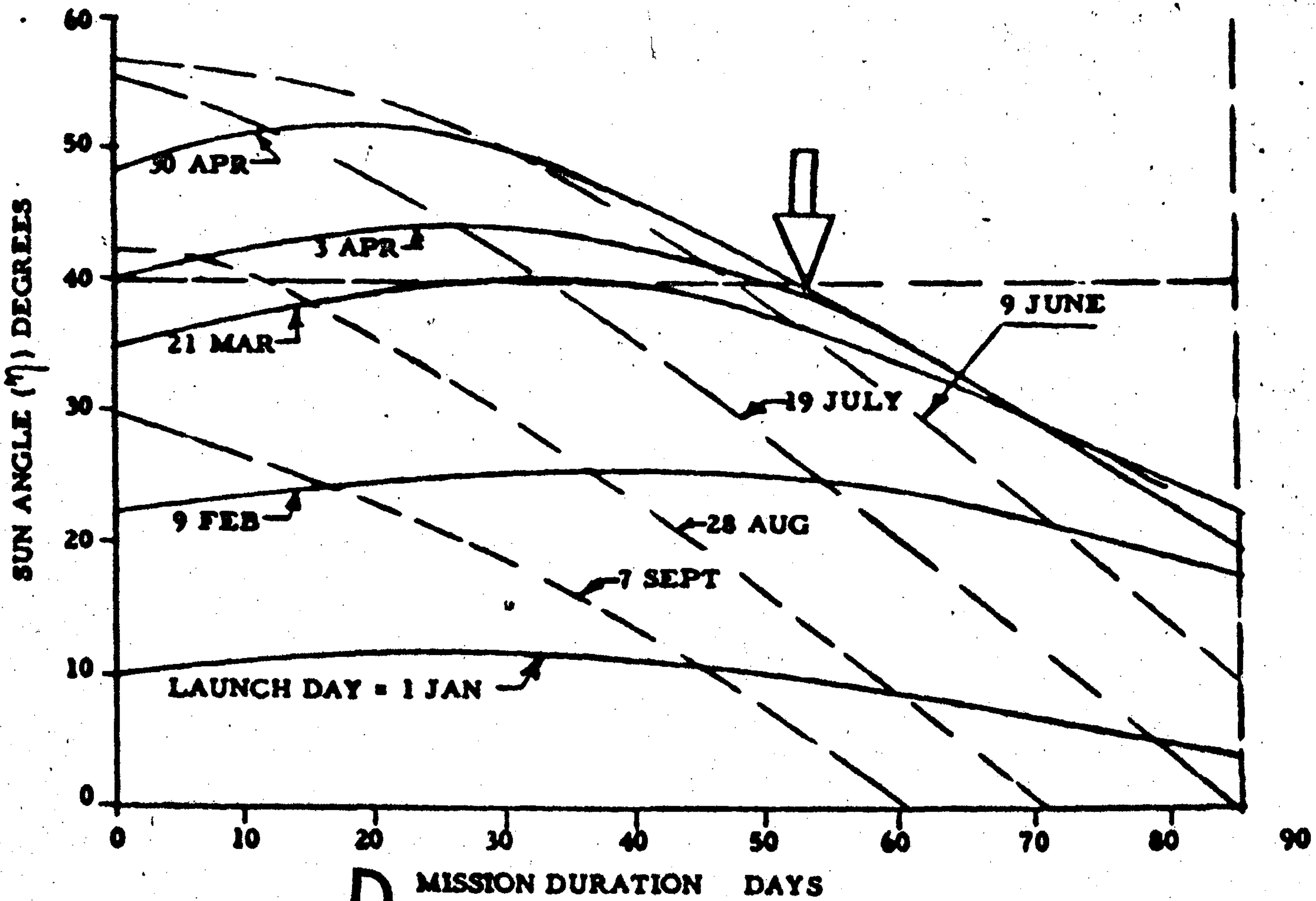
MODULE	AM (65 DAY)	WUM (5 SEG-35 DAY)	WUM (7 SEG-85 DAY)
LABORATORY VEHICLE	12,546	--	--
CONTROL MODULE	--	6,330	14,268
MISSION SUPPORT MODULE	7,753	3,040	4,662
MISSION MODULE	7,355	8,380	8,380
TOTAL*	27,654	17,750	27,310

*CONTINGENCY WGT FOR GROWTH NOT INCLUDED

PERFORMANCE

SUNLIGHT CONSIDERATIONS

$i = 90°$



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17

WUM PERFORMANCE

- **PROPELLANT RATES**

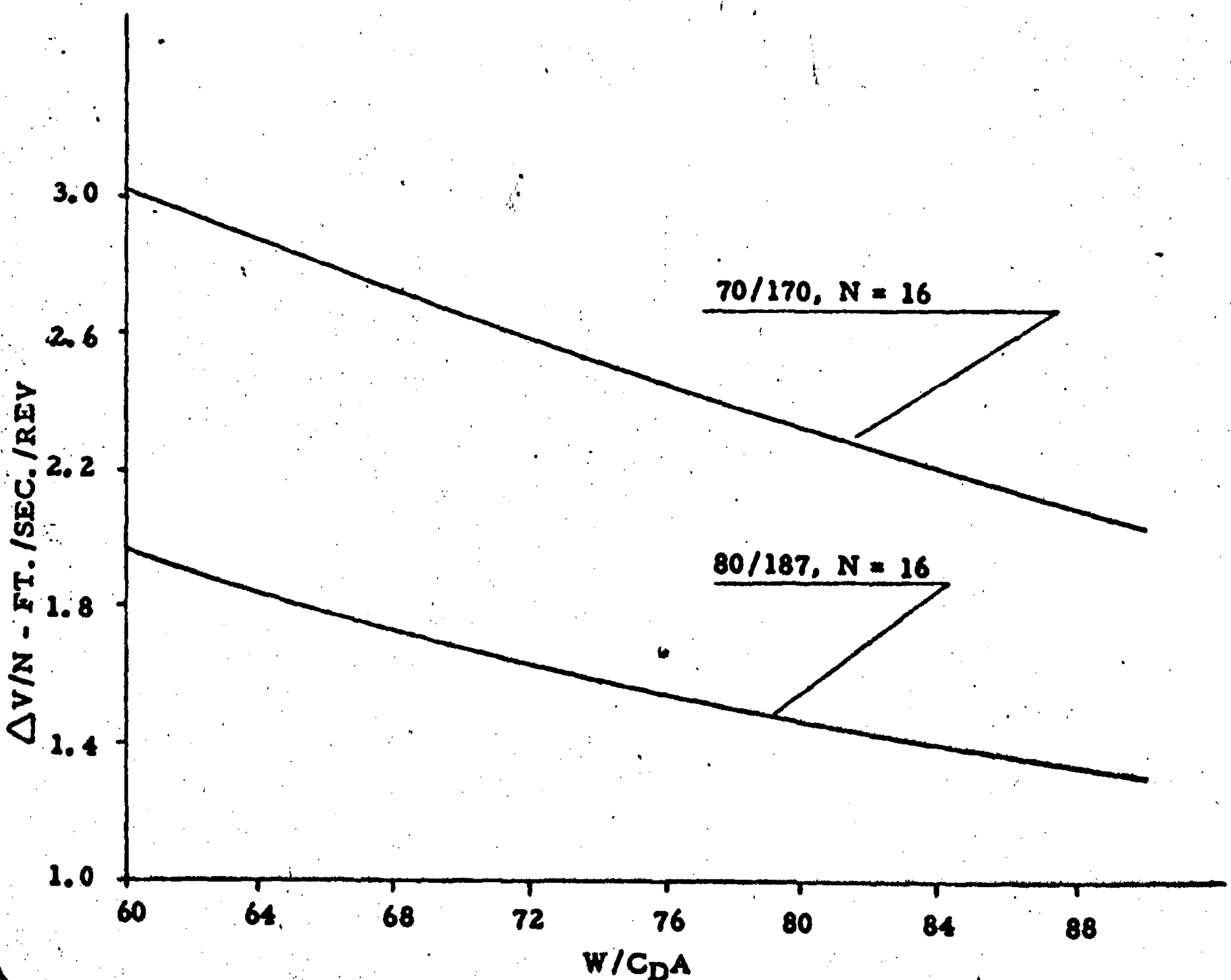
$\overset{\circ}{\Delta W}$ (PROPULSION)	=	68 LB/DAY
$\overset{\circ}{\Delta W}$ (STABILIZATION)	=	21 LB/DAY
TOTAL (INCLUDING 10% CONTINGENCY)	=	**98 LB/DAY**

- **MISSION DURATION**

AVAILABLE PROPELLANT	=	8,320 LBS.
DURATION (8,320 ÷ 98)	=	**85 DAYS**

16
18

VELOCITY KEEPING
WUM - WITH SOLAR PANELS
ORBIT INCL. = 90°



RELIABILITY

MEAN MISSION DURATION

7-SEGMENT WUM

PERFORMANCE SUMMARY

(80/180 N. M.)

ORBIT INCLINATION, DEG.	90	97
NUMBER OF D.R.V.'s	8	7
MAXIMUM MISSION DURATION, DAYS	85	81
*MEAN MISSION DURATION, DAYS	51	48
FILM USE RATE, LB./DAY	5.7	6.0

*INCLUDES BOOSTER R = .93

54 ÷ .93 ? ? 54?

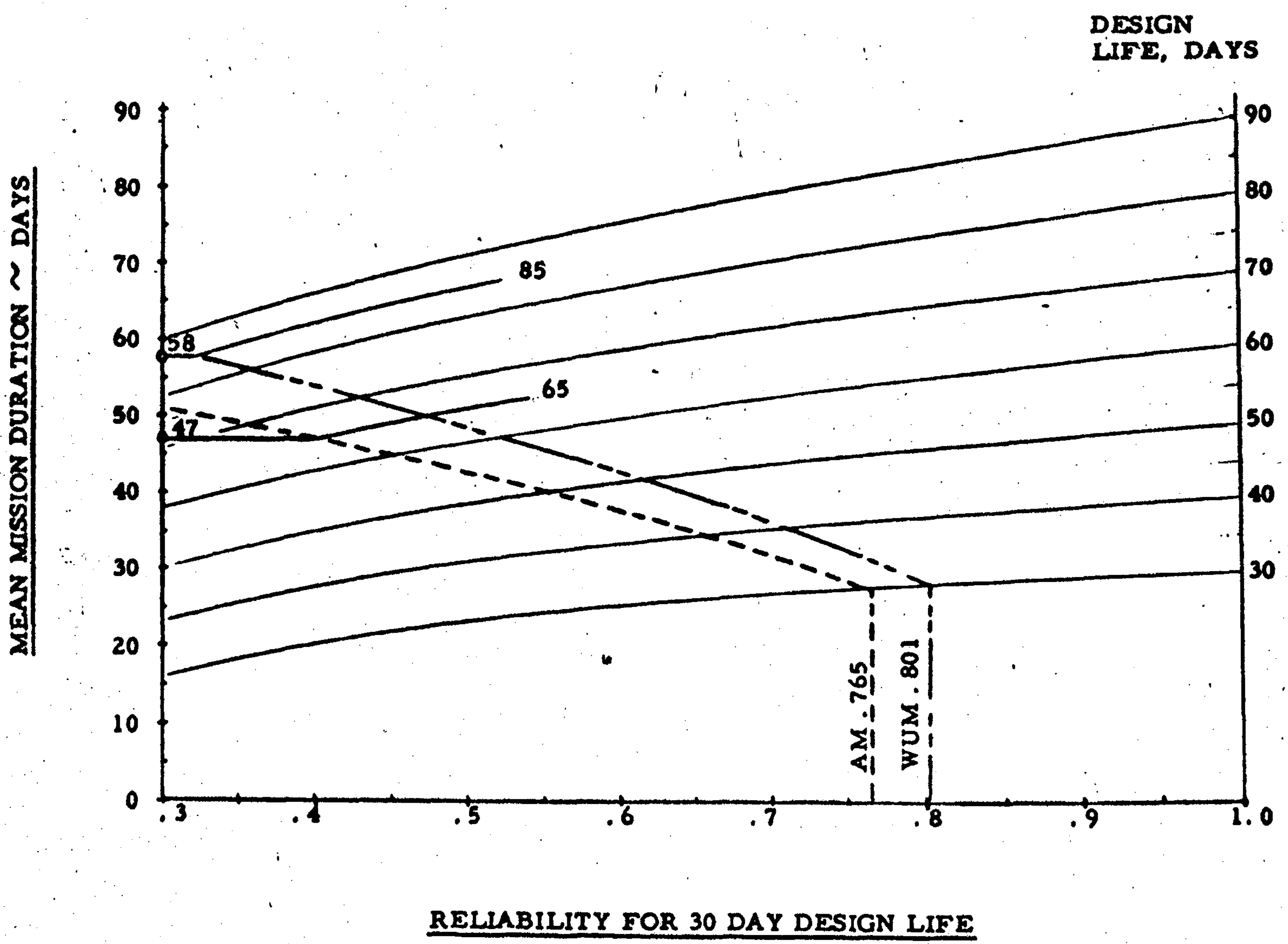
20

VEHICLE RELIABILITY ESTIMATES (30 DAYS)

SUBSYSTEM	MOL - AM		7 SEG. WUM	
EPS	.998		.995	
THERMAL CONTROL	.999		.9999	
CRYO	.999		--	
ACTS - P	.996		.998	
ACTS - E	.995		.999	
COMMUNICATIONS	.960		.985	
COMPUTER	.985		.985	
MALFUNCTION CORRECTION/CONTROL	.940		.960	
STRUCT/RADIATOR	.999		.9999	
LAB VEHICLE SEGMENT		.880		--
CONTROL MODULE		--		.924
MISSION MODULE / SUPPORT MODULE		.869		.869
TOTAL		.765		.801

MEAN MISSION DURATION

SIMPLIFIED RELIABILITY MODEL - STANDBY REDUNDANCY

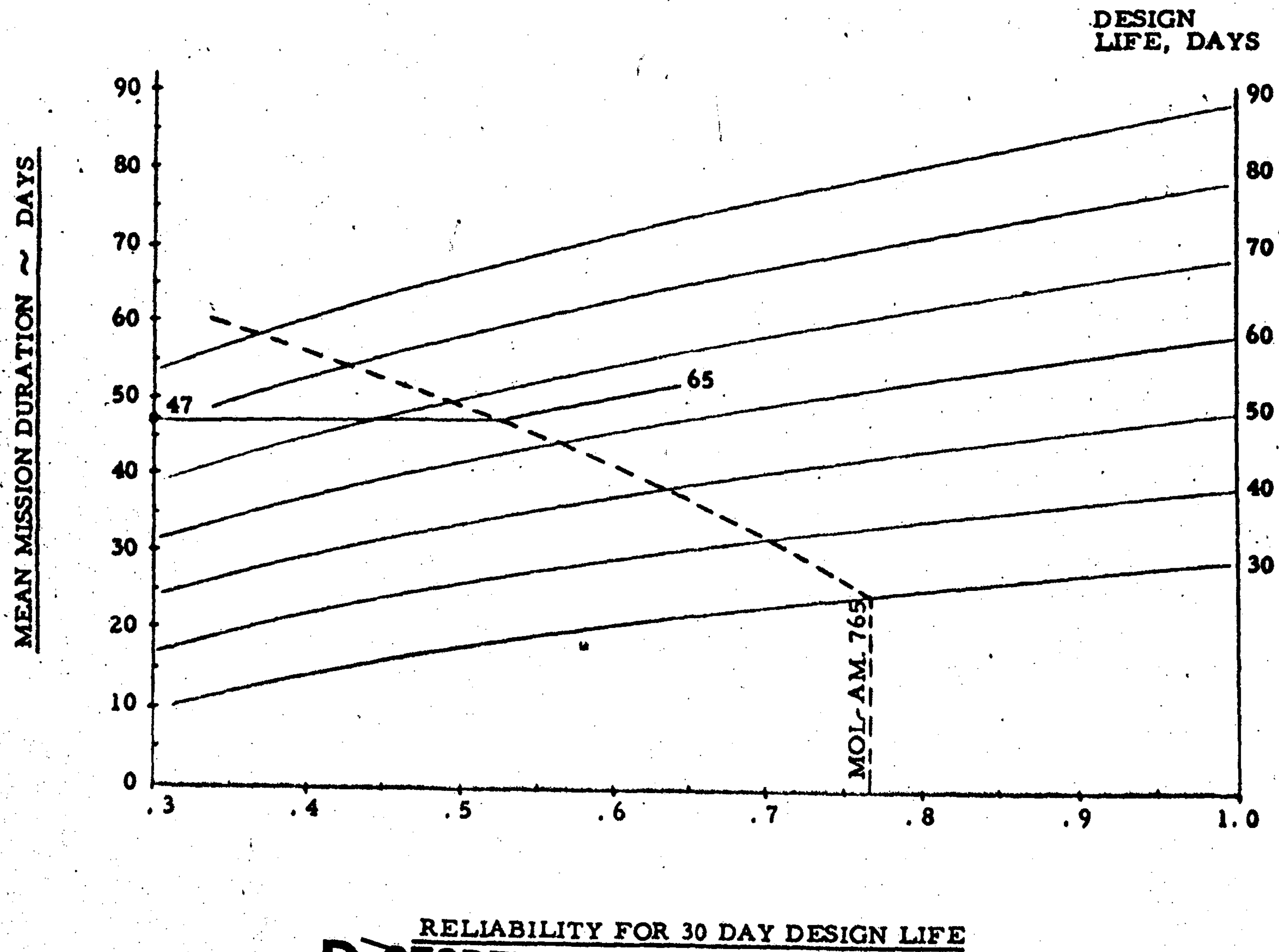


22

MEAN MISSION DURATION

MOL - AM

Ⓐ COMPUTER MODEL



7-SEGMENT WUM

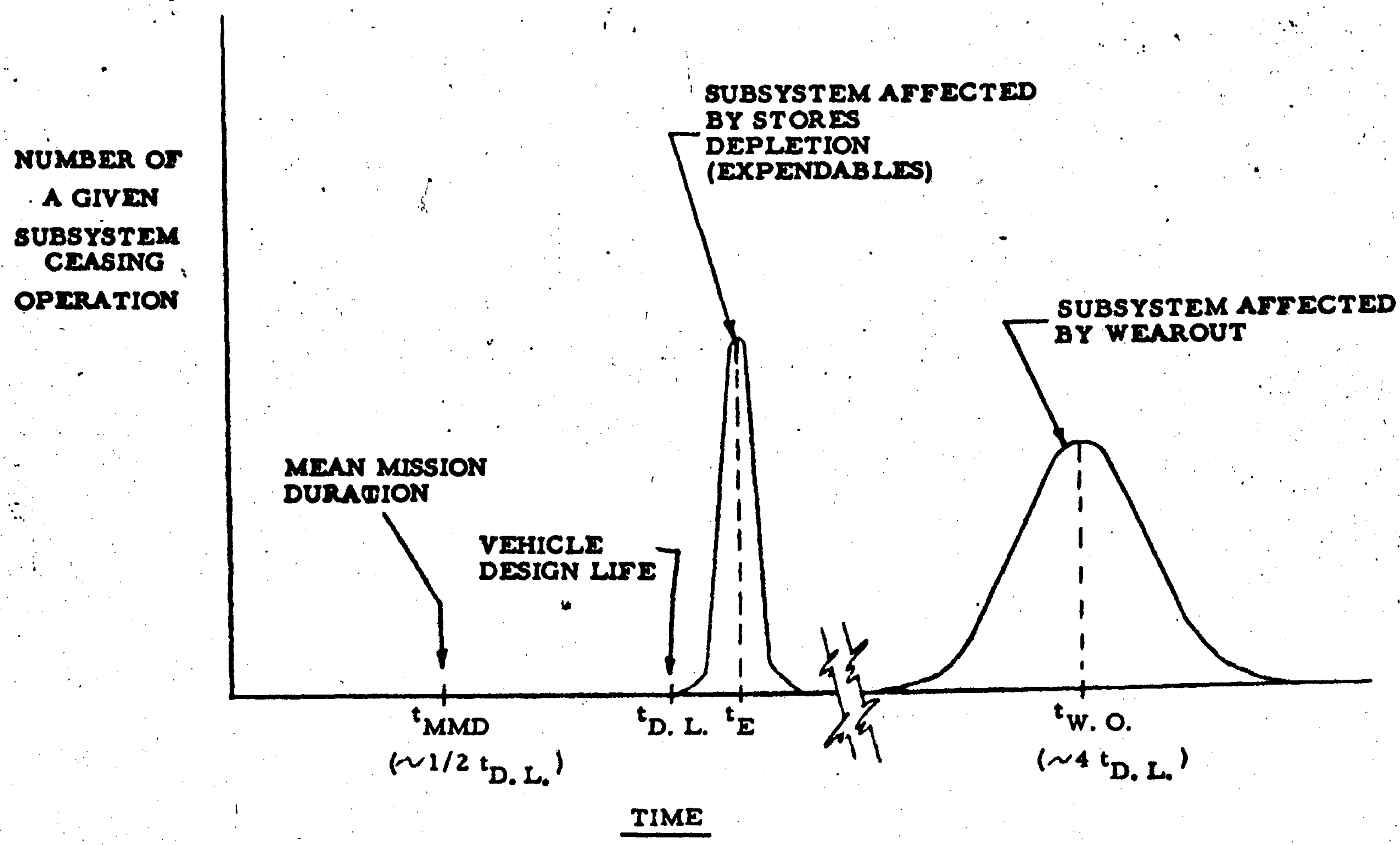
TIME/CYCLE SENSITIVE COMPONENTS

Component	Vehicle Segment	Nominal Mission Life Rqmt (1)	Estimated Wearout Life	Wearout Life ÷ Mission Life Rqmt	Nature of Wearout
Gyro (2)	CM, MM	2040 hr.	8000 hr.	3.9	Bearing degradation
Horiz. Sensor(2)	CM	2040 hr.	> 1 yr.	4.3	Flexure fatigue
Bi-Pro Thruster (2)	CM	1.5 hr.	> 6 hr.	> 4.0 (3)	Throat or injector erosion
Tape Recorders (2)	CM	2040 hr.	6570 hr.	3.2	Bearing degradation, drive belt fatigue, tape wear
Batteries (2)	CM	2040 hr.	2 yr. (≤ 30% depth of discharge)	8.6	Separator destruction
Propellant Valves (2)	CM	< 100 cyc.	> 100,000 cyc.	Large	Seat galling
Cold Gas Valves (2)	CM	80,000 cyc	> 300,000 cyc.	3.8	Seat galling
Press. Switch (2)	CM	300,000 cyc	1,000,000 cyc.	3.3	Diaphram failure
Solar Panel Actuator (2)	CM	~10 steps	3 yr.	Large	Linkage wear
Pump (2)	CM	2040 hr.	3 yr.	12.9	Bearing degradation
Torquer	MM	680 hr/40,800 cyc	3 yr.	38.6	Bearing degradation
Mirror Bearing	MM	680 hr/40,800 cyc	3 yr.	38.6	Bearing degradation
IMC Mechanism	MM	- hr/40,800 cyc	> 150,000 cyc	3.7	Linkage wear
Thermal Door Mech.	MM	20,400 cyc	> 150,000 cyc	7.4	Linkage wear

(1) Orbital Operation Only
(2) Redundant in CM
(3) Vendor Estimate, B_e T.C.A.

TYPICAL DISTRIBUTION FUNCTIONS OF CESSATION OF SUBSYSTEM OPERATION

DUE TO WEAROUT AND/OR STORES DEPLETION



COSTS

COST SUMMARY COMPARISONS

NONRECURRING	7 SEGMENT WUM 6 FLIGHTS	5 SEGMENT WUM 6 FLIGHTS	MOL 5 FLIGHTS
OCV	351.4	344.4	716.8
MISSION PAYLOAD	270.1	270.1	285.5
LAUNCH VEHICLE	142.0*	42.8	206.9*
LAUNCH FACILITY	--	78.0	--
GSE/TD	26.0	26.0	46.2
OTHER	--	--	16.5
SUBTOTAL	789.5	761.3	1,271.9
RECURRING			
OCV	121.8	111.0	220.1
MISSION PAYLOAD	147.4	140.4	137.0
LAUNCH VEHICLE	102.0	56.4	105.0
RECOVERY, TRACKING	24.0	16.2	9.0
OTHER	--	--	8.4
SUBTOTAL	395.2	324.0	479.5
TOTAL PROGRAM			
OCV	473.2	455.4	936.9
MISSION PAYLOAD	417.5	410.5	422.5
LAUNCH VEHICLE	244.0	99.2	311.9
RECOVERY, TRACKING	24.0	16.2	9.0
LAUNCH FACILITY	--	78.0	--
GSE/TD	26.0	26.0	46.2
OTHER	--	--	24.9
TOTAL PROGRAM	1,184.7	1,085.3	1,751.4
10 FLIGHT PROGRAM	1,448.3	1,120	
		DESIGN FOR EXTENDED DURATION + LIFE TESTING	33.6
			1,785.0

* INCL. FACILITY COSTS, BUT DOES NOT INCL. $37.1M OF T-III LINE FUNDS.

RECURRING COST COMPARISON
(DOLLARS IN MILLIONS)

ITEM	WUM 7 SEGMENT	WUM 5 SEGMENT	BASELINE MOL AM	BASELINE MOL M
LABORATORY VEHICLE	--	--	33.5 (1)	53.7 (2)
CONTROL MODULE	20.3	18.5	--	--
MISSION EQUIPMENT	24.6	23.4	24.0	27.0
LAUNCH VEHICLE	17.0	9.4	21.0	21.0
RECOVERY, TRACKING	4.0	2.7	2.7	4.0
TOTAL	65.9	54.0	81.2	105.7

(1) INCLUDES SUPPORT MODULE @ 4.0M
(2) INCLUDES GEMINI @ $19.2 M

2io

COMPARISON OF 7 SEGMENT AND 5 SEGMENT WUM RECURRING COSTS IN MILLIONS

	7 SEGMENT		5 SEGMENT	
OCV	___	20.29	___	18.50
CONTROL MODULE	18.74		17.2	
SUPPORT MODULE STRUCTURE	0.50		0.50	
MISSION MODULE STRUCTURE	0.80		0.80	
FAIRING	0.25		___	
MISSION PAYLOAD	___	24.60	___	23.4
MISSION MODULE EQUIPMENT	20.6		20.6	
SUPPORT MODULE EQUIPMENT	4.0		2.8	
LAUNCH VEHICLE		17.00		9.4
RECOVERY		2.00		1.5
FLIGHT OPERATION SUPPORT		2.00		1.2
TOTAL		65.89		54.0

D SECRET SPECIAL HANDLING

COST COMPARISON

7 SEGMENT & 5 SEGMENT WUM

MAJOR SYSTEM

(DOLLARS IN THOUSANDS)

	6 FLIGHT PROGRAM			
	NON-RECURRING		RECURRING	
	7 SEGMENT	5 SEGMENT	7 SEGMENT	5 SEGMENT
OCV				
CONTROL MODULE & FAIRING	345,000	338,000	114,000	103,200
MISSION MODULE STRUCTURE	3,400	3,400	4,800	4,800
SUPPORT MODULE STRUCTURE	3,000	3,000	3,000	3,000
TOTAL OCV	351,400	344,400	121,800	111,000
MISSION PAYLOAD				
EQUIPMENT	245,000	245,000	123,400	123,400
FACILITIES	13,100	13,100	- -	- -
SUPPORT MODULE EQUIP.	12,000	12,000	24,000	17,000
TOTAL PAYLOAD	270,100	270,100	147,400	140,400

D SECRET SPECIAL HANDLING

COST COMPARISON - CONTROL MODULE 7 SEGMENT & 5 SEGMENT WUM

DOLLARS IN MILLIONS

	NON-RECURRING		RECURRING (6 FLT. PROG.)	
	7 Segment	5 Segment	7 Segment	5 Segment
MANAGEMENT	15.0	15.0	1.4	1.4
SYSTEM ENGINEERING	30.0	30.0	---	---
MODULE DESIGN	172.0	177.9	---	---
FLIGHT HARDWARE	---	---	81.6	72.5
AGE	54.9	60.0	10.0	10.0
OV TEST AND LAUNCH	6.8	6.8	6.0	6.0
ON ORBIT SUPPORT	1.5	1.5	3.0	3.0
FLIGHT EVALUATION	1.2	1.2	2.4	2.4
LOGISTICS & SPARES	3.5	3.5	8.1	7.9
TEST MODELS	34.6	34.6	---	---
INTEGRATION	7.5	7.5	---	---
FAIRING	8.0	*	1.5	*
ADDED CONFIDENCE TESTING FOR WEAR-OUT	10.0	---	---	---
TOTAL	345.0	338.0	114.0	103.2

* INCLUDED IN MODULE DESIGN AND FLIGHT HARDWARE COSTS

SUBSYSTEM COST COMPARISON/7 SEG. AND 5 SEG WUM

DOLLARS IN MILLIONS

	NON RECURRING		RECURRING (6 FLT. PROG.)	
	7 Segment	5 Segment	7 Segment	5 Segment
Structure	5.500	3.270	3.00	2.70
ACTS Stabilization	1.500	1.000	.90	.60
Orbit Adjust Propulsion	11.120	8.210	5.50	4.80
ACTS Electronic	18.800	18.800	3.62	3.12
Electrical Power	20.000	20.000	18.00	8.52
Cryogenics	---	8.900	---	3.00
Environmental Control	5.000	8.660	1.58	2.58
Separation	.500	.500	.60	.60
Data Management	12.800	12.800	5.00	4.40
TT&C	17.600	17.600	8.88	8.88
Instrumentation	3.000	3.000	3.00	3.00
Assembly & Test	22.150	21.400	9.10	8.46
Sustaining Engineering	---	---	10.38	10.38
ST/TE	21.830	21.830	---	---
Mockups - Substitutes	3.450	3.450	---	---
SUB-TOTAL	143.250	149.420	69.56	61.04
Travel, Other Direct, Fee	28.75	28.48	12.04	11.46
TOTAL CM	172.00	177.9	81.60	72.50

WEAROUT LIFE TESTING REQUIREMENTS

85 DAY WUM

	SUBSYSTEM LIFE		COST
	DEMONSTRATED	REQUIRED	
● BI-PRO THRUSTER	10,000 SEC.	30,000 SEC.	$ 3.5M (3 TEST ITEMS)
● IMC MECHANISM	--	250,000 CYC.	$ 6.5M (25 TEST ITEMS)
			$10.0M

TITAN III M (OPTION 6)

Baseline	Nonrecurring Dev.	Nonrecurring GBQ	Nonrecurring LVD	Nonrecurring Total	Recurring Manned (3)	Recurring Automatic (2)	Recurring Total	Option 6 Total
Titan IIIM Option 6 7 Flt.	164.9	21.0	21.0	206.9	63.0	42.0	105.0	311.9* +37.1 349.0
Step 1 Not Man-Rated	-10.0 154.9	-21.0 0	-21.0 0	-52.0 154.9	-1.5 61.5	-1.0 41.0	102.5	257.4
2 T-III C Reliab.	-30.0 124.9	0	0	-30.0 124.9	-10.5 51.0	-7.0 34.0	17.5 85.0	209.9**

Step 1. Remove Man/Remove Crew Safety. Remove GBQ and LVD Flts.

Step 2. Remove Man/Remove Reliability, i.e., except T-III C Reliability.

	Remove	Nonrecurring	Recurring
Step 1.	Strap down Guidance Pkg. Gemini Backup Malfunction Detection Kit. GBQ and LVD 10 + 42 = 52	52.0	0.5 Each
Step 2.	Triple Redundancy Autopilot & go to the T-III C G &C with risp comp 30	30.0	3.5 Each

Total: 311.9 - (40.0 + 42) = 82 + (5 x 4.0 each) = 311.9 - 102.0 = 209.9

*311.9 Includes facilities cost but does not include $37.1 M of T-III line money.

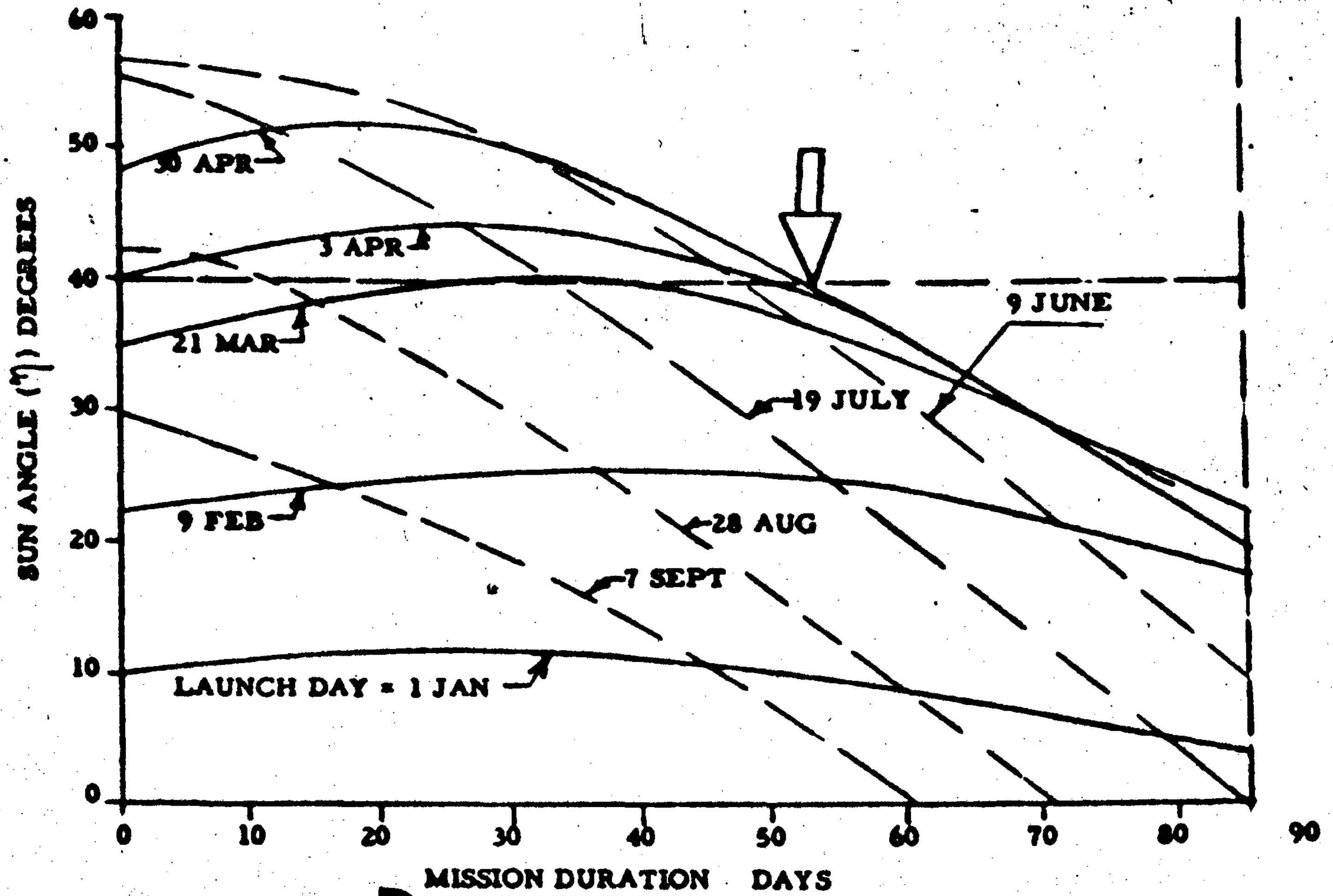
**If LVD Flight Incl.

Baseline	Unmanned		Total		LVD	
311.5	-102	=	209.9	+	17.0	= 226.9

COST - BENEFIT COMPARISONS

SUNLIGHT CONSIDERATIONS

i = 90°



COMPARISON OF BASELINE AND POTENTIAL RENDEZVOUS VEHICLE CAPABILITIES FOR TECHNICAL INTELLIGENCE DATA RETURN

	6 M/AM FLIGHTS	6 AM FLIGHTS	6 WUM FLIGHTS 7 SEG.	2 RAMV + 5 RRV FLIGHTS
• TOTAL NUMBER OF CLEAR PHOTOGRAPHS/YEAR	13,308	21,060	24,000	29,200
• TOTAL NUMBER OF CLEAR, SPECIAL PHOTOGRAPHS/YEAR	1,344	894	1,020	2,540
• ANNUAL COST - M$	520.8	402.0	327.0	343.0
• RELATIVE COST, PER C.S.P.	2.9	3.3	2.4	1.0

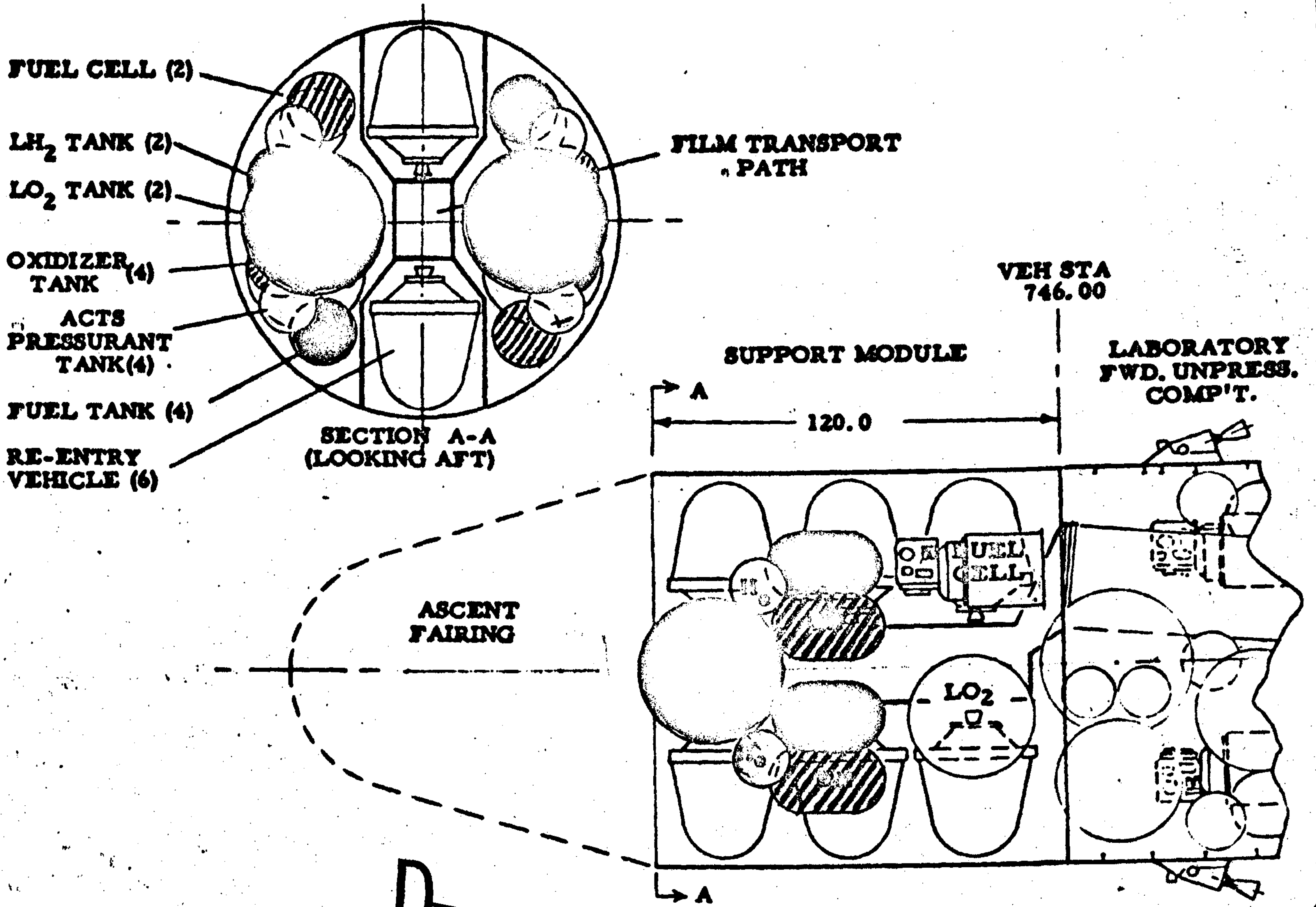
RECURRING COST EST. (M$)

MAM	(ED) AM	7 SEG. WUM	RAM	RRV
87	67	54.5	67	42

212

65 DAY AUTOMATIC MODE VEHICLE BRIEFING

65 DAY MISSION SUPPORT MODULE
INTERNAL ARRANGEMENT



WEIGHT SUMMARY
AUTOMATIC MODE MOL VEHICLE
65 DAY DESIGN LIFE

SEGMENT	WEIGHT, LBS.
SUPPORT MODULE	8,050
LAB VEHICLE	12,200
MISSION MODULE	7,285
CONTINGENCY	3,465
TOTAL	31,000

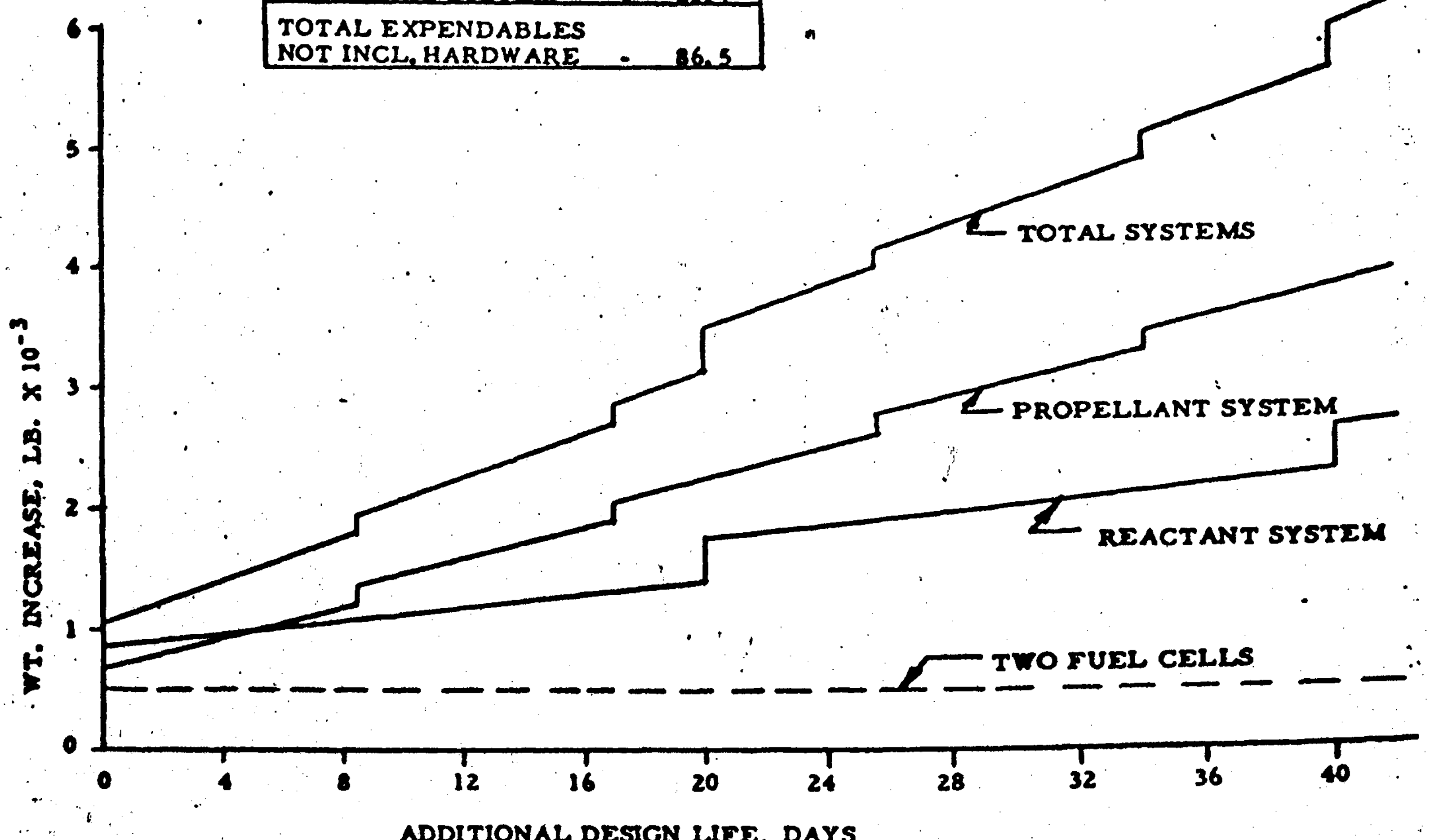
WEIGHT ESTIMATE
SUPPORT MODULE
(65 DAY DESIGN LIFE)
80/180 NM

ITEM	WEIGHT, LBS.
STRUCTURE (10' LONG)	610
NOSE CAP (EFFECTIVE) + JETTISON	70
DRVs (6)	1,860
DRV SUPPORT STRUCTURE	180
JETTISONABLE DOORS (6)	120
TRANSPORT SYSTEM	350
INTERFACE ATTACH	90
INSTRUMENTATION/CABLES	70
	(3,350)
*PROPELLANT TANKAGE AND RESIDUALS (4 SETS)	720
USABLE PROPELLANT	1,880
**CRYOGENIC REACTANT TANKAGE & RESIDUALS (2 SETS)	800
USABLE REACTANTS	800
FUEL CELLS, INSTALLED (2)	500
TOTAL	8,050

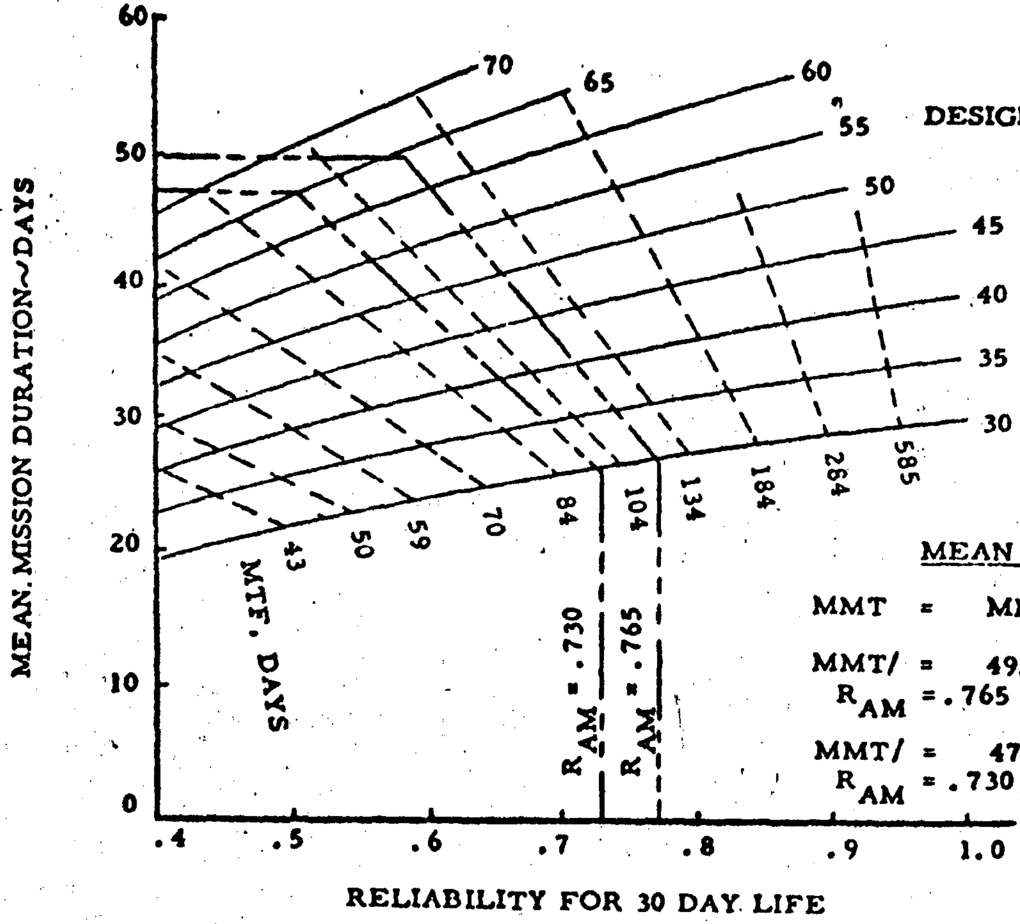
*BASELINE MOL HARDWARE
**65 DAY THERMAL COVERING

ADDITIONAL WEIGHT REQUIREMENTS FOR EXTENDED AM DESIGN LIFE

EXPENDABLE RATE - LBS/DAY	
PROPULSION SYSTEM -	60.8
CRYOGENIC SYSTEM -	25.7
TOTAL EXPENDABLES NOT INCL. HARDWARE -	86.5



INCREASE IN MEAN MISSION DURATION WITH EXTENDED DESIGN LIFE



MEAN MISSION TIME

MMT = MMD X $R_{BOOSTER}$

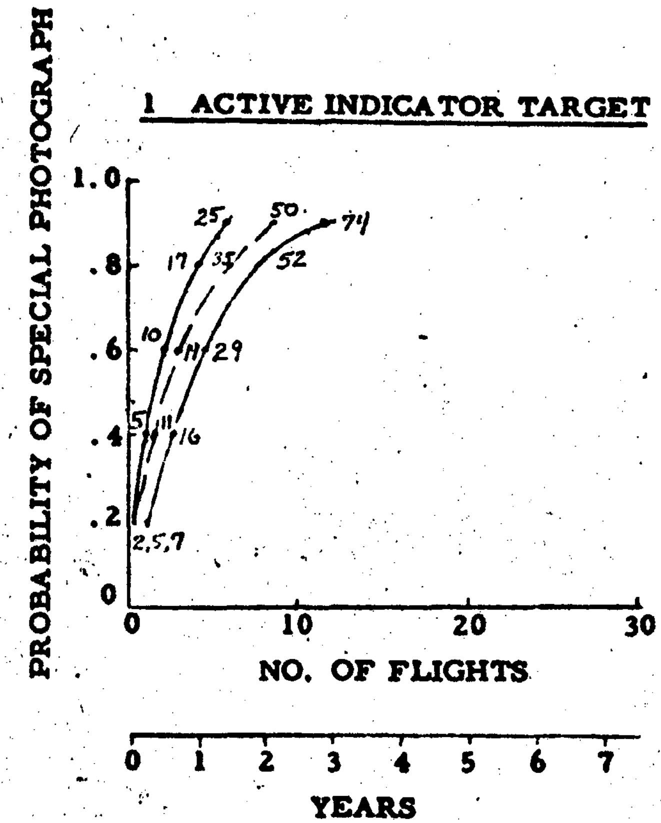
MMT/ R_{AM} = .765 = 49.3 X .93 = 45.9 DAYS

MMT/ R_{AM} = .730 = 47.1 X .93 = 43.8 DAYS

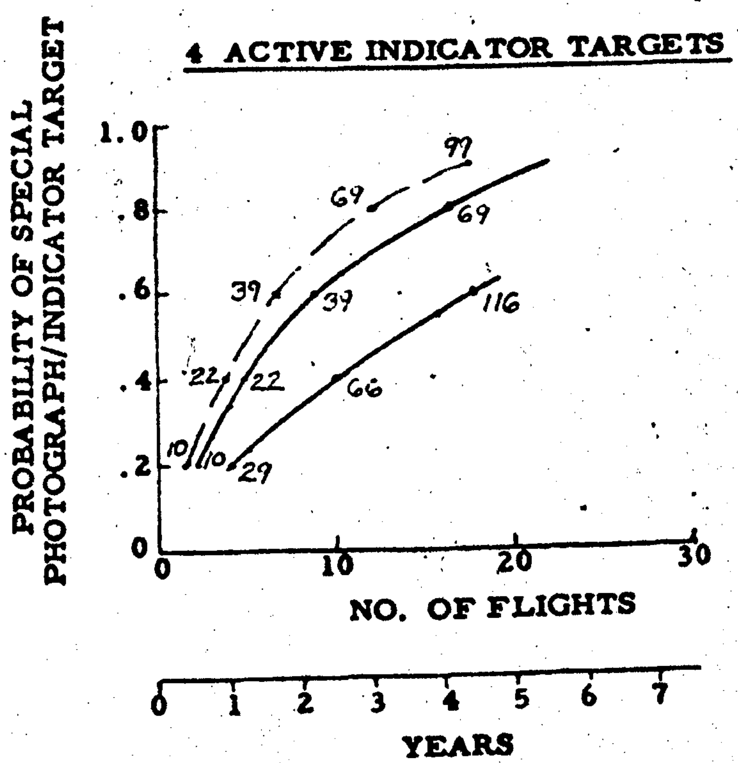
EFFECT OF PROGRAMMING FOR ACTIVE INDICATORS TARGETS (TYPICAL TARGET COMPLEX)

- 30% CLOUD COVER
- 0.09 INCIDENCE OF ACTIVE INDICATOR

1 ACTIVE INDICATOR TARGET



4 ACTIVE INDICATOR TARGETS



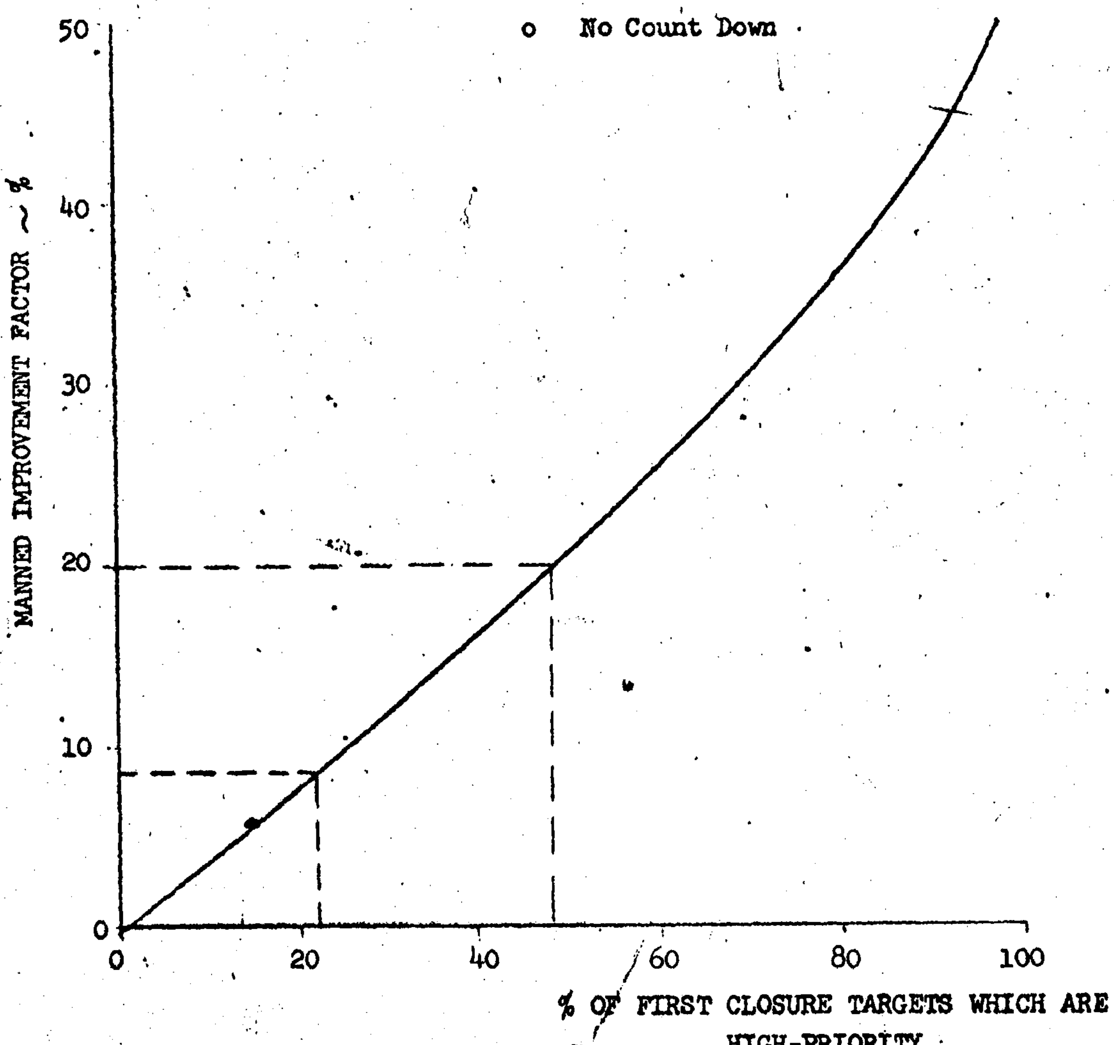
COST - COMPARISONS

MANNED AND UNMANNED PROGRAMS

MOL BASELINE	$1,784M
WHOLLY UNMANNED PROGRAM (35-DAY, TIII 5-SEG)	$1,120M-$1,255M
(65-DAY, TIII 7-SEG)	$1,400M-$1,570M
FOLLOW-ON RECURRING	
MOL - AM	$ 67M
WHOLLY UNMANNED	
5-SEG	$ 45M
7-SEG	$ 57M

VERIFICATION EFFECTIVENESS FOR TOTAL TAKE

- V_{AVG} = 0.5
- 50% OF TARGETS HAVE TWO ACCESSES PER CLOSURE
- No Count Down

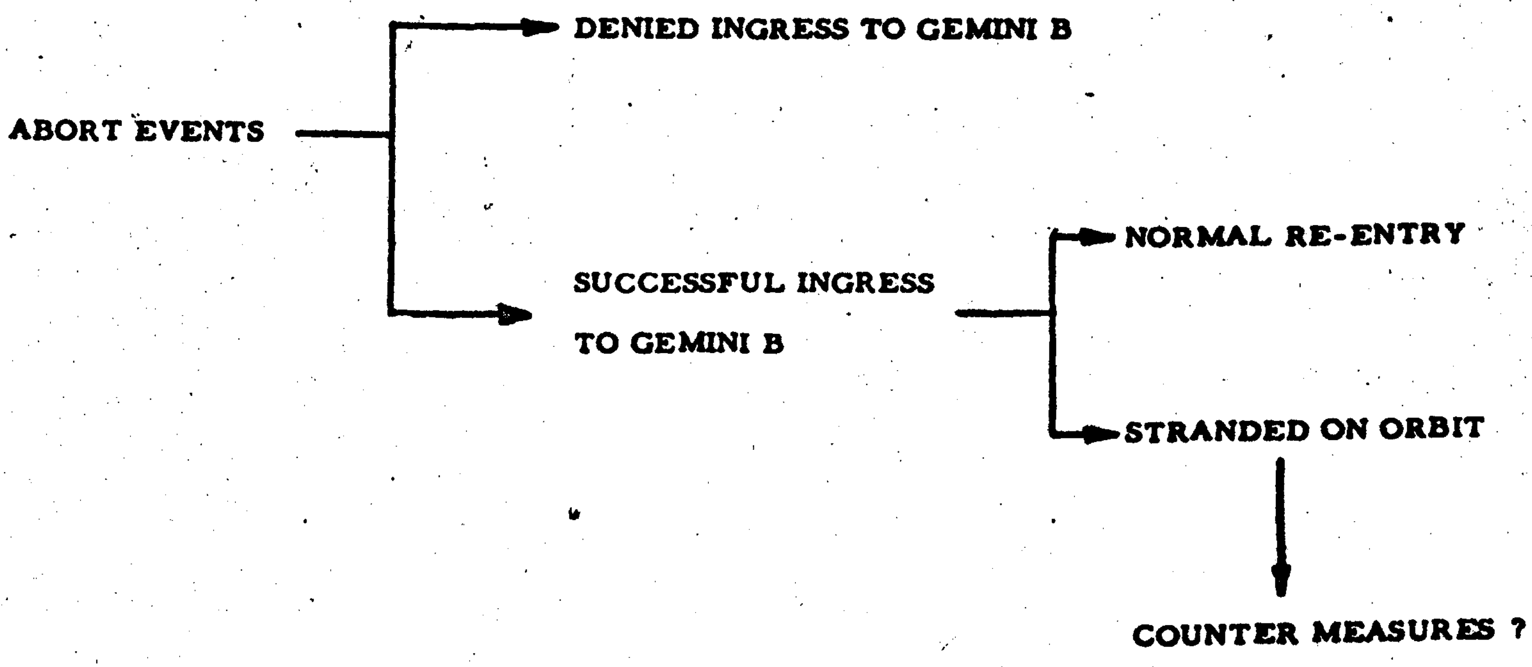


ORBIT PHASE RESCUE/ESCAPE

CONSIDERATIONS FOR THE MOL

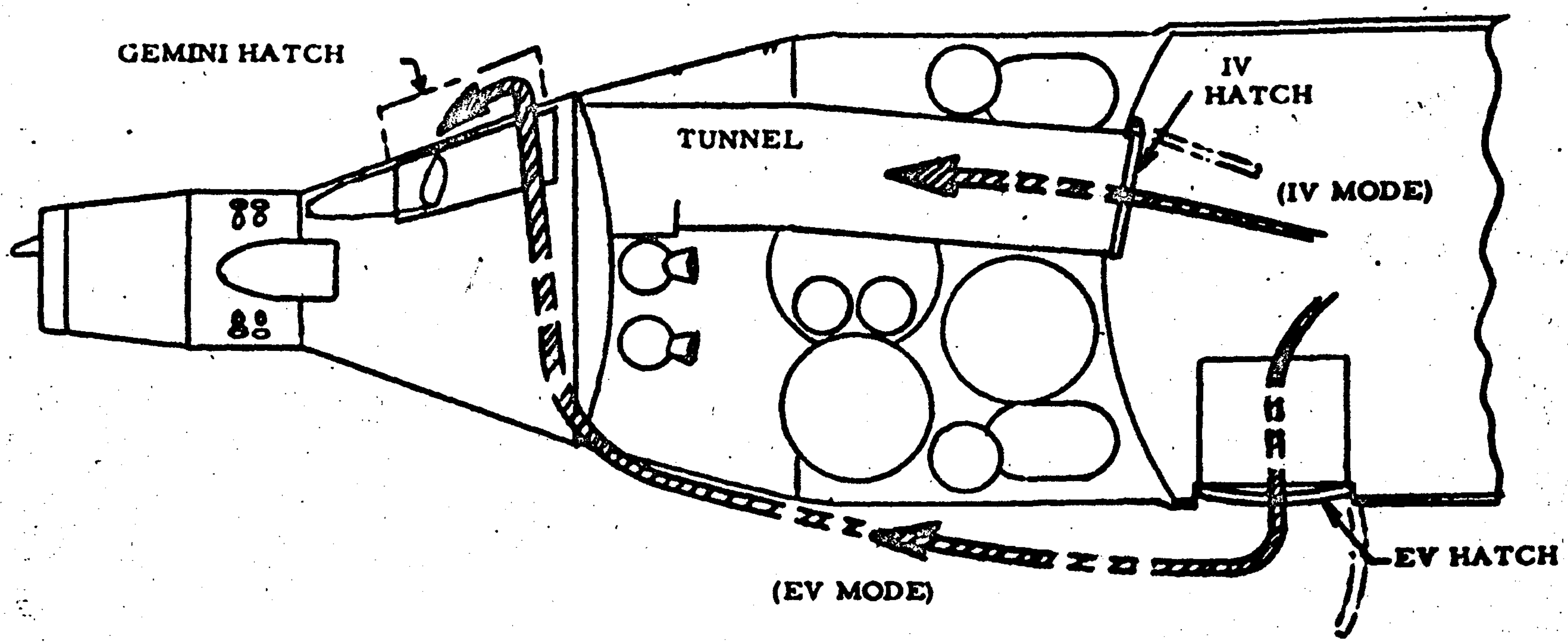
- RESPONSE TO HOUSE COMMITTEE ON SCIENCE & ASTRONAUTICS QUESTIONNAIRE: "SPACE FLIGHT EMERGENCIES"
  - ✓ ESTIMATE CREW ORBITAL STRANDING RISK
  - ✓ REVIEW EFFECTIVENESS OF POSSIBLE COUNTERMEASURES

APPROACH TO ON-ORBIT STRANDING ESTIMATE



ACCESS ROUTE PROBABILITIES

(LABORATORY TO GEMINI B)



INTRA-VEHICULAR MODE (IV)	
EVENT	**PROBABILITY***
● HATCH INOPERATIVE	3.0×10^{-6}
● CRUSHED TUNNEL	$.3 \times 10^{-6}$

EXTRA-VEHICULAR MODE (EV)	
EVENT	**PROBABILITY***
● DRV TUBE HATCH INOPERATIVE	3.0×10^{-6}
● PRESSURE SUIT ASSEMBLY INOPERATIVE	$.03 \times 10^{-6}$
● GEMINI B HATCH INOPERATIVE (OPEN)	6×10^{-6}

* PROBABILITY OF OCCURRENCE FOR 30 DAY IN-ORBIT

PROBABILITY OF DENIED INGRESS TO GEMINI B

ABORT FAILURE OR HAZARD	COMPARTMENT LOCATION OF FAILURE/HAZARD	PATH OF INGRESS TO GEM. B	PROBABILITY OF DENIED INGRESS TO GEM. B
FIRE	U.C.	I.V. WITH E.V. BACKUP	50×10^{-12}
		E.V. IF TUNNEL DAMAGE	15×10^{-6}
	P.C.	I.V. ONLY	3×10^{-6}
EXPLOSION	U.C.	CRUSHED TUNNEL, USE E.V.	15×10^{-6}
	P.C.	I.V.	3×10^{-6}
DEPRESSURIZATION	P.C.	GENERALLY I.V. WITH E.V. BACKUP	50×10^{-12}
NOXIOUS GASES	P.C.	I.V. OR E.V.	50×10^{-12}
SUBSYSTEM ANOMOLIES	U.C.	I.V. OR E.V. DEPENDING ON EFFECT ON SYSTEM (POWER LOSS, 0_2 LOSS)	15×10^{-6} TO 50×10^{-12}
	P.C.	I.V. OR E.V. DEPENDING ON EFFECT ON SYSTEM	

PROBABILITY OF DENIED INGRESS TO GEMINI B IS VERY REMOTE

POSSIBLE CAUSES OF FAILURE OF GEMINI B TO INITIATE NORMAL RE-ENTRY

SYSTEM	TYPE OF EVENT (RE-ENTRY PRECLUDING FAILURES)	PROBABILITY OF OCCURRENCE FOR 30 DAYS IN-ORBIT
GUIDANCE & CONTROL	HAND CONTROLLER INOPERATIVE OR FAILURE IN BOTH DIRECT AND RATE COMMAND MODE.	0.001×10^{-5}
PROPULSION	LEAKAGE OF BOTH RCS RINGS OR BURST OF PRESSURE TANK DAMAGING BOTH RINGS.	9.686×10^{-5}
	SHORT OR OPEN CIRCUIT - BOTH RINGS INOPERATIVE. FAILURE OF MORE THAN FOUR RETRO-ROCKETS	0.200×10^{-5}
ENVIRON. CONTROL SYSTEM	BURSTING OF O_2 TANKS CAUSING O_2 LOSS OR RETRO-ROCKET DAMAGE	7.200×10^{-5}
ELECTRICAL POWER	SHORT TO GROUND OF COMMON BUS CAUSING LOSS OF ALL FUNCTIONS. MULTIPLE BATTERY LOSS.	7.475×10^{-5}
CREW TRANSFER (I.V.)	HEAT SHIELD/PRESSURE HATCH FAILURE OR FAILURE TO SEPARATE GEMINI FROM LAB	0.400×10^{-5}
	TOTAL PROBABILITY OF A GEMINI B EQUIPMENT FAILURE WHICH WOULD PRECLUDE INITIATION OF RE-ENTRY	24.962×10^{-5}

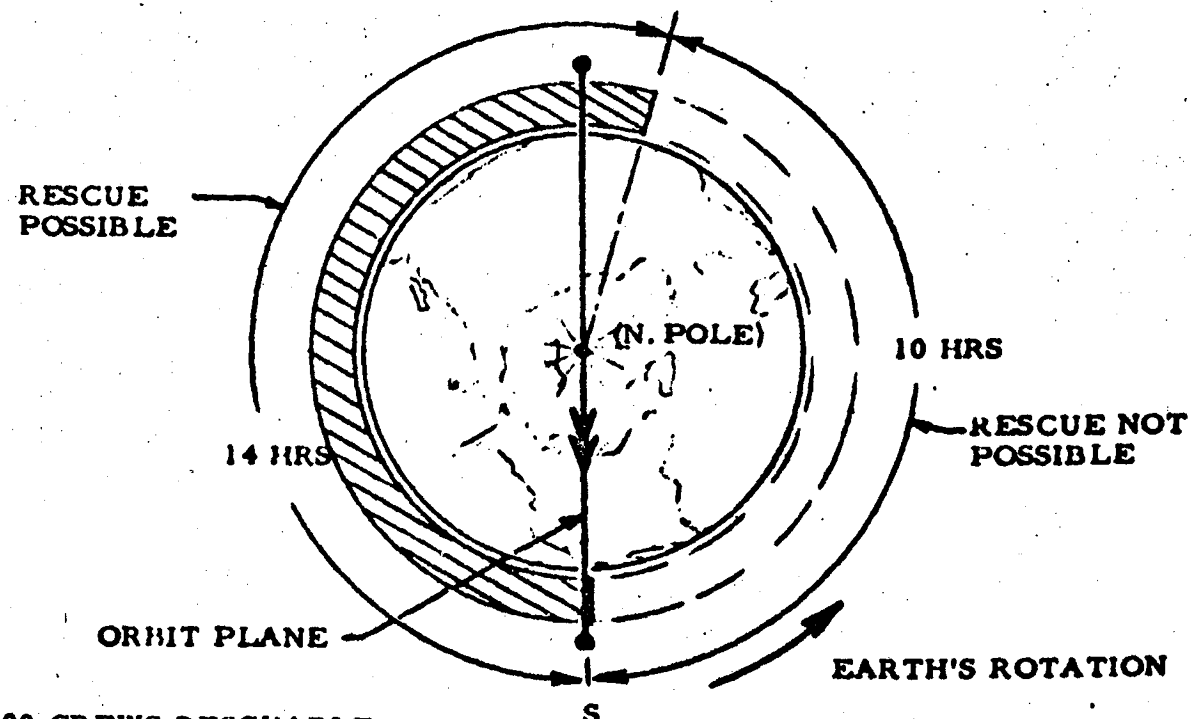
~2½ per 10,000 missions

PROBABLE RESCUE OR ESCAPE ESTIMATE SUMMARY

EVENT	PROBABLE EVENTS PER 10,000 MISSIONS	
• OCCURRENCE PRECLUDING INGRESS TO GEMINI B FROM LAB	MUCH LESS THAN	1
• OCCURRENCE PRECLUDING RE-ENTRY OF GEMINI B	AT MOST	3
• ESTIMATED EVENTS PRECLUDING RESCUE OR ESCAPE (CREW FATALTIES, VEHICLE DYNAMICS)	AT LEAST	1
• ESTIMATED RESCUE OR ESCAPE OPPORTUNITIES	AT MOST	2

EARTH BASED RESCUE CONSIDERATIONS

- WITH NO CONSTRAINTS ON GEMINI B OR LAUNCH VEHICLE CAPABILITY
  - ✓ SYSTEM USED TWICE IN 10,000 MISSIONS
- CURRENT GEMINI B LOITER AND LAUNCH VEHICLE PAYLOAD CONSTRAINTS FURTHER REDUCE EFFECTIVENESS.



< 1/10,000 CREWS RESCUABLE

ON-BOARD ESCAPE SYSTEM CONSIDERATIONS

- TECHNOLOGY GENERALLY AVAILABLE
- SYSTEM COMPATIBILITY REQUIRES EARLY DESIGN INTEGRATION
  (TOTAL SYSTEM DESIGN)
- LIMITED UTILITY, CONSIDERING ALL CAUSES OF ORBITAL STRANDING
  (DEVICES DISABLED OR NOT AVAILABLE)
- RE-ENTRY, RECOVERY, RETRIEVAL HAZARDS.
  (UNSOPHISTICATED SUBSYSTEMS, LARGE DISPERSIONS)

COMPARISON OF ORBITAL STRANDING RISK WITH RISKS OF SOME FAMILIAR ACTIVITIES

ACTIVITY	100,000 MAN DAYS
DOMESTIC PASSENGER AIR CARRIERS	4.0
ESTIMATED MOL CREW STRANDING	.7
ACCIDENT FATALITY RATE, U.S. POPULATION	.2

SUMMARY

MOL BASELINE PROGRAM ORBITAL RESCUE/ESCAPE

- MOL SYSTEM DEVELOPMENT APPROACH
  - ✓ RELIABILITY
  - ✓ BLOCK AND FUNCTIONAL REDUNDANCY
  - ✓ TESTING
  - ✓ SYSTEMS MONITORING
  - ✓ EMERGENCY PROCEEDURES AND TRAINING
- REMOTE POSSIBILITY OF ORBITAL STRANDING (.9998 PER MISSION)

NO SUBSTANTIAL REQUIREMENT FOR RESCUE OR ESCAPE SYSTEMS IN THE MOL DEVELOPMENT PROGRAM.

FOLLOW-ON PROGRAM CONSIDERATIONS

- MOL MAY HAVE RENDEZVOUS/RESUPPLY CAPABILITY IN EARLY SEVENTIES -
- NASA AAP PLANS RENDEZVOUS/RESUPPLY OPERATIONS STARTING IN LATE SIXTIES -
- ELEMENTS OF THESE TWO SYSTEMS MIGHT BE COMBINED TO PERMIT AN EARLY SPACE RESCUE SYSTEM

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MOL/NASA APPLICATIONS "A"

POSSIBLE UTILIZATION OF MOL FOR ACCOMPLISHMENT OF NASA SCIENTIFIC EXPERIMENTS - SPACE APPLICATIONS MISSION "A."

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

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MOL/APPLICATIONS "A"
BACKGROUND

- NASA STUDIES/DEFINITION OF "APPLICATIONS A" PKG. (OSSA)
  - DEVELOPMENT-IMPROVEMENT OF AUTOMATED METEOROLOGICAL SATELLITES
  - 14 EXPERIMENTS-CURRENT BREADBOARD OR FURTHER ADVANCED
  - EXPERIMENTERS REQUIRE POLAR ORBIT AT 125 N. MI. CIRCULAR
- NASA S-1B/APP "A" INTEGRATION STUDY (MSC)
  - CAN ATTAIN 50° INCLINATION AT 125 N. MI. CIRCULAR
  - EXPERIMENT VOLUME NECESSITATES SPECIAL CARRIER
  - PERFORMANCE CAPABILITY LIMITS MISSION TO 2 WEEKS
  - SUBSYSTEM PROBLEM AREAS FOR CSM
    - ✓ POWER
    - ✓ DATA
    - ✓ THERMAL
    - ✓ DISPLAY/CONTROL
  - COST $32M EXPERIMENTS + $20M FOR SPECIAL CARRIER
- NASA SUBMITTAL OF "APP A" TO MANNED SPACE FLIGHT EXP. BOARD 6 FEB. '67
  - DOD QUESTIONED NEED FOR MAN TO CONDUCT EXPERIMENTS
  - ACCOMMODATION OF SOME OR ALL EXPERIMENTS ON MOL FLIGHTS?
- MOL SYSTEM OFFICE DIRECTIVE 8 FEB. '67 TO MOL/SPO
  - COST & SCHED TO FLY "APP A" ON SEPARATE MOL FLIGHT (POLAR ORBIT)
  - ACCOMMODATIONS FOR INDIVIDUAL EXPERIMENTS ON BASELINE FLIGHTS
    - ✓ PIGGYBACK BASIS
    - ✓ MANNED FLIGHT
    - ✓ UNMANNED FLIGHT
  - [illegible]

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

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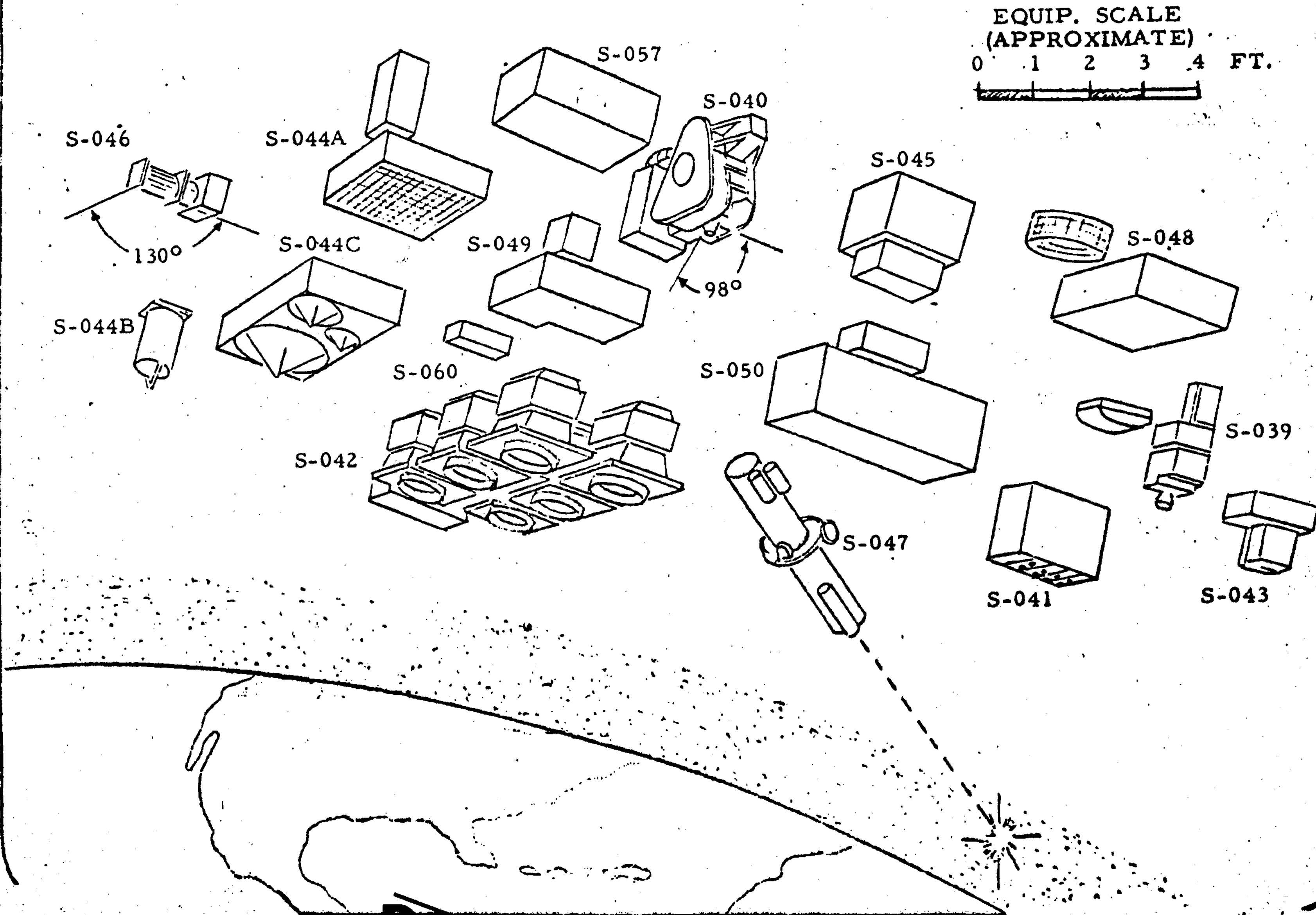
"APPLICATIONS A" EXPERIMENTS

OBSERVABLE PHENOMENA - METEOROLOGY

ATMOSPHERIC PHENOMENA	SENSING MODE	EXPERIMENTS
CLOUD CHARACTERISTICS	PHOTOGRAPHY	S-039, S-040, S-042
	SPECTROMETRY	S-050
	RADIOMETRY	S-048, S-057
ATMOSPHERIC CIRCULATION	SPECTROMETRY	S-045, S-048, S-049, S-050
SEVERE STORMS	PHOTOGRAPHY	S-039, S-040, S-042
	SPECTROMETRY	S-049
	RADIOMETRY	S-057
VERTICAL PRESSURE PROFILE	STAR TRACKING	S-047
VERTICAL TEMPERATURE PROFILE	PHOTOGRAPHY	S-047
	SPECTROMETRY	S-043, S-050, S-049
	RADIOMETRY	S-044C, S-060
HEAT BALANCE	SPECTROMETRY	S-045
	RADIOMETRY	S-057
WATER VAPOR DISTRIBUTION	SPECTROMETRY	S-046, S-049, S-045
	RADIOMETRY	S-044B, S-060
PRECIPITATION DISTRIBUTION	RADIOMETRY	S-044A, S-044B
ATMOSPHERIC ATTENUATION OF MICROWAVES	RADAR	S-041

"APPLICATIONS A" EXPERIMENTS

SCHEMATIC ARRANGEMENT



"APPLICATIONS A" EXPERIMENTS

TECHNICAL REQUIREMENTS

EXPERIMENT EQUIP.	WEIGHT (LBS)		VOLUME (FT^3)		POWER		DATA			ATT. CONTR		TIMING
	ASC	RET	ASC	RET	WATTS	KWH	FILM (FRMS	DGTL (BPS)	ANLG (CH)	POINT (DEG)	RATE (°/SEC)	(SEC)
S-039 DAY-NITE CAMERA	75	20	2.1	0.5	79	10.25	0	5	6	±5°	.05	1
S-040 DIELECTRIC TAPE CAMERA	83	0	2.0	0	55	0.6	0	0	35	10°	.15	1
S-041 MILLIMETER WAVE PROP	200	0	5.0	0	224	4.5	0	80	0	±5°	-	1
S-042 MULTI-SPECTRAL PHOTO	1,400	200	39.0	2.5	900	3.0	10.4K	0	7	0.5°	0.10	1
S-043 IR TEMP SOUNDING	40	10	1.8	0.3	100	26.8	1.0K	1.3K	0	+1°	0.2	0.4
S-044 O_2 & H_2O MICRO-WAVE	260	0	14.8	0	166	16.6	0	76 100 100	-	±2°	-	0.005
S-045 IR FILTER WEDGE	30	0	1.3	0	5	0.04	0	204	0	±2°	-	1
S-046 POLARIZATION	51	1	2.2	0.1	50	4.0	100	160	0	0.5°	0.05	1
S-047 STELLAR REFRACTION	110	0	4.5	0	70	4.6	0	890	0	0.5°	0.05	0.001
S-048 UHF SFERICS	35	0	0.7	0	10	3.3	0	50	0	±2°	-	1
S-049 IR INTERFEROMETER	36	0	1.4	0	14	1.6	-	4K	0	±0.5°	0.05	1
S-050 IR TEMP PROFILE	90	0	5.8	0	25	1.7	-	1.5K	0	±1°	±1	1
S-057 MULTI-CH RADIOMETER	18	0	0.8	0	9	1.6	-	50K	0	±0.5°	0.05	0.1
S-060 CHOPPER RADIOMETER	28	0	1.7	0	18	6.0	-	42	0	±2°	±1	0.5
TOTAL OR MOST STRINGENT REQM'T.	2,456	231	83.1	3.4	1,725	84.59	11.5K	56.1K	48	±0.5°	±0.05	0.001

ANALYSIS OF "APPLICATIONS A" BY JOINT METEOROLOGY SATELLITE PROGRAM OFFICE

EXP. NO.	SUBJECT	SPONSOR AFFILIATION	CURRENT PLANS FOR SAME OR SIMILAR EXPER.	FEASIBILITY OF AUTOMATED EXPER.
S-044	MICROWAVE RADIOMETER	GODDARD INST. & MIT	--	AUTO
S-046	VISIBLE RADIATION POLARIZATION MEAS. FROM ATMOS.	UCLA	--	AUTO
S-057	RADIOMETRIC MAPPING	U OF CAL.	--	AUTO
S-040	CLOUD COVER METEOROLOGY TV	GODDARD SFC	--	AUTO
S-047	ATMOS. MEAS. FROM STELLAR REFRACTION	U OF MICH	--	MAN REQ'D
S-060	CHOPPER RADIOMETER	OXFORD U	NIMBUS D-1970	AUTO
S-045	IR FILTER WEDGE SPECTROMETER	GODDARD SFC	NIMBUS D-1970	AUTO
S-043	IR TEMP SOUNDING	OHIO ST. U	NIMBUS B-1967, NIMBUS D-1970	AUTO
S-039	DAY/NITE CLOUD COVER IMAGE ORTHICON	GODDARD SFC	ATS-D, 1968	AUTO
S-049	IR INTERFEROMETER SPECTROMETER	GODDARD	NIMBUS B-1967, NIMBUS D-1970	AUTO
S-048	UHF SFERICS	U OF WIS	NIMBUS D-1970	AUTO
S-050	IR TEMP. PROFILE	ESSA	NIMBUS B-1967, NIMBUS D-1970	AUTO
S-042	MULTI-SPECTRAL PHOTOGRAPHY	ARMY ENGRS.	NOT SPECIFICALLY METEOROLOGY	MAN REQ'D
S-041	MILLIMETER WAVE PROPAGATION	GODDARD SFC	NOT SPECIFICALLY METEOROLOGY	AUTO

MOL/NASA APPLICATIONS "A"

CONSIDERATIONS FOR EXPERIMENT INTEGRATION

- VEHICLE SUBSYSTEM
  - STRUCTURE
  - POWER
  - COMMUNICATIONS/COMMAND/DATA MANAGEMENT
  - GUIDANCE AND ATTITUDE CONTROL
  - PROPULSION
  - THERMAL CONTROL
  - EXPERIMENT DISPLAY AND CONTROL
- AGE
- OPERATIONS
  - TEST FLOW
  - LAUNCH/FLIGHT
  - CREW ACTIVITY
- SOFTWARE
  - ON-BOARD COMPUTER PROGRAMMING
  - GROUND BASED COMPUTER PROGRAMS

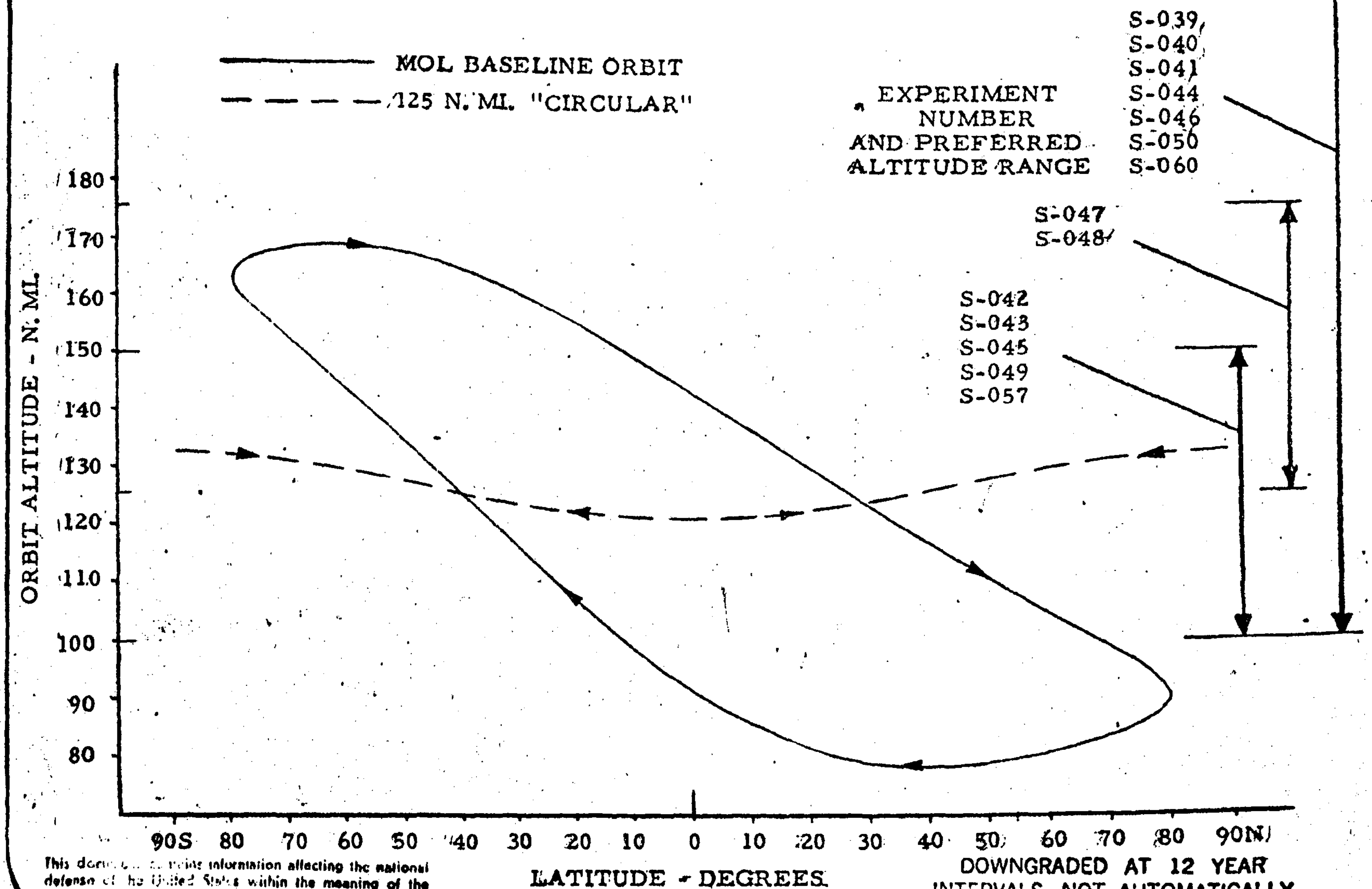
MOL/APPLICATIONS "A"

STUDY APPROACH

- FLTS 1, 2 - NOT FEASIBLE FOR APP. A - LACK NEEDED SUBSYSTEM CAPABILITY
- FLTS 3, 4, 5 - INDIVIDUAL EXPERIMENTS PIGGYBACK - WITHIN FLT. CAPABILITY?
  - SELECT FROM 5 EXPERIMENTS RECOMMENDED BY JMSPO (040, 044, 046, 047, 057)
  - NO INSTALLATION IN MM
- FLTS 6, 7 - UP TO COMPLETE APP. A PKG PIGGYBACK - WITHIN FLT CAPABILITY?
  - AUTOMATED EXPERIMENTS
  - INSTALL IN SM OR LM
- SEPARATE MOL VEHICLE FOR APPLICATIONS "A"
  - COMPLETE APP. A PKG.
  - DURATION UP TO 60 DAYS
  - PHYSIOLOGICAL AND PSYCHOLOGICAL TESTING CAPABILITY

"APPLICATIONS A" EXPERIMENTS

ORBIT ALTITUDE CHARACTERISTICS VS. PREFERRED ALTITUDES FOR EXPERIMENTS



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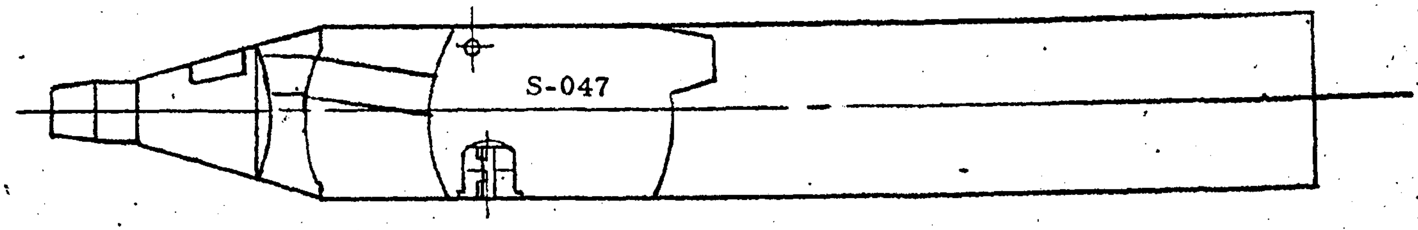
MOL/NASA APPLICATIONS "A"

MOL DEVELOPMENT PROGRAM

MOL/NASA APPLICATIONS "A"

FLIGHTS 3, 4, AND 5 (MANNED)

(30 DAY DURATION)



- S-047 STELLAR REFRACTION EXPERIMENT
  (158 LBS - 74 WATTS OPERATING POWER)

✓ MANUAL OPERATION FOR STAR ACQUISITION

✓ MINIMUM SUBSYSTEM IMPACT

✓ INSTALLATION REQUIREMENTS COMPATIBLE WITH VEHICLE DESIGN FEATURES

✓ LESS THAN 1 KWH ELECTRICAL ENERGY PER MISSION

✓ LESS THAN 4 HOURS OF CREW TIME PER MISSION

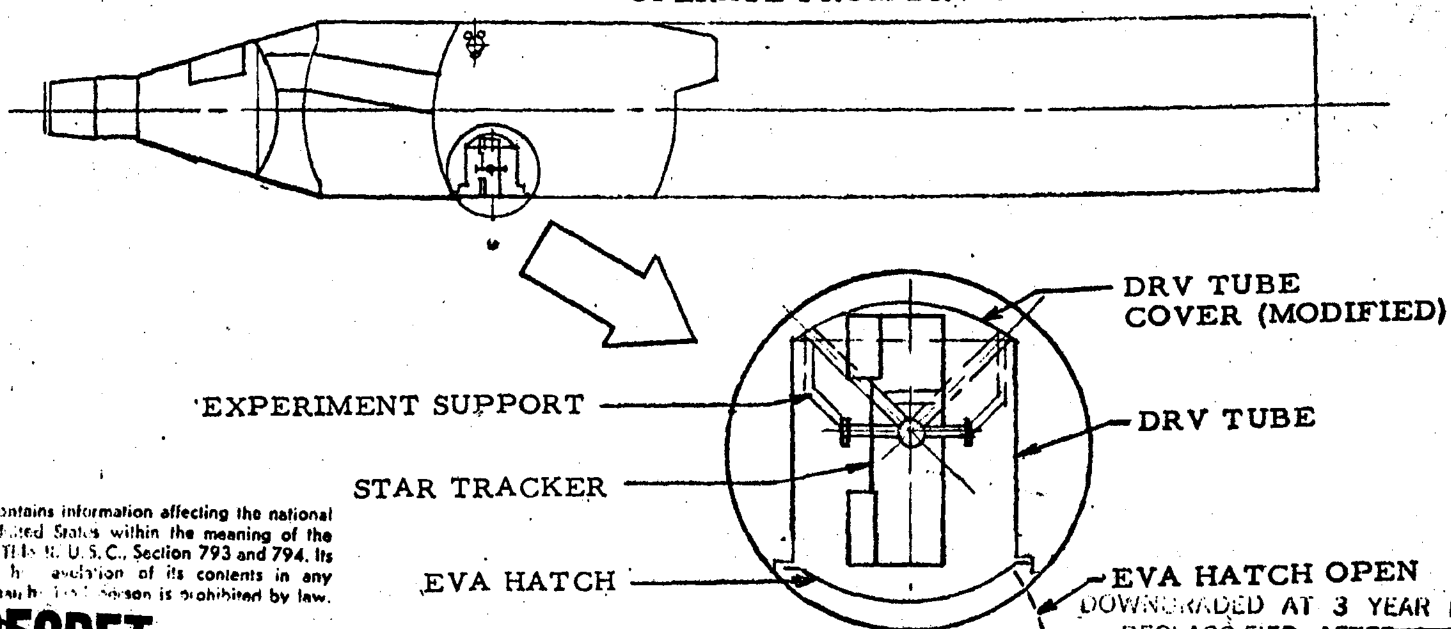
POSSIBLE S-047 EXPERIMENT INSTALLATION

(MOL FLIGHTS 3, 4, AND 5)

- S-047 WEIGHT (INSTALLED) — 158 LBS
- S-047 VOLUME (STOWAGE) — 4.5 CU. FT.
- S-047 ELECTRICAL ENERGY — 9.5 KWH
- S-047 POWER PEAK — 74 WATTS
- CREW TIME REQUIRED — 20 HRS
- ACTS PROPELLANT REQUIRED — 20 LBS

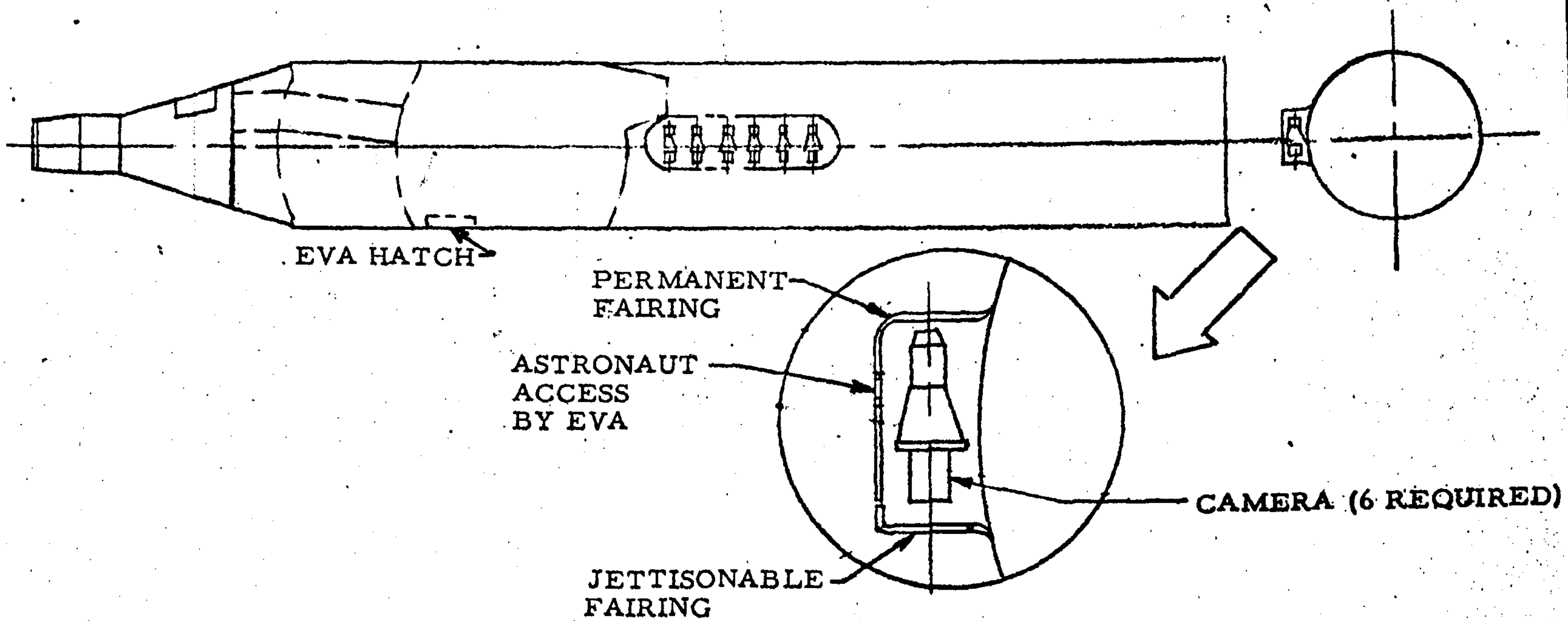
STOW IN SLEEP POSITION FOR LAUNCH

OPERATE FROM DRV TUBE



POSSIBLE S-042 EXPERIMENT INSTALLATION

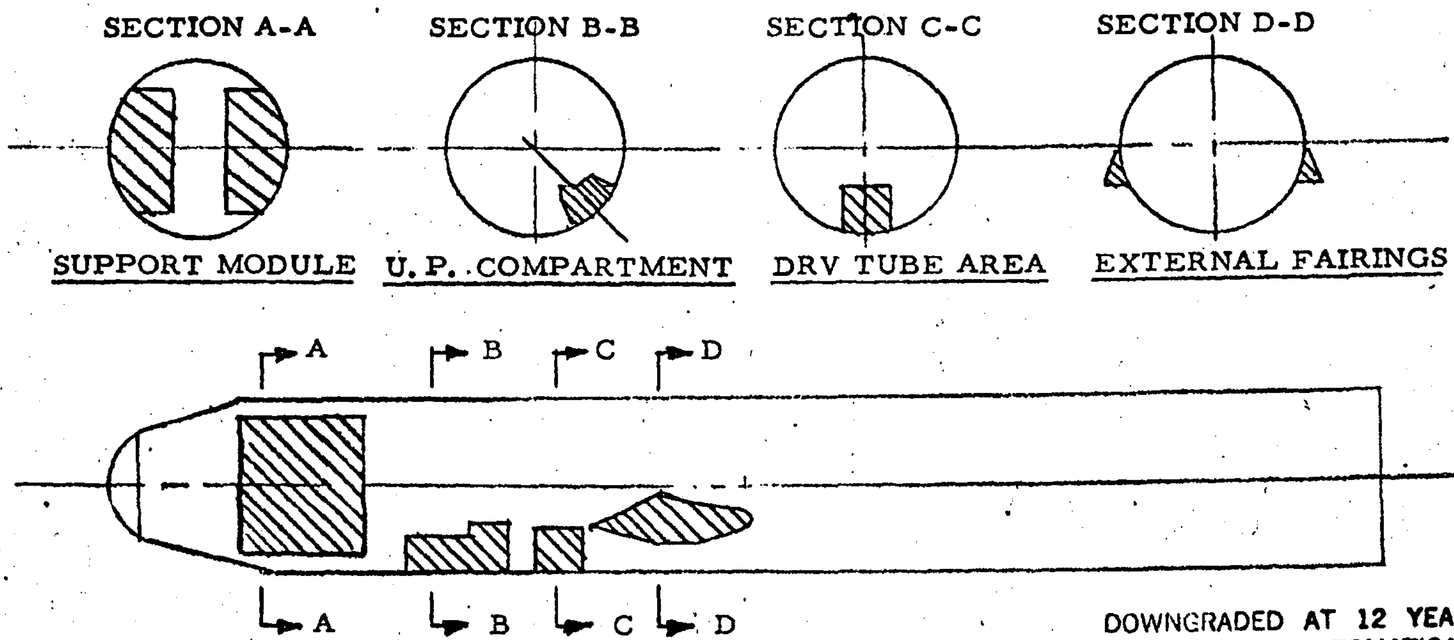
(MOL FLIGHTS 3, 4, AND 5)



• S-042 WEIGHT (INSTALLED)	~2000 LBS
• S-042 ELECTRICAL ENERGY	3.2 KWH
• S-042 POWER PEAK	945 WATTS
• EVA REQUIRED FOR EXPERIMENT SUPPORT	~1.5 HRS
• CREW EXPERIMENT OPERATING TIME	2 HRS
• DATA RETURN	200 LBS

AVAILABLE VOLUME FOR EXPERIMENTS

(MOL FLIGHTS 6 AND 7)



- AVAILABLE VOLUME

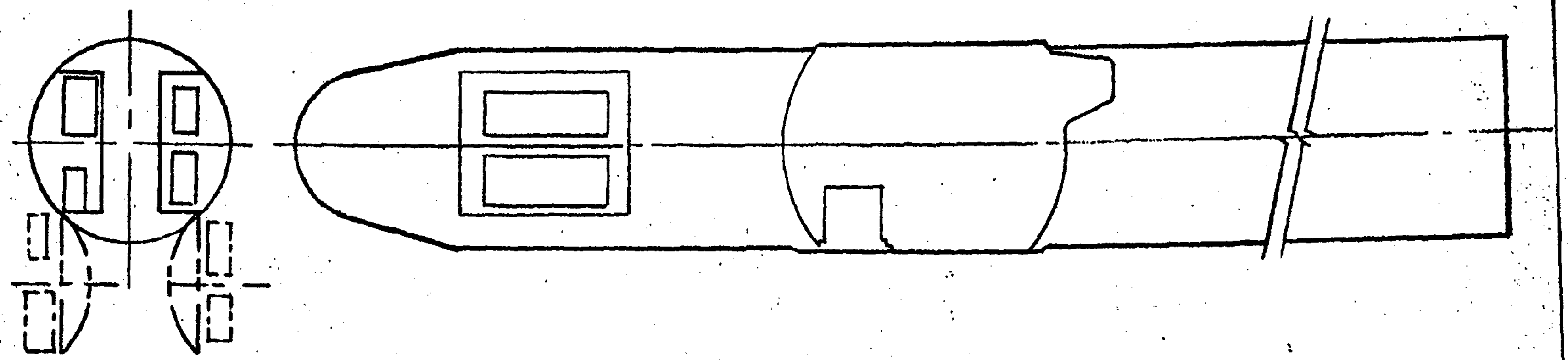
SUPPORT MODULE	366 CU. FT.
U.P. COMPARTMENT	33 CU. FT.
DRV TUBE AREA	23 CU. FT.
EXTERNAL FAIRING (2)	36 CU. FT.

SPECIAL ACCESS REQUIRED
CLASSIFIED SPACE PROGRAM
NUMBER 632a

MOL/NASA APPLICATIONS "A"

FLIGHT 6 OR 7 (UNMANNED)

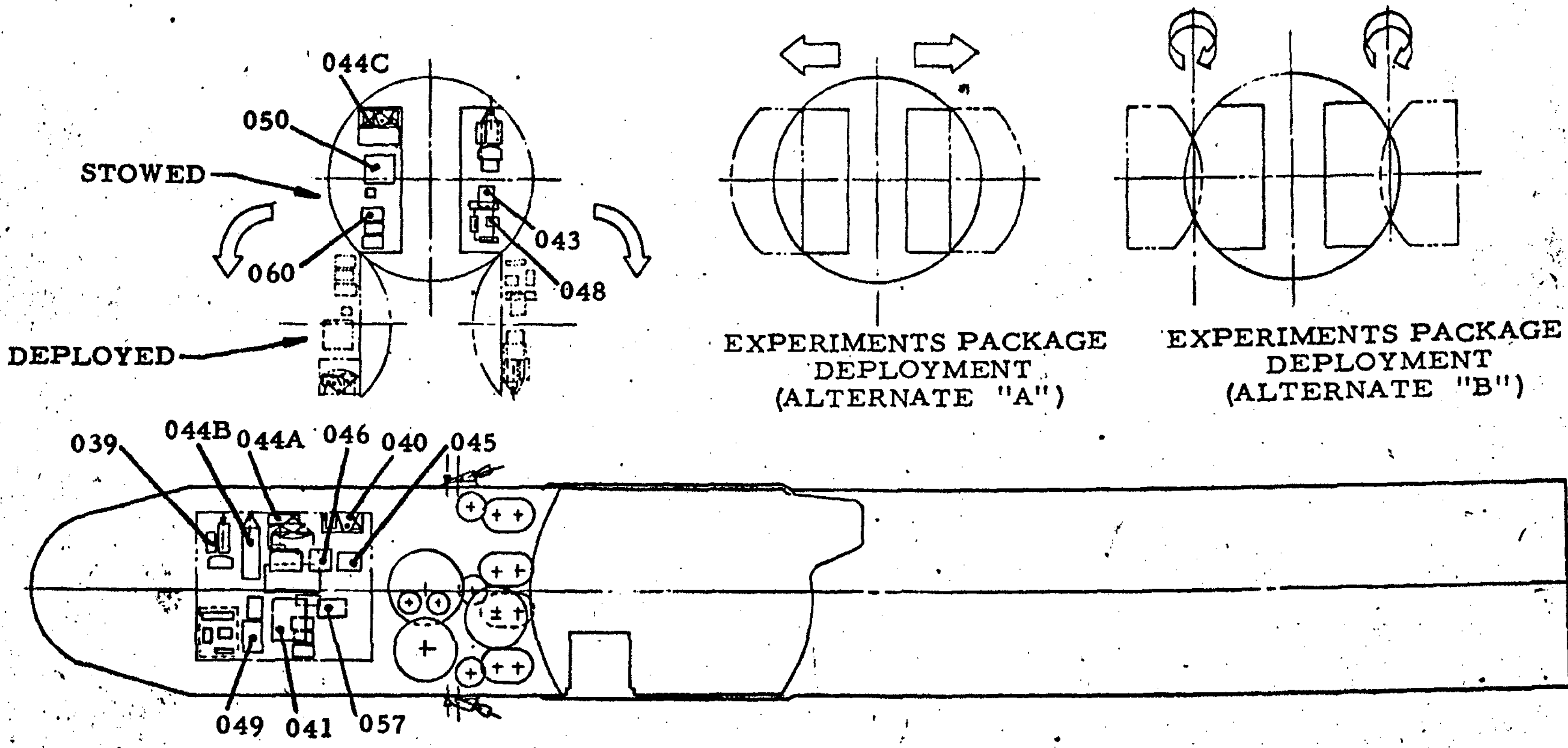
(30 DAY DURATION)



- CAPABILITY FOR ALL EXPERIMENTS EXCEPT S-042 AND S-047
- AMPLE VOLUME AVAILABLE IN SUPPORT MODULE FOR EXPERIMENT INSTALLATION
- ADEQUATE PAYLOAD MARGIN FOR EXPERIMENT WEIGHT REQUIREMENTS
- ADEQUATE POWER AVAILABLE FOR EXPERIMENT REQUIREMENTS
- SYSTEM IMPACT
  - ✓ SUPPORT MODULE DESIGN MODIFICATIONS
  - ✓ DATA MANAGEMENT SUBSYSTEM AUGMENTATION
  - ✓ ON-BOARD SOFTWARE REVISION
  - ✓ SYSTEM TEST FLOW/AGE REVISIONS

PROPOSED CONFIGURATION

NASA APPLICATIONS "A" EXPERIMENTS ON FLIGHT 6 OR 7



- ~~MISSION DURATION~~ 30 DAYS 45
- AVAILABLE PAYLOAD MARGIN 7460 LBS
- EXPERIMENTS PAYLOAD WEIGHT 1440 LBS

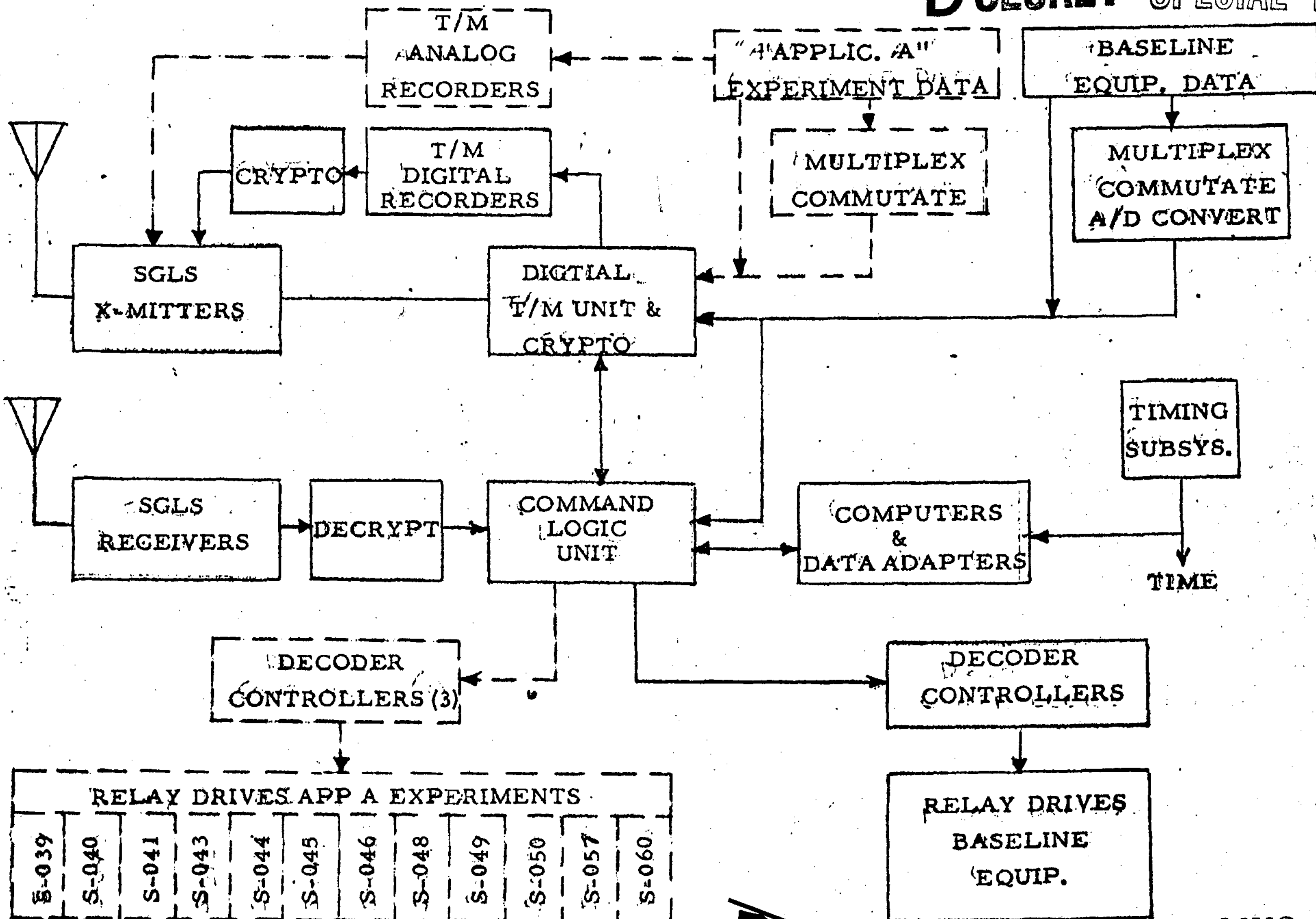
ELECTRICAL POWER CONSUMPTION
POSSIBLE FLTS 6/7 WITH NASA APPLICATIONS "A" EXP. INTEGRATED

	CONTINUOUS AVERAGE* (WATTS)	PEAK (WATTS)	ENERGY* (KWH)
● BASELINE POWER - SUBSYSTEM CAPABILITY	2,170	4,500	1,567
● ELECTRICAL POWER LOAD ESTIMATE			
√ NORMAL FUNCTIONS	1,510	3,500	1,087
√ APPLICATIONS "A" EXP.	130	979	85
MAXIMUM LOAD CONDITION	1,640	3,500	1,172
● POWER MARGIN	530	1,000	395

*SHOWN FOR 30 DAY TIME PERIOD

MOL FLIGHTS 6/7

COMMAND/DATA MANAGEMENT SUBSYSTEM AUGMENTATION*
FOR "APPLICATIONS A" EXPERIMENTS



* ADDITIONS INDICATED BY DASHED LINES

MOL/NASA APPLICATIONS "A"

FLIGHT 6/7 IMPACT

- APPLICATIONS "A" EXPERIMENTS
  - FLY 12 OUT OF 14 (S-047 AND S-042 AS PRESENTED REQUIRE MAN)
  - ADD NIMBUS VIDICON SUBSYSTEM TO SUPPLY VISIBLE IMAGING FOR IR GROUP.
  - EXPERIMENT AUTOMATION FEASIBLE (INHERENT IN THE SELECTED 12)
- IMPACT ON VEHICLE SUBSYSTEMS
  - STRUCTURE - MODIFY SUPPORT MODULE FOR INSTALLATION
  - ELECTRICAL - ACCOMMODATE THROUGH PROPER OPS SCHEDULING
  - COMMUNICATIONS/DATA
    - ADD REMOTE MULTIPLEXER FOR EXPERIMENTS
    - ADD ANALOG RECORDERS
  - COMMAND/CONTROL
    - ADD DECODER/CONTROLLERS FOR EXPERIMENT OPS.
  - ATTITUDE CONTROL - CAPABLE OF HANDLING EXPERIMENT REQMTS.
  - PROPULSION - ~ 100 LB Δ DRAG PROPELLANT

~100 lb Δ drag propellant

- IMPACT ON AGE/SYSTEM TEST
  - SIGNIFICANT INTEGRATION EFFORT EXPECTED FOR SYSTEM TESTS (FACTORY & LAUNCH BASE)
  - COMPATIBILITY OF EXPERIMENT/VEHICLE CHECKOUT EQUIP MUST BE ASSURED.
- MISSION SOFTWARE
  - ON-BOARD SOFTWARE MAY BE SIGNIFICANTLY IMPACTED
    - / TIMING AND STATE OF DEVELOPMENT OF EXECUTIVE PROGRAM
  - AUGMENTATION OF GROUND COMPUTER SOFTWARE REQUIRED
    - / COMMAND PROGRAMS
    - / TELEMETRY FORMAT

MOL/NASA APPLICATIONS "A"

COST ESTIMATE SUMMARY

MODIFICATIONS TO FLIGHT 6 OR 7

(R. O. M.)

● DEVELOPMENT AND MODIFICATIONS*		$27.0M
• SUPPORT MODULE MODIFICATIONS	(14.0)	
✓ ENG. - DESIGN CHANGES	4.0	
✓ MODIFIED SM	4.0	
✓ TEST QUAL. VEH. FOR #6	4.0	
✓ STATIC & DEVELOPMENT TESTS	2.0	
• LM MODIFICATIONS	(13.0)	
✓ ENG. - DESIGN CHANGES	5.0	
✓ MODIFICATIONS TO LM (ADD. HDWR)	4.0	
✓ AUGMENTED QUAL. TEST	2.0	
✓ STATIC & DEVELOPMENT TESTS	2.0	
● REVISION OF ON-BOARD SOFTWARE PROGRAMS		$ 5.0M
● SYSTEMS ENGINEERING*		$17.0M
• GSE/TD/TD	2.0	
• SYSTEMS	8.0	
• AGE	7.0	
TOTAL		$49.0M

FISCAL YEAR	1968	1969	1970
MILLION DOLLARS	$10.0	$25.0	$14.0

* DOES NOT INCLUDE NASA PECULIAR COSTS

MOL/NASA APPLICATIONS "A"

PRELIMINARY CONCLUSIONS

BASELINE DEVELOPMENT PROGRAM

- MANNED FLIGHTS #3/4/OR 5:

  ✓ S-047, STELLER REFRACTION EXPERIMENT, APPEARS TO BE COMPATIBLE WITH MOL FLIGHTS 3/4/OR 5 AND WOULD REQUIRE MODEST INTEGRATION EFFORT.

- AUTOMATIC MODE FLIGHTS #6 OR 7:

  ✓ CAPABILITY FOR ALL EXPERIMENTS EXCEPT S-042 & S-047

  ✓ SIGNIFICANT IMPACT ON SYSTEM DESIGN AND TEST

  ✓ EARLIEST LAUNCH DATE APPEARS TO FALL IN LAST QUARTER OF CY 1971

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MOL/NASA APPLICATIONS "A"

POSSIBLE SEPARATE VEHICLE CONCEPTS

~~CONFIDENTIAL~~

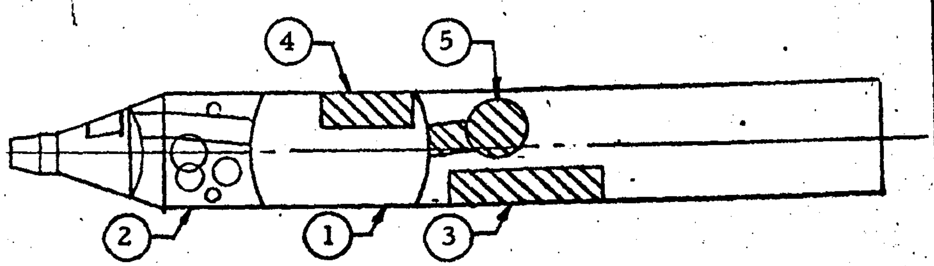
D ~~SECRET~~ SPECIAL HANDLING

MOL/NASA APPLICATIONS "A"

POSSIBLE SEPARATE VEHICLE APPLICATION CONCEPTS

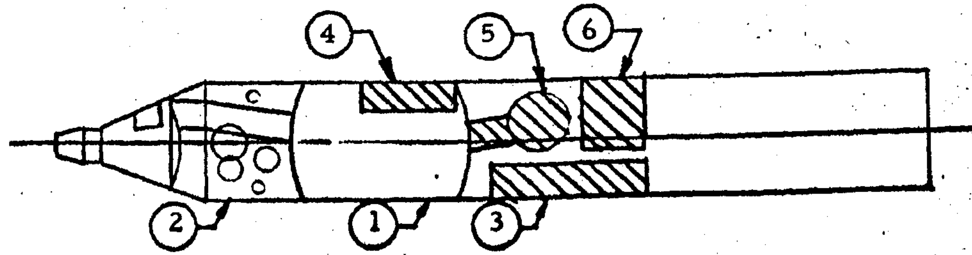
- CONCEPT A

1. BASELINE VEHICLE (LESS MISSION P/L EQUIP)
2. 30 DAY SYSTEMS QUAL
3. APP. "A" PACKAGE
4. BIO-TEST (P11 AND P12)
5. AIRLOCK



- CONCEPT B

1. BASELINE VEHICLE (LESS MISSION P/L EQUIP)
2. 30 DAY SYSTEMS QUAL
3. APP. "A" PACKAGE
4. BIO-TEST (P11 AND P12)
5. AIRLOCK
6. EXTENDED DURATION CAPABILITY (Δ 30 DAYS)
   - ELECTRICAL POWER (CRYOGENIC TANKS AND FUEL CELLS)
   - POWER CONDITIONING AND DISTRIBUTION
   - EC/LS EXPENDABLES



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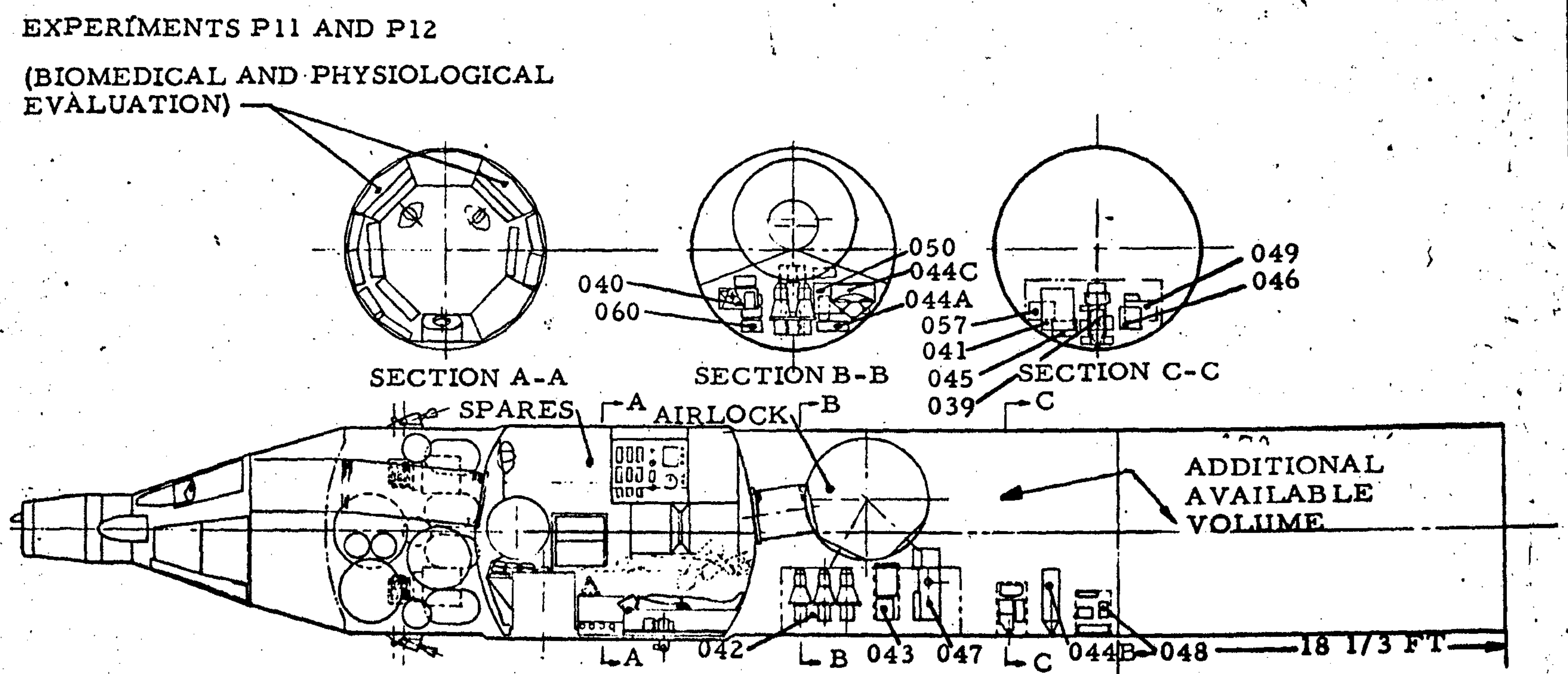
POSSIBLE SEPARATE VEHICLE APPLICATION - CONCEPT A



- MISSION DURATION — 30 DAY EXPENDABLES
- PRESSURIZED VOLUME (INCLUDING AIRLOCK) — 1125 CU. FT.
- EXPERIMENT PAYLOAD — NASA APP. "A" + P11 + P12
- ADDITIONAL AVAILABLE VOLUME (UNPRESSURIZED) — ~ 1700 CU. FT.

POSSIBLE SEPARATE VEHICLE PERFORMANCE

CONCEPT A

● ORBIT ALTITUDE	125 N. MI. CIRCULAR
● ORBIT INCLINATION	80°
● T-III M (PAYLOAD SELF INJECT)	32,500 LBS
● ORBITING VEHICLE	
/ MISSION DURATION	30 DAYS
/ O.V. DRY WEIGHT	19,100 LBS
/ NASA APPLICATIONS "A" PKG	3,500 LBS
/ BIO-TEST PKG (P11, P12)	600 LBS
/ 30 DAY EXPENDABLES	2,200 LBS
/ AVAILABLE DISCRETIONARY PAYLOAD	7,100 LBS

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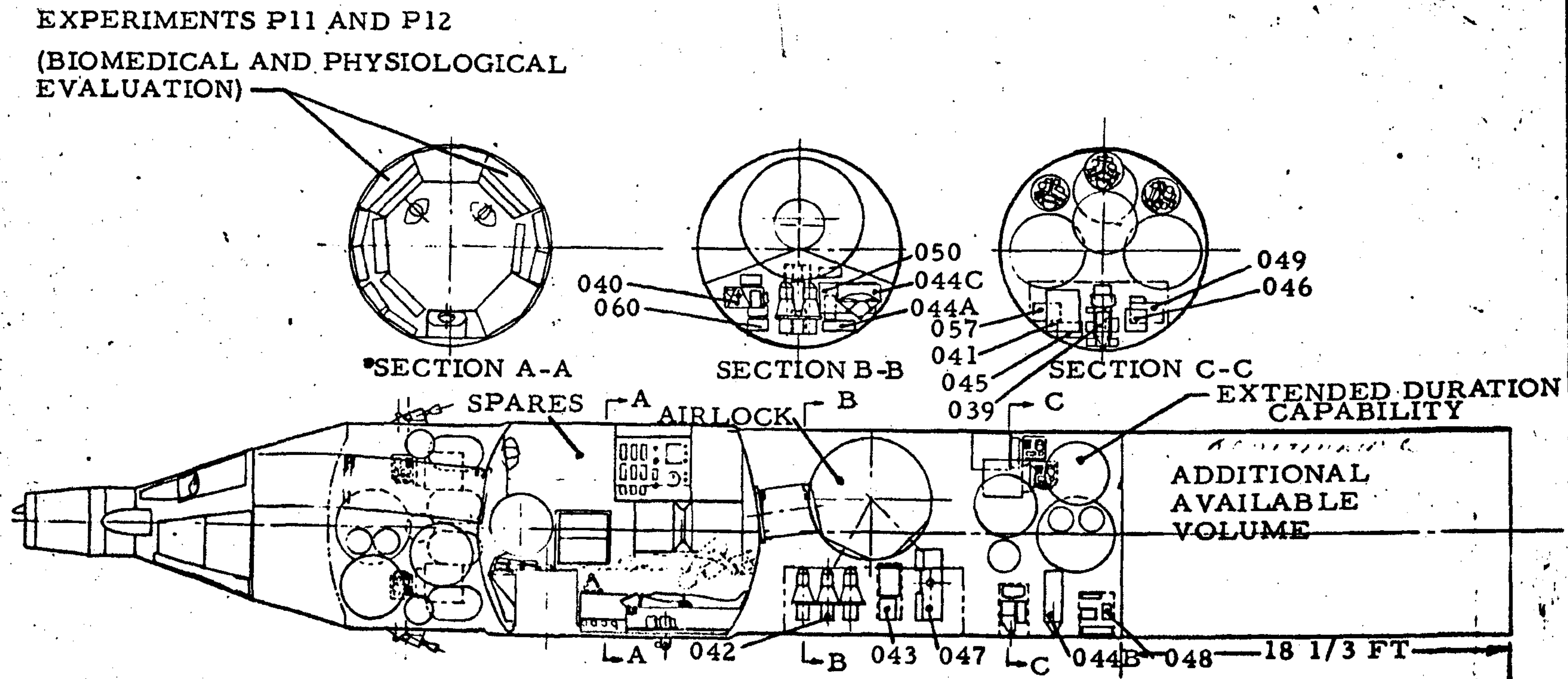
POSSIBLE SEPARATE VEHICLE APPLICATION - CONCEPT B



- MISSION DURATION — 60 DAY ~~EXPENDABLES~~
- PRESSURIZED VOLUME (INCLUDING AIRLOCK) — 1125 CU. FT.
- EXPERIMENT PAYLOAD — NASA APP. "A" + P11 + P12
- ADDITIONAL AVAILABLE VOLUME (UNPRESSURIZED) — ~ 1400 CU. FT.

POSSIBLE SEPARATE VEHICLE PERFORMANCE

CONCEPT B

● ORBIT ALTITUDE	125 N. MI. CIRCULAR
● ORBIT INCLINATION	80°
● T-III M (PAYLOAD SELF INJECT)	32,500 LBS
● ORBITING VEHICLE	
✓ MISSION DURATION	60 DAYS
✓ O. V. DRY WEIGHT	21,000 LBS
✓ NASA APPLICATIONS "A" PKG	3,500 LBS
✓ BIO-TEST PKG (P11, P12)	600 LBS
✓ 60 DAY EXPENDABLES	4,400 LBS
✓ AVAILABLE DISCRETIONARY PAYLOAD	3,000 LBS

POSSIBLE SEPARATE VEHICLE

COST ESTIMATE SUMMARY

(M$)

FY	68	69	70	71	TOTAL
● VEHICLE					
DEVELOPMENT	66.5	79.0	30.5	1.0	177.0
FLIGHT SYSTEM	.2	29.5	39.0	16.3	85.0
	66.7	108.5	69.5	17.3	262.0 **
● B/L PROGRAM SCHEDULE IMPACT	58.0*				
TOTAL REQMTS '68	124.7				

* B/L PROGRAM FUNDS FROM FISCAL YEARS 69 - 71 REQUIRED IN FISCAL YEAR '68 DUE TO INCLUSION OF ADDITIONAL NASA LAUNCH VEHICLE IN FISCAL YEAR '71.

** DOES NOT INCLUDE ANY NASA - PECULIAR HARDWARE, SUPPORT EQUIPMENT, SOFTWARE, OR PROGRAM MANAGEMENT COSTS.

SS... OFFICE PROGRAM

...MBER 632a

...information affecting the national ... within the meaning of the ... Laws, ... U.S.C., Section 793 and 794. Its ... or the revelation of its contents in any ... to an unauthorized person is prohibited by law.

POSSIBLE SEPARATE VEHICLE DEVELOPMENT COST ESTIMATE

FY	68	69	70	71	TOTALS	
LAB. VEHICLE						
ENG., DEV. & TEST						
- SYSTEMS ENG. & INTEGRATION	7.0	6.0	1.5	.5	15.0	
- SUB-SYSTEMS ENGR. (EPS, CRYO, MM)	14.0	10.0	1.0		25.0	
- SUB-SYSTEM TEST		10.0	5.0		15.0	
- AGE INTEGRATION		3.0	2.0		5.0	
- MISSION SIMULATOR ADAPTER	4.0	5.0	1.0		10.0	
- QUALIFICATION TESTING	6.0	8.0	1.0		15.0	
- AIR LOCK DEVELOPMENT	3.0	2.0			5.0	90.0
HARDWARE						
- SUB-SYSTEM DEV. HARDWARE	1.0	2.0	1.0		4.0	
- SIMULATORS	1.0	4.0	2.5		7.5	
- SUBSTITUTES	1.5	1.0			2.5	
- OTHER (SPEC. TOOLING, TEST EQUIP.)	2.5	5.0	2.5		10.0	
- QUAL TEST VEHICLE AND MM STATIC	10.0	10.0	5.0		25.0	49.0
OTHER						
- TEST OPERATIONS	2.0	3.0	2.0		7.0	
- PROGRAM MANAGEMENT (CONTRACTOR)	3.5	3.0	2.0	.5	9.0	
- GSE/TD	2.0	2.0	1.0		5.0	21.0
GEMINI B						
- DEV. 60 DAY ON-ORBIT STORAGE	4.0	5.0	3.0		12.0	12.0
ADDN'L PROD. FACILITIES - FINAL ASSY AREA & TOOLING	5.0				5.0	5.0
	66.5	79.0	30.5	1.0		177.0

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NUMBER 632a

POSSIBLE SEPARATE VEHICLE

FLIGHT SYSTEM COST ESTIMATE

FY	68	69	70	71	TOTALS
GEMINI		5.2	11.0	3.0	19.2
LAB. VEHICLE		18.0	15.7	4.0	37.7
T-III M		6.0	12.0	3.0	21.0
RECOVERY, TRACKING, ETC.				6.0	6.0
GSE/TD	.2	.3	.3	.3	1.1
NASA PECULIAR					
- HARDWARE			NOT INCLUDED		----
- LAUNCH OPS.			NOT INCLUDED		----
ESTIMATED TOTAL COST					85.0

POSSIBLE SEPARATE VEHICLE

MOL FUNDING SHIFT DUE TO RESCHEDULING

PROGRAM SCHEDULE IMPACT	FY 1968
- GEMINI	8.0
- LAB VEHICLE	39.0
- T-III M	11.0
	58.0

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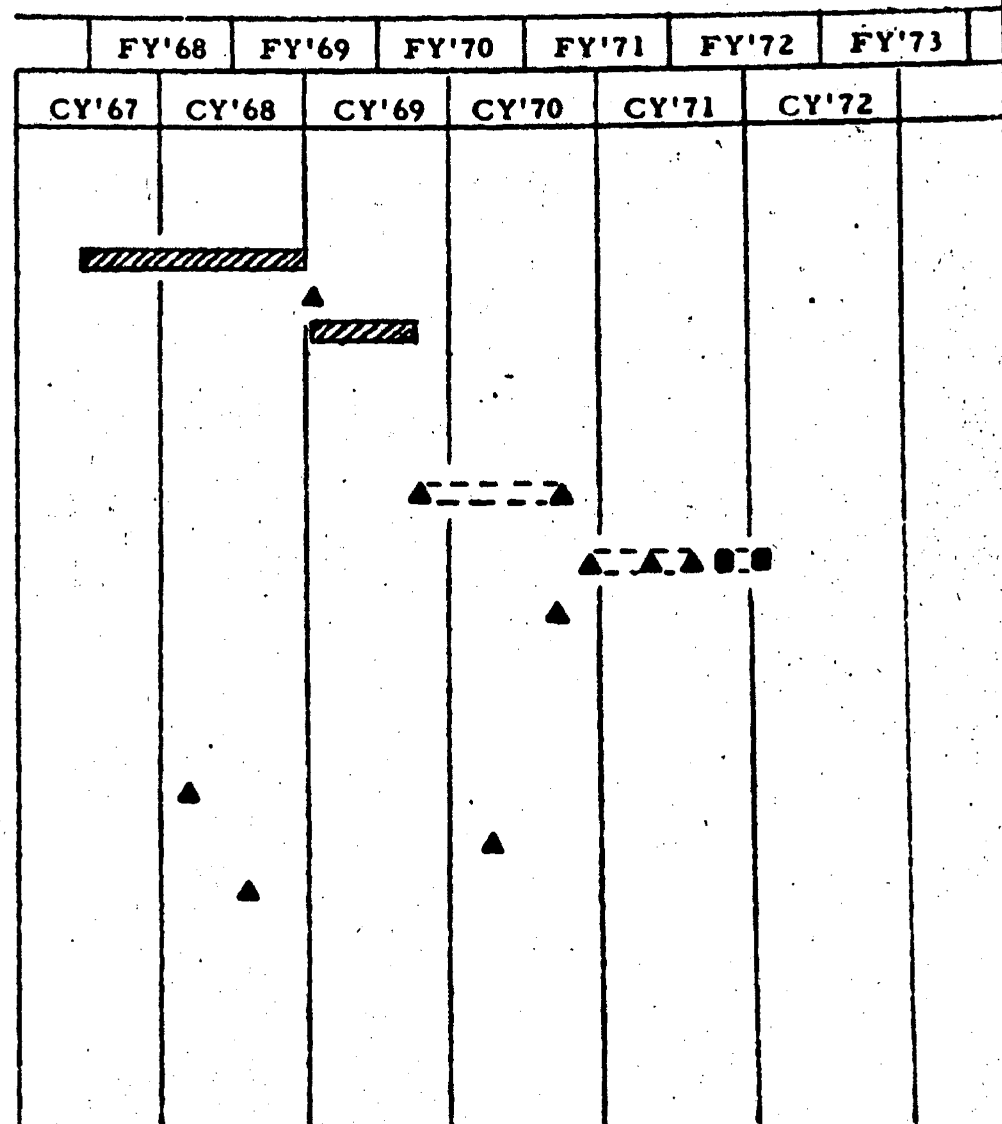
SCHEDULE ESTIMATES



"APPLICATIONS A" EXPERIMENTS

(14 EXPERIMENTS)

FLT. HDWE. DEVELOPMENT

DELIVERY OF FLT. HDWE.

EXPERIMENT INTEGRATION

POSSIBLE LAUNCH DATES

SATURN/APOLLO (SIVB REVISIT)

MOL BASELINE PROGRAM

SEPARATE FLIGHT VEHICLE

METEOROLOGICAL SATELLITES

NIMBUS-B

NIMBUS-D

ATS-D

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NUMBER 632a

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WHS-311
Page 164

GROUND RULES FOR COSTS/SCHEDULES
POSSIBLE SEPARATE VEHICLE

- NASA FLIGHT (FV-8) IN SEPT. 1970
- NASA VEHICLE (FV-8) AND AIR FORCE VEHICLE (FV-3) ARE BOTH MANNED
  - ∴ SAME PREFLIGHT TEST OBJECTIVES
  - ✓ COMPLETE DYNAMICS TEST FOR FV-8 LAB VEHICLE
  - ✓ ACOUSTIC AND STATIC TEST FOR FV-8 MISSION MODULE
  - ✓ SEPARATE NASA MISSION MODULE QUALIFICATION ARTICLE
  - ✓ ELECTROMAGNETIC COMPATIBILITY TEST MUST BE IN FV-8 FLOW
  - ✓ AT LEAST TWO COMPLETE SETS OF NASA EXPTS REQUIRED (COMPATIBILITY TESTS & FLT. ITEMS + BACKUPS)
- QUALIFICATION OF NASA VEHICLE FOR 30 DAY MISSION DURATION ONLY
- SCHEDULING INTERFERENCES REQUIRE
  - ✓ PROVISION OF SEPARATE NASA ASSEMBLY AREA @ DAC, HUNTINGTON BEACH
  - ✓ SEPARATE NASA MISSION SIMULATOR ADAPTER
  - ✓ TWO STATIC TEST FACILITIES REQUIRED
  - ✓ NO THERMO VACUUM FACILITY DOWN TIME OVER SPAN OF 20 MONTHS
  - ✓ ECLS ACCELERATION (5 MONTHS IN ADVANCE OF 12 MONTH SCHEDULE)
- COSTS INCLUDE AEROSPACE GSE AND TD
- NASA EXPERIMENTS WILL BE AVAILABLE JANUARY 1969, FOR INTERFACE COMPATIBILITY TESTS
- ONE LAUNCH - NO FOLLOW-ON SCHED. OR DOLLARS

PROGRAM MANAGEMENT INTERFACE CONSIDERATIONS: NASA/DOD

- SPECIFIC RESPONSIBILITIES/DEGREE OF PARTICIPATION HAS NOT BEEN DEFINED
- ASSUME NASA TO SUPPLY (FOR PURPOSES OF STUDY)
  - EXPERIMENTS QUALIFIED TO MOL SPECIFICATIONS
    - ✓ APPLICATIONS "A" EXPERIMENTS
    - ✓ PHYSIOLOGICAL AND PSYCHOLOGICAL TESTING EXPERIMENTS
  - MANAGEMENT OF EXPERIMENTS DEVELOPMENT, TEST AND ACCEPTANCE
    - ✓ INTERFACE REQUIREMENTS
    - ✓ CONFIGURATION CONTROL
    - ✓ INTEGRATION ACTIVITIES, SCHEDULES, MILESTONES
  - EXPERIMENT AGE & SUPPORT REQUIRED AT FACTORY AND LAUNCH SITE
  - EXPERIMENT DATA REDUCTION AND DOCUMENTATION

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WHS-311
166

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NUMBER 632a

MOL/NASA APPLICATIONS "A" POSSIBLE SEPARATE VEHICLE PRELIMINARY CONCLUSIONS

- SEPARATE MOL VEHICLE FOR COMBINED NASA APPLICATIONS "A" EXPERIMENTS AND PROLONGED BIOMEDICAL TESTING IS TECHNICALLY FEASIBLE.
- LAUNCH IN LAST QUARTER OF CY 1970 APPEARS POSSIBLE, BUT WOULD REQUIRE RESCHEDULING OF MOL DEVELOPMENT FLIGHTS #1 & #2, & SIGNIFICANT TEST FLOW MODIFICATIONS.
- UNRESOLVED PROBLEMS REQUIRING FURTHER CONSIDERATION -
  - ✓ LAUNCH DELAY OR FLIGHT FAILURE OF THE FLIGHT WOULD RESULT IN MOL PROGRAM SLIP;
  - ✓ SERIOUS DIVERSION OF EFFORT DURING EARLY, CRITICAL PHASE OF MOL PROGRAM;
  - ✓ LARGE-SCALE ENGINEERING AND MANAGEMENT RESOURCES REQUIRED TO MAINTAIN SEPARATE DESIGN, TEST, INTERFACE, TRAINING, AND PROGRAM DOCUMENTATION.
  - ✓ IMPLICATIONS OF "COST SHARING" APPROACH:
    - PROGRAM MANAGEMENT AUTHORITY AND RESPONSIBILITY
    - DOD/NASA INTERFACE STRUCTURE
    - IMPACT ON MOL DEVELOPMENT PROGRAM FUNDING
  - ✓ INTERFACE DEFINITIONS INVOLVED IN PROGRAMS WITH DIFFERENT OBJECTIVES.

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SUBSYSTEM LIFE EXTENSION

4/11/67

OUTLINE

SUBSYSTEM LIFE EXTENSION

- STUDY OBJECTIVES
- LIFE EXTENSION APPROACH
- STUDY ROADMAP
- SUMMARY OF EARLY STUDIES
- SUMMARY OF RECENT STUDIES
- LIFE EXTENSION CONCEPTS
- FAILURE EVENT AND EFFECTS SUMMARY
- LIFE EXTENSION APPROACH BY SUBSYSTEM
- LABORATORY RELIABILITY AS FUNCTION OF MISSION DURATION
- WEIGHT CONSIDERATIONS FOR SUBSYSTEM LIFE EXTENSION
- COST ESTIMATE FOR EXTENDED LIFE SUBSYSTEMS
  - / NON-RECURRING
  - / RECURRING
- MAINT/REPAIR/REPLACEMENT TIME VS MISSION DURATION
- IMPORTANCE OF MAN'S ROLE
  - / MAN VS REDUNDANCY
  - / UNIQUE ABILITIES FOR TROUBLE SHOOTING/CORRECTIVE ACTION
  - / SPECIFIC EXAMPLES FOR AIRCRAFT AND SPACE FLIGHTS
- CONCEPT OF MEAN MISSION DURATION
- SUMMARY

SUBSYSTEM LIFE EXTENSION STUDIES

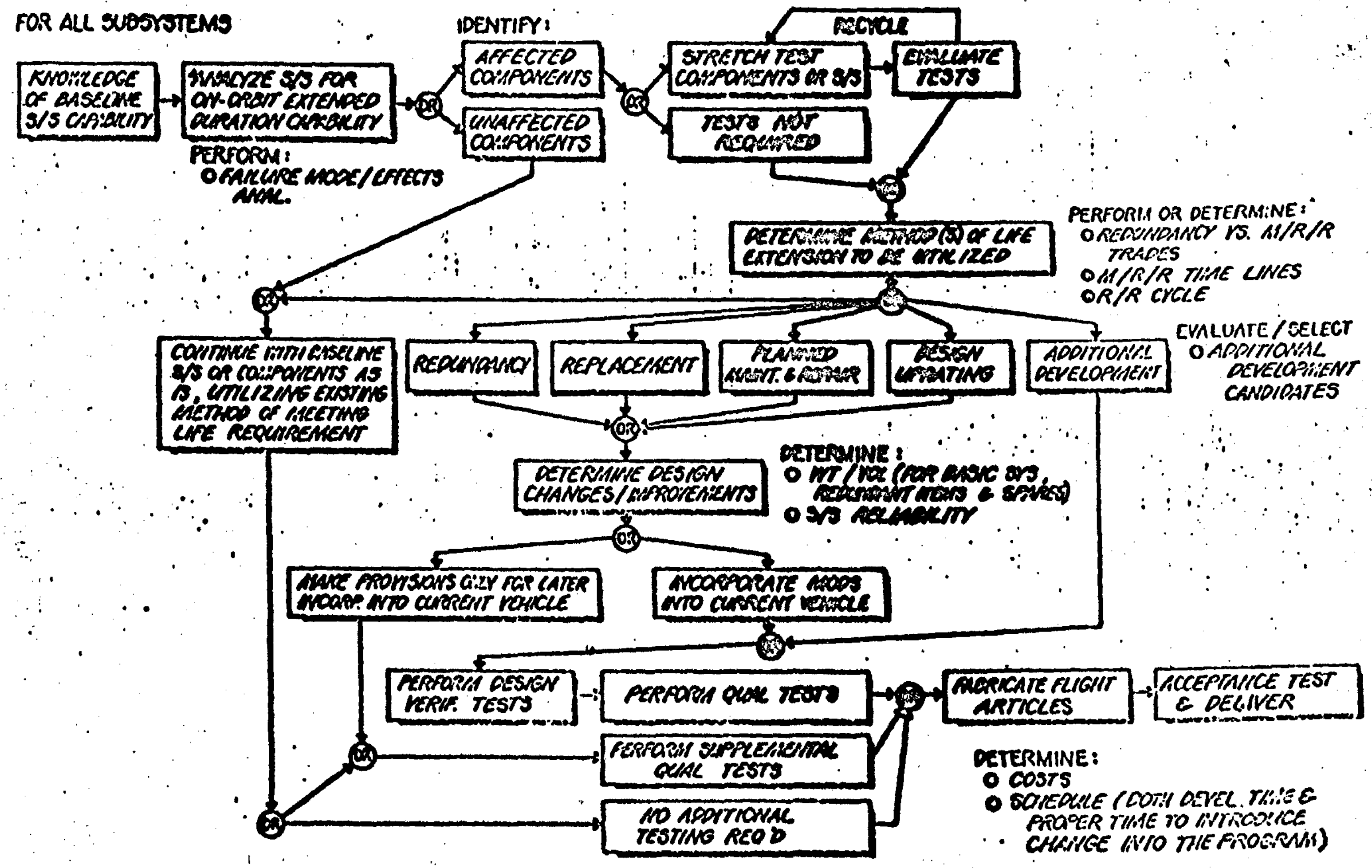
- **OBJECTIVES**
  - ✓ DEFINE MEANS TO EXTEND SUBSYSTEM OPERATING TIMES TO ACCOMMODATE MISSION DURATIONS OF 60 DAYS OR LONGER WITH NO APPRECIABLE DEGRADATION IN THE PROBABILITY OF MISSION SUCCESS.
  - ✓ IDENTIFY LIMITATIONS DUE TO FAILURE-RATE, WEAR OUT, & STORES DEPLETION.
  - ✓ DETERMINE OPTIMUM DESIGN MIX BETWEEN ON-ORBIT MAINTENANCE/REPAIR/ SPARES REPLACEMENT AND REDUNDANCY.
  - ✓ ESTIMATE COSTS TO ATTAIN EXTENDED OPERATING TIME FOR SUBSYSTEMS

- **APPROACH**

  SUBSYSTEM-BY-SUBSYSTEM ANALYSIS TO DETERMINE METHOD(S) UTILIZED SUCH AS:

  - ✓ "STRETCH" QUALIFICATION TESTING AND DESIGN MODIFICATION/UPRATING
    - EXPLOIT OVERDESIGNED CAPABILITY WHEREVER PRACTICAL
    - IMPROVE ACCESSIBILITY FOR MAINTENANCE
    - REDUCE WEAR-OUT RATE
  - ✓ ON-ORBIT MAINTENANCE/REPLACEMENT/REPAIR BY FLIGHT CREW
    - PREVENTIVE MAINTENANCE FOR WEAR-OUT LIMITED ITEMS
    - CORRECTIVE MAINTENANCE BY REPLACING FAILED ITEMS WITH SPARES
    - MALFUNCTION DIAGNOSIS AND REPAIR WHERE FEASIBLE
  - ✓ ADD REDUNDANCY
    - MALFUNCTION REQUIRES IMMEDIATE SWITCHING FOR SAFETY OR MISSION
    - MAINTENANCE NOT PRACTICAL BY REASON OF COMPLEXITY OR TIME
  - ✓ ADDITIONAL DEVELOPMENT
    - WHERE OBJECTIVES CANNOT BE ATTAINED BY OTHER METHODS

SUBSYSTEM LIFE EXTENSION STUDIES



LABORATORY DESIGN OPTIMIZATION

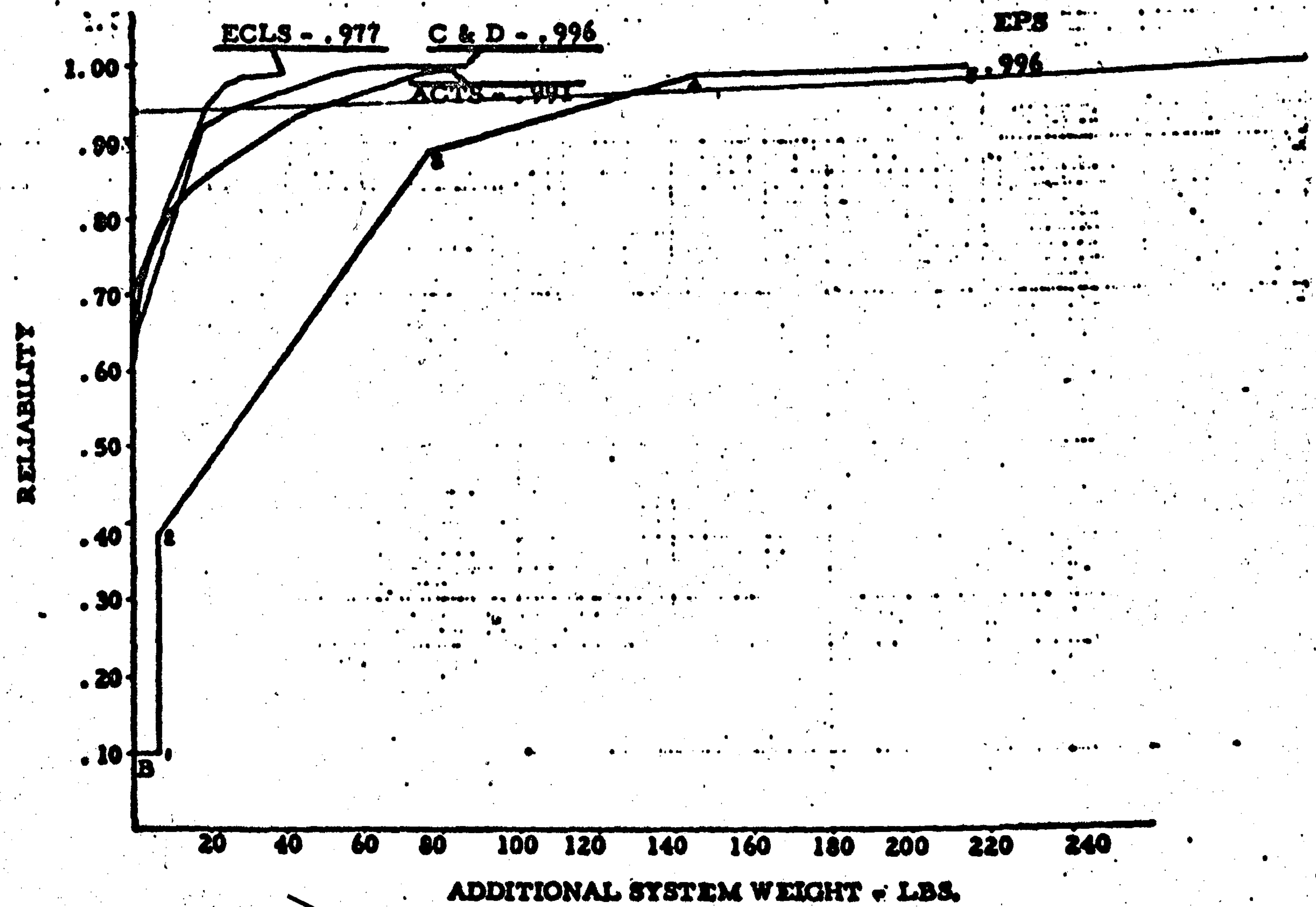
(30 DAY DESIGN)

Subsystem	Basic Design (Non-Redundant, Unspared) Reliability	+ Optimum Redundancies & Spares (Pounds)	(Pounds)	= Optimum Baseline Design Reliability
EPS	.771	347	0	.992
Fuel Cells	(.942)	(248)	(0)	(.996)
Dist. & Control	(.817)	(99)	(0)	(.996)
ECLS	.696	28	8	.988
CRYOGENICS	.996	2	0	.997
ACTS	.606	5	67	.984
Electronics	(.618)	(0)	(67)	(.994)
Prop. & Tank.	(.980)	(5)	(0)	(.990)
C & D	.632	45	11	.998
NAVIGATION	.787	35	10	.996
MDS & IFTS	.950	18	0	.999
STRUCT. & FURNISH.	.999	0	0	.999
CONT. & INTERFACE	.996	116	24	.996
	.153	596	120	.948

27 May

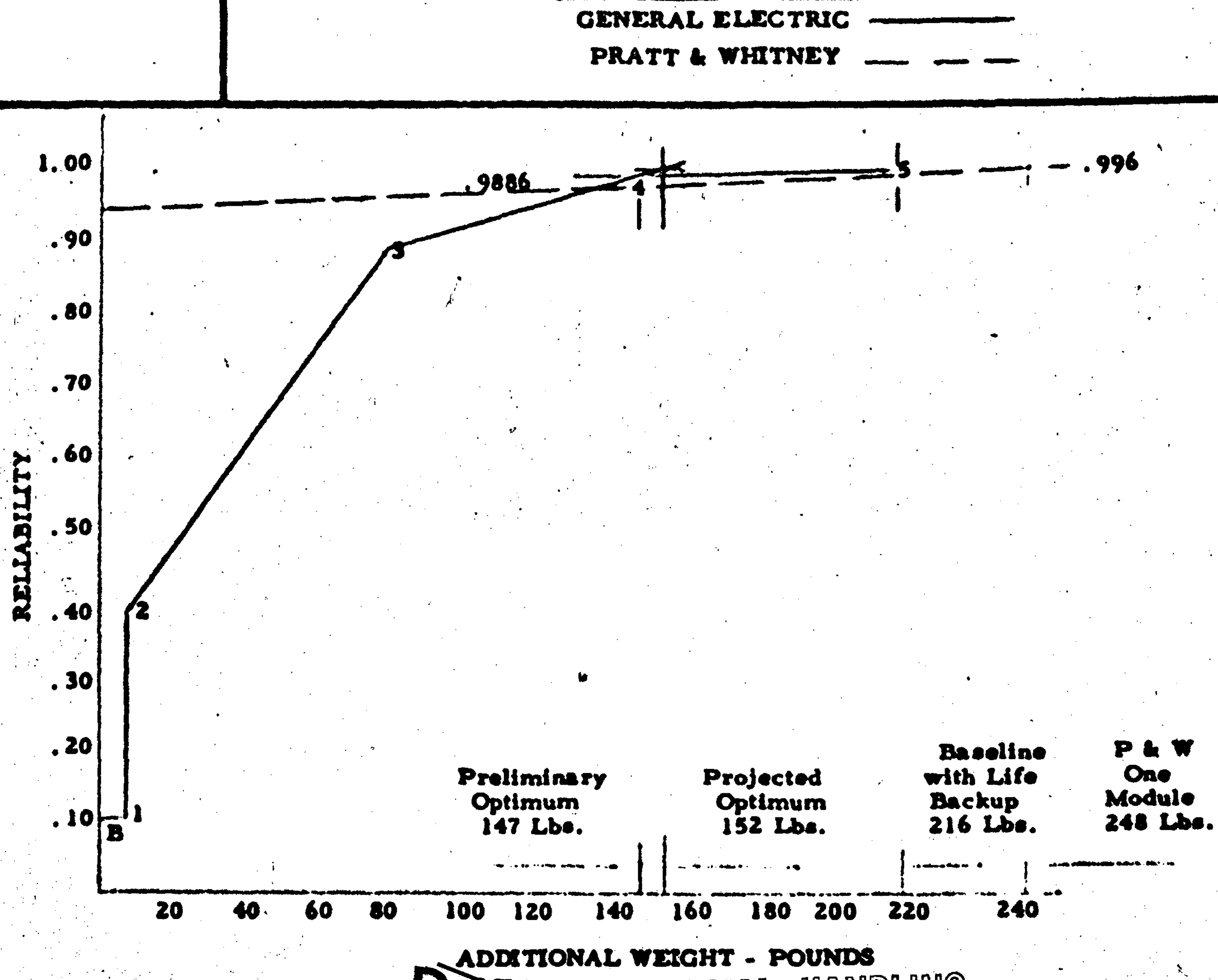
LABORATORY VEHICLE

SUBSYSTEM RELIABILITY OPTIMIZATION

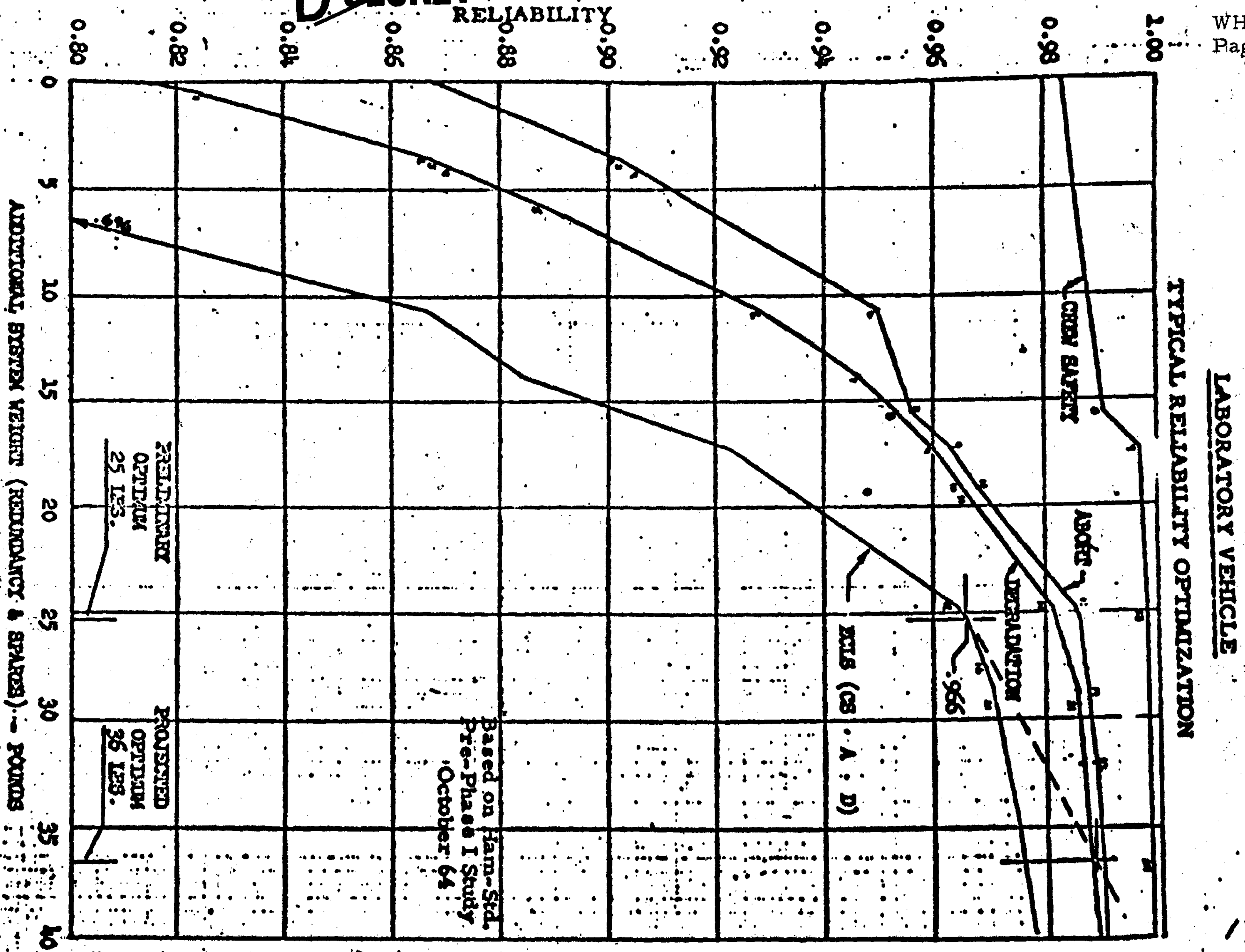


18

FUEL CELL RELIABILITY



10


LABORATORY VEHICLE
TYPICAL RELIABILITY OPTIMIZATION
RELIABILITY
0.80 0.82 0.84 0.86 0.88 0.90 0.92 0.94 0.96 0.98 1.00
0 5 10 15 20 25 30 35 40
ADDITIONAL SYSTEM WEIGHT (REDUNDANCY & SPARES) - POUNDS
CREW SAFETY
ABORT
DEGRADATION
MOLS (CS · A · D)
.966
PRELIMINARY OPTIMUM 25 LBS.
PROJECTED OPTIMUM 36 LBS.
Based on Ham-Std. Pre-Phase I Study October 64
.977
.989
.990
.996

17

EC/LSS RELIABILITY - HAMILTON-STANDARD

MOD #	DESCRIPTION	CUM W	CUM R
0	BASIC SYSTEM	-	.696
1	GEMINI/TUNNEL 0.5 PSI PRESS. SWITCH (1st S)	.62	.713
2	CABIN FAN ASSEMBLY (1st S)	3.62	.769
3	WATER CHECK VALVE (R)	3.69	.771
4	0_2 RELIEF VALVE (R)	4.00	.776
5	0_2 SHUT-OFF VALVE (R) & REPRESS. VALVE (S)	5.73	.791
6	COOLANT PUMP (R)	10.73	.867
7	INSTALL VOTING CIRCUITS ON REPRESS. SWITCHES	13.71	.884
8	FWD. CABIN DUMP AND RELIFE VALVE (R)	15.51	.904
9	AFT CABIN DUMP AND RELIFE VALVE (R)	17.31	.923
10	0_2 INFLOW VALVE (R)	18.90	.933
11	SHUT-OFF VALVE FOR WATER HOSE ASSY. (R)	19.15	.934
12	SUIT FAN (R)	24.85	.964
13	GEMINI/TUNNEL 5 PSI REPRESS. SWITCH (1st S)	25.32	.966
14	AFT CABIN ATMOS. RETURN CHECK VALVE (R)	26.02	.967
15	FWD. CABIN ATMOS. RETURN CHECK VALVE (R)	26.72	.968
16	PRESSURE RELIFE VALVE - AFT CABIN (R)	27.52	.969
17	PRESSURE RELIEF VALVE - FWD CABIN (R)	28.23	.970
18	CAP GLYCOL QUICK DISCONNECT - FEMALE (R)	28.42	.971
19	CAP GLYCOL QUICK DISCONNECT - MALE (R)	28.52	.971
20	CAPS AND REPAIR KIT - WATER DISPENSER (S)	28.77	.971
21	SECOND SPARE FOR MOD. 1	29.39	.971
22	COOLANT ACCUM. & SHUT-OFF VALVE (R)	32.18	.973
23	WATER ACCUM. & SHUT-OFF VALVE (R)	34.97	.975
24	SUIT RELIEF VALVE (R)	36.72	.976
25	SECOND SPARE FOR MOD 2	39.72	.977

DTR

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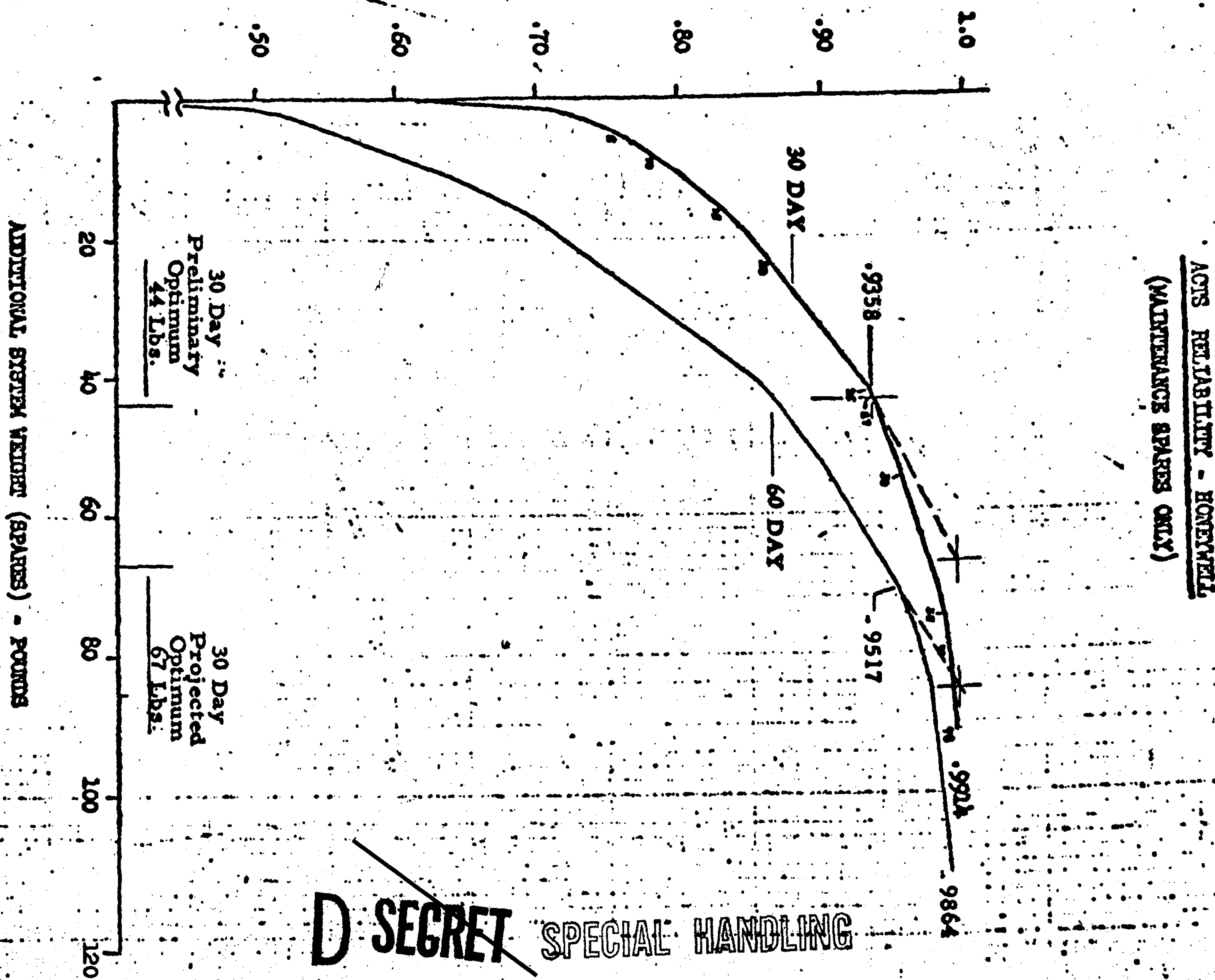
EC/LSS RELIABILITY - HAMILTON-STANDARD

MOD #	DESCRIPTION	$\frac{\Delta R_D}{\Delta W}$*
1	REPLACE GEMINI/TUNNEL 0.5 PSI PRESS. SWITCH (1st SPARE) (351)**	.03004
2	REPLACE CABIN FAN ASSEMBLY (1st SPARE) (102)	.01093
3	SERIES REDUNDANT WATER CHECK VALVE (401)	.01054
4	REDUNDANT O_2 RELIEF VALVE (303)	.01000
5	REDUNDANT O_2 SHUT-OFF VALVE (304) AND SPARE REPRESS. VALVE (309)	.00963
6	REDUNDANT COOLANT PUMP (290)	.00815
7	INSTALL VOTING CIRCUITS ON REPRESSURIZATION SWITCHES (308)	.00607
8	REDUNDANT FWD. CABIN DUMP AND RELIEF VALVE (307)	.00386
9	REDUNDANT AFT CABIN DUMP AND RELIEF VALVE (307)	.00383
10	REDUNDANT O_2 INFLOW VALVE (306)	.00309
11	BACKUP SHUT-OFF VALVE FOR WATER HOSE ASSY. (491)	.00302
12	REDUNDANT SUIT FAN (118)	.00272
13	REPLACE GEMINI/TUNNEL 5 PSI PRESS. SWITCH (1st SPARE) (354)	.00125
14	REDUNDANT AFT CABIN ATMOS. RETURN CHECK VALVE (113)	.00108
15	REDUNDANT FWD. CABIN ATMOS. RETURN CHECK VALVE (113)	.00108
16	REDUNDANT PRESSURE RELIEF VALVE - AFT CABIN (157)	.00095
17	REDUNDANT PRESSURE RELIEF VALVE - FWD. CABIN (157)	.00095
18	CAP GLYCOL QUICK DISCONNECT - FEMALE (223)	.00072
19	CAP GLYCOL QUICK DISCONNECT - MALE (214)	.00070
20	PROVIDE CAPS AND REPAIR KIT - WATER DISPENSER (452)	.00057
21	SECOND SPARE FOR MOD. 1 (351)	.00034
22	REDUNDANT COOLANT ACCUM. (210) & SHUT-OFF VALVE	.00033
23	REDUNDANT WATER ACCUM. (451) & SHUT-OFF VALVE	.00033
24	REDUNDANT SUIT RELIEF VALVE (117)	.00025
25	SECOND SPARE FOR MOD 2 (102)	.00021

*R_D = Degradation Reliability

** Numbers in parentheses are Hamilton-Standard element identification numbers.


ACTS RELIABILITY - HONEYWELL
(MAINTENANCE SPARES ONLY)
.50
.60
.70
.80
.90
1.0
30 DAY
60 DAY
.9358
.9517
.9904
.9864
20
40
60
80
100
120
30 Day
Preliminary
Optimum
44 Lbs.
30 Day
Projected
Optimum
67 Lbs.
ADDITIONAL SYSTEM WEIGHT (SPARES) - POUNDS

D SECRET SPECIAL HANDLING

DTR

ACTS RELIABILITY - HONEYWELL

MAINTENANCE SPARES ONLY

MOD. #	DESCRIPTION	CUM W	CUM R
0	Basic System (264.73#)	0	.6177
1	BMAG Gyro	1.500	.7111
2	Rate Gyro	2.100	.7265
3	Attitude Control, Amp. Assy., AGA P-G & N Demod.	3.014	.7369
4	Attitude Control, Jet Driver Assembly	3.856	.7460
5	Attitude Control, Amp. Assy., Stick & Rate Demod.	4.886	.7563
6	Attitude Control, Jet Summing Assembly	5.610	.7632
7	BMAG Elect., Buffer Preamp.	6.214	.7683
8	BMAG Elect., TCA & TIA Assy.	6.764	.7726
9	BMAG Elect., Torquer Amp. Assy.	7.546	.7787
10	Attitude Control, Amp. Assy., Jet Switching	8.227	.7839
11	Attitude Control, Min. Impulse Feedback	8.825	.7882
12	Attitude Control, Power Supply DC	10.975	.8035
13	BMAG Gyro	12.475	.8115
14	AGCU Resolver Assy., Pitch & Yaw	14.771	.8254
15	Attitude Control, Mode & Jet Select Logic Assy., P & Y	15.577	.8301
16	Attitude Set	17.797	.8406
17	FDAI Amp. Assy., Servo, P,R,Y Att.	18.468	.8437
18	BMAG Elect., Mode Logic	19.652	.8491
19	Att. Control, Mode & Jet Select Logic Assy., Roll	20.484	.8527
20	AGCU Resolver Assy., Roll	22.948	.8621
21	BMAG Elect., Power Supply	25.191	.8708
22	Mode Select Relay Assy., SCS CP	26.101	.8743
23	Horizon Scanner	40.601	.9279
24	FDAI Amp. Assy., Meter, P, Y Error	41.214	.9302
25	BMAG Elect., TC Logic	42.320	.9329
26	AGCU, Stepping Motor Control Logic	43.000	.9344
27	FDAI Amp. Assy., Meter, Roll Velocity & Relays	43.681	.9358
28	AGCU, Amplifier & Level Detector	44.390	.9371
29	Flight Director Attitude Indicator	53.990	.9540
30	FDAI Amp. Assy., Servo, Roll Error	54.662	.9552
31	FDAI Amp. Assy., Meter, P, Y Velocity	55.287	.9563
32	Inverter	71.087	.9799
33	AGCU, 400 cps. Reg. Carrier Supply	72.908	.9819
34	Aux. ECA Aux. Par. Supply, AC-DC	73.844	.9828
35	AGCU, Sq. Wave Reference & Gating Sw. Assy.	74.657	.9835
36	FDAI Logic Switch Assy.	75.214	.9840

D SECRET SPECIAL HANDLING

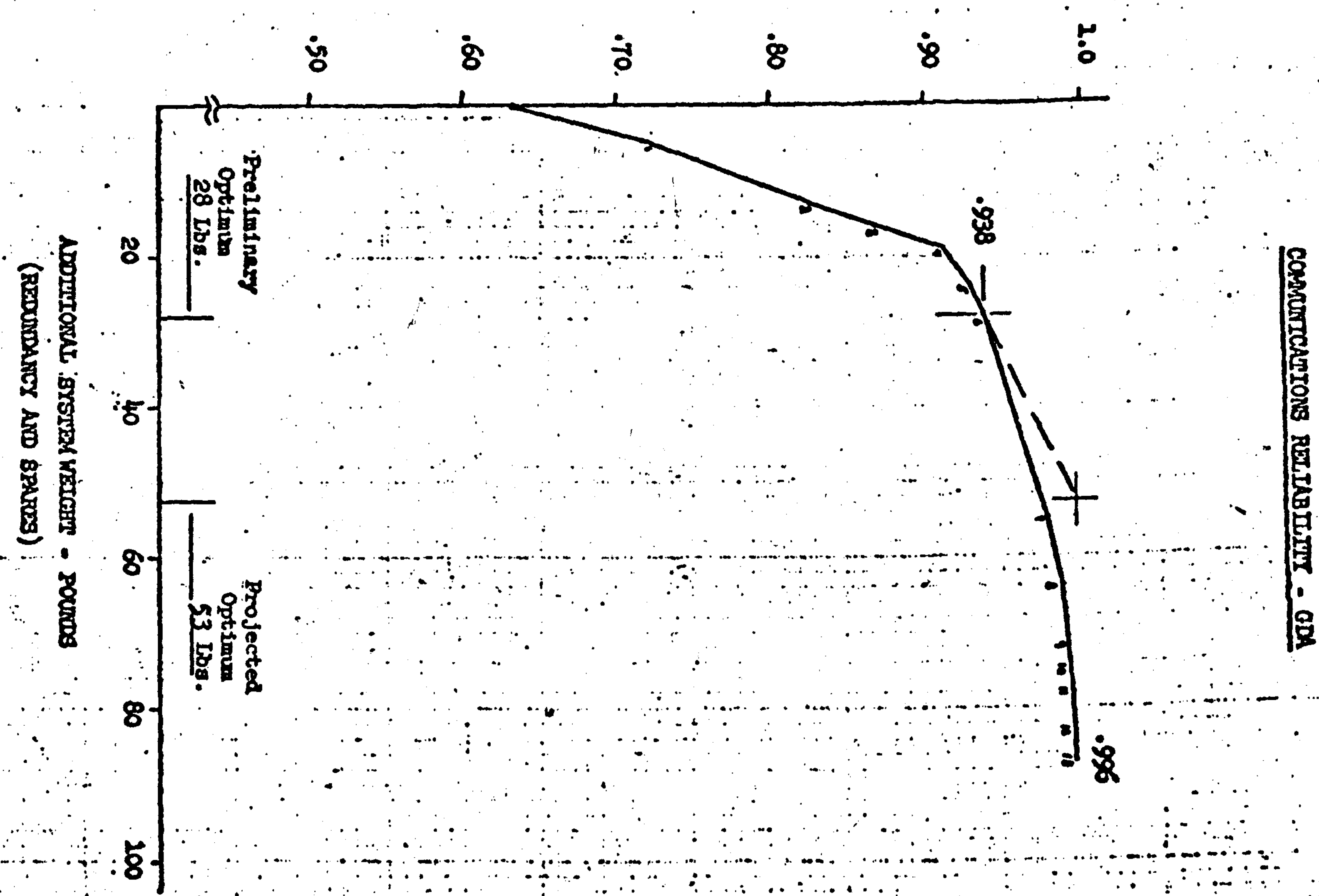
13
DTR

ACTS RELIABILITY - HONEYWELL (CONT.)

MAINTENANCE SPARES ONLY

MOD. #	DESCRIPTION	CUM W	CUM R
37	FDAI/GPI Power Supply	76.385	.9849
38	FDAI/ASGPD, Signal Transformers & Relays	78.186	.9864
39	AGCU, Demod. Assy.	78.998	.9869
40	Att. Control, Source Redundancy & EMI	78.418	.9871
41	Aux. ECA Transformer & Reg. Assy.	81.353	.9882
42	Rate Gyro Electronics	82.133	.9886
43	Rate Gyro	82.733	.9888

~~SECRET~~ D SPECIAL HANDLING


COMMUNICATIONS RELIABILITY - GDA
.50
.60
.70
.80
.90
1.0
.938
.996
Preliminary Optimum 28 Lbs.
Projected Optimum 53 Lbs.
20
40
60
80
100
ADDITIONAL SYSTEM WEIGHT - POUNDS
(REDUNDANCY AND SPARES)

COMMUNICATIONS RELIABILITY - GDA

MOD #	DESCRIPTION	CUM W	CUM R
0	BASIC SYSTEM (283#)	0	.632
1	AUDIO CONTROL CENTER (S)	5	.723
2	C-BAND BEACON (R)	13	.827
3	UHF VOICE XMTR-REC (S)	16	.868
4	PCM-FM TELEMETRY XMTR (S)	19	.912
5	VOICE RECORDER (S)	24	.930
6	AUDIO CONTROL CENTER (S)	28	.938
7	DIGITAL COMMAND SYSTEM (R)	55	.979
8	C-BAND BEACON (R)	64	.988
9	C-BAND POWER DIVIDER (R)	72	.991
10	UHF VOICE XMTR-REC (S)	75	.992
11	PCM-FM TELEMETRY XMTR (S)	78	.994
12	UHF BLADE/WHIP ANTENNA (R)	83	.995
13	UHF STUB ANTENNA (R)	87	.996

D SECRET SPECIAL HANDLING

COMMUNICATIONS RELIABILITY - GDA

MOD #	DESCRIPTION	CUM W	CUM R
0	BASIC SYSTEM (283#)	0	.632
1	AUDIO CONTROL CENTER (S)	5	.723
2	C-BAND BEACON (R)	13	.827
3	UHF VOICE XMTR-REC (S)	16	.868
4	PCM-FM TELEMETRY XMTR (S)	19	.912
5	VOICE RECORDER (S)	24	.930
6	AUDIO CONTROL CENTER (S)	28	.938
7	DIGITAL COMMAND SYSTEM (R)	55	.979
8	C-BAND BEACON (R)	64	.988
9	C-BAND POWER DIVIDER (R)	72	.991
10	UHF VOICE XMTR-REC (S)	75	.992
11	PCM-FM TELEMETRY XMTR (S)	78	.994
12	UHF BLADE/WHIP ANTENNA (R)	83	.995
13	UHF STUB ANTENNA (R)	87	.996

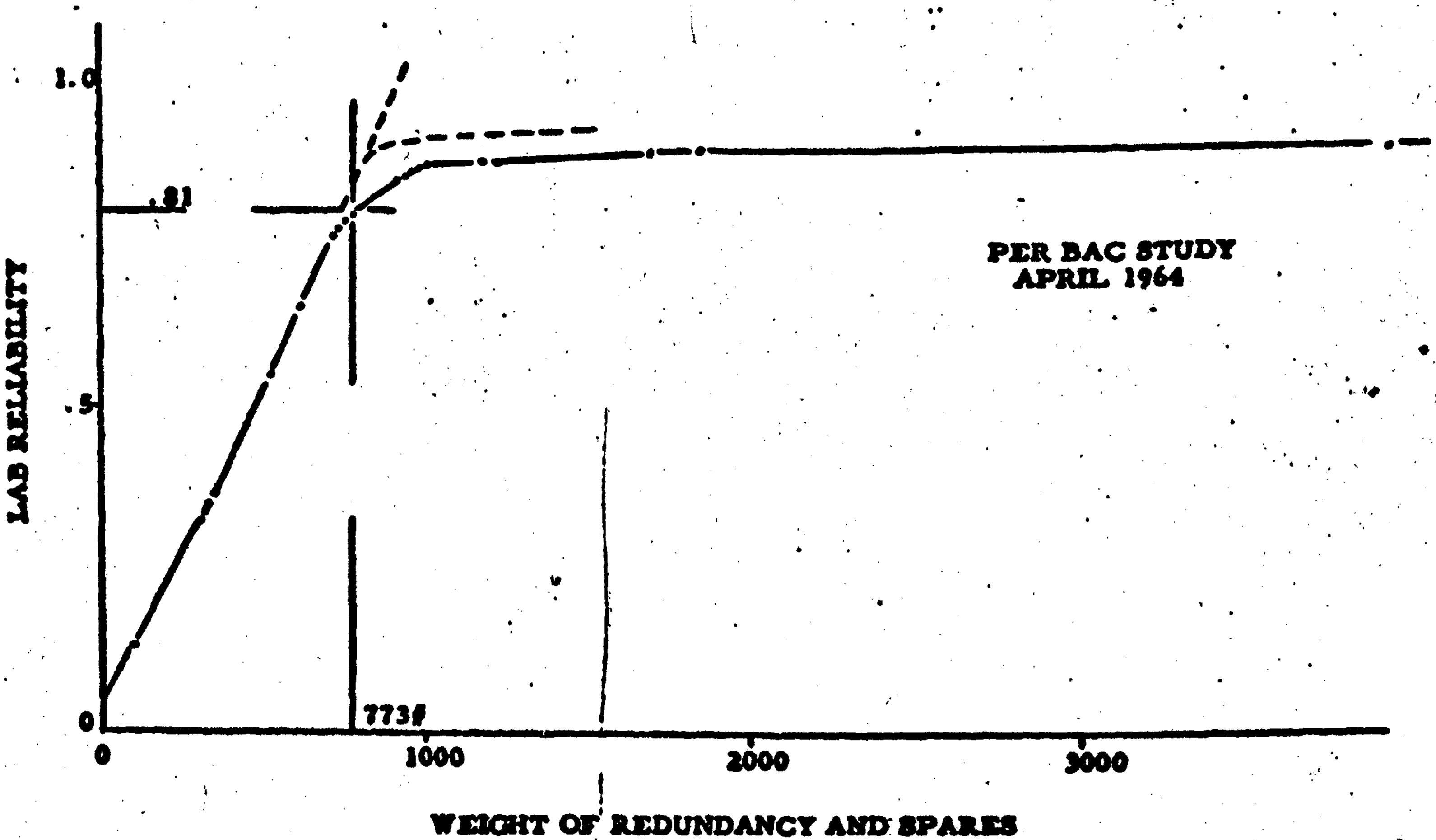
DTR

9 DTR

FUEL CELL RELIABILITY - GE
(REDUNDANCY ONLY)

MOD #	DESCRIPTION	CUM W	CUM R
0	BASIC SYSTEM	0	.1043
1	TWO DUAL REGULATORS/ SECTION	6.4	.104
2	CROSS-OVER ELIMINATED PARALLEL STACK COOLING INLET TEMP (103°) REDUCED TO 75°	6.4	.3856
3	ADD SIXTH SECTION	76.4	.8893
4	ADD SEVENTH SECTION	146.4	.9886
5	ADD EIGHTH SECTION	216	.9966

LABORATORY RELIABILITY OPTIMIZATION



TYPICAL LABORATORY RELIABILITY IMPROVEMENT ITEMS
(REDUNDANCY/MAINTENANCE)

REPLACEABLE U.V. LAMP (EC/LS)

REDUNDANT LiOH CANNISTER (EC/LS)

REDUNDANT WATER SEPARATOR AND TREATMENT UNIT (EC/LS)

MAINTAINABLE PUMP IN WATER MANAGEMENT UNIT (EC/LS)

REDUNDANT CHECK VALVES, SHUT OFF VALVES, RELIEF VALVES, INJECTOR SOLENOIDS (ATTITUDE CONTROL PROPULSION)

REPLACEABLE ACCU ELECTRO-MECHANICAL ASSY., RATE GYROS (ATTITUDE CONTROL ELECT.)

REDUNDANT REACTANT CONTROLS (POWER)

MAINTAINABLE TV, WIDE BAND RECORDER, DATA AND WIRE RECORDER (COMMUNICATIONS)

REDUNDANT FUEL CELLS (POWER)

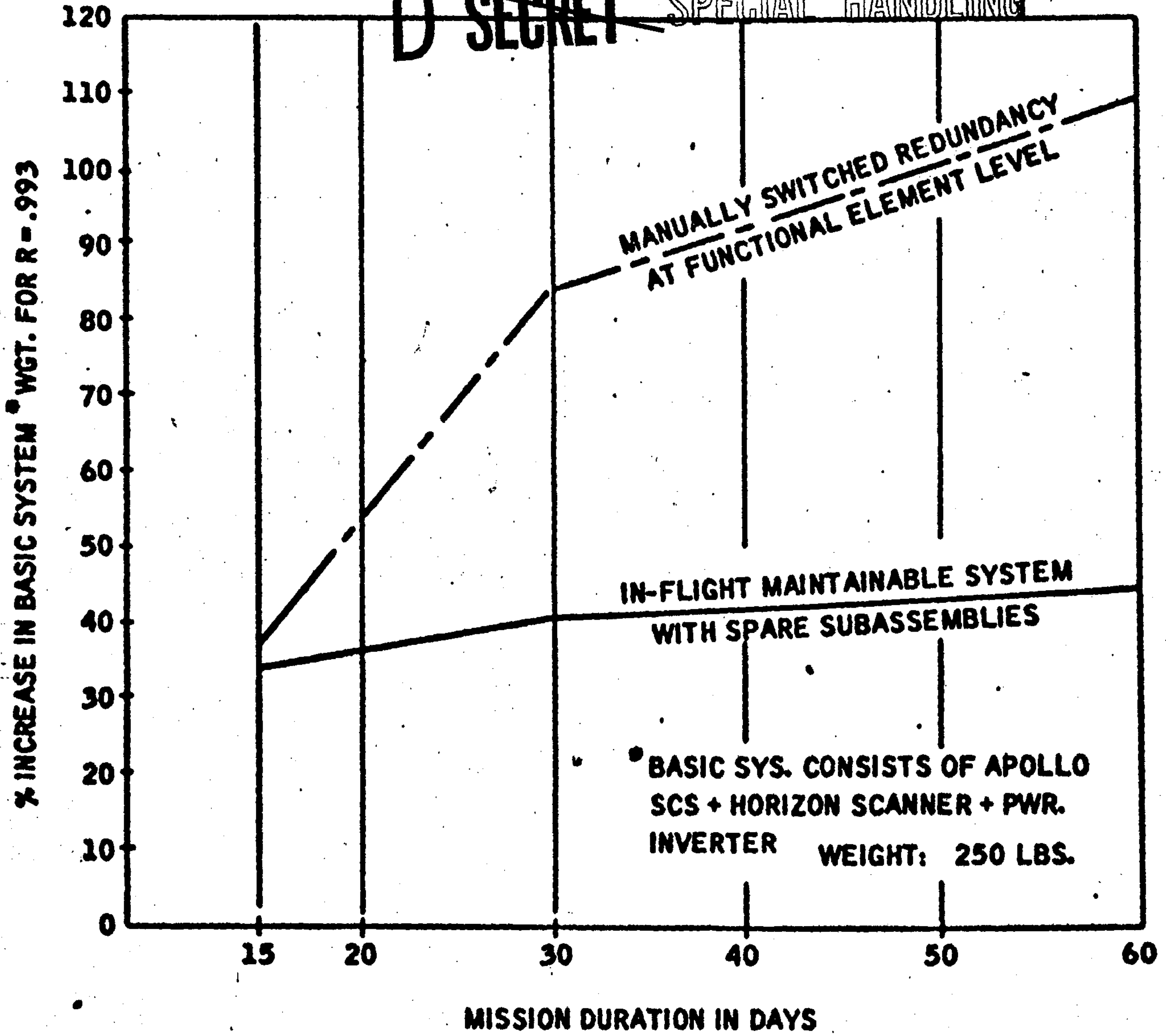
REDUNDANT TIME PROGRAMMER, TIME CODE GENERATOR, TRANSCEIVERS, S-BAND BEACON, HEADSETS, MICROPHONES (COMMUNICATIONS)

REDUNDANT SUPERCRITICAL TANK HEATERS, TRANSDUCERS, PLUS CONTROLS AND PLUMBING (EC/LS)

REDUNDANT HEAT TRANSFER LOOP (EC/LS)

PER BAC APRIL '64
M-H SEPT. '64

WEIGHT PENALTIES FOR TWO TYPES OF REDUNDANCY AS A FUNCTION OF MISSION DURATION



RECENT STUDIES - SUBSYSTEM LIFE EXTENSION

- **ALL ASSOCIATE CONTRACTORS**
  - ✓ DETERMINATION OF COMPONENT ON-ORBIT ACCESSIBILITY
- **DAC**
  - ✓ LIFE EXTENSION TRADES OF ALTERNATE SUBSYSTEM CONCEPTS
  - ✓ UPDATING OF COMPUTERIZED SYSTEM MODEL AND RELIABILITY EVALUATION
- **AEROSPACE**
  - ✓ ANALYSES OF ON-ORBIT SPARES PROVISIONING
  - ✓ EVALUATION OF ACCESSIBILITY OF SUBSYSTEM COMPONENTS
  - ✓ CAPITALIZATION OF MEAN MISSION DURATION CONCEPT BY PROPER DESIGNATION OF STORES DEPLETION TIME FOR CERTAIN SUBSYSTEMS
  - ✓ ROLE OF MAN, BACKUP MODES ANALYSES, FUNCTIONAL VERSUS BLOCK REDUNDANCY
  - ✓ DETERMINATION OF THE PROBABILITY OF SYSTEM BEING OUT-OF-COMMISSION. SUBSYSTEMS AFFECTED BY WEAROUT AND STORES DEPLETION REPLACED BY RENDEZVOUS AND RESUPPLY.

Rev 4/67
3/10/67
ALP

FAILURE DISTRIBUTION FUNCTIONS FOR VEHICLE SUBSYSTEMS

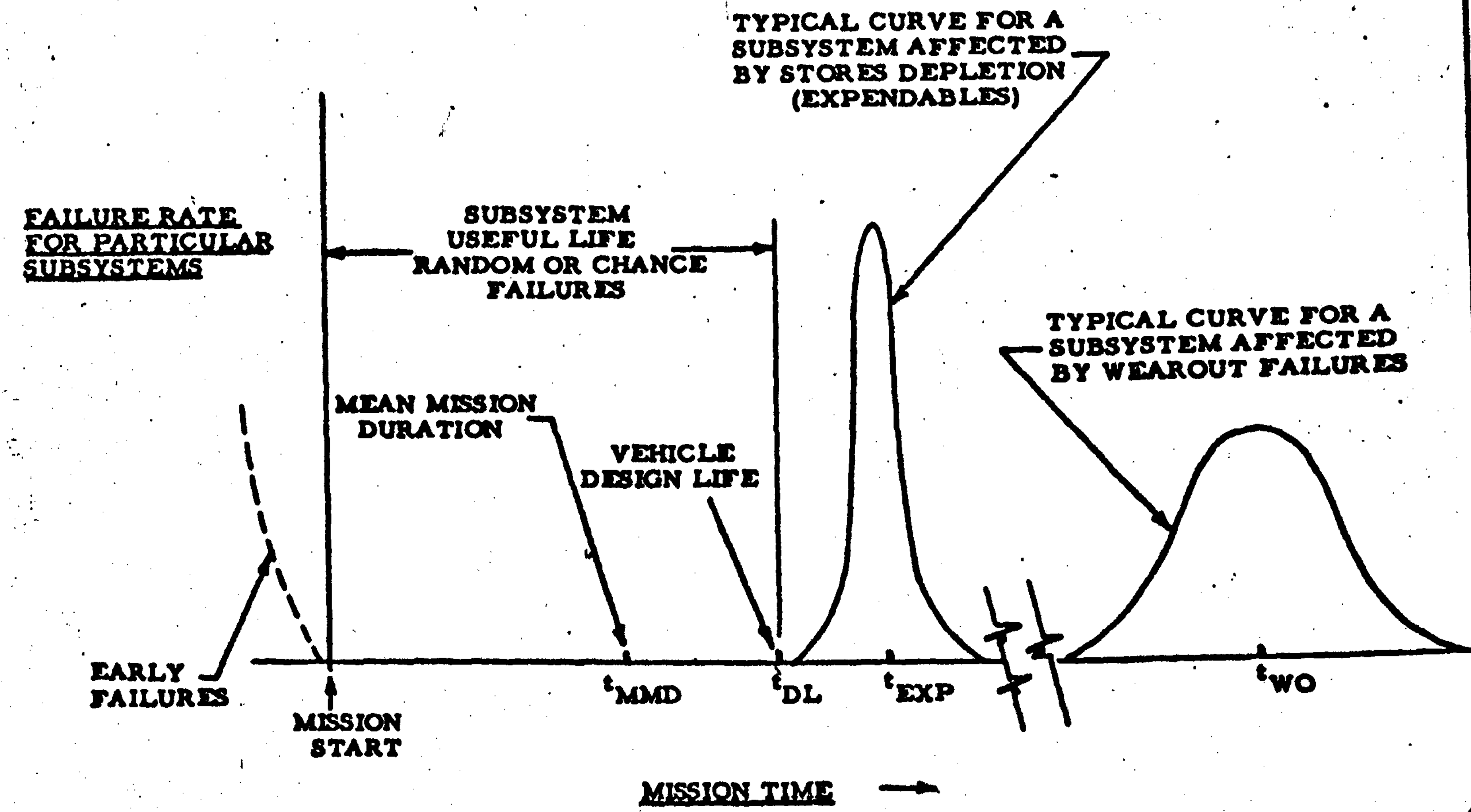


Fig. 1

SUBSYSTEM RELIABILITY AND PROBABILITY OF BEING OUT-OF-COMMISSION

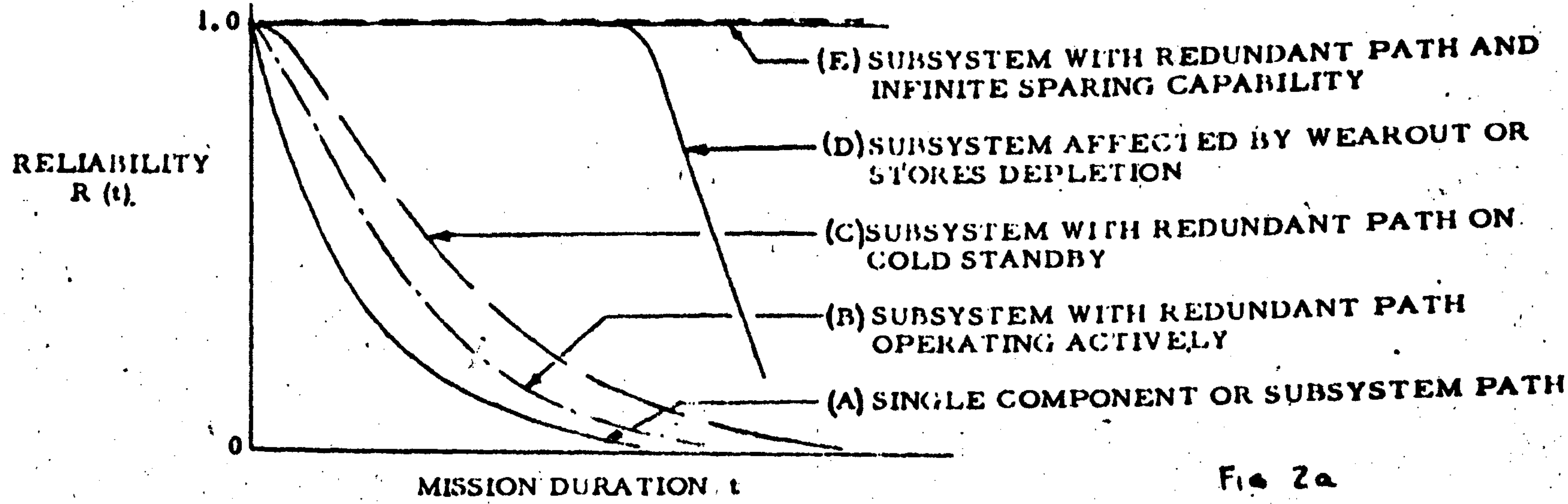


Fig 2a

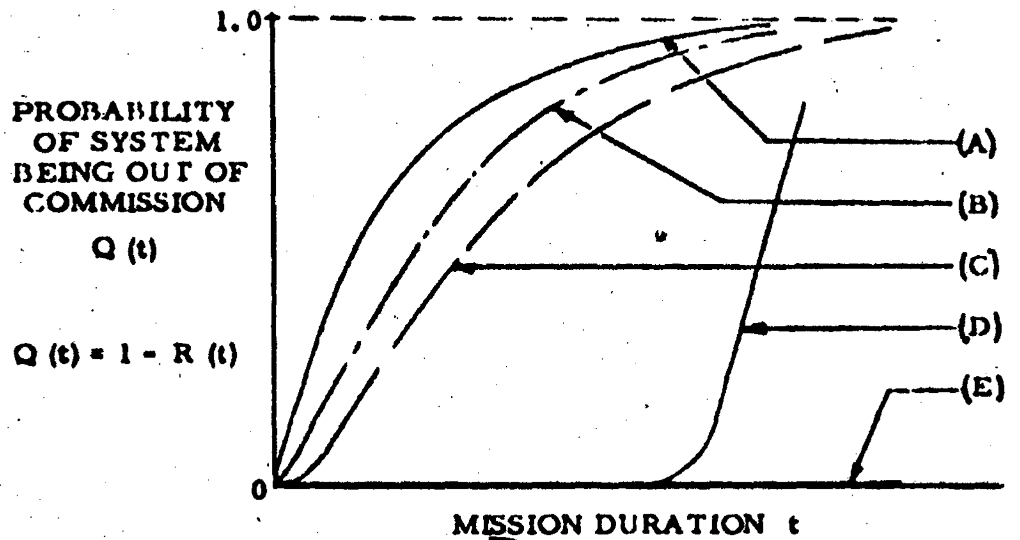
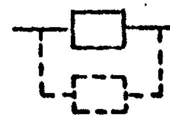
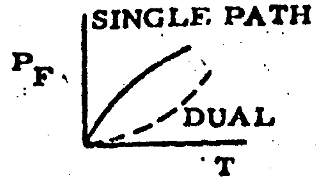
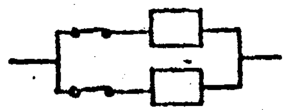
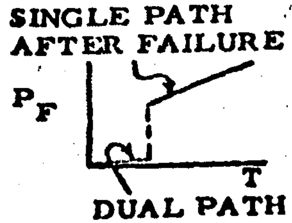
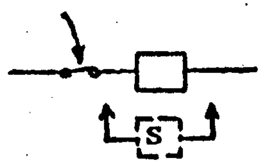
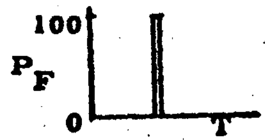
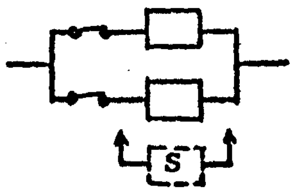
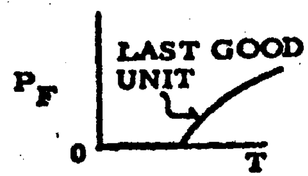
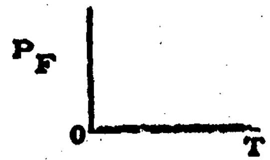


Fig 2b

SUBASSEMBLY CONTRIBUTIONS TO SYSTEM PROBABILITY OF FAILURE

LIFE EXTENSION OR M/R/R* CONCEPT OF COMPONENT ASSEMBLY	TYPICAL SUBSYSTEM	SCHEMATIC	PROBABILITY FUNCTION
1. NO SPARING OR REPAIR POSSIBLE MAY HAVE REDUNDANCY TO ACHIEVE PARTIAL PERFORMANCE (UNIMPROVABLES)	COOLANT LOOP, PROPULSION		
2. REDUNDANT PATHS PLUS SWITCHING	COMM		
3. SPARING/REPAIR ONLY (SUB-SYSTEM DOWN DURING SPARING/REPAIRING)	ECS-FAN		
4. REDUNDANCY PLUS SPARING/REPAIRING (FINITE SOURCE OF REPLACEMENT UNITS)	ACTS-SCE		
5. SAME AS 4. WITH INFINITE SOURCE OF REPLACEMENT UNITS	—	SAME	

* M/R/R = MAINTENANCE/REPLACEMENT/REPAIR

FIG. 3

ACHIEVEMENT OF 60 DAY MISSION DURATION FROM BASELINE DESIGN

- COMPONENTS AFFECTED BY WEAROUT
  - ✓ AT LEAST ONE COMPONENT (FUEL CELL) HAS BEEN IDENTIFIED FOR WHICH WEAROUT LIFE MAY BE < 60 DAYS.
  - ✓ 3 B. L. CELLS WILL BE SUPPLEMENTED WITH 3 ADDITIONAL CELLS ON COLD STANDBY.
- SUBSYSTEMS WITH STORES DEPLETION
  - ✓ PROPELLANTS - IMPULSE REQUIREMENT MET WITH B. L. STORED CAPACITY.
  - ✓ REACTANTS, OXYGEN, He - 60 DAY REQUIREMENTS MET BY ADDITIONAL TANKAGE.
- COMPONENTS AFFECTED BY RANDOM OR CHANCE FAILURES
  - ✓ GROWTH CAPABILITY INHERENT IN B. L. (REDUNDANCY, BACKUP MODES) IS FULLY UTILIZED.
  - ✓ ADDITIONAL SPARES, TOOLS AND CREW TIME ARE PROVIDED FOR PLANNED MAINTENANCE/REPLACEMENT/REPAIR.

3/10/67
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SUBSYSTEM LIFE EXTENSION

SUBSYSTEM/ COMPONENT	LIFE EXTENSION APPROACH AND M/R/R PROVISIONS
EPS	
FUEL CELL	ADD 3 FUEL CELLS ON COLD STANDBY. NO ACCESS. ADDITIONAL SENSORS AND SWITCHING FOR STARTUP.
DISTRIB. & CONTROL	SPARE TIMER, INVERTER AND 0. LOAD DEVICES. PROVIDE ADDITIONAL TEST POINTS AND ACCESS DOORS.
EC/LS	
CRYO STORAGE	ADD TANKAGE; SYS. SEGMENTATION MINIMIZES LOSS. NO ACCESS
FLUID LOOPS	GROWTH CAPABILITY INHERENT IN B. L. REDUNDANCY. NO ACCESS
MOLEC. SIEVE	B. L. HAS TRIPLE REDUNDANCY, CYCLE TO VACUUM.
FAN, VALVES, TRANSDUCER TIMER, P. P. SENSOR	ADDITIONAL SPARING. EXTEND B. L. M/R/R PROVISIONS
ACTS-ELECTRONICS	
CIRCUIT CARDS	ADDITIONAL SPARING; CANNIBALIZATION WITHIN SUBSYSTEM - Added to B.L.
GYRO & ELECT.	USE B. L. REDUNDANCY AND COMMON SPARING } EXTENDED BASELINE PROVISIONS
H/S & ELECT.	USE B. L. REDUNDANT HEADS AND CIRCUITRY } EXTENDED BASELINE PROVISIONS
ACTS-PROPULSION	
TCA'S	USE B. L. REDUNDANT MODES. NO ACCESS
TANKS & PROP. DISTRIBUTION	B. L. HAS REDUNDANCY; SYSTEM SEGMENTATION MINIMIZES LOSS. NO ACCESS
COMM	
REC'VR, DTU ETC.	USE B. L. REDUNDANCY, MULTI-PATHS. PROVIDE SPARING
RECORDERS	MAINTAIN, POSSIBLE REPLACEMENT. PROVIDE ACCESS
DATA MANAGEMENT	USE B. L. REDUNDANCY. M/R/R NOT UTILIZED IN 60 DAY DESIGN
INSTR & MON/ALARM	USE B. L. REDUNDANCY ON CRITICAL PATHS. UTILIZE COMMON SPARING.
STRUCTURE	PROVIDE ADDITIONAL SEALS & LATCH KIT TO REPAIR HATCH.

FIG. 4

SUBSYSTEM LIFE EXTENSION

ACCESSIBILITY FOR MAINTENANCE/REPLACEMENT/REPAIR

GEMINI B

SUBSYSTEM/ COMPONENT	LOCATION	ACCESSIBLE	M/R/R[1] REQUIREMENTS	POSSIBLE PROVISIONS FOR TROUBLE SHOOTING
BATTERIES	ADAPTER	NO	REMOTE ACTI-VATE REDUNDANT UNIT	PROVIDE ACCESS PANELS
PARACHUTE	NOSE	NO	NONE	-
RETRO ROCKETS	ADAPTER	NO	REDUNDANT	-
ECS PUMPS	CABIN SEC.	NO	REDUNDANT	-
INSTRUMENT.	VARIOUS	SOME	REDUNDANT ON CRIT. COMP.	-
RCS PROP. TANKS	NOSE SEC.	NO	NONE	-

ADDITIONAL CONSIDERATIONS

GEMINI STATUS MUST BE MONITORED

LOW PRESSURE WILL BE MAINTAINED IN VEHICLE TO ELIMINATE HARD VACUUM

(1) M/R/R = MAINTENANCE/REPLACEMENT/REPAIR

FAILURE EVENT AND EFFECTS SUMMARY

EVENT/CRITICAL COMPONENT	CRITICALITY OF FAILURE	ESTIMATED TIME FOR CORR. ACTION	REMARKS
1. LOSS OF ATTITUDE CONTROL	MISSION ABORT		
o HOR. SENS. & ELECTRONICS	DEGRADATION	<24 HRS.	SWITCH TO STANDBY UNIT - MAN BACK-UP
o GYRO & ELECTRONICS	"	"	"
o CONTROL ELECTRONIC ASSEMBLY	"	"	"
2. LOSS OF ΔV CAPABILITY	DEGRADATION		SHORTENS MISSION
o THRUST CHAMB. ASSEM.	"	IMMEDIATELY	SAVE PROPELLANT
o PROP. PRESSURIZATION	CREW SAFETY	"	TANK RUPTURE MAY RESULT
o PROP. STORAGE/FEED	DEGRADATION	<90 MIN.	SWITCH TANKS
3. LOSS OF ELECTRICAL POWER	MISSION ABORT		AFFECTS CREW SAFETY IN SHORT TIME
o POWER PLANT	DEGRADATION	IMMEDIATELY	
o CONTR/PROTECT UNIT	"	"	PROTECT FUEL CELL
o INVERTER	"	"	SWITCH INVERTER
o DC/DC CONVERTERS	"	"	SWITCH CONVERTER
o CRYOGENIC	"	"	ISOLATE MAL-FUNCTIONED CRYO. LOOP

FAILURE EVENT AND EFFECTS SUMMARY (CONT'D)

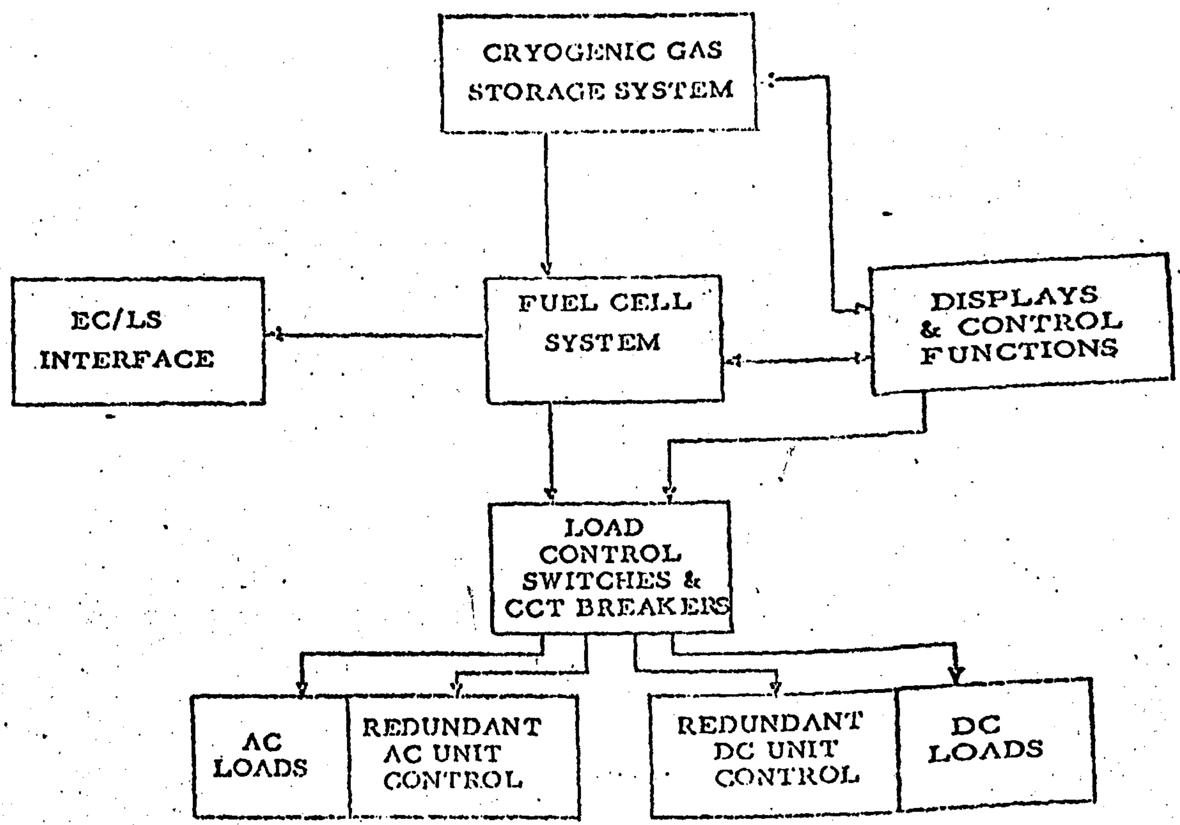
EVENT/CRITICAL COMPONENT	CRITICALITY OF FAILURE	ESTIMATED TIME FOR CORR. ACTION	REMARKS
4. LOSS OF COMMAND & DATA HANDLING	DEGRADATION		CREW CONTINUES WITH VOICE LINK
o SIGNAL COND/PROCESSOR	"	<90 MIN.	
o TRANSMITTER	"	"	
o RECEIVER	"	"	
o MULTIPLEXER	"	"	
o CONVERTER	"	"	
o RECORDER & TELEPRINTER	"	"	
o COMPUTER	"	IMMEDIATELY	
5. LOSS OF VOICE COMM.	DEGRADATION		CREW CONTINUES WITH TELEPRINTER AND COMPUTER/ DATA MANAGEMENT EQUIPMENT
o SIGNAL COND/PROCESSOR	"	<90 MIN.	
o TRANSMITTER	"	"	
o RECEIVER	"	"	
o MULTIPLEXER	"	"	
o CONVERTER	"	"	
o VOCODER COMPONENTS	"	"	
o VOICE CONTROL CENTER	"	"	

FAILURE EVENT AND EFFECTS SUMMARY (CONT'D)

EVENT/CRITICAL COMPONENT	CRITICALITY OF FAILURE	ESTIMATED TIME FOR CORR. ACTION	REMARKS
6. LOSS OF CABIN ATMOSPHERE CONTROL			TEMPORARY OPER. BY CREW IN SUIT
o FAN	DEGRADATION	IMMEDIATELY	
o MOLECULAR SIEVE	"	<90 MIN.	
o PO_2 SENSOR	"	IMMEDIATELY	
o REGULATOR/VALVING	"	<90 MIN.	
o CRYOGENICS	"	IMMEDIATELY	
7. LOSS OF THERMAL CONTROL	DEGRADATION		PROVOKES FAILURE OF TEMP. CRITICAL EQUIPMENT
o PUMP	"	<90 MIN.	
o FLUID LOOP	"	"	
8. LOSS OF MONITOR & ALARM	CREW SAFETY		CREW CAN ASSESS SOME MALFUNCTIONS WITHOUT INSTR.
o SENSORS	DEGRADATION	<90 MIN.	
o CONTROLLERS	"	"	
o ELECTRONIC CIRCUITS	"	"	
o DISPLAYS	"	"	
o TRANSDUCERS	"	"	

ELECTRICAL POWER SUBSYSTEM

BLOCK DIAGRAM



ELECTRICAL POWER SUBSYSTEM

LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING
- FUEL CELL POWERPLANT
- PURGE TIMER
- ELECTRICAL CONTROL AND PROTECTION UNIT(ECPU)
- INVERTERS AND DC/DC CONVERTERS

REDUNDANT ITEMS
- ADDITIONAL STANDBY FUEL CELL MODULES FOR 60 DAYS (INCLUDES ECPU)
- VOLTAGE LIMITER SENSOR
- INVERTERS
- DC/DC CONVERTERS

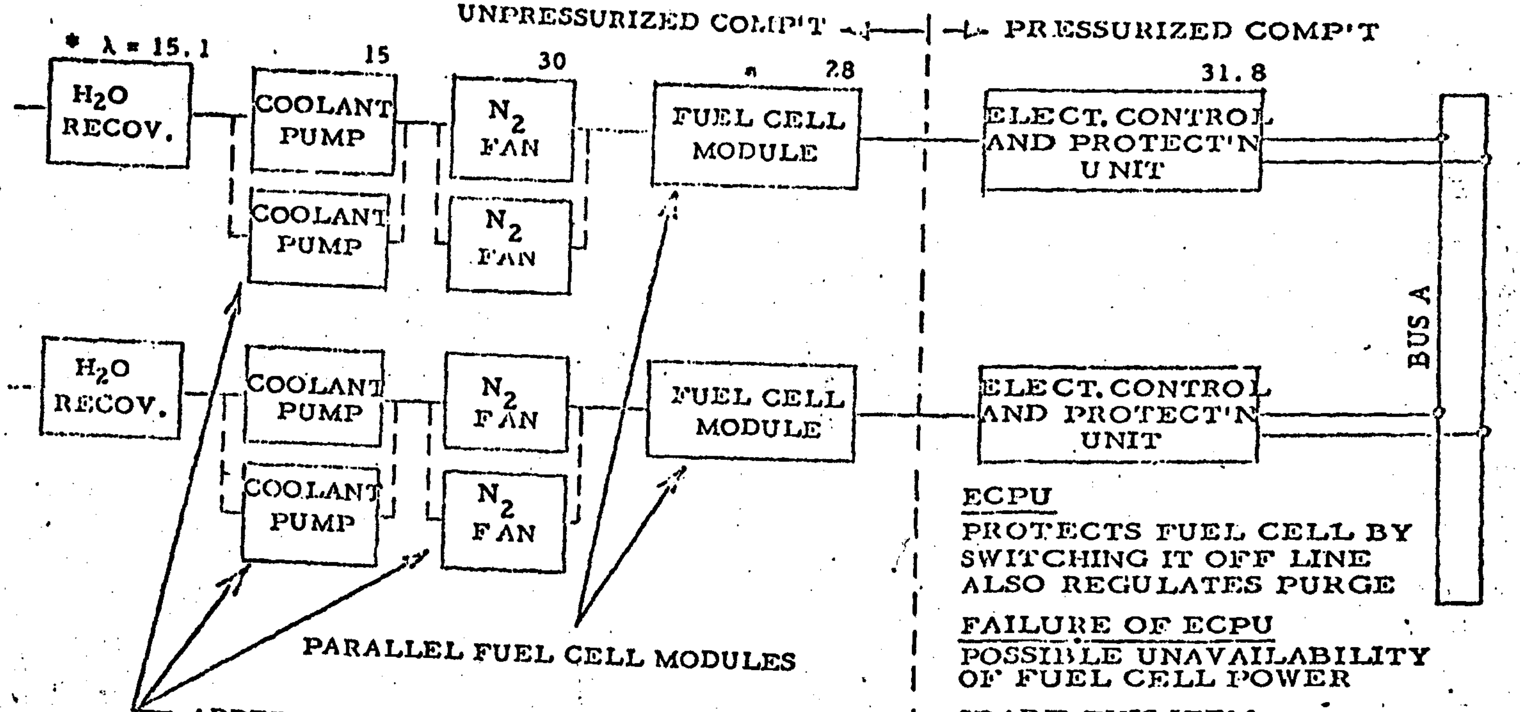
SPARED ITEMS
- INVERTERS
- PURGE TIMER
- ELECTRICAL CONTROL AND PROTECTION UNIT (ECPU)
- SWITCHING AND OVERLOAD DEVICES (DISTRIBUTION)
- DC/DC CONVERTERS

DESIGN MODIFICATIONS
- MINOR MODS DISCLOSED BY STRETCH TESTING

NEW DEVELOPMENT
- NONE EXPECTED FOR 60 DAYS
- CONSIDER USE OF LONGER LIFE FUEL CELLS NOW UNDER DEVELOPMENT

REDUNDANCY AND SPARE REPLACEMENT

FUEL CELL POWER SOURCE



ADDED REDUNDANCY FOR EXT. MISSION
- UNPRESSURIZED COMPARTMENT
- DIFFICULT PUMP REPLACEMENT

ECPU

PROTECTS FUEL CELL BY SWITCHING IT OFF LINE ALSO REGULATES PURGE

FAILURE OF ECPU

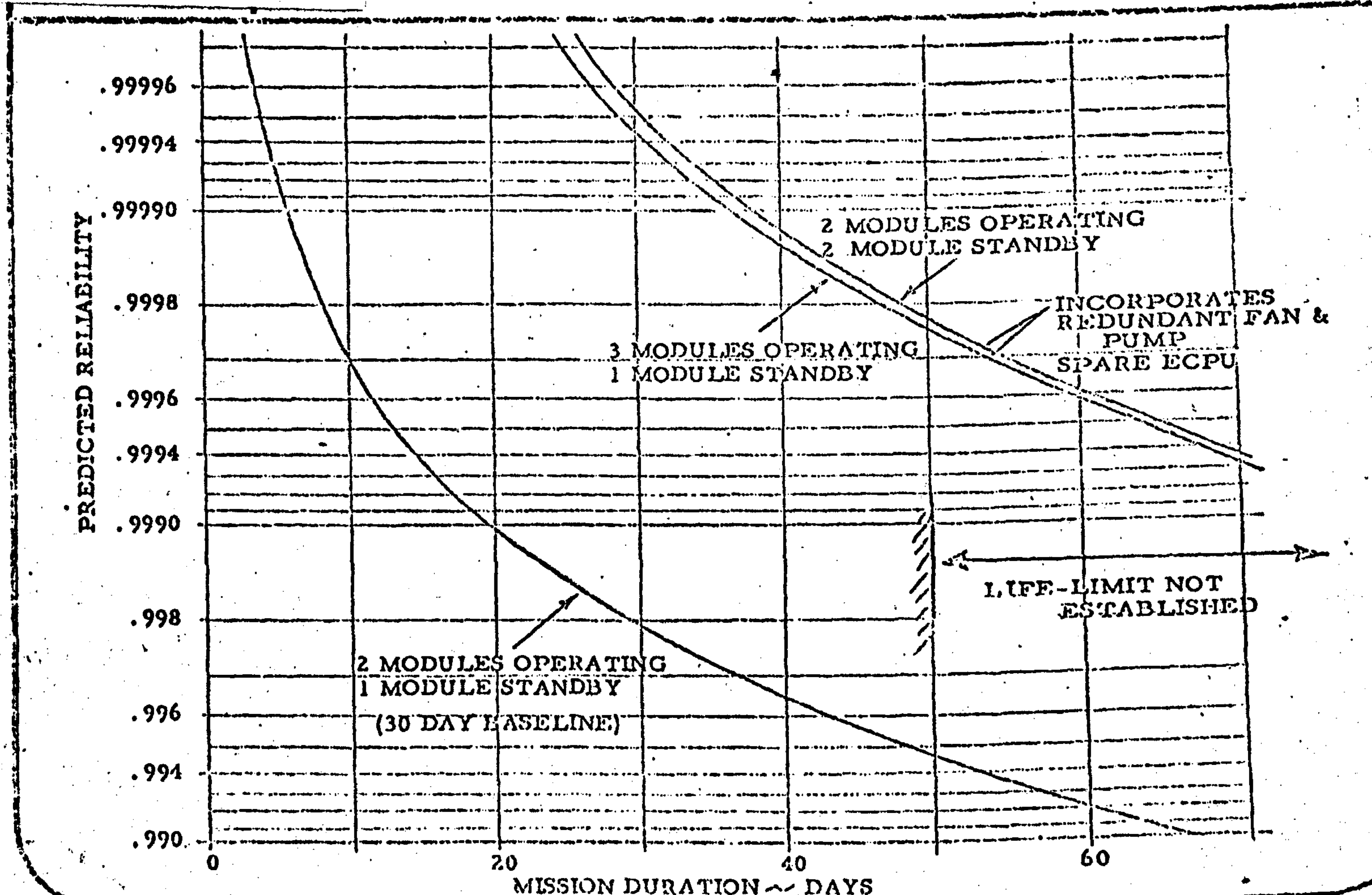
POSSIBLE UNAVAILABILITY OF FUEL CELL POWER

SPARE THIS ITEM
- COMMONALITY OF EQUIPMENT
- ACCESSIBLE IN PRES. COMP'T
- FAILURE COULD BE CRITICAL TO MISSION SUCCESS
- APPRECIABLE WT. ITEM = 20 LB

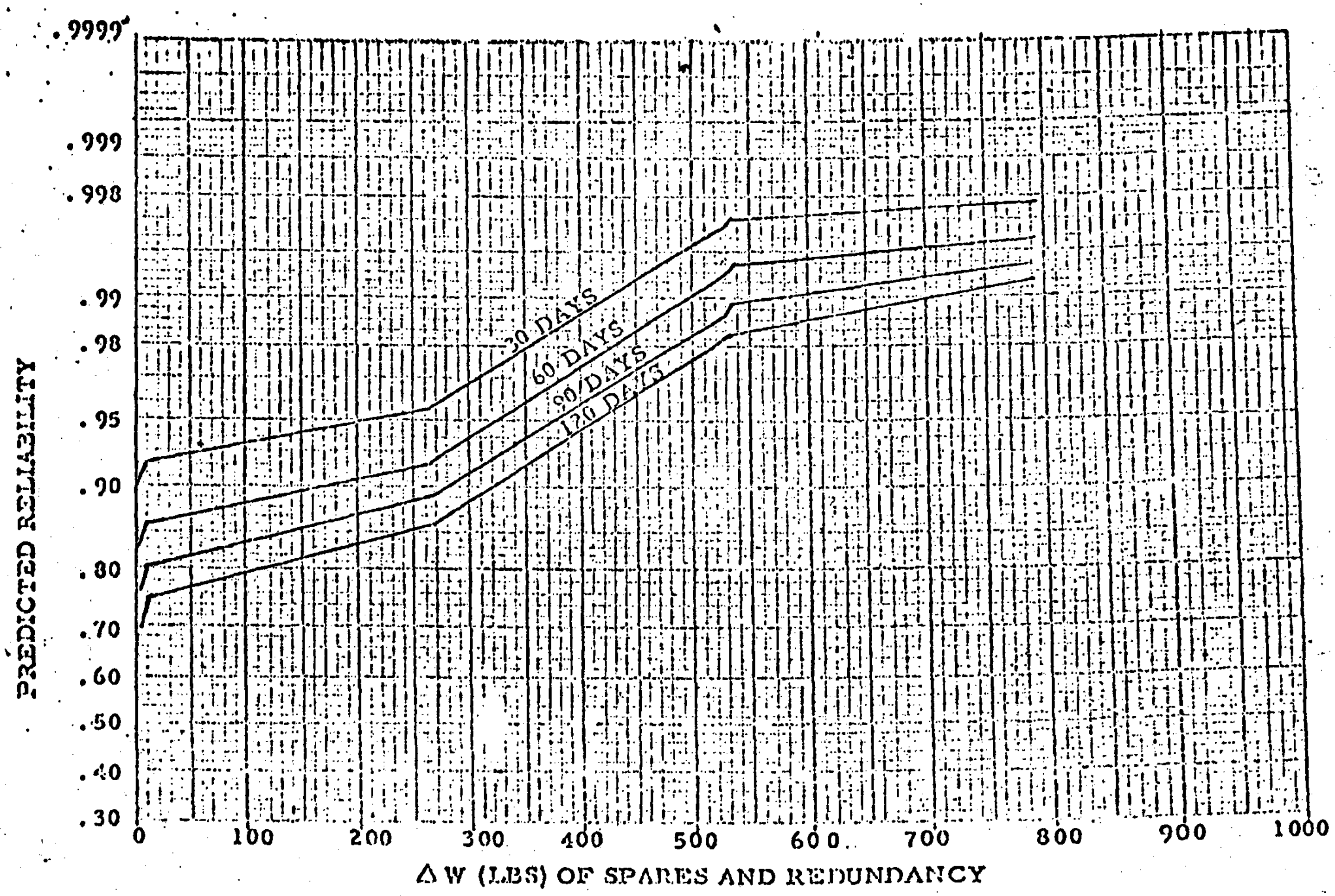
* λ = FAILURE RATE/10^6 HOURS

FUEL CELL POWER SOURCE

RELIABILITY VS MISSION DURATION BASED ON FAILURE RATES

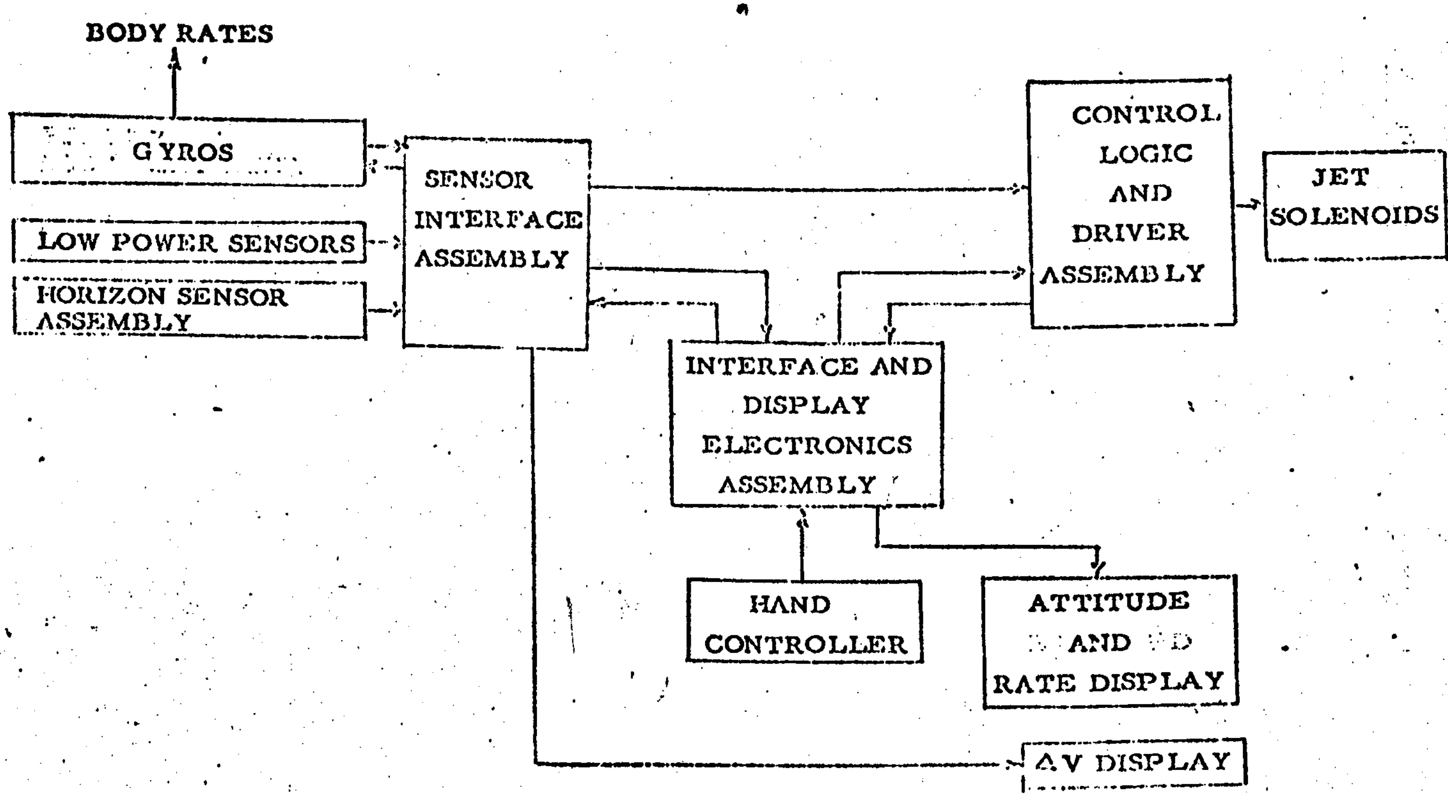


ELECTRICAL POWER SUBSYSTEM
PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY
FOR VARIOUS MISSION DURATIONS



ATTITUDE CONTROL AND TRANSLATION SUBSYSTEM

BLOCK DIAGRAM

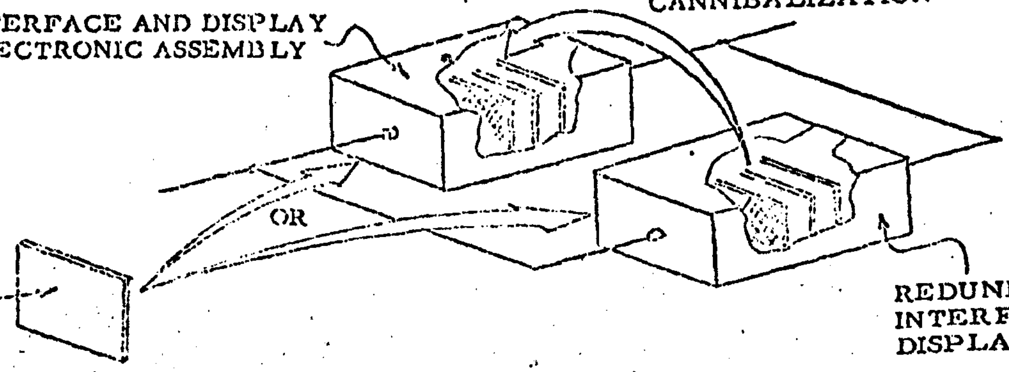


ATTITUDE CONTROL AND TRANSLATION SUBSYSTEM

LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING	- HORIZON SENSOR (H. S.) - GYROS - REGULATOR AND VALVES	- THRUST CHAMBER ASSEMBLIES (TCA'S) - PROPELLANT TANK & EXPULSION DEVICE
REDUNDANT ITEMS	- H. S. HEADS & ELECTRONICS - LOW POWER SENSORS - RATE INDICATOR - GYRO PACKAGE & ELECT. - INVERTER	- TCA'S - REGULATORS & VALVES - PROP MODULES INTER-CONNECTED FOR DEGRADED MODE OPER.
SPARED ITEMS	- H. S. ELECTRONICS - GYROS - ELECTRONIC CIRCUIT CARDS (VARIOUS ELECTRONIC ASSEM)	- H. S. HEADS > 60 DAYS - INVERTER - POWER SUPPLY - SWITCHES
DESIGN MODIFICATIONS	- MINOR MODS DISCLOSED BY STRETCH TESTS - PROVIDE ACCESSIBILITY FOR MAINTENANCE - EXPLOIT COMMONALITY OF COMPONENTS FOR SPARING	
NEW DEVELOPMENT	- NONE EXPECTED FOR 60 DAY MISSION USE OF LONG LIFE GAS BEARING GYROS AND EDGE TRACKING H. S. UNDER DEVELOPMENT	

USE OF REDUNDANCY AND SPARES
IN THE ACTS - ELECTRONICS SUBSYSTEM



ASSEMBLY CONTAINS - SIGNAL CONDITIONING, POWER SUPPLIES, GYRO ELECTRONICS AND DISPLAY ELECTRONICS

REDUNDANCY - PARALLEL ASSEMBLIES REQUIRED FOR FAST SWITCHOVER TO PREVENT LOSS OF ATTITUDE CONTROL.

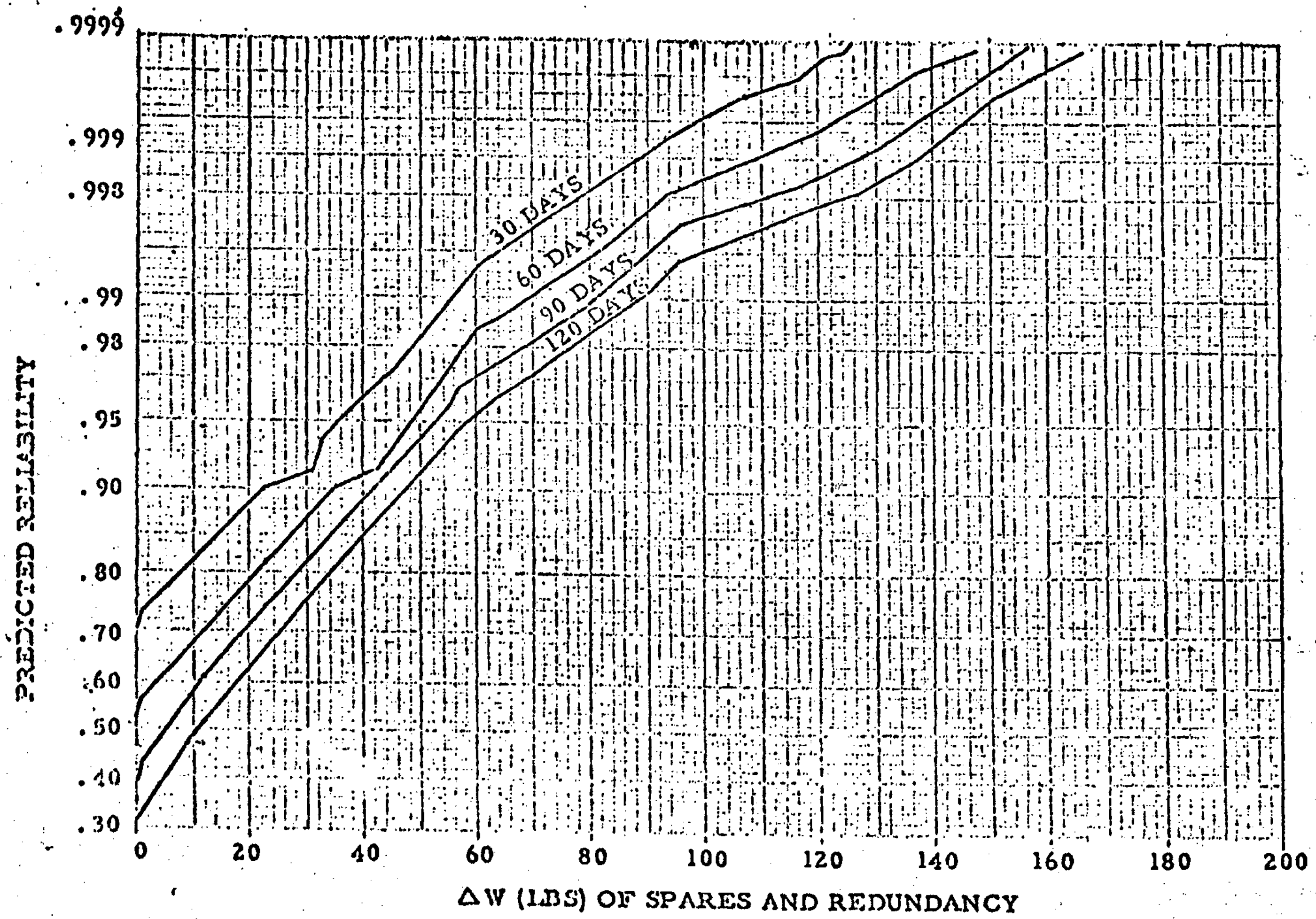
SPARING
- SIMILAR CIRCUITS PERMIT EXPLOITING COMMONALITY OF SPARED CIRCUIT CARDS.
- MULTIPLE USE OF SPARES AND USE OF DUAL REDUNDANCY FOR LONG MISSIONS PERMITS WEIGHT SAVINGS.
- SPARES NOT AT RISK TO OPERATIONAL FAILURE AS ARE OPERATING REDUNDANCIES.

CANNIBALIZATION - CANNIBALIZING OR SALVAGING PARTS WHERE TWO SIMILAR (OR DIFFERENT) COMPONENTS HAVE FAILED, SO AS TO CREATE ONE THAT WILL PROVIDE PERFORMANCE

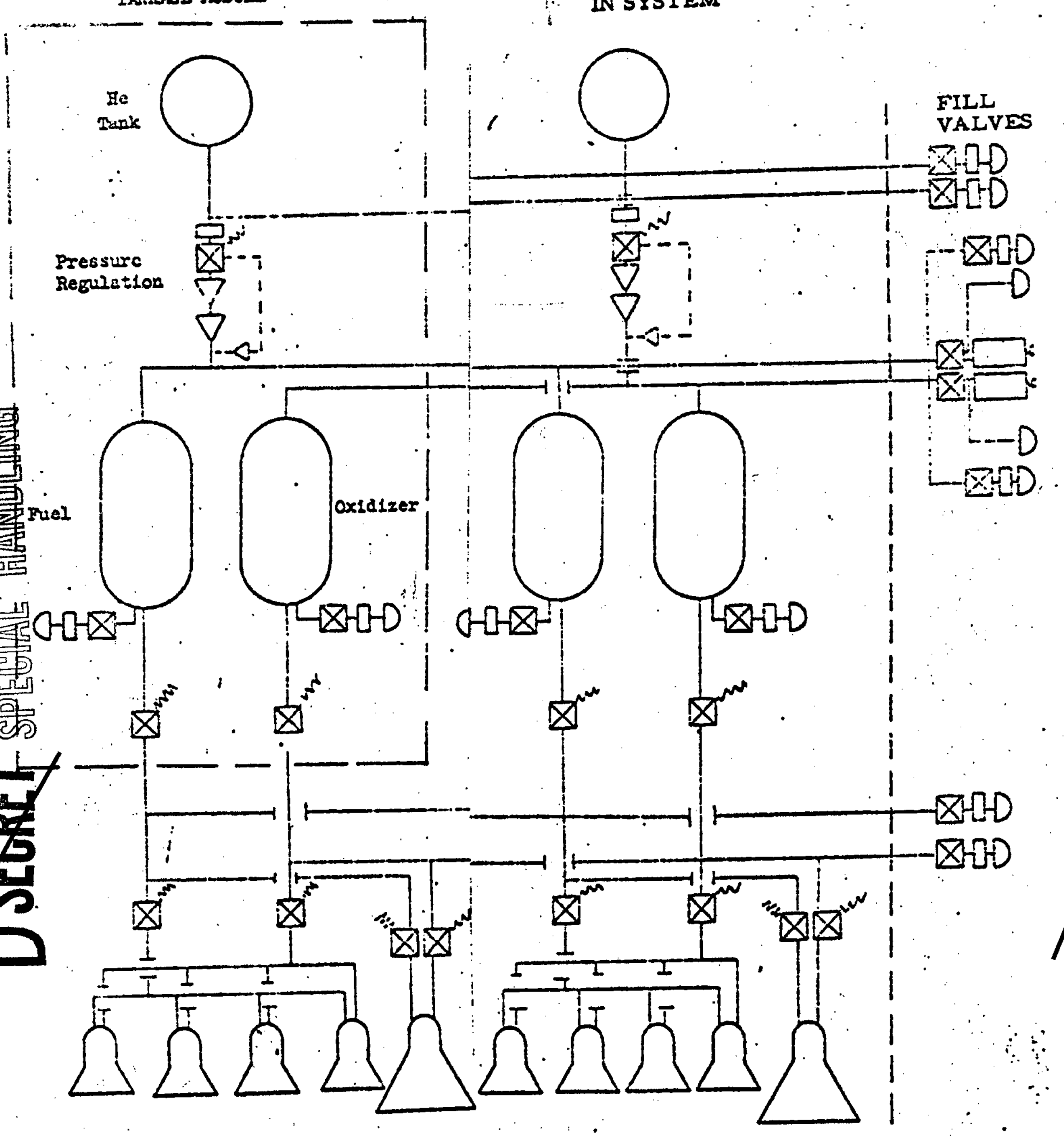
ATTITUDE CONTROL AND TRANSLATION SUBSYSTEM - ELECTRONICS

PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY

FOR VARIOUS MISSION DURATIONS



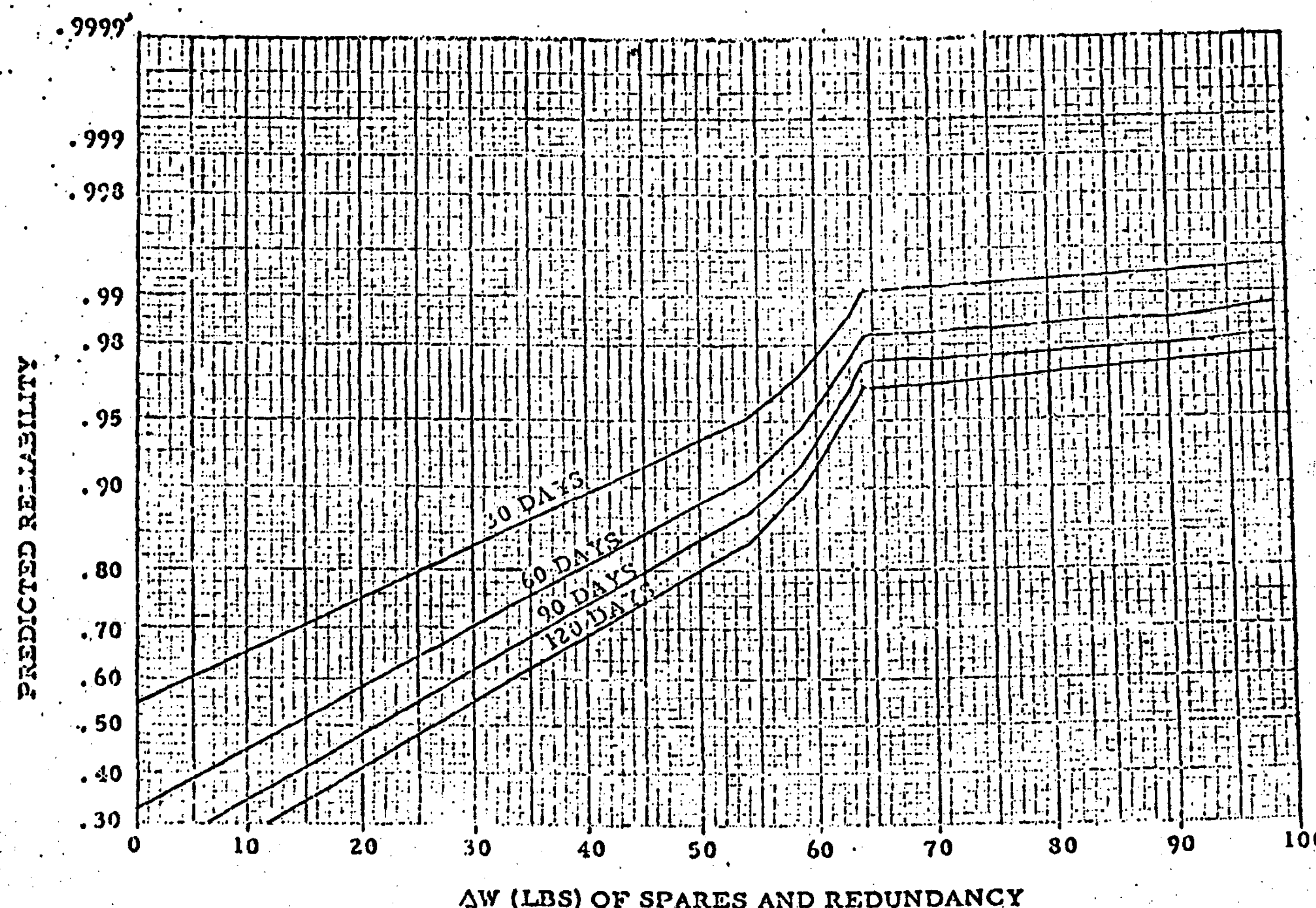
ACTS - PROPULSION BLOCK DIAGRAM



ATTITUDE CONTROL AND TRANSLATION SUBSYSTEM - PROPULSION

PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY

FOR VARIOUS MISSION DURATIONS



ENVIRONMENTAL CONTROL/LIFE SUPPORT SUBSYSTEM

LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING

- CATALYTIC OXID. UNIT
- VALVING
- MOLEC. SIEVE ASSEM.
- CO_2 REMOVAL UNIT
- H. EXCH. - WICK SEP.
- FAN
- PUMP PACKAGE
- TEMP. CONTROLLER

REDUNDANT ITEMS

- MOLEC. SIEVE ASSEM.
- CRYO TANK HEATERS
- PARALLEL REG
- HEAT EXCHANGER/ COLD PLATES
- PUMP/MOTOR
- WATER HEATER
- LIQUID LINES
- RADIATOR

SPARED ITEMS

- PO_2 SENSOR & ELECTRONICS
- TOTAL PRESS. SENSOR
- CHEMISORBENT CARTRIDGES
- SENSOR & CONTROL ELEC.
- FANS
- H_e AND O_2 FILTERS
- PUMPS
- MOTORS
- MOTOR SPEED CONTROL

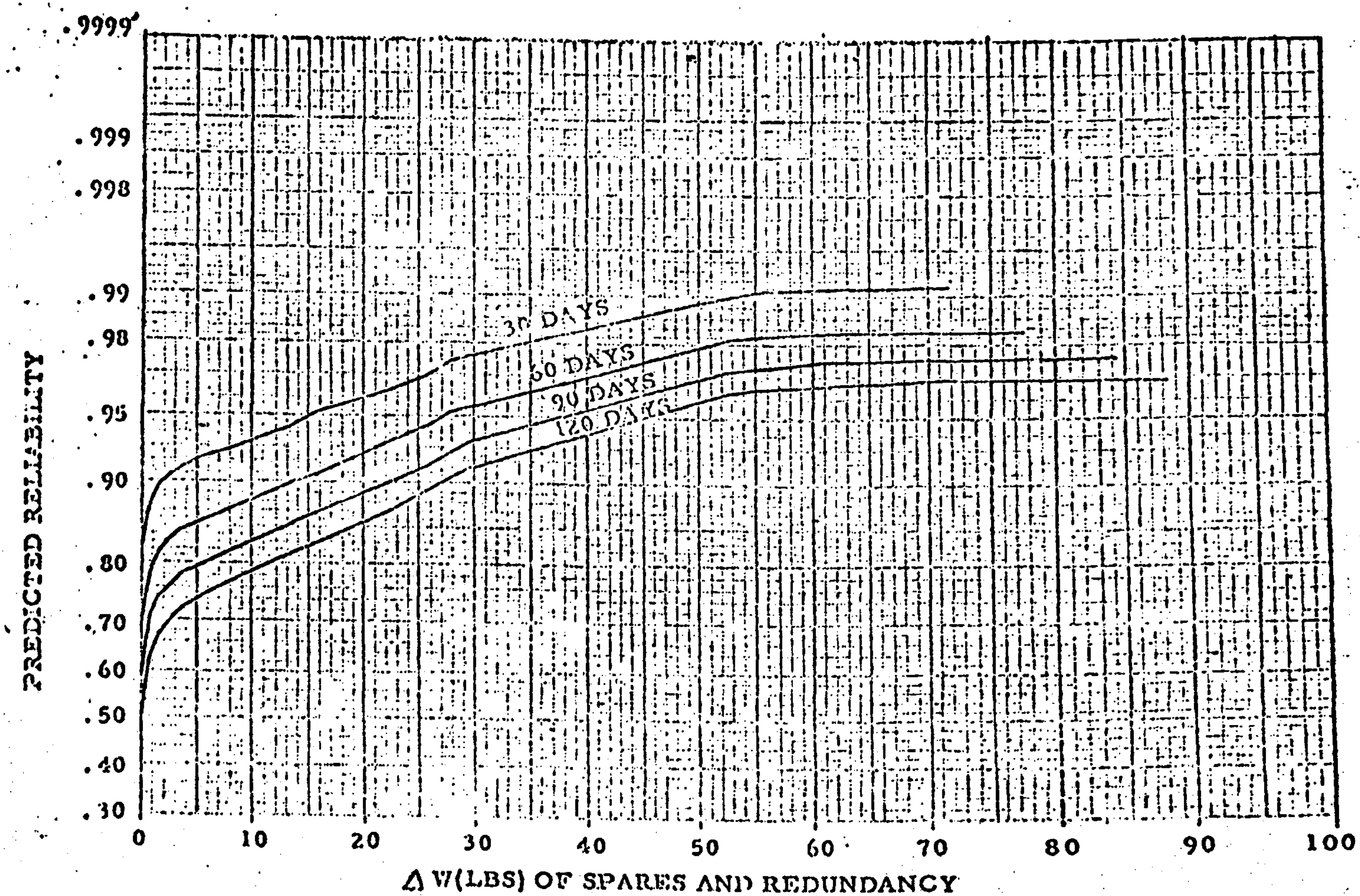
DESIGN MODIFICATIONS

- ... MODS DISCLOSED BY STRETCH TESTING
- IMPROVE CRYOGENIC TANK INSULATION & VENTING

NEW DEVELOPMENT

- SOME DEVELOPMENT FOR CRYOGENIC TANK INSULATION

ENVIRONMENTAL CONTROL/LIFE SUPPORT SUBSYSTEM
PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY FOR VARIOUS MISSION DURATIONS



COMMUNICATIONS/DATA HANDLING
LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING
- RECORDER
- TELEPRINTER
- POWER SUPPLY(S)

REDUNDANT ITEMS
- SIGNAL CONDITIONER
- TRANSMITTERS
- RECEIVERS
- CONVERTERS (D-TO-A)
- COMPUTER
- MULTIPLEXERS
- VOICE CONTROL CENTER
- OTHER VOICE LINK COMPONENTS
- SECURE DEVICES

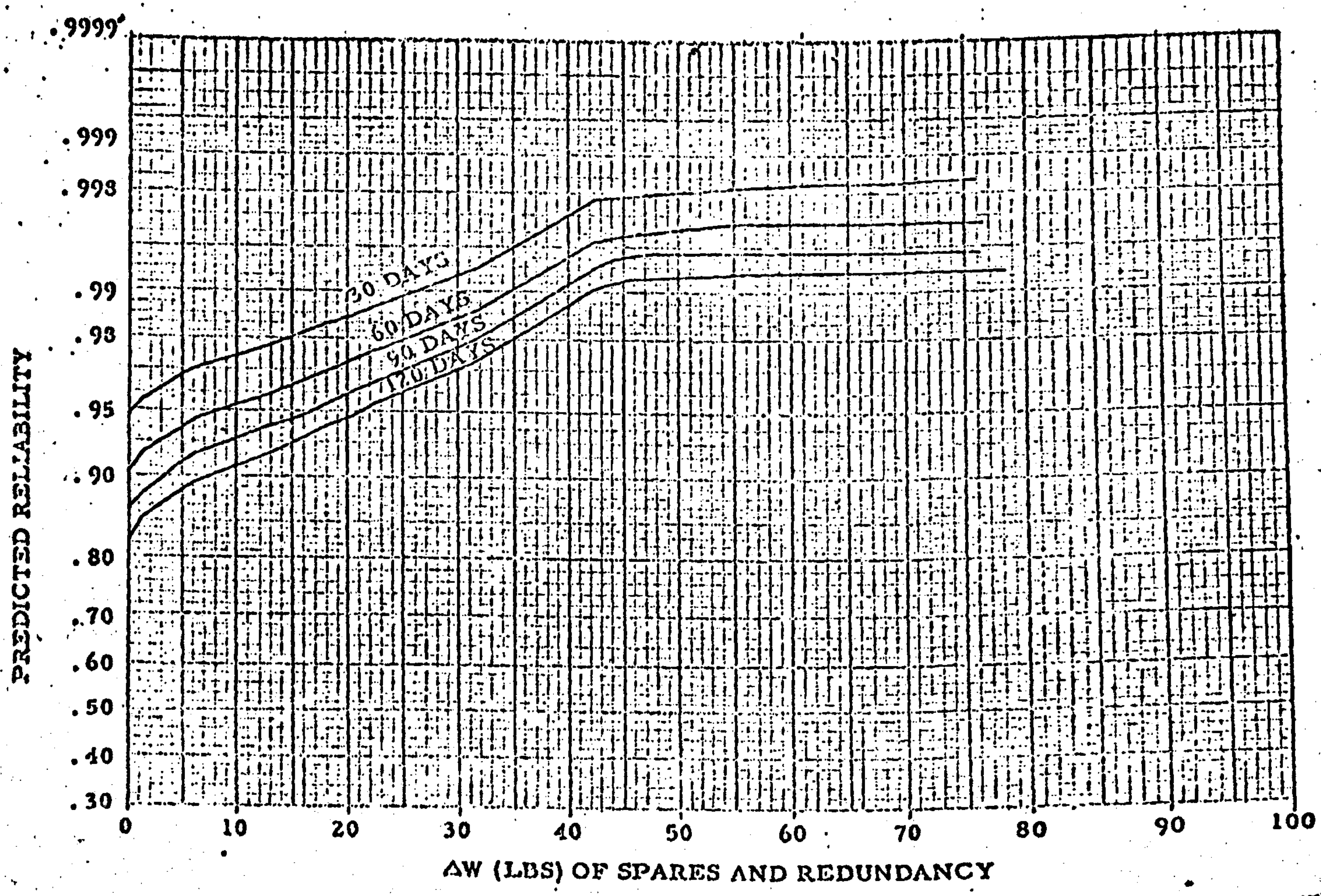
SPARED ITEMS
- RECORDER COMPONENTS (HEADS)
- TELEPRINTER COMPONENTS (HEAD)
- POWER SUPPLY(S)

DESIGN MODIFICATIONS
- NONE EXPECTED FOR 60 DAYS

NEW DEVELOPMENT
- NONE EXPECTED FOR 60 DAYS

COMMUNICATIONS SUBSYSTEM

PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY FOR VARIOUS MISSION DURATIONS



INSTRUMENTATION/MONITOR-ALARM SUBSYSTEM

LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING
- POWER CONVERSION/CONDITIONING

REDUNDANT ITEMS
- CONVERTERS (D-TO-A)
- EXCITERS
- BASEBAND ASSEMBLY
- DTU
- TWT
- UHF TRANSMITTERS
- SECURE DEVICES

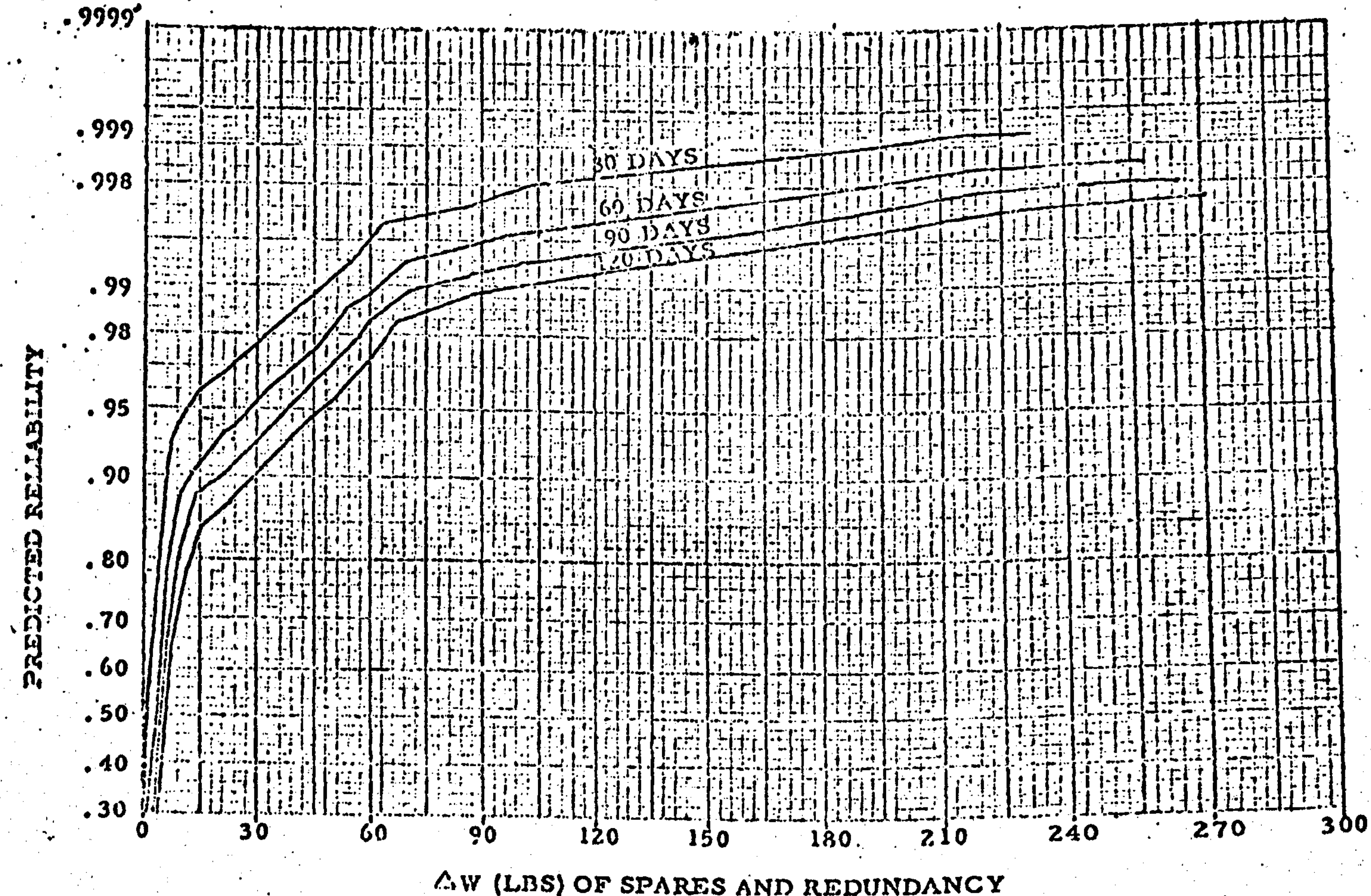
SPARED ITEMS
- CREW CAN ESSENTIALLY "SPARE" BY SWAPPING CHANNELS
  - o SIGNAL CONDITIONING
  - o REMOTE MULTIPLEXERS

DESIGN MODIFICATIONS
- NONE EXPECTED FOR 60 DAYS

NEW DEVELOPMENT
- NONE EXPECTED FOR 60 DAYS

INSTRUMENTATION/MONITOR-ALARM SUBSYSTEM

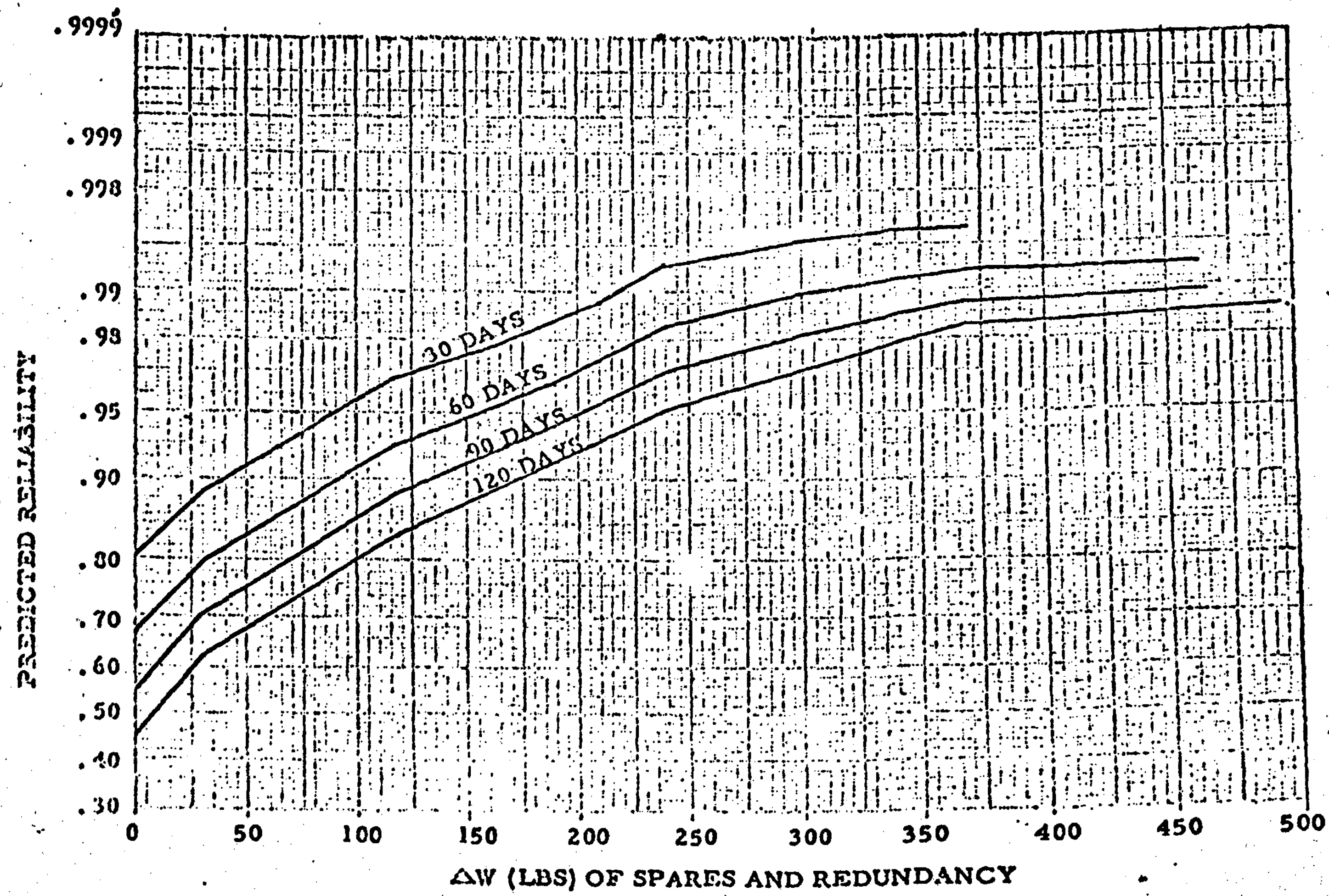
PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY FOR VARIOUS MISSION DURATIONS



DATA MANAGEMENT SUBSYSTEM

PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY

FOR VARIOUS MISSION DURATIONS



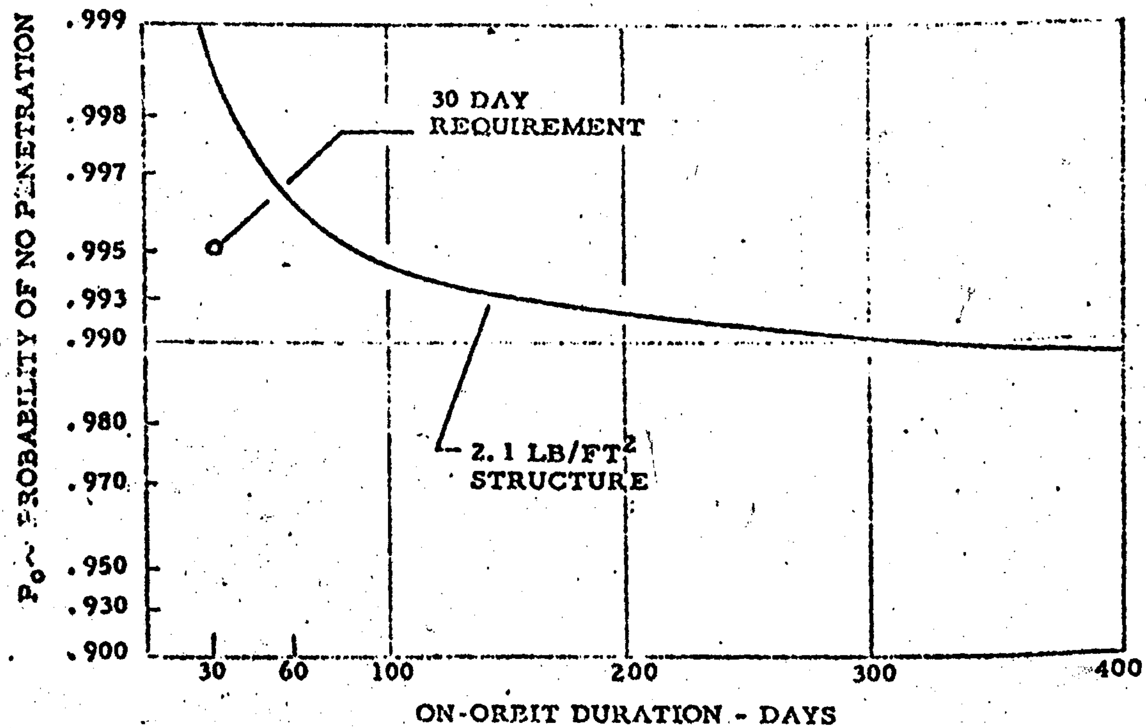
STRUCTURES SUBSYSTEM

LIFE EXTENSION SUMMARY

ITEMS FOR STRETCH TESTING	- RADIATOR
REDUNDANT ITEMS	- UTILIZE BASIC SYSTEM AS IS
SPARED ITEMS	- DOOR SEALS - LEAK KIT - DOOR LATCH KIT
DESIGN MODIFICATIONS	- INCREASE WALL THICKNESS LAB AND RADIATOR FOR MISSIONS > 60 DAYS (MICROMETEOROID) CRITERIA) TO MAINTAIN $P_o = .995$ - LENGTHEN FWD UNPRESSURIZED COMPARTMENT
NEW DEVELOPMENT	- NONE EXPECTED FOR 60 DAYS

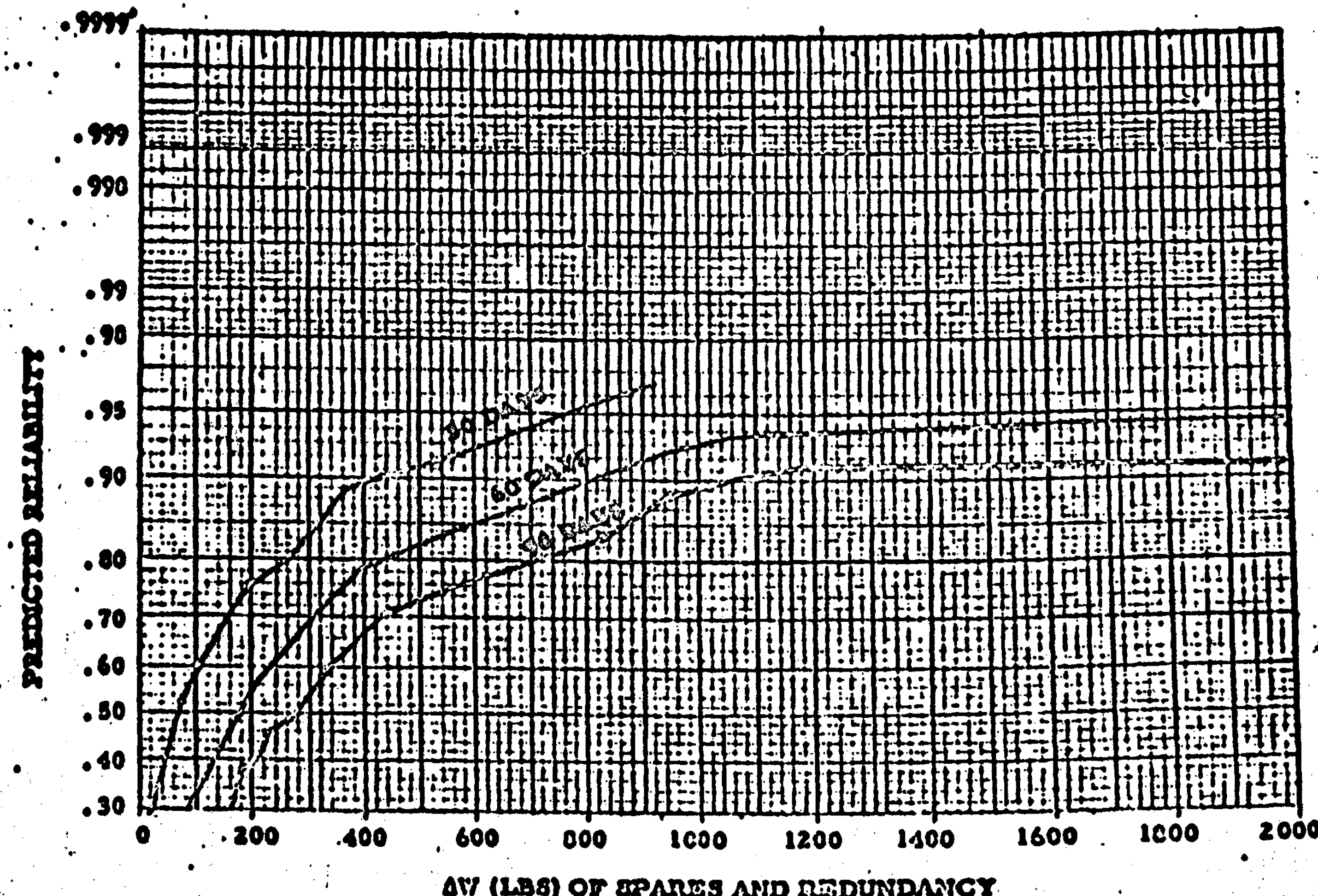
SUBSYSTEM LIFE EXTENSION
STRUCTURE
METEOROID CRITERIA IMPACT ON LABORATORY DESIGN

PROBABILITY OF NO PENETRATION VERSUS TIME

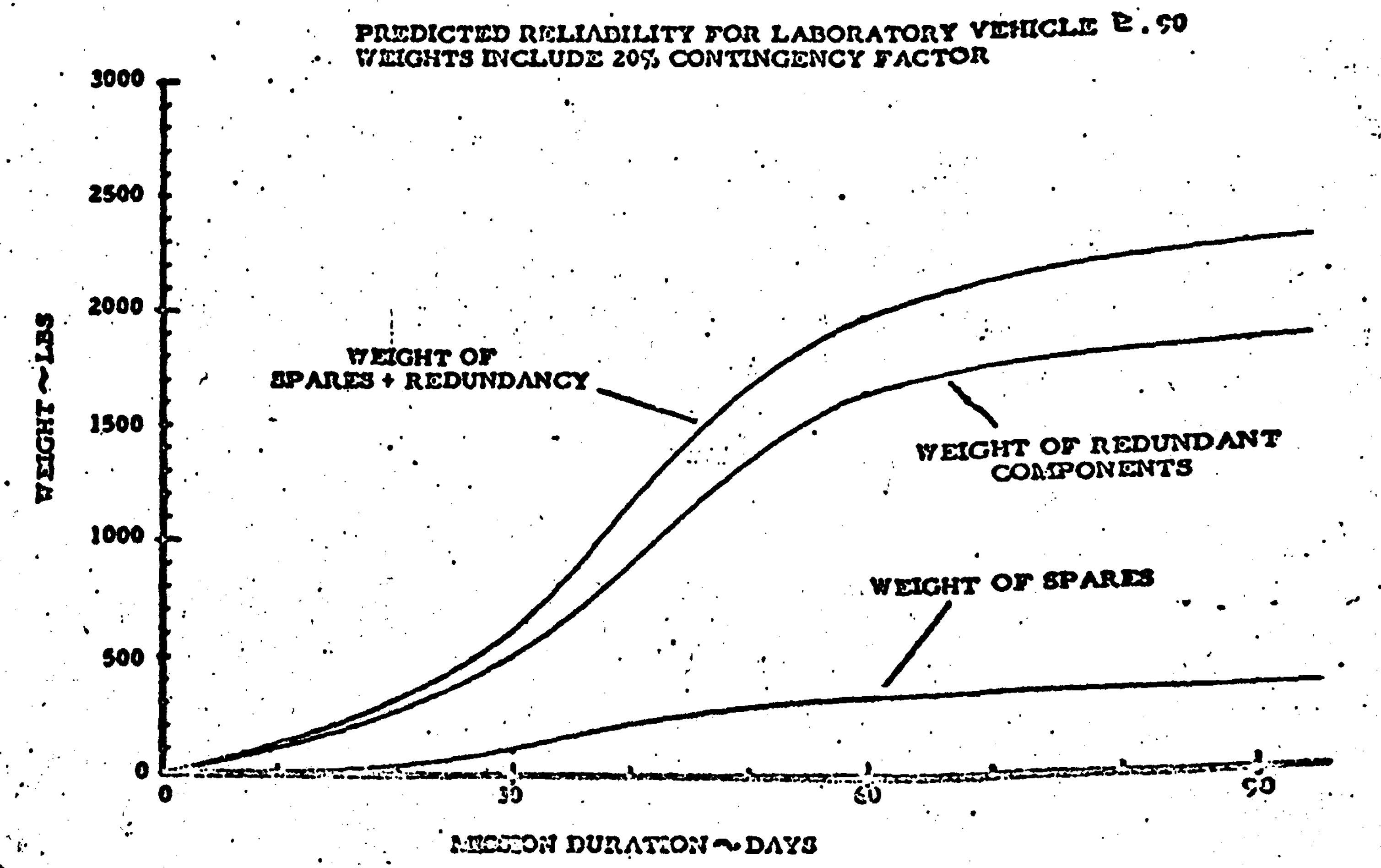


LABORATORY VEHICLE

PREDICTED RELIABILITY VERSUS ADDED SPARES AND REDUNDANCY FOR VARIOUS MISSION DURATIONS



WEIGHT CONSIDERATIONS FOR SUBSYSTEM LIFE EXTENSION
LABORATORY VEHICLE



SUBSYSTEM LIFE EXTENSION

NON-RECURRING Δ COST ESTIMATE FOR 60 DAY SUBSYSTEMS

SUBSYSTEM		NON-RECURRING Δ COST $
o ATTITUDE CONTROL		7,000,000
o PROPULSION		10,000,000
o ENVIRONMENTAL CONTROL/LIFE SUPPORT		6,000,000
o COMMUNICATIONS/DATA HANDLING		4,000,000
o ELECTRICAL POWER		13,000,000
FUEL CELLS	5,000,000	
CRYOGENIC SYSTEM	8,000,000	
o MISSION P/L EQUIPMENT		10,000,000
o INSTRUMENTATION		1,000,000
o STRUCTURE, PRIMARY AND SUPPORT		7,000,000
o GEMINI B		2,000,000
		60,000,000

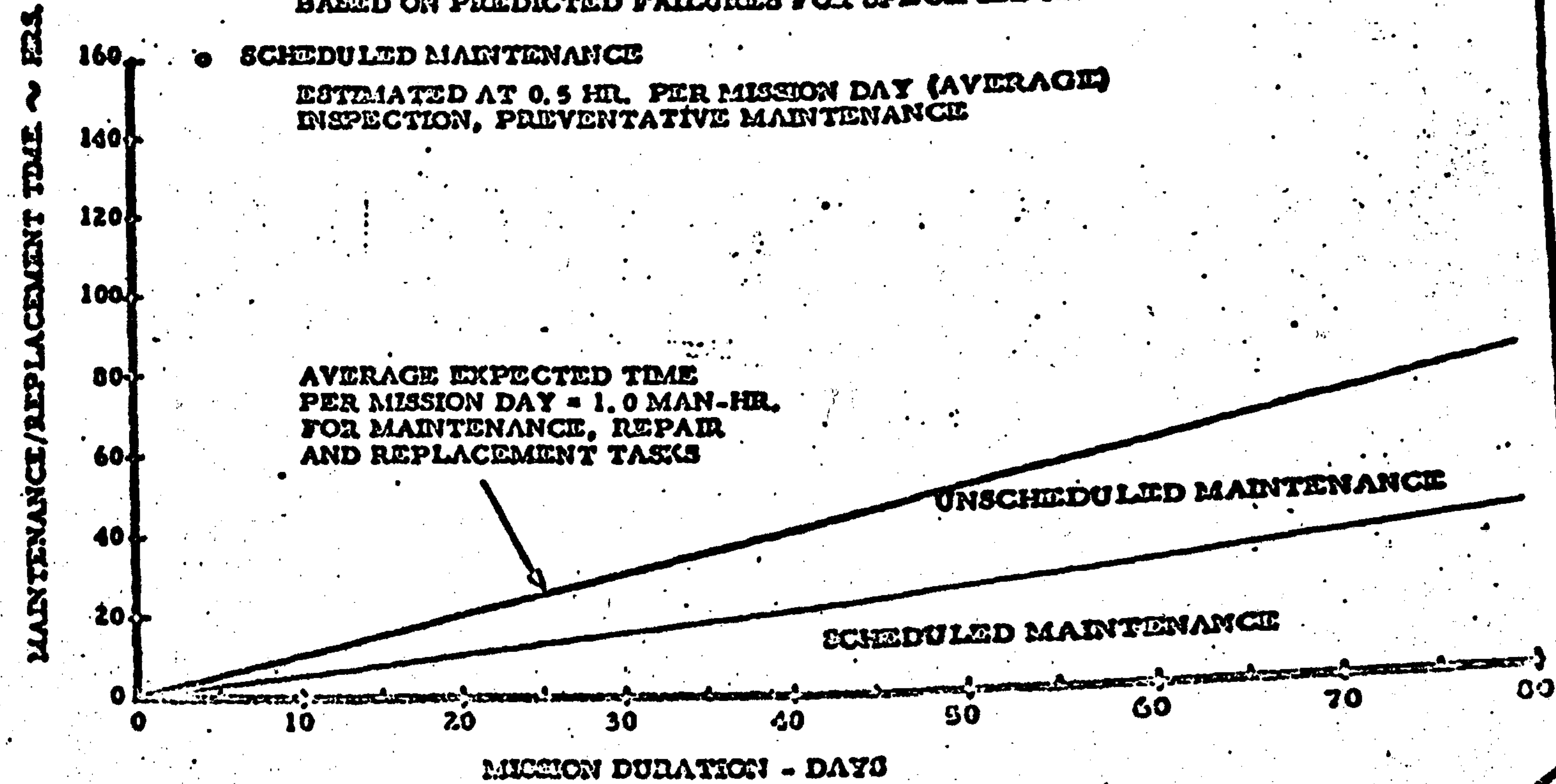
SUBSYSTEM LIFE EXTENSION
RECURRING △ COST ESTIMATE FOR 60 DAY SUBSYSTEMS

SUBSYSTEM	RECURRING △ COST $
O ATTITUDE CONTROL AND PROPULSION	1,800,000
O ENVIRONMENTAL CONTROL/LIFE SUPPORT	291,000
O COMMUNICATIONS/DATA HANDLING	830,000
O ELECTRICAL POWER SUBSYSTEM (CRYOGENICS AND FUEL CELLS)	1,200,000
O MISSION P/L EQUIPMENT	700,000
O INSTRUMENTATION	150,000
O STRUCTURE	600,000
O GEMINI B	90,000
TOTAL	5,661,000

ORBITING VEHICLE - SUBSYSTEM LIFE EXTENSION MAINTENANCE/REPAIR/REPLACEMENT TIME VERSUS MISSION DURATION

NOTES:

- UNSCHEDULED MAINTENANCE
  CALCULATED TIME FOR SPARE EQUIPMENT REPLACEMENT BASED ON PREDICTED FAILURES FOR SPECIFIED MISSION DURATION
- SCHEDULED MAINTENANCE
  ESTIMATED AT 0.5 HR. PER MISSION DAY (AVERAGE) INSPECTION, PREVENTATIVE MAINTENANCE



ON-ORBIT MAINTENANCE/REPLACEMENT/REPAIR (BASELINE VEHICLE)

ON-ORBIT MAINTENANCE/ REPLACEMENT/REPAIR	PRELAUNCH CHECKOUT/ TEST/CORRECTIVE ACTION
DESIGN PROVISIONS	
• ACCESSIBILITY	• ACCESSIBILITY
• INTERCHANGEABILITY	• INTERCHANGEABILITY
STATUS AND OPERATING DATA	
• INSTRUMENTATION	• INSTRUMENTATION
• MONITOR/ALARM & TELEMETRY	• MONITOR/ALARM & TELEMETRY & UMBILICAL
TROUBLE SHOOTING	
• EQUIP. TEST POINTS	• EQUIP. TEST POINTS
• PANEL & J-BOX ACCESS PANELS	• PANEL & J-BOX ACCESS PANELS
• CIRCUIT & PIN DIAGRAM & DATA	• CIRCUIT & PIN DIAGRAM & DATA
	• AGE
REPLACE FAULTY EQUIPMENT	
• DISCONNECT & PLUG-IN FEATURES	• DISCONNECT & PLUG-IN FEATURES
• AVAILABLE SPARE REPLACEMENT	• AVAILABLE SPARE REPLACEMENT
• TOOLS AND TEST CHECK EQUIP.	• TOOLS AND TEST CHECK EQUIP.

- THE DESIGN PROVISIONS, AND PROCEDURES TO PERFORM ON-ORBIT MAINTENANCE/REPLACEMENT/REPAIR ARE BASICALLY THE SAME AS REQUIRED FOR PRE-LAUNCH TEST AND CHECK-OUT OPERATIONS. THUS, FOR ALL PRACTICAL PURPOSES, THE IMPLEMENTATION TO ACCOMPLISH ON-ORBIT TROUBLE SHOOTING AND CORRECTIVE ACTION IS INHERENT IN THE BASIC VEHICLE IF ADEQUATE SPARES ARE PROVIDED ON-ORBIT.

SUBSYSTEM LIFE EXTENSION

MAN VERSUS REDUNDANCY

- MAN AND EQUIPMENT REDUNDANCY ARE COMPLEMENTARY
  - SWITCH TO STANDBY UNIT WHEN TIME IS VITAL
  - MAN CAN FIX FAILED REDUNDANT UNIT WITHOUT SHUTTING DOWN SUBSYS.
  - REDUNDANT UNIT ON LO-DUTY CYCLE COULD PROVIDE SOURCE OF COMMON PARTS NEEDED IN MORE CRITICAL SUBSYSTEM.
- WITHOUT REDUNDANCY
  - CREW MUST NECESSARILY DEVOTE HIGHER DEGREE OF ATTENTION TO EQUIPMENT OPERATING STATUS AND "STATE-OF-HEALTH" - LESSENS TIME FOR OPERATIONS AND OUTSIDE OBSERVATION.
- HOW MUCH REDUNDANCY?
  - REDUNDANCY/SPARES SHOULD OPTIMIZE CREW TIME FOR OPERATIONS, MONITORING AND CORRECTIVE/PREVENTATIVE MAINTENANCE.
  - TIME CRITICAL FUNCTIONS FOR CREW SAFETY AND MISSION OBJECTIVES SHOULD BE BACKED UP WITH REDUNDANCY.
  - AVOID CASCADING REDUNDANT COMPONENTS THAT WILL REQUIRE COMPLICATED VOTING LOGIC AND SWITCHING SCHEMES.
- CREW MANAGEMENT OF REDUNDANCY
  - CREW MUST MAINTAIN COGNIZANCE OF PRIMARY/STANDBY STATUS AND OPERATING TIME FOR REDUNDANT UNITS.
  - AUTOMATIC SWITCHING MUST BE "FLAGGED" FOR CREW ATTENTION
  - AVOID SWITCHING BACK AND FORTH BETWEEN PRIMARY AND STANDBY UNITS (FIRST LAW OF NEWTON EFFECT).

SUBSYSTEM LIFE EXTENSION
IMPORTANCE OF MAN'S ROLE
UNIQUE ABILITIES FOR TROUBLE SHOOTING/CORRECTIVE ACTION

1. MAN HAS REASONING ABILITY (UNMATCHED BY MACHINE), ADAPTABILITY (CAN REPROGRAM), AND VERSATILITY (CAN CORRECT ERRORS).
2. QUICKLY SENSES AND REACTS TO UNEXPECTED FAILURE MODES.
3. IS CAPABLE OF REPLACING ANY OF A LARGE NUMBER OF COMPONENTS (USING HIMSELF AS A MULTI-PURPOSE SPARE).
4. IS SELECTIVE IN INSTALLING SPARES.
5. CAN SENSE INCIPIENT FAILURES AND TAKE ALTERNATIVE STEPS PRIOR TO THE FAILURE OCCURRING AND PERHAPS SPREADING OUT IN SYSTEM.
6. DETERMINES WHERE OR WHAT FAILURE ACTUALLY IS (NOT JUST SYSTEM, WHICH IS INSTRUMENTED, BUT AT PART LEVEL).
7. CAN UTILIZE MAN/GROUND COORDINATION TO DEFINE CORRECTIVE ACTION.
8. PROVIDES AN UNDERSTANDING OF REASONS FOR FAILURE.
9. HAS ABILITY TO BY-PASS MALFUNCTIONS OF FAULT DETECTION AND ISOLATION SYSTEM.
10. CAN CANNIBALIZE PARTS OR COMPONENTS FROM ONE SYSTEM (NOT NEEDED AT THAT MOMENT) FOR USE IN A CURRENT CRITICAL SYSTEM.
11. CAN CONTINUE UNDER CONDITIONS OF DEGRADED PERFORMANCE, ATTAIN OPERATION WHERE AUTOMATIC SYSTEM WOULD JUST SHUT DOWN (OR WOULD HAVE TO AWAIT ANALYSIS AND SPECIAL INSTRUCTIONS).
12. PROVIDES DETAIL INFORMATION FOR DESIGN IMPROVEMENT & FUTURE DEVELOPMENT.

5/19/66

SUBSYSTEM LIFE EXTENSION
IMPORTANCE OF MAN'S ROLE
UNIQUE ABILITIES FOR TROUBLE SHOOTING/CORRECTIVE ACTION

1. MAN HAS REASONING ABILITY (UNMATCHED BY MACHINE), ADAPTABILITY (CAN REPROGRAM), AND VERSATILITY (CAN CORRECT ERRORS).
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12. PROVIDES DETAIL INFORMATION FOR DESIGN IMPROVEMENT & FUTURE DEVELOPMENT.

SUBSYSTEM LIFE EXTENSION
IMPORTANCE OF MAN'S ROLE
SPECIFIC EXAMPLES FOR AIRCRAFT AND SPACE FLIGHTS

- **X-15 EXPERIENCE**
  - FLIGHT 22 - PILOT SUCCESSFULLY RESET CONTROLS AND STARTED UPPER ENGINE AFTER INITIAL START FAILURE - MISSION SAVED.
  - FLIGHT 25 - PILOT MANUALLY RESET ALL CHANNELS AFTER STABILITY AUGMENTATION SYSTEM TRIPPED OUT - MISSION SAVED.
  - FLIGHT 50 - PILOT DIAGNOSED FROZEN LN_2 VALVE PROBLEM, CHANGED COOLING MODES AND THAWED VALVE - MISSION COMPLETED.
- **GEMINI EXPERIENCE**
  - GEMINI 5 - COOPER DISASSEMBLED, TROUBLE SHOT, AND REPAIRED RETICLE SIGHT FOR EXPERIMENTS. REPLACED FRAYED POWER CORD SHORTING OUT LIGHTING ELEMENTS WITH SPARE AND REASSEMBLED.
  - GEMINI 5 - ASTRONAUT REPLACED FRAYED O-RING SEAL FOR BLOOD PRESSURE CUFF IN PRESSURE SUIT WITH SPARE ITEM.
  - GEMINI 7 - ELECTRICAL CONNECTOR BETWEEN COMMAND PILOT SUIT AND SEAT UNLOCKED DURING MISSION, WAS RECONNECTED AND LOCKED BY ASTRONAUT.
  - GEMINI 8 - CREW INSERTED ALUMINUM FOIL FROM FOOD PACKAGE BETWEEN WINDOW AND FILTER TO BLOCK HEAT AND LIGHT DURING SLEEP PERIODS.
- **B-70 EXPERIENCE**
  - NOSE GEAR JAMMED BY DOORS IMPROPERLY SEQUENCED BY COMPUTER MALFUNCTION, CREW WITH GROUND ASSISTANCE DIAGNOSED PROBLEM, SHORTED-OUT HOLDING CIRCUIT WITH METAL CLIP ALLOWING GEAR TO BE LOWERED - AIRCRAFT SAVED.

SUBSYSTEM LIFE EXTENSION
APPLICATION OF 60 DAY "BUILDING BLOCK" SUBSYSTEMS
TO POSSIBLE GROWTH VEHICLE CONFIGURATIONS

(BASELINE) INTEGRAL T-IIIC(U) ORBITING VEH. 30 DAYS	INTEGRAL LDC-1 ORBITING VEH. 60 DAYS	RENDEZVOUS RESUPPLY VEH. 50-60 DAYS	RENDEZVOUS ORBITING VEH. 60-300 DAYS (DOCKING INTERFACE)
STRUCTURE	STRUCTURE	STRUCTURE →	STRUCTURE
P/L EQUIP	P/L EQUIP		P/L EQUIP.
INSTRUM/MON-ALARM	INSTRUM/MON-ALARM		INSTRUM/MON-ALARM
COMM/DATA MGT.	COMM/DATA MGT.		COMM/DATA MGT
ELECT PWR & DISTR.	ELECT PWR & DISTR.	ELECT PWR →	ELECT DISTR.
ACTS ELECT & PROP.	ACTS ELECT & PROP.	ACTS PROPULSION →	ACTS ELECTRONICS
EC/LS	EC/LS	CRYOGENICS →	EC/LS
CREW PROV & EQUIP	CREW PROV & EQUIP	CREW EQUIP →	CREW PROVISIONS
SPARES	SPARES	SPARES →	SPARES
GEMINI B	GEMINI B	GEMINI B	
EXPENDABLES	EXPENDABLES	EXPENDABLES	
MANNED	MANNED	MANNED (GEMINI B) ASCENT	MANNED (EXCEPT CREW ROT.)
AUTOMATIC OPS CAPAB	REDUNDANCY ALL CRITICAL SUBSYS	REDUNDANCY CRITICAL SUBSYS	REDUNDANCY ALL CRITICAL SUBSYS.
REDUNDANCY ALL CRITICAL SUBSYS	SPARES ALL CRITICAL SUBSYS	SPARES TRANSPORT FOR ALL SUBSYS ROV AS REQ'D. ON 50 DAY CYCLES.	SPARES ALL CRITICAL SUBSYS. REPLENISH ON 50 DAY CYCLE
SPARES MINIMAL, MAINLY FOR EC/LS SUBSYS	MAINT & REPAIR TOOLS & TEST EQUIP REPAIR AIDS		MAINT & REPAIR TOOLS & TEST EQUIP. REPAIR AIDS

MEAN MISSION DURATION CONCEPT

MEAN MISSION DURATION, $MMD_{ROV} = \int_0^{\text{Design Life, } L} R(t)\,dt$

FOR A SINGLE THREADED SYSTEM:

$$MMD = \theta\left(1 - e^{-\frac{L}{\theta}}\right)$$

WHERE θ = MEAN-TIME-TO-FAILURE OF THE SYSTEM

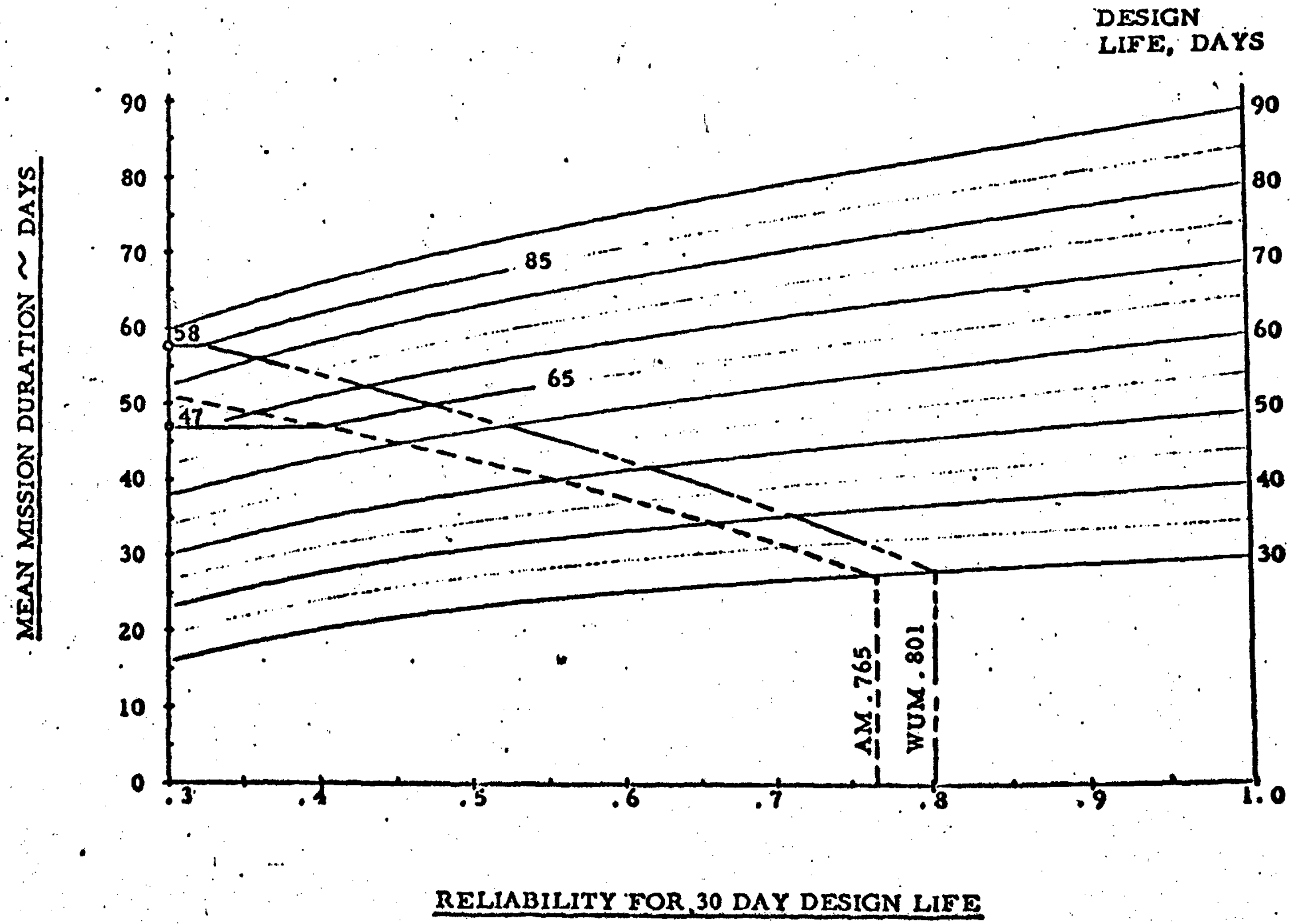
FOR A BASIC SYSTEM WITH STANDBY REDUNDANCY:

$$MMD = 2\theta\left[1 - e^{-\frac{L}{\theta}}\left(1 + \frac{L}{2\theta}\right)\right]$$

THE RENDEZVOUS ORBITING VEHICLE, WITH SOME SPARING AND MULTIPLE REDUNDANCY, OPERATES SIMILARLY TO THE SECOND EQUATION FOR A SYSTEM WITH STANDBY REDUNDANCY.

MEAN MISSION DURATION

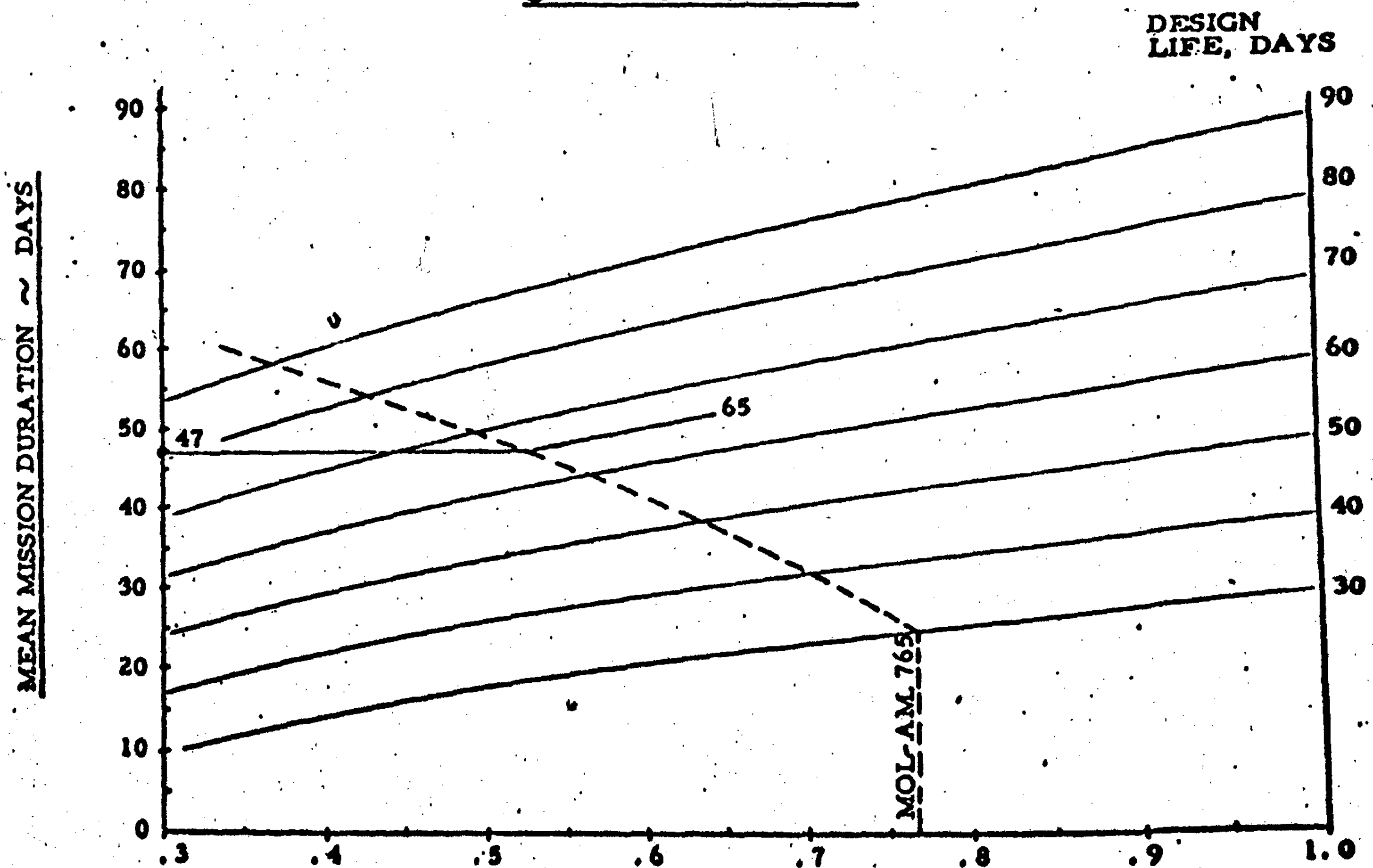
SIMPLIFIED RELIABILITY MODEL - STANDBY REDUNDANCY



MEAN MISSION DURATION

MOL - AM

Ⓐ COMPUTER MODEL



RELIABILITY FOR 30 DAY DESIGN LIFE

3/10/67
ALP

ESTIMATED VEHICLE RELIABILITIES AND SPARE ALLOTMENT

SUBSYSTEM	BASELINE 30 DAY DESIGN RELIABILITY	BASELINE 30 DAY DESIGN WT - SPARES (LBS)	60 DAY VEHICLE DESIGN RELIABILITY	60 DAY VEHICLE DESIGN WT - SPARES (LBS)
EPS				
FUEL CELLS	.994	----	.992(1)	----
DISTRIB. & CONTROL				18.0
EC/LS				
L.S./ATMOS CNTRL	.990	33.3	.988	60.0
THERMAL CNTRL	.994	----	.988	----
CRYOGENICS				
CRYOGENICS	.998	----	.995(2)	----
ACTS				
ELECTRONICS	.999	36.5	.996	72.0
PROPULSION	.998	----	.906	----
COMM	.9999	[illegible]	.9997	98.0
DATA MANAGEMENT	.985	----	.944	----
INSTR & MON/ALARM	.992	20.4	.991	44.0
STRUCTURE	.9998	1.5	.9996	8.0
LAB. VEH. SEG.	.950	192.0	.895	300.0
EXPERIMENTS	.960	----	----	----
GEMINI-B	.990	----	.988	----
TOTAL	.903	192.0	.884	300.0

(1) CONSIDERS 3 F. CELLS ON COLD STANDBY, ADDITIONAL SENSORS/SWITCHING FOR STARTUP AND PARTS OF DISTRIBUTION SYSTEM USED COMMONLY.
(2) DOUBLE TANKAGE OF BASELINE, BUT LESS DUTY CYCLE PER TANK SINCE NEAR BASELINE DEMAND.

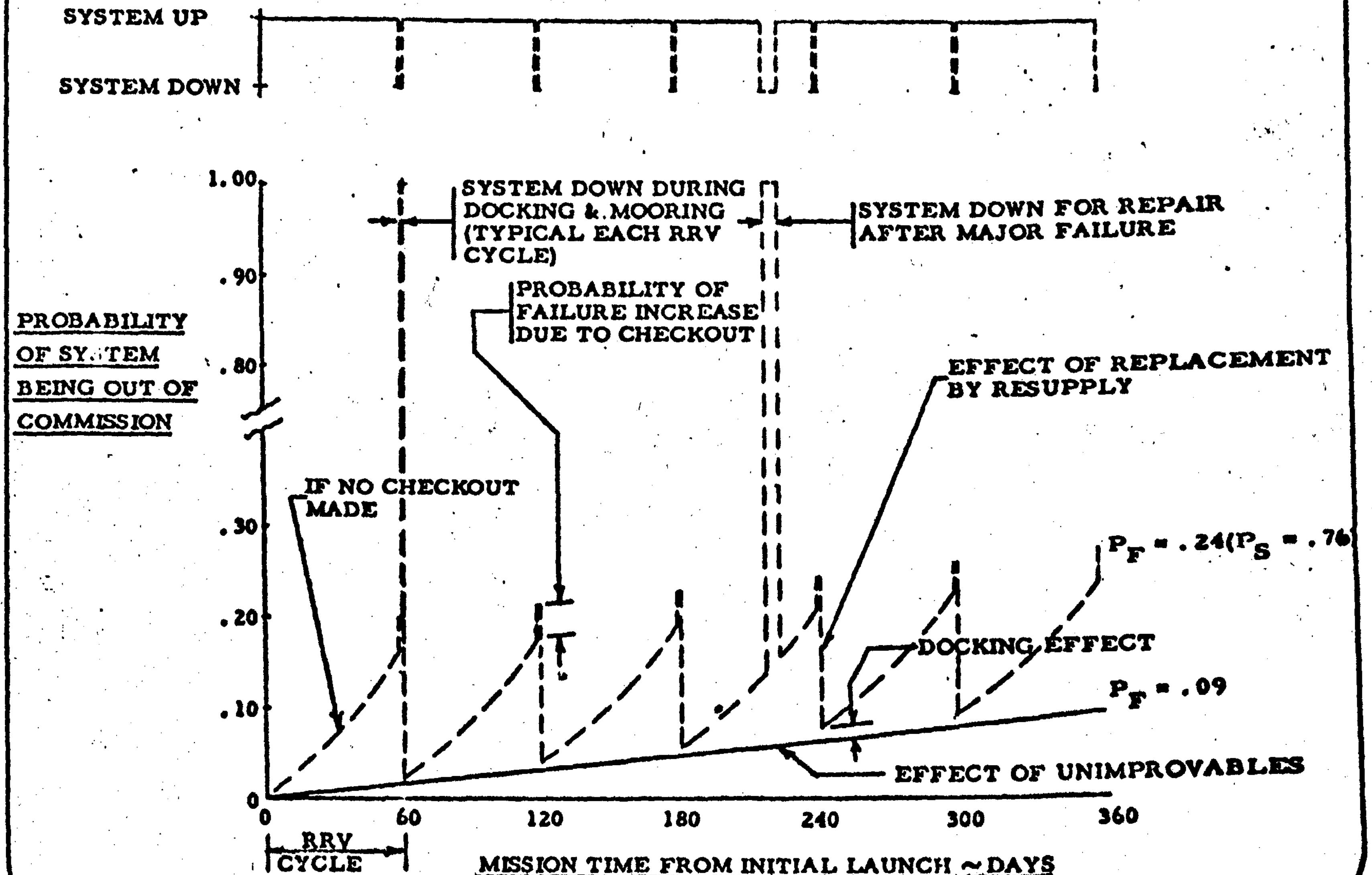
VEHICLE ESTIMATED PROBABILITIES OF SUCCESSFUL OPERATION

INITIAL LAUNCH RIV (1)	P_s (30 DAYS)	=	.88 (LAB) X .87 (M/M)	= .765
BASELINE M/AM	P_s (30 DAYS)	=	.95 (LAB) X .96 (M/M) X .99 (GEM)	= .903
M/AM(2)	P_s (30 DAYS)	=	.960 (LAB) X .96 (M/M)	= .922
RIV	P_s (60 DAYS)	=	(60 DAY DESIGN, SPARES WT. = 375 LBS)	= .888
RRV	P_s (60 DAYS)	=	.988 (GEM) X .979 (MODULE LESS DATA) X .99 (DATA)	= .958
ROV	P_s (60 DAYS)	=	.888 (RIV) X .958 (RRV)	= .851

(1) UNATTENDED, WITHOUT GEMINI

(2) PROPULSION, CRYOGENICS, FUEL CELLS AND GEMINI REMOVED FROM BASELINE M/AM

RENDEZVOUS ORBITING VEHICLE AVAILABILITY FOR LONG DURATION



CONCEPT OF EXTENDED LIFE SYSTEMS

(RESUPPLY SYSTEM)

- COMPLETE REPLACEMENT EACH RESUPPLY CYCLE
  - ✓ FUEL CELLS
  - ✓ CRYOGENIC TANKAGE
  - ✓ THRUST CHAMBER ASSY.
  - ✓ PROPELLENT TANKS/FUEL SYSTEMS
- INTENSE APPLICATION OF SPARES FOR MANNED MAINTENANCE/ REPAIRS/REPLACEMENT.
- UTILIZATION OF MAN IN TROUBLE-SHOOTER ROLE
- ELIMINATION OF MAJOR EQUIPMENT PROBLEMS DURING INITIAL MOL DEVELOPMENT PROGRAM.

4-8

SUBSYSTEM LIFE EXTENSION SUMMARY

- COMBINATIONS OF LIFE EXTENSION METHODS APPEAR MOST EFFECTIVE FOR MOL AND FURTHER STUDIES ARE REQUIRED TO DEFINE OPTIMUM APPROACHES
- M/AM ORBITING VEHICLE DESIGN INCORPORATES MUCH REDUNDANCY
- FOLLOW-ON LONGER-LIFE ORBITING VEHICLES SHOULD UTILIZE M/AM REDUNDANCY TO GREATEST ADVANTAGE
  - REDUNDANT EQUIPMENT BACKED-UP WITH SPARES FOR 60 DAYS OR LONGER
  - PROVIDE FOR "PLUG-IN" REPLACEMENT CAPABILITY AT MODULE LEVEL
  - MODULES TO PROVIDE FOR COMPONENT REPLACEMENT WHERE ADVANTAGEOUS
    - ✓ OPTIMIZED FOR WEIGHT/COMPLEXITY/REPAIR TIME/FAILURE MODES
    - ✓ MAXIMIZE USE OF PART COMMONALITY (CIRCUIT CARDS, SWITCHES)
  - RETAIN AUTO AND REMOTE CONTROL SWITCHING FEATURES OF M/AM WHERE ADVANTAGEOUS
    - ✓ CREW ROTATION DURING RENDEZVOUS/DOCKING
- 60 DAY SUBSYSTEMS WITH SPARES PROVISIONING APPEAR TO BE "BUILDING BLOCKS"
  - INTEGRAL LAUNCH WITH LDC-1
  - RENDEZVOUS/RESUPPLY VEHICLE WITH T-IIIC (U)
  - MAINTAINABLE SUBSYSTEMS FOR 60-300 DAY RENDEZVOUS ORBITING VEHICLE
- SPECIAL CONSIDERATIONS FOR 60-300 DAY RENDEZVOUS ORBITING VEHICLE INCLUDE
  - METEOROID CRITERIA
    - ✓ ADD APPROX 200 LB. (PRES. STRUCT. & RADIATOR) OR ACCEPT 0.990 PROB. OF NO PUNCTURE
  - PLAN FOR ACCOMPLISHMENT OF MORE EXTENSIVE MAINTENANCE BY CREW
    - ✓ EVA FOR ACCESS AND REPLACEMENT FOR EXTERNALLY MOUNTED EQUIPMENT
    - ✓ LIQUID LOOP COMPONENT REPLACEMENT (VALVES/PUMPS/FILTERS)
- IMPLEMENTATION
  - GROUND TEST PROGRAM FOR EQUIPMENT AND COMPONENTS
    - ✓ DEFINE LIFE AND DETERMINE WEAK POINTS
    - ✓ MAKE NECESSARY IMPROVEMENTS FROM ANALYSIS AND TEST DATA
  - ADDITIONAL QUALIFICATION PROGRAM FOR IN SPACE START FUEL CELLS & TANKS
  - FWD LOOKING DESIGN APPROACH FOR M/AM TO FACILITATE MAINT. & INSTALL SPARES

SUMMARY OF EXTENDED VEHICLE LIFE

- MEAN MISSION DURATION FOR MAJORITY OF BASELINE SUBSYSTEM EQUIPMENT APPROACHES 60 DAYS.
- UNFIXABLE VEHICLE EQUIPMENTS ARE FEW, TEND TO BE PASSIVE ELEMENTS OR HAVE EXTREMELY LOW PROBABILITY OF FAILURE.
- COMPLETELY REPLACE LIFE-LIMITED EQUIPMENT AND WEAR-OUT ITEMS AT RESUPPLY INTERVALS.
- INTENSE APPLICATION OF SPARES FOR MANNED MAINTENANCE/REPAIRS/REPLACEMENT WITH SPARES UPDATED AND REPLENISHED AT EACH RESUPPLY CYCLE.
- CREW TROUBLE SHOOTS PROBLEMS IN CONJUNCTION WITH GROUND TO PROVIDE A HIGHLY EFFECTIVE TEAM FOR DIAGNOSIS AND CORRECTIVE ACTION.
- PROJECTED VEHICLES AVAILABILITIES SHOULD BE ATTAINABLE WITH MINIMUM CHANGES TO BASELINE SUBSYSTEMS.
  - 5 FULL DEVELOPMENT FLIGHTS IN BASELINE PROGRAM

UNFIXABLE VEHICLE EQUIPMENT EXAMPLES

- ITEMS AFFECTING MISSION ABORT
  - MALFUNCTION OF INACCESSIBLE COMPONENTS
    - √ PROPELLANT/CRYOGENIC FLUID LINE AND TANK LEAKAGE
    - √ WATER LINE, TANK AND HEAT EXCHANGER LEAKAGE
    - √ DEBRIS TRAP MALFUNCTION
    - √ LEAKAGE OF STRUCTURAL SHELL
    - √ INACCESSIBLE TERMINALS AND WIRING FAILURE
  - MULTIPLE FAILURES OF REDUNDANT EQUIPMENT
  - LOSS OF PRIMARY COMPONENT AND EXHAUSTION OF SPARED EQUIPMENT STOCK

- ITEMS AFFECTING SYSTEM PERFORMANCE
  - FAILURE OF EQUIPMENT WHICH IS INHERENTLY INCOMPATIBLE WITH REDUNDANCY
    - √ DRIVE MIRROR
    - √ FLAT MIRROR
    - √ ROSS CORRECTOR SYSTEM
    - √ THERMAL DOORS
  - LOSS OF EQUIPMENT WITH SUCH HIGH RELIABILITY THAT REDUNDANCY IS NOT ECONOMICAL
  - SIMILAR COMMENTS AS ABOVE FOR INACCESSIBLE, REDUNDANT AND SPARED EQUIPMENT

THE UNRELIABILITY OF SINGLE UNFIXABLE COMPONENTS IS EXTREMELY SMALL; BUT A FINITE UNRELIABILITY FOR SUMMED UNFIXABLE EQUIPMENT EXISTS.