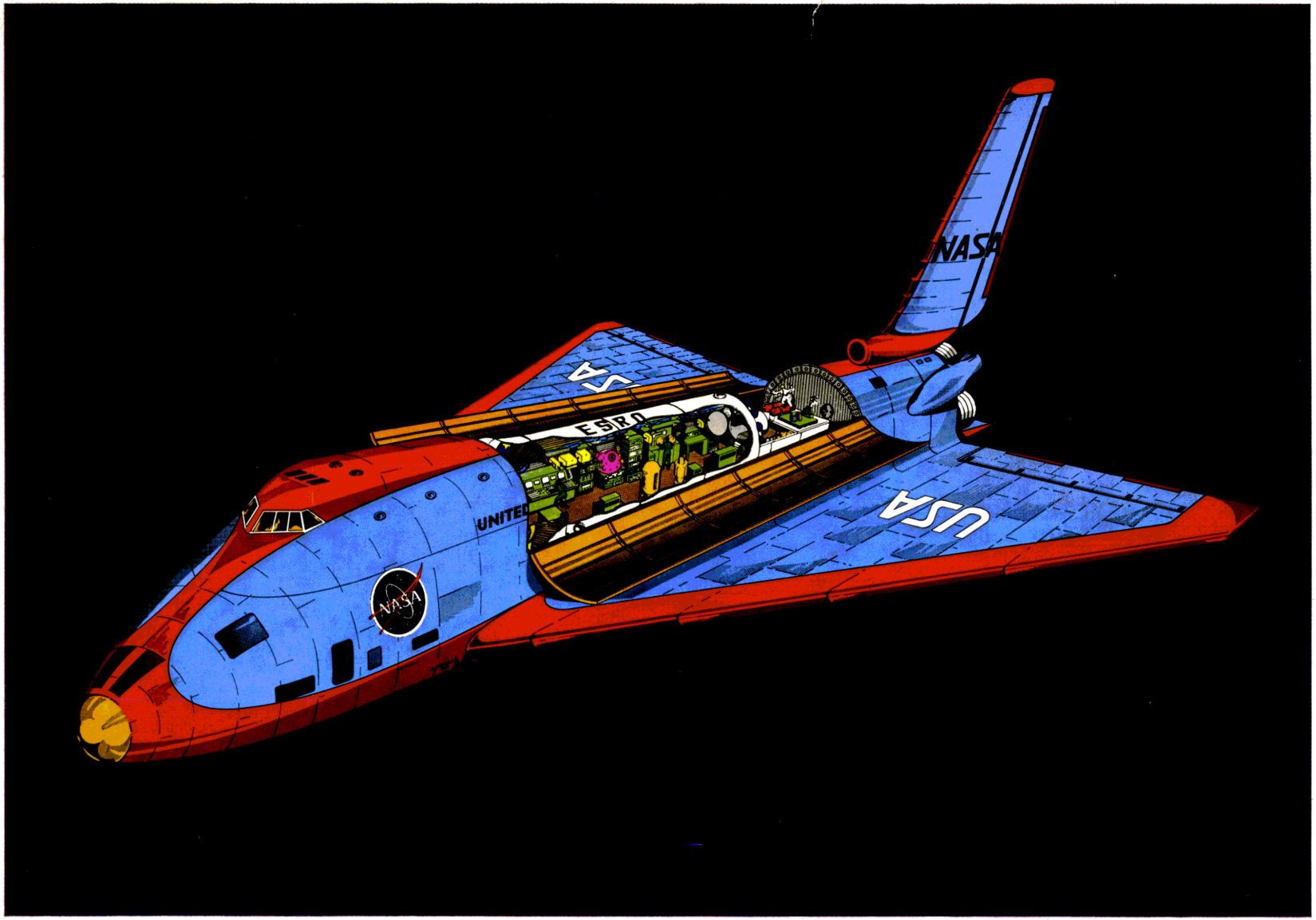
ERNO VFW-FOKKER

AEG-AERITALIA-BTM-DORNIER-FOKKER/VFW-HSD-INTA-MATRA-SABCA-SEL-TCSF

SL-B2

Final Presentation

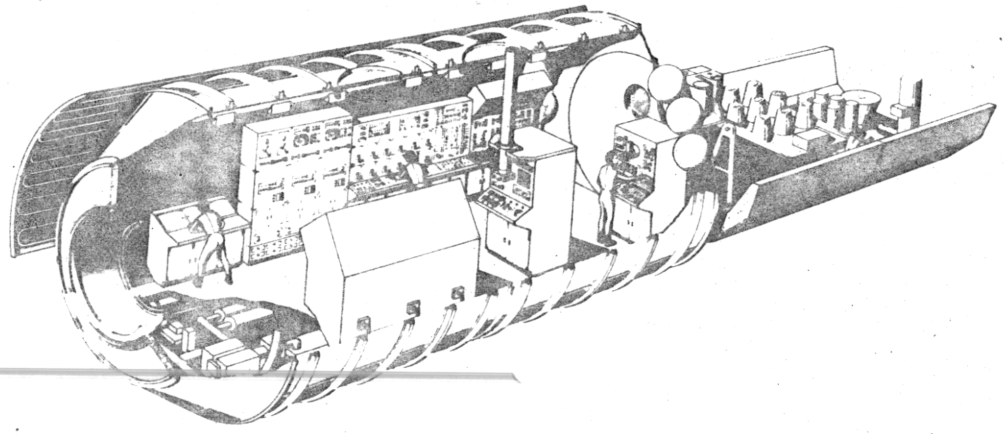


VOLUME 1

Briefing Brochure

JUNE 1973

ERNO-VFW/FOKKER



PHASE B2 FINAL PRESENTATION

TO ESRO/ESTEC-NASA

Noordwijk, 28th of June 1973

AGENDA

INTRODUCTION	-	PROF. G. EGGERS
STUDY OVERVIEW	-	H. HOFFMANN
STUDY APPROACH	-	K. BERGE
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MECHANICAL SUBSYSTEMS	-	W. WIENSS
ELECTRICAL SUBSYSTEMS	-	H. J. POSPIESZCZYK
PROGRAM CONCEPT	-	K. BERGE
PROGRAM VARIATIONS	-	K. BERGE
CONCLUSIONS & RECOMMENDATIONS	-	H. HOFFMANN

SIGNIFICANCE OF SPACELAB PROGRAM TO EUROPE

- ESTABLISHES EUROPEAN ROLE IN MANNED SPACE
- INSURES EUROPEAN INFLUENCE IN EXPLORATION OF SPACE AND EARTH
- STRENGTHENS MULTI-NATIONAL COOPERATION AND INTERDEPENDENCE
- ADVANCES EUROPEAN TECHNOLOGY

N.V. Koninklijke Nederlandse Vliegtuigenfabriek Fokker, Amsterdam — 50%

VFW-Verwaltungsgesellschaft mbH, Bremen — 50%

ZENTRALGESELLSCHAFT VFW-FOKKER mbH, DÜSSELDORF

100%
- Fokker-VFW B.V., Amsterdam
  - Fokker-VFW Schiphol Plant
  - Fokker-VFW Drechtsteden Plant
  - Fokker-VFW Avio-Fokker Ypenburg
  - Fokker-VFW Avio-Fokker Woensdrecht
  - Lichtwerk B.V., Hoogeveen
    - S.E.C.B.A.T. S.a.r.l., Paris
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100%
- Handelmij. Avio-Diepen B.V., Amsterdam

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  - 42,8% S.A. Belge de Constructions Aéronautiques S.A.B.C.A., Brussels
  - 50% Henschel Flugzeug-Werke AG, Kassel

100%
- ERNO Raumfahrttechnik GmbH, Bremen
  - 92,3% Elektro-Mechanischer Fluggerätebau GmbH, Hamburg

100%
- Rhein-Flugzeugbau GmbH, Mönchengladbach
  - 50% Sportavia-Pützer GmbH & Co. KG, Dahlem/Eifel

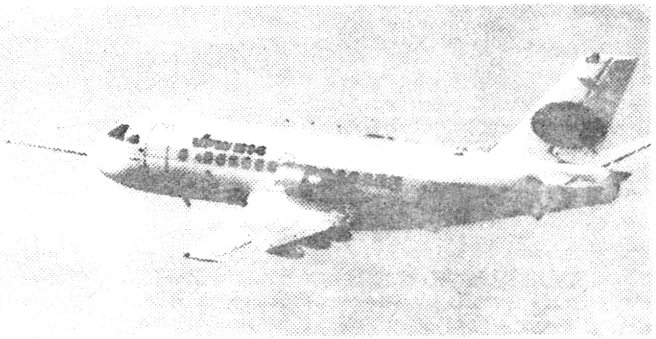
100%
- Vereinigte Flugtechnische Werke-Fokker GmbH, Bremen
  - VFW-Fokker Bremen Plant
  - VFW-Fokker Lemwerder Plant
  - VFW-Fokker Speyer Plant
  - VFW-Fokker Einswarden Plant
  - VFW-Fokker Varel Plant
  - VFW-Fokker Hoykenkamp Plant
  - Deutsche Airbus GmbH, Munich
  - „Weser" Wohnstätten GmbH, Einswarden

VFW-FOKKER

Schematic Diagram of the Company Structure and Major Participations

MAJOR PROGRAMS OF THE VFW-FOKKER GROUP

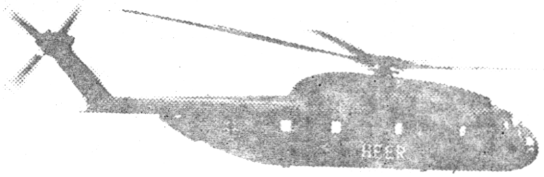
TURNOVER 1972: 1,2 BILL.DM
EMPLOYEES: APPR. 18.000



VFW 614

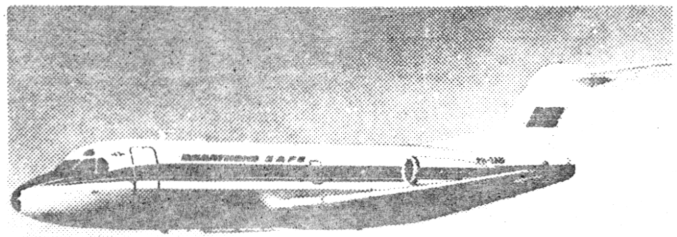


VTOL
AIRCRAFT
VAK 191 B



CH - 53 G

F 28
FELLOWSHIP

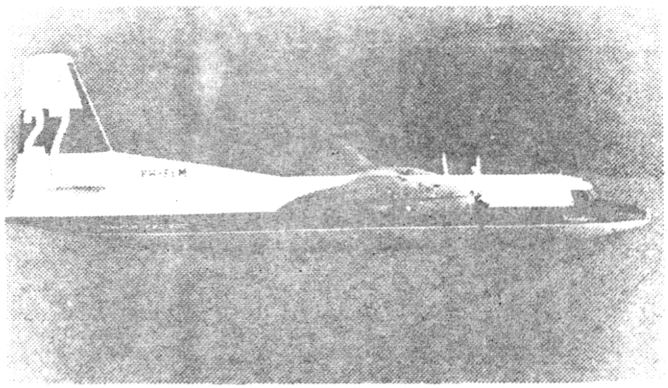




C 160
TRANSALL



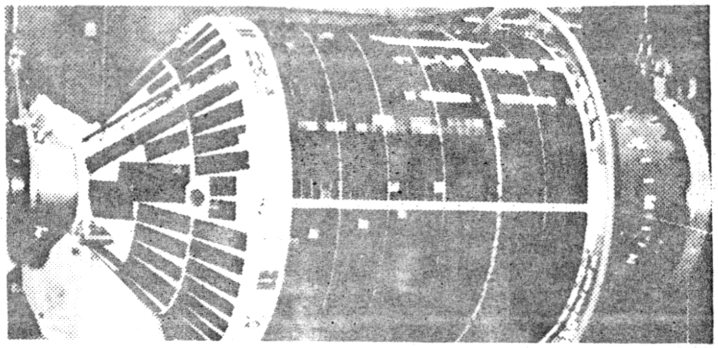
F 27
FRIENDSHIP

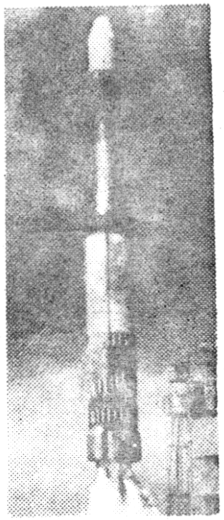


MAJOR PROGRAMS OF ERNO

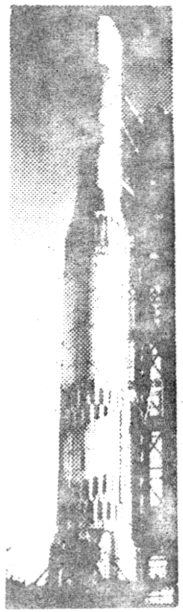
TURNOVER 1972: 60 MILL.DM
EMPLOYEES: APPR. 1.100

AZUR 625 A 1





EUROPA I



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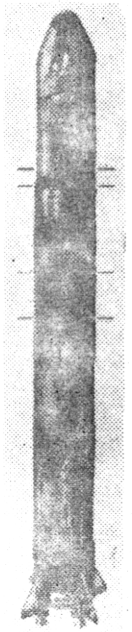
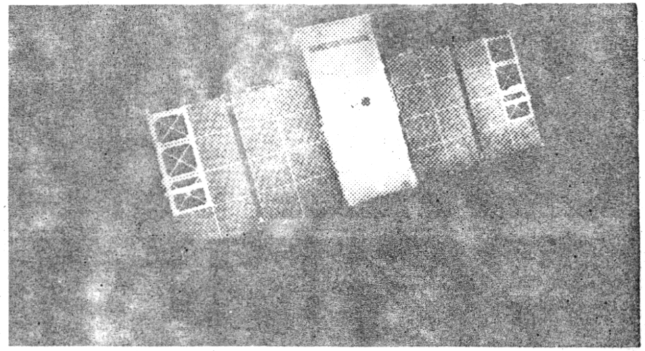
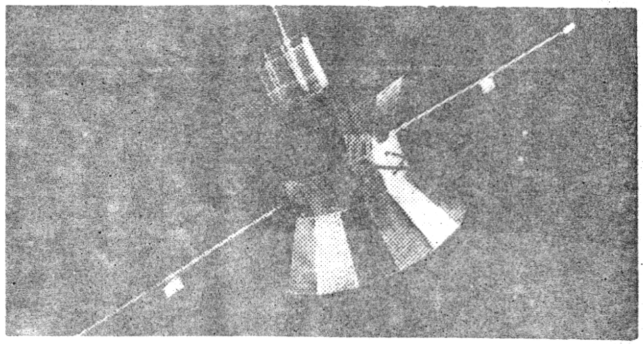


EUROPA III

TD 1-A



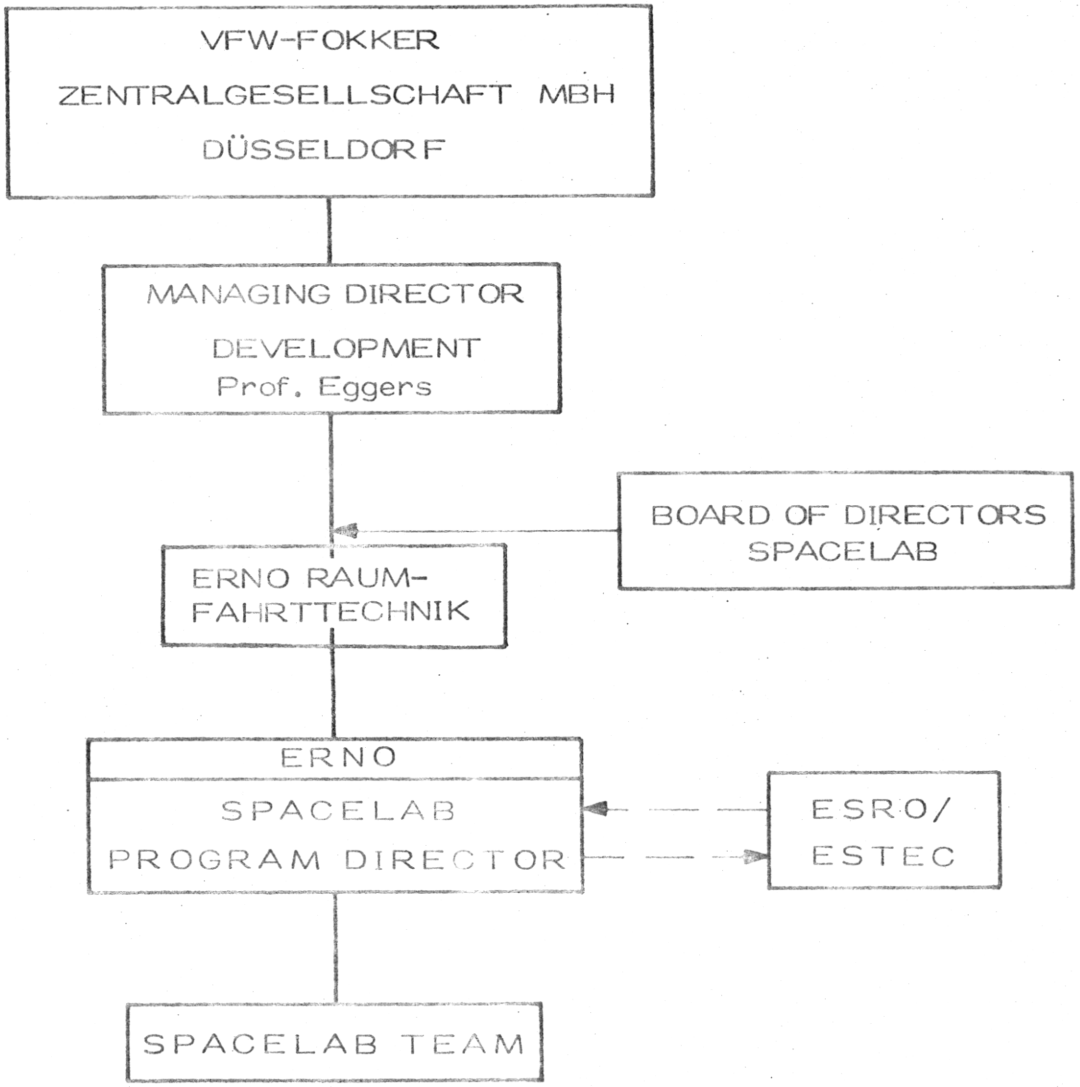


HELIOS

SPACELAB MANAGMENT

- THE VFW FOKKER GROUP IS TOTALLY COMMITTED TO SUPPORT OF THE SPACELAB PROGRAM
- ERNO WILL BE DESIGNATED PRIME CONTRACTOR
- THE ERNO CONSORTIUM CONSISTS OF NINE EXPERIENCED EUROPEAN AEROSPACE COMPANIES
- THE BOARD OF DIRECTORS IS MADE UP OF THE MANAGING DIRECTORS OF EACH COMPANY
- THE CHAIRMAN OF THE BOARD OF DIRECTORS IS PROFESSOR EGGERS OF VFW-FOKKER, DÜSSELDORF

ORGANIZATIONAL RELATIONSHIP ERNO-VFW/FOKKER



SPACELAB CONSORTIUM

CHAIRMAN - BOARD OF DIRECTORS
PROF. EGGERS
VFW - FOKKER

ERNO RAUMFAHRT-TECHNIK	AERITALIA	ENGINS MATRA	HAWKER SIDDELEY DYNAMICS LTD.	AEG-TELE-FUNKEN	DORNIER A.G.	BELL TELE-PHONE MANU-FACTURING COMPANY	INTA
MR. HOFF-MANN (TECHNICAL DIRECTOR) MR. KOSE-GARTEN (COMMER-CIAL DIRECTOR)	T. B. D.	MR. LAGAR-DÈRE (DIREC-TEUR GÉNÉ-RALE)	DR. HOUGH (DEPUTY MANAGING DIRECTOR)	DR. VON WRANGEL (TECHNICAL DIRECTOR)	DR. SCHMIDT (MEMBER OF THE BOARD OF DIRECTORS DORNIER)	MR. VAN POUCKE (MANAGER LINE&RADIO TRANSMIS. DIVISIONS)	COL. PEREZ DEL PUERTO (INTA DEPART-MENT HEAD)

FUNCTION OF SPACELAB BOARD OF DIRECTORS

- REPRESENT THE JOINT EFFORTS AND CAPABILITIES OF THE PARTICIPATING COMPANIES
- PROMOTION OF THE SPACE LAB DEVELOPMENT BY SUB-ORDINATION OF INDIVIDUAL INTERESTS TO THE COMMON INTEREST
- TO DISCUSS ESSENTIAL QUESTIONS AND PROBLEMS AND TO AGREE ON SOLUTIONS IN A FORM BINDING ALL PARTICIPANTS
- MEETINGS WILL TAKE PLACE AT THREE MONTHS INTERVALS AND PRIOR TO ESSENTIAL MILESTONES AS REQUIRED

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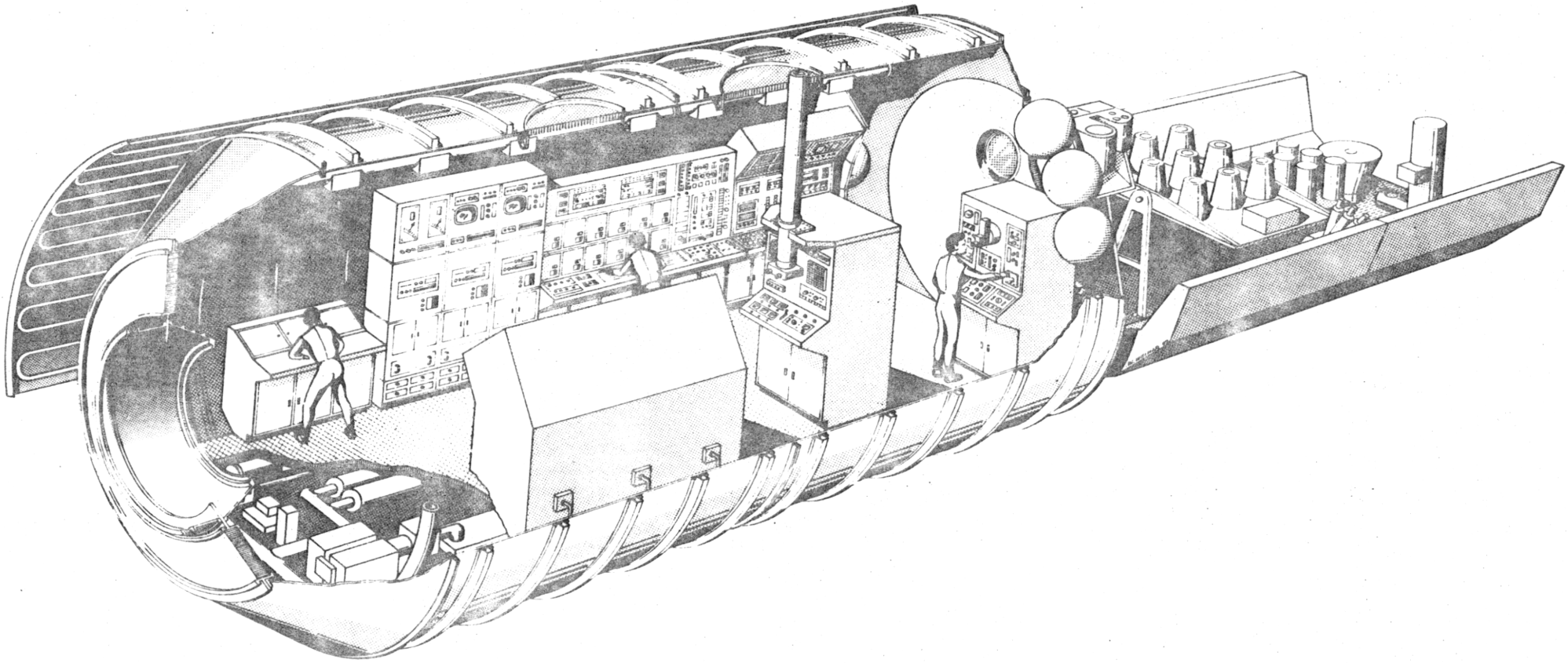
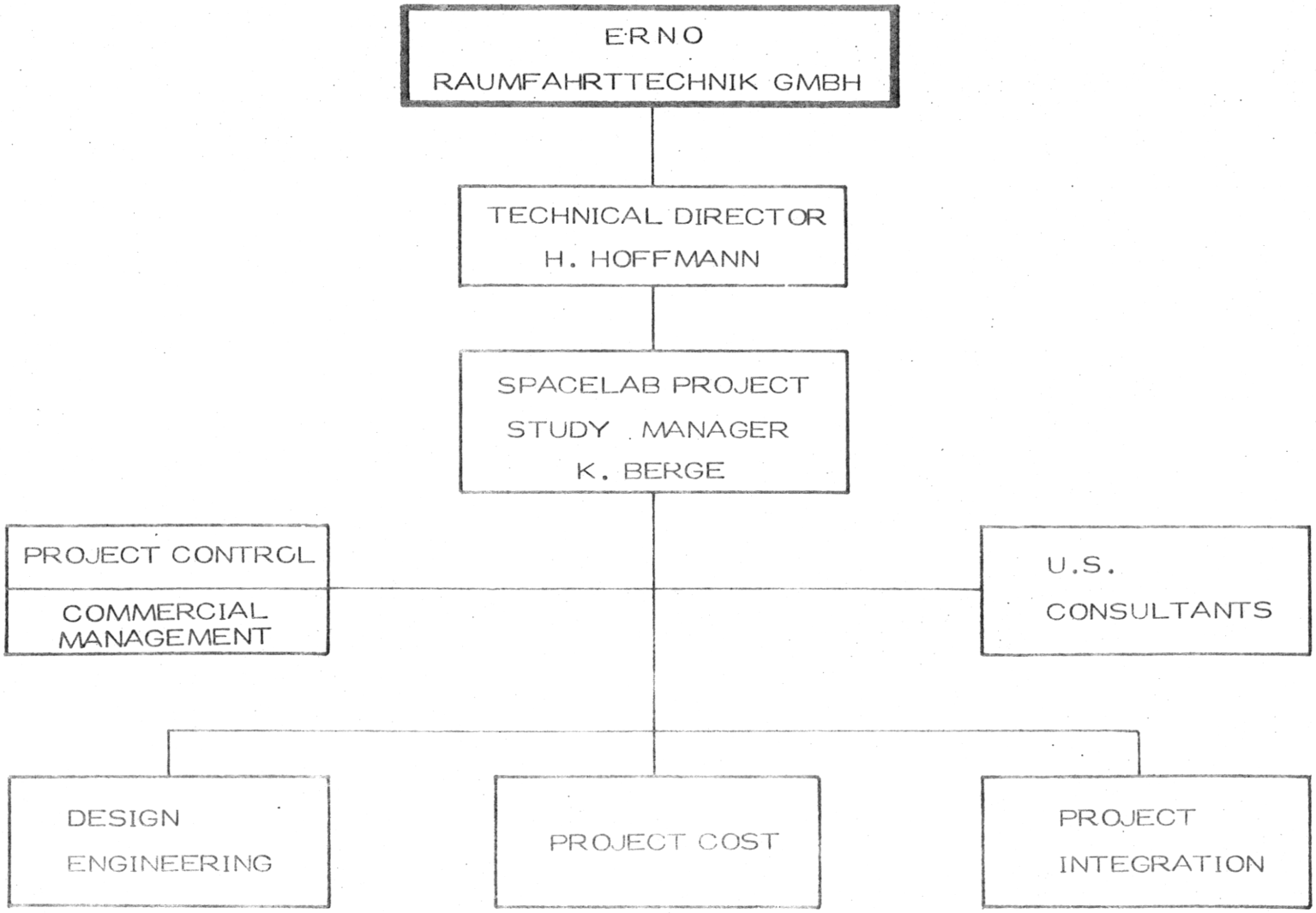
RECOMMENDED SPACELAB CONCEPT



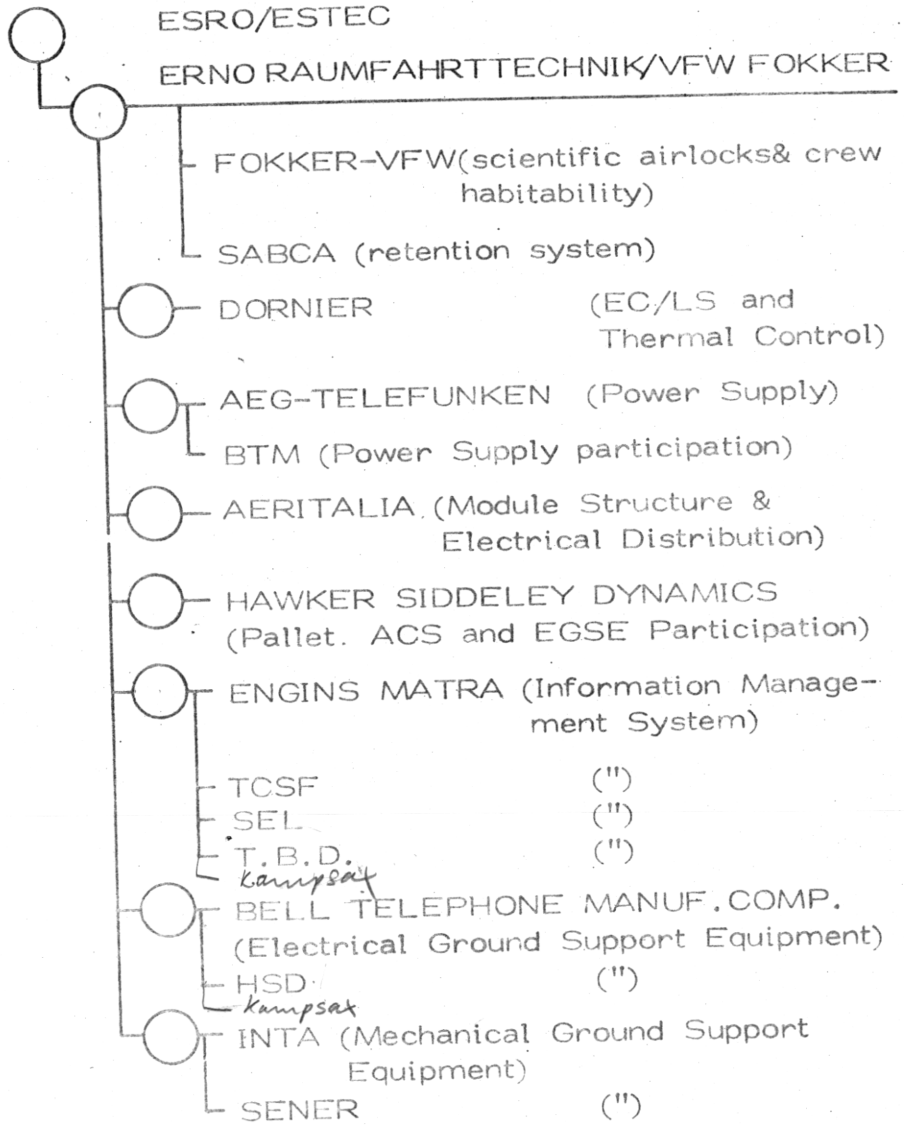
STUDY SPACELAB ORGANISATION



THE STUDY TEAM AND THE DISTRIBUTION OF MAJOR TASKS

ERNO - VFW/FOKKER
- PRIME CONTRACTOR -

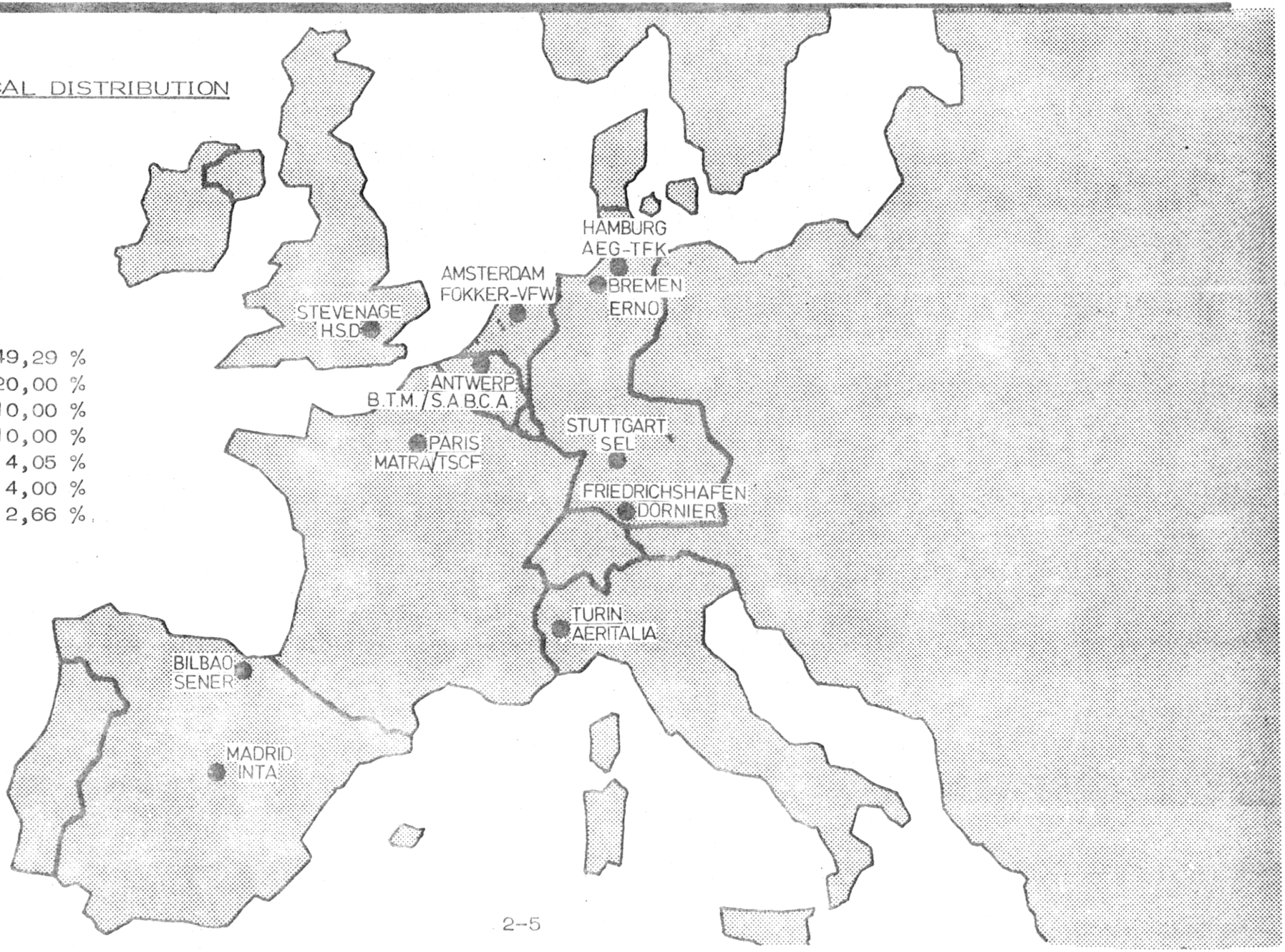
• DORNIER	GERMANY
• AEG-TELEFUNKEN	GERMANY
• SEL	GERMANY
• AERITALIA	ITALY
• INTA	SPAIN
• SENER	SPAIN
• BTM	BELGIUM
• SABCA	BELGIUM
• HSD	ENGLAND
• MATRA	FRANCE
• TCSF	FRANCE
• FOKKER - VFW	NETHERLANDS
	FRANCE
+ MDC & TRW-SYSTEM	USA



GEOGRAPHICAL DISTRIBUTION

PARTICIPATING COUNTRIES

GERMANY	49,29 %
ITALY	20,00 %
ENGLAND	10,00 %
FRANCE	10,00 %
BELGIUM	4,05 %
NETHERLANDS	4,00 %
SPAIN	2,66 %



QUESTIONS ANSWERED IN PHASE B2

1. WHAT IS A REASONABLE PROGRAMMATIC/DESIGN CONCEPT FOR SPACELAB WHICH COST NO MORE THAN 175 M.A.U. ?

2. TO WHAT EXTENT DOES THIS CONCEPT DIFFER FROM CUSTOMER GUIDELINES & REQUIREMENTS?

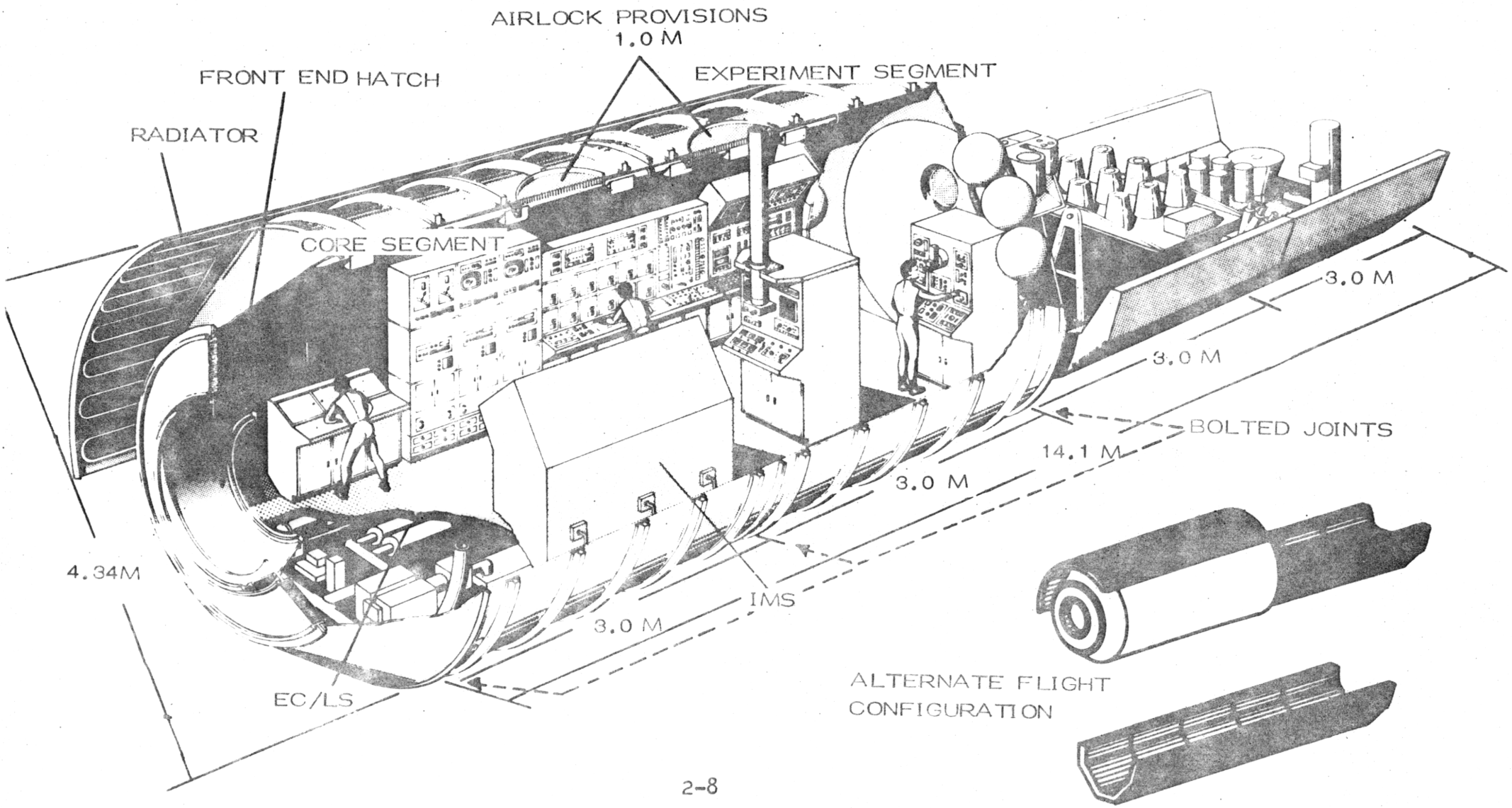
3. WHAT VARIATIONS (DELTA'S) IN PROGRAMMATICS AND DESIGN CAN BE APPLIED SHOULD THE 175 M.A.U. TARGET COST BE INCREASED OR DECREASED?

175 MAU PROGRAM IS FEASIBLE

COST SUMMARY

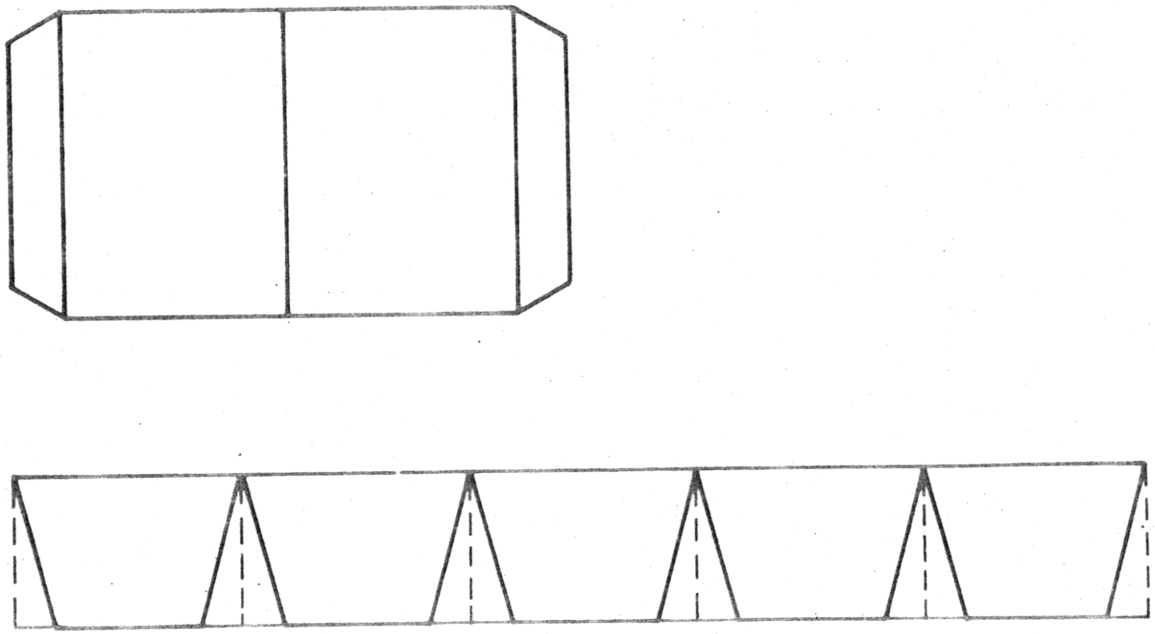
	M.A.U.
EUROPEAN DEVELOPMENT & INITIAL PRODUCTION	147,6
U.S. PROCUREMENT (10,27 % OF TOTAL)	18,0
CONTRACTORS' FEE	9,9
TOTAL PROGRAM ESTIMATE	175,5

EXTERIOR CONFIGURATION

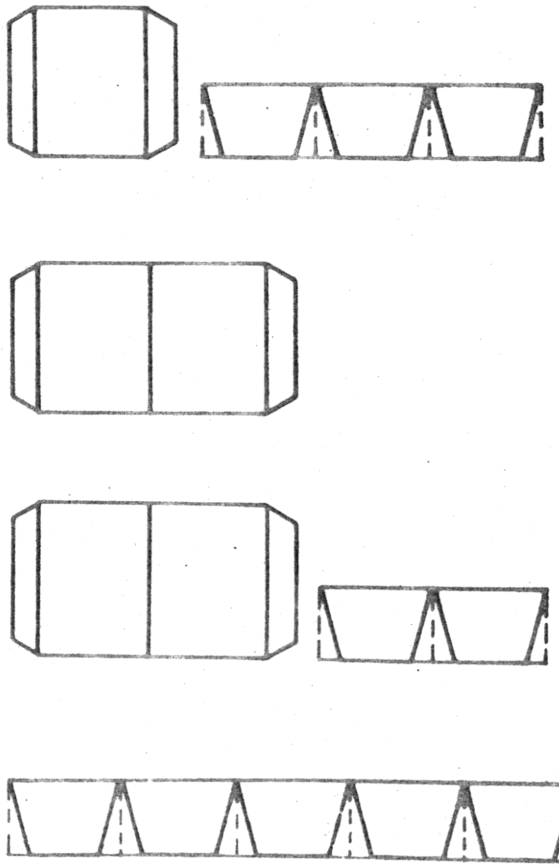


RECOMMENDED SPACELAB

FLIGHT HARDWARE CONTENT



MISSION USES

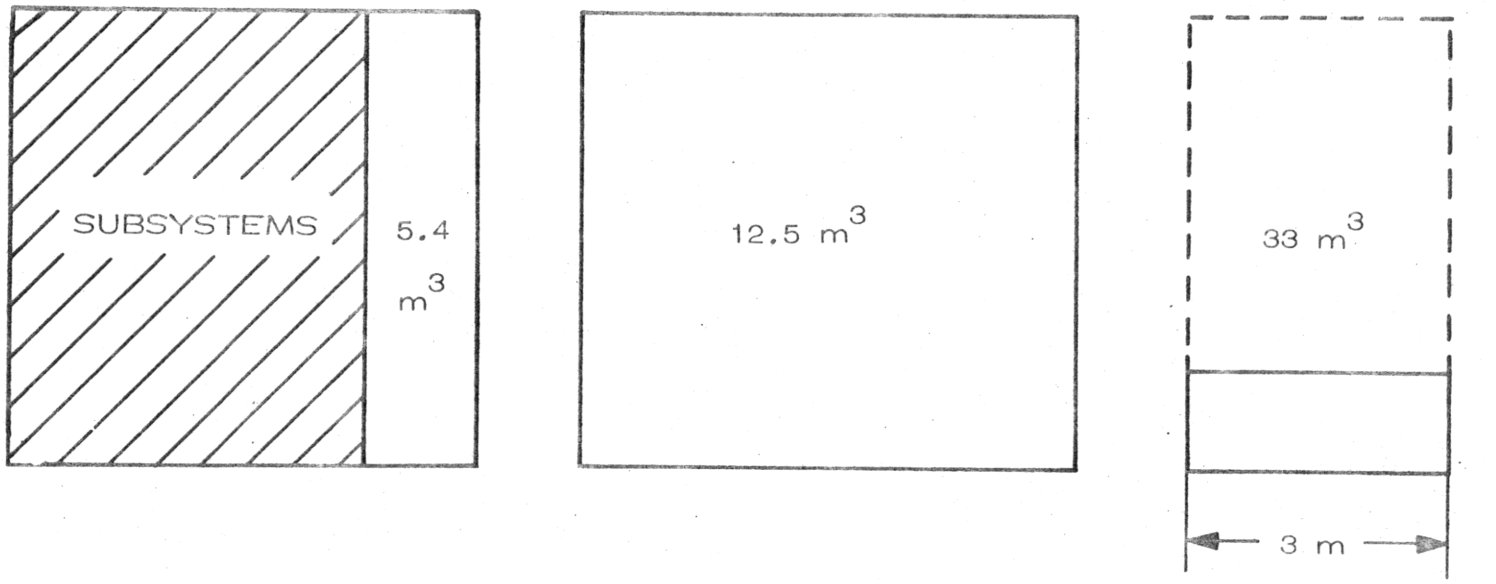


AND OTHER COMBINATIONS

CHARACTERISTICS OF THE RECOMMENDED SPACELAB CONFIGURATION

- GENERAL PURPOSE LABORATORY
- MODULAR CONCEPT
  - SEGMENTED PRESSURE SHELL
    - SUBSYSTEMS IN CORE SEGMENT
    - DEDICATED SEGMENT FOR EXPERIMENTS
  - SEGMENTED PALLET
  - SEGMENTS CAN BE ASSEMBLED IN VARIOUS COMBINATIONS
- GROWTH POTENTIAL PROVIDED THROUGH ADDITION OF EXPERIMENT SEGMENTS

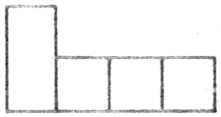
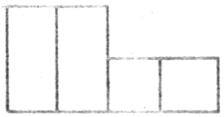
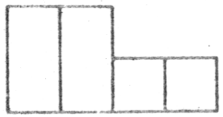
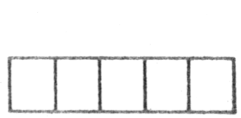
PAYLOAD LENGTH AND VOLUME CAPABILITY



CORE SEGMENT EXPERIMENT SEGMENT PALLET SEGMENT

SPACELAB RESPONSIVNESS TO PAYLOAD CONFIGURATION

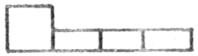
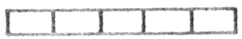
SIZING REQUIREMENTS

REFERENCE MISSION	A ASTRONOMY	B EARTH OBS OR COMM/NAV	C MATL.SC. OR LIFE SC	D SPACE PHYSICS	E TECHNOLOGY
MODULE REQMT (VOLUME)	1.03 m^3	7.25 m^3	9.5 m^3	14.5 m^3	——
PALLET REQMT (LENGTH)	9 m	6 m	——	6 m	15 m (EVA ACCESS)
REQUIRED CONFIGURATION					

SPACELAB RESOURCES AND SERVICES FOR USERS

RESOURCES

- VOLUME
  - CORE SEGMENT — 5.4 m^3
  - EXPERIMENT SEGMENT — 12.5 m^3
  - PALLET (EACH) — 33.0 m^3

- MASS
  -  — 7.120 kg
  -  — 5.990 kg
  -  — 7.850 kg

- ELECTRICAL POWER
  - AVERAGE — 3.6 KW
  - PEAK — 8.6 KW
  - VARIETY — 28 VDC, 115/200 VAC, 400 Hz

- THERMAL CAPACITY
  - AVERAGE — 2.2/7.8 KW
  - PEAK — 9.3 KW

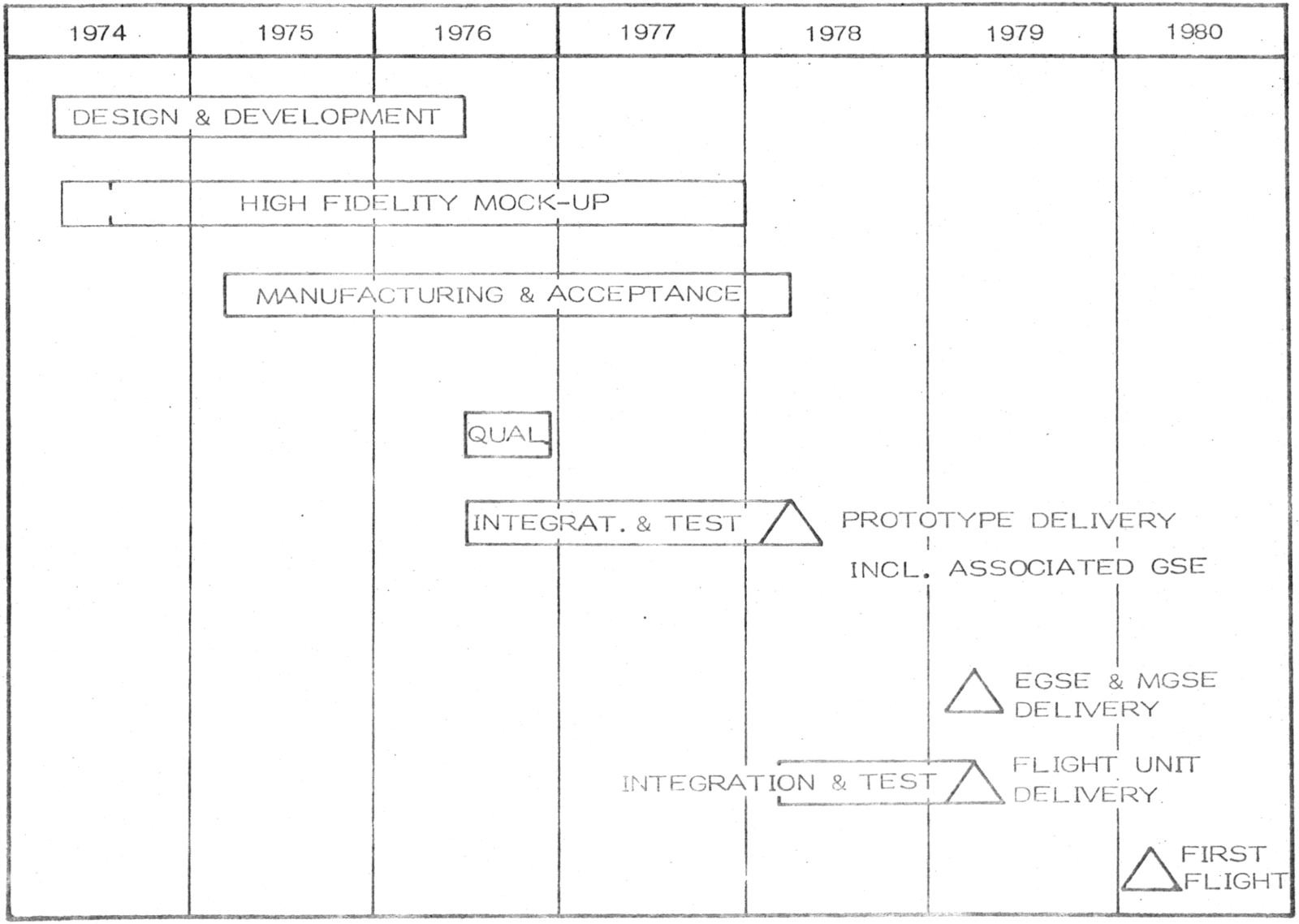
SPACELAB RESOURCES AND SERVICES FOR USERS (CONT'D)

- DATA STORAGE — 4×10^{10} BITS/REEL
- POINTING (ORBITER PROVIDED) — $\pm 0.1^{\circ}$ ($\pm$ 20 ARC. SEC.)

SERVICES

- POWER CONDITIONING
- DATA CONDITIONING, RECORDING, FORMATTING & DISPLAY
- EVENT TIMING & SEQUENCING
- CHECKOUT AND MONITORING
- CAUTION AND WARNING
- MANIPULATION
- WORK AREAS AND PROVISIONS

RECOMMENDED PROGRAM SCHEDULE



FEATURES OF RECOMMENDED PROGRAM

- 59 MONTHS SCHEDULE TO FLIGHT UNIT DELIVERY
- HIGH FIDELITY MOCKUP FOR DEVELOPMENT
- MULTIPLE USE OF TEST ARTICLES
- CONCENTRATED TESTING AT SUBSYSTEM LEVEL
- PROTOTYPE DELIVERED INSTEAD OF ENGINEERING MODEL(S)
- TWO SETS OF GSE
- ONE SET OF SIMULATORS & UNIT TESTERS
- ENGINEERING MODELS (ELECTRICAL & MECHANICAL) FOR SUBSYSTEM DEVELOPMENT

PROGRAM DEVIATIONS TO STAY WITHIN 175 MAU

	ESTEC REQUIREMENTS	BASELINE PROGRAM 175 MAU
A. SCHEDULE		
• FLIGHT UNIT DELIVERY	56 MONTHS	59 MONTHS
B. HARDWARE QUANTITIES		
• SPACELAB MOCKUP	1	1
• ENGR MODEL SPACELABS	2	1 (partly integrated)
• PROTOTYPE SPACELAB	1	1
• FLIGHT SPACELAB	1	1
• GSE (SETS)	3	2
• S/L SIMULATORS	2	1
• UNIT TESTERS	3	1 +(1)
C. MISSION SUCCESS		
• GOAL	0.95	0.94
D. PROCUREMENT FROM U.S.		
• GOAL	MINIMIZE	10.30 %

PROGRAM DEVIATIONS (CONT'D)

	ESTEC REQUIREMENTS	BASELINE PROGRAM
PAYLOAD SUPPORT		
COMMON PAYLOAD SUPPORT EQUIPMENT	MAXIMIZE COMMON SUPPORT FOR REFERENCE MISSIONS	• 100% PROVISIONS • EQUIPMENT LIMITED BY BUDGET
AUTONOMY FROM SHUTTLE		
THERMAL CONTROL	TBD, SHUTTLE SUPPORT FOR PALLET-ONLY MISSION	• ORBITER SUPPLEMENT
IMS	TBD	• ORBITER COMPUTER FOR BACK-UP • MASS MEMORY SUPPORT

SPACELAB PROGRAM VARIATIONS ANALYSES

- PAYLOAD ACCOMMODATION
- SPACELAB AUTONOMY VS. ORBITER SUPPORT
- EUROPEAN VS. US PROCUREMENT
- OTHER DESIGN & REQUIREMENT VARIATIONS
- SPACELAB PROGRAM-LEVEL VARIATIONS

SPACELAB PHASE B2 MAJOR CONCLUSIONS

I. 175 MAU PROGRAM IS FEASIBLE

- CONFIGURATION/DESIGN CONCEPT IS RESPONSIVE TO USER REQUIREMENTS
- PROVIDES FOR AN ADEQUATE DEVELOPMENT PROGRAM
- QUANTITY OF ARTICLES SATISFIES INITIAL PROGRAM NEEDS
- MAXIMUM USE OF TEST ARTICLES, EQUIPMENT, FACILITIES & PERSONNEL THROUGH SCHEDULE OPTIMIZATION
- U.S. ASSISTANCE FOR "MANNED-SPACE" ELEMENTS REQUIRED

SPACELAB PHASE B2 MAJOR CONCLUSIONS (CONT'D)

II. MODULAR SPACELAB CONCEPT IS PREFERRED

- OFFERS HIGHEST POTENTIAL FOR EFFICIENT USE OF ORBITER PAYLOAD CAPABILITIES
- PROVIDES PROGRAM AND MISSION FLEXIBILITY
- FINAL LEVEL OF MODULARITY REQUIRED DESERVES FURTHER STUDY

SPACELAB PHASE B 2 MAJOR CONCLUSIONS (CONT'D)

- [illegible] 10 MAY VS. ORBITER SUPPORT ISSUE STILL OPEN
- [illegible] RESOURCES REDUCES SPACELAB COSTS
- [illegible] SHOULD BE STANDARDIZED
- [illegible] UPDATES
- [illegible] MAKES [illegible]

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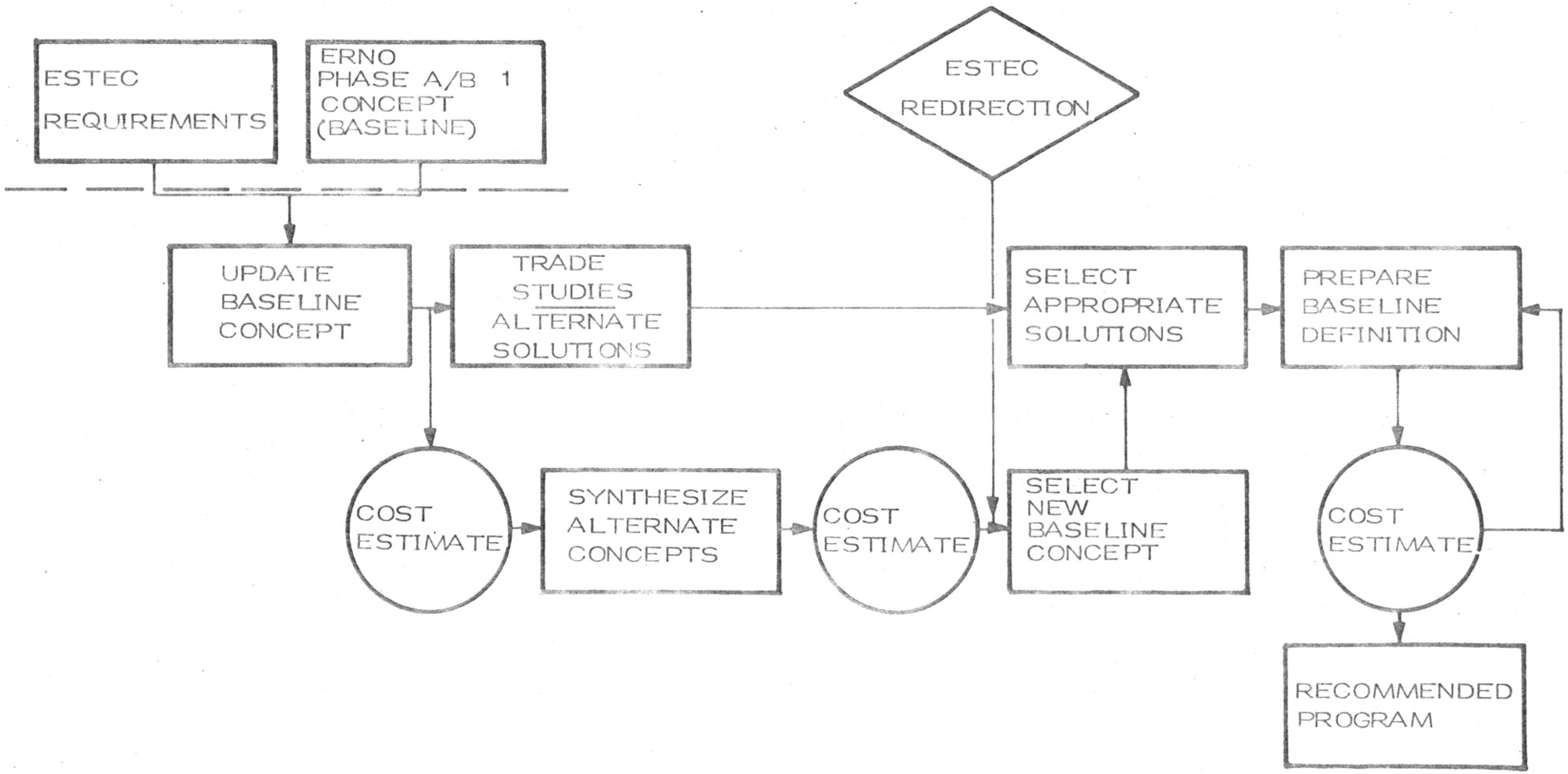
CONCLUSIONS & RECOMMENDATIONS	–	H. HOFFMANN

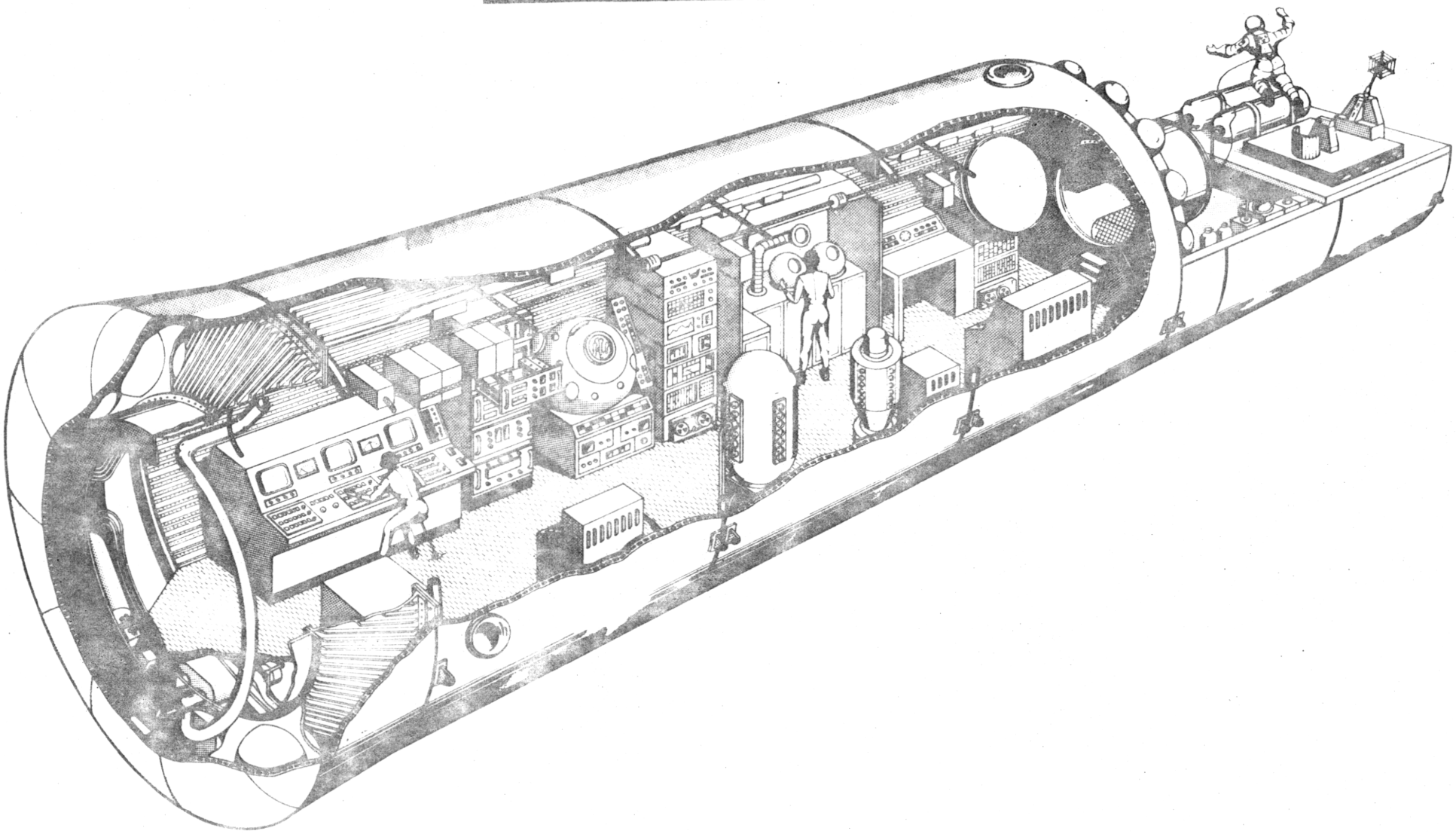
PHASE B2 STUDY FLOW



INITIAL REQUIREMENTS SUMMARY

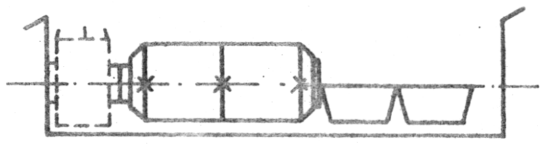
- 7 DAY MISSION GROWTH TO 30 DAYS
- 50 FLIGHTS OR 5 YEARS
- ACCOMMODATE 5 EXPERIMENT CATEGORIES
- MINIMIZE COST TO IOC, LOW TOTAL COST
- IOC IN 1979/TODAYS TECHNOLOGY
- CREW SIZE: 2 TO 6; 4 NOMINAL
- AUTONOMOUS SUBSYSTEMS/SHUTTLE SUPPLEMENTS LAB FOR PEAKS
- RAPID GROUND TURN-AROUND
- CAPABILITY FOR PALLET-ONLY MODE AND SECONDARY MISSIONS

INITIAL BASELINE CONCEPT



ALTERNATE CONFIGURATION/DESIGN CONCEPTS

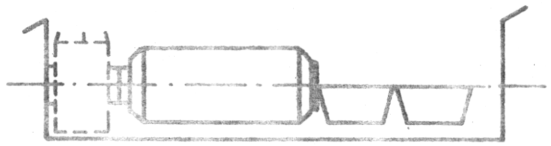
CONCEPT 1



CHARACTERISTICS

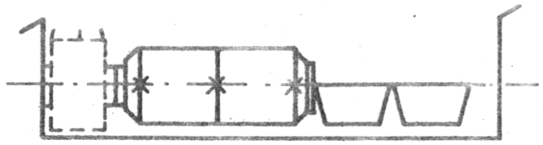
- FULLY RESPONSIVE TO CUSTOMER RQMTS
- MODULAR SEGMENTED PRESS SHELL & PALLET
- CONTAINS AUTONOMOUS SUBSYSTEMS
- EXPECTED TO EXCEED TARGET COST

CONCEPT 2



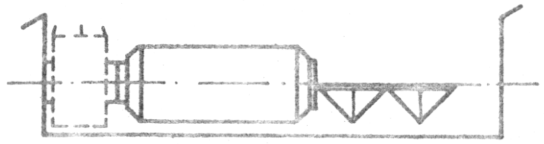
- FULLY RESPONSIVE TO CUSTOMER RQMTS
- SINGLE MODULE PRESSURE SHELL
- CONTAINS AUTONOMOUS SUBSYSTEMS
- EXPECTED TO EXCEED TARGET COST

CONCEPT 3



- DOES NOT MEET ALL CUSTOMER RQMTS
- SAME CONFIGURATION AS CONCEPT 1
- SUBSYSTEM CAPABILITY ADJUSTED TO MEET COST TARGET
- MEETS COST TARGET OF (TBD)

CONCEPT 4



- DOES NOT MEET ALL CUSTOMER REQMTS
- CONFIGURATION SIMILAR TO CONCEPT 2
- SUBSYSTEM CAPABILITY FURTHER REDUCED
- COST LESS THAN CONCEPT 3

ALTERNATE PROGRAMMATIC CONCEPTS

CHARACTERISTICS

PROGRAM A
DOCUMENT 8

FULLY COMPLIANT WITH ESTEC REQUIREMENTS

- SPECIFIED QUANTITIES
- 56 MONTHS TO FLIGHT UNIT DELIVERY

PROGRAM B
INTERMEDIATE

FULLY COMPLIANT WITH ESRO/NASA LEVEL 1 REQUIREMENTS

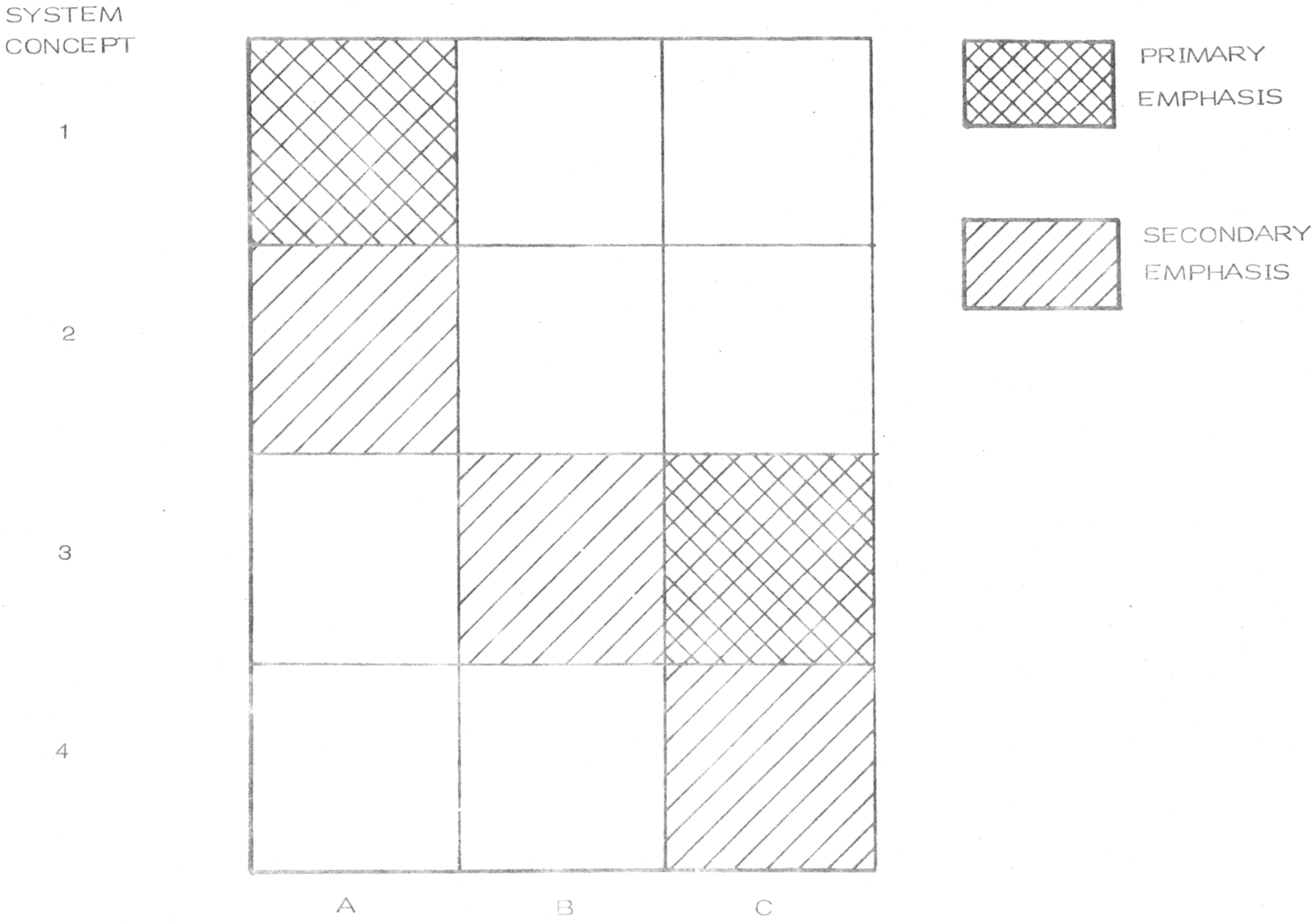
- QUANTITIES REDUCED
- 59 MONTHS TO FLIGHT UNIT DELIVERY
- SHARING OF TEST ARTICLES

PROGRAM C
RECOMMENDED

ESSENTIALLY COMPLIANT WITH ESRO/NASA LEVEL 1 REQUIREMENTS

- QUANTITIES REDUCED BY DEFERED ACTIVATION OF SECOND LAUNCH SITE
- 59 MONTHS TO FLIGHT UNIT DELIVERY
- SHARING OF TEST ARTICLES
- DELIVERY OF PROTOTYPE TO US IN LIEU OF EM
- CONCENTRATES TESTING AT SUBSYSTEM LEVEL

SYSTEM DESIGN / PROGRAM MATRIX



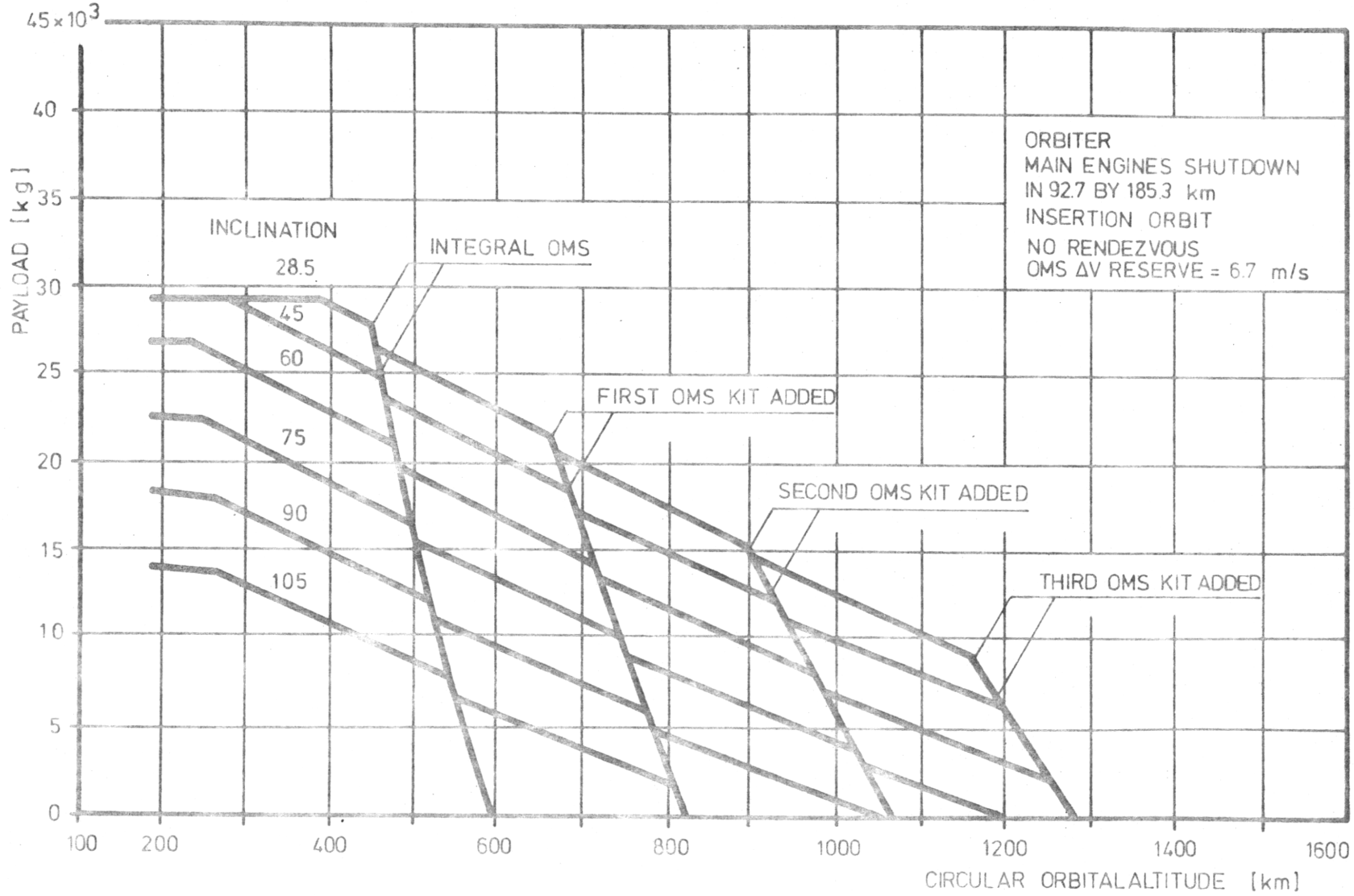
AGENDA

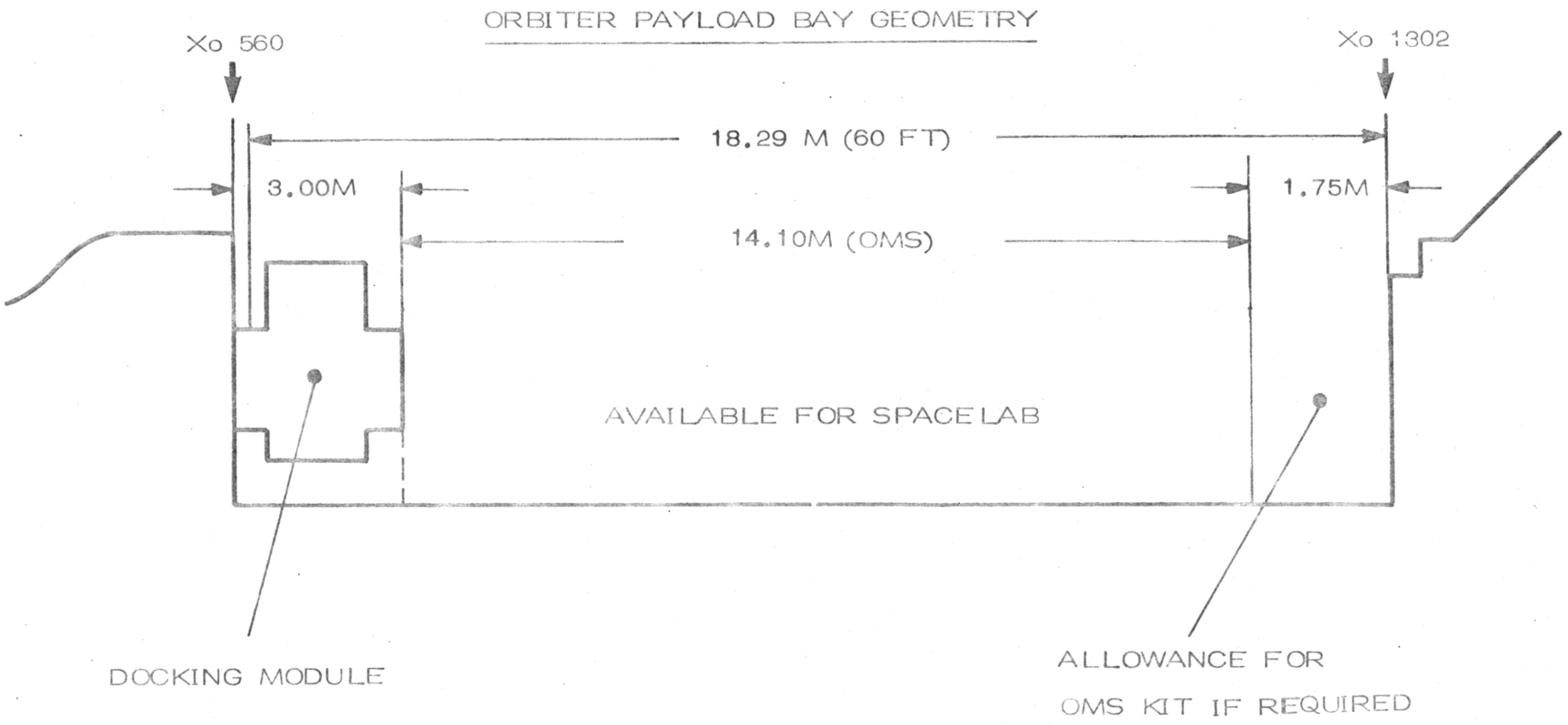
INTRODUCTION	-	PROF. G. EGGERS
STUDY OVERVIEW	-	H. HOFFMANN
STUDY APPROACH	-	K. BERGE
SYSTEM CONCEPT	-	W. WIENSS
MECHANICAL SUBSYSTEMS	-	W. WIENSS
ELECTRICAL SUBSYSTEMS	-	H. J. POSPIESZCZYK
PROGRAM CONCEPT	-	K. BERGE
PROGRAM VARIATIONS	-	K. BERGE
CONCLUSIONS & RECOMMENDATIONS	-	H. HOFFMANN

SYSTEM DESIGN REQUIREMENTS & CONSTRAINTS

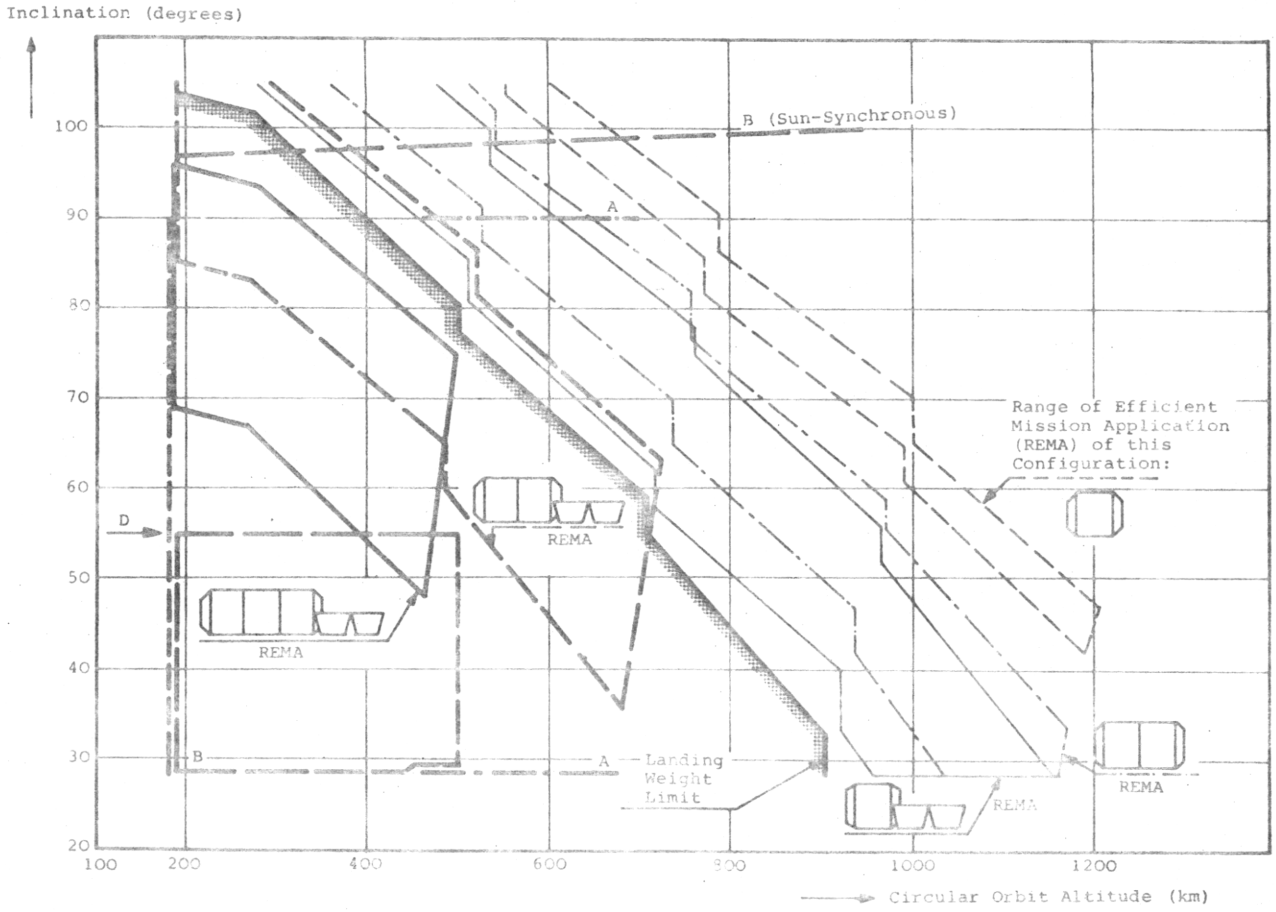
- AT LEAST ONE PRESSURIZED MODULE PROVIDING SHIRTSLEEVE ENVIRONMENT
- UNPRESSURIZED PALLET
- FLEXIBLE, EMPLOYING MODULARITY & COMMONALITY
- EQUIPMENT EASILY ACCESSIBLE FOR INSPECTION
- MAX. WT. OF SPACE LAB IS 9,000 KG (20.000 LBS)
- MAX. LANDING WT. IS 14.500 KG (32.000 LBS)
- WITHIN PAYLOAD BAY ENVELOPE -4.57 M.DIA (15 FT.) & 18.29 M.LT.(60 FT)
- ALL MANNED SPACE LAB MISSIONS WITH DOCKING MODULE - 2.85 M.LT.
- OMS KITS, IF REQUIRED
- SPACE LAB C.G. WITHIN OLD 3% ORBITER ENVELOPE; DESIGN GOAL; WITHIN NEW 3% ORBITER ENVELOPE

ORBITER PAYLOAD WEIGHT CAPABILITY VS. CIRCULAR ORBITAL ALTITUDE AT VARIOUS INCLINATIONS




ORBITER PAYLOAD BAY GEOMETRY
Xo 560
Xo 1302
18.29 M (60 FT)
3.00M
1.75M
14.10M (OMS)
AVAILABLE FOR SPACELAB
DOCKING MODULE
ALLOWANCE FOR
OMS KIT IF REQUIRED

RANGE OF EFFICIENT MISSION APPLICATIONS



Experiment Stacking Densities

$$0.1 \leqq \varrho_{Module} \leqq 0.2 \left[\frac{tons}{m^3}\right]$$

$$0.05 \leqq \varrho_{Pallet} \leqq 0.1 \left[\frac{tons}{m^3}\right]$$

Compare With	$\frac{tons}{\varrho\ m^3}$
Apollo Command Module	0.344
Manned Orbit. Labor.	0.160
Orbital Work Shop	0.050

Scientific Payloads (Doc. 8):

A: Astronomy

B: Comm./Nav. or Earth Observation

C: Material Science
Space Manufacturing
Life Science

D: Space Physics

E: Technology

Orbital Requirements:

C, E: Any Altitude, Any Inclin.

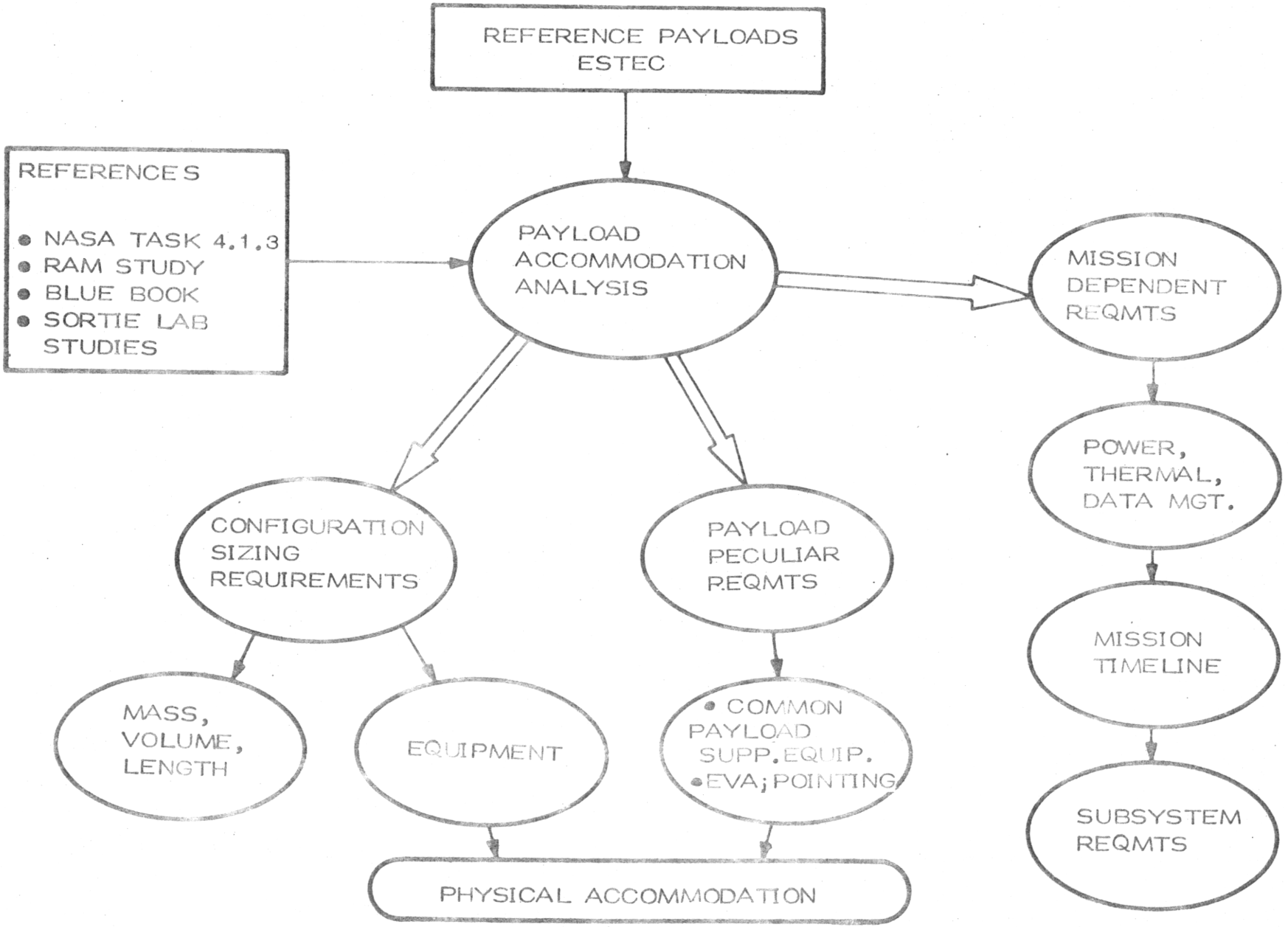
D: Any Altitude

Others: See Figure

REFERENCE PAYLOADS - ESTEC

PAYLOAD	DISCIPLINE
A	ASTRONOMY
B	COMMUNICATIONS & NAVIGATION OR EARTH OBSERVATION
C	MATERIALS SCIENCE & MANUFACTURING OR LIFE SCIENCE
D	SPACE PHYSICS
E	TECHNOLOGY

PAYLOAD ACCOMMODATION



PAYLOAD MASS, VOLUME, ALTITUDE ACCOMMODATION

PAYLOAD	REQUIREMENTS MASS(KG)	REQUIREMENTS VOLUME (M^3)	ALT (KM)	PREFERRED CONFIGURATION	ACCOMMODATION MASS(KG)	ACCOMMODATION VOLUME (M^3)	ALT
A	PRESS } 4070	2,1	460 TO 670		5991	5,4	ACCOMPLISHED
	UNPRESS }	34,0				99,0	
B	PRESS } 3795	7,6	185 TO 500		5578	17,9	
	UNPRESS	10,0				66,0	
C	PRESS } 3153	10,0	ANY		7118	17,9	
	UNPRESS }	—				—	
D	PRESS } 3755	14,5	> 185		5590	17,9	
	UNPRESS }	3,0				66,0	
E	PRESS } 4953	—	ANY		7847	—	
	UNPRESS }	62,0				165,0	

COMMON PAYLOAD SUPPORT EQUIPMENT

(INCL. IN 175 MAU)

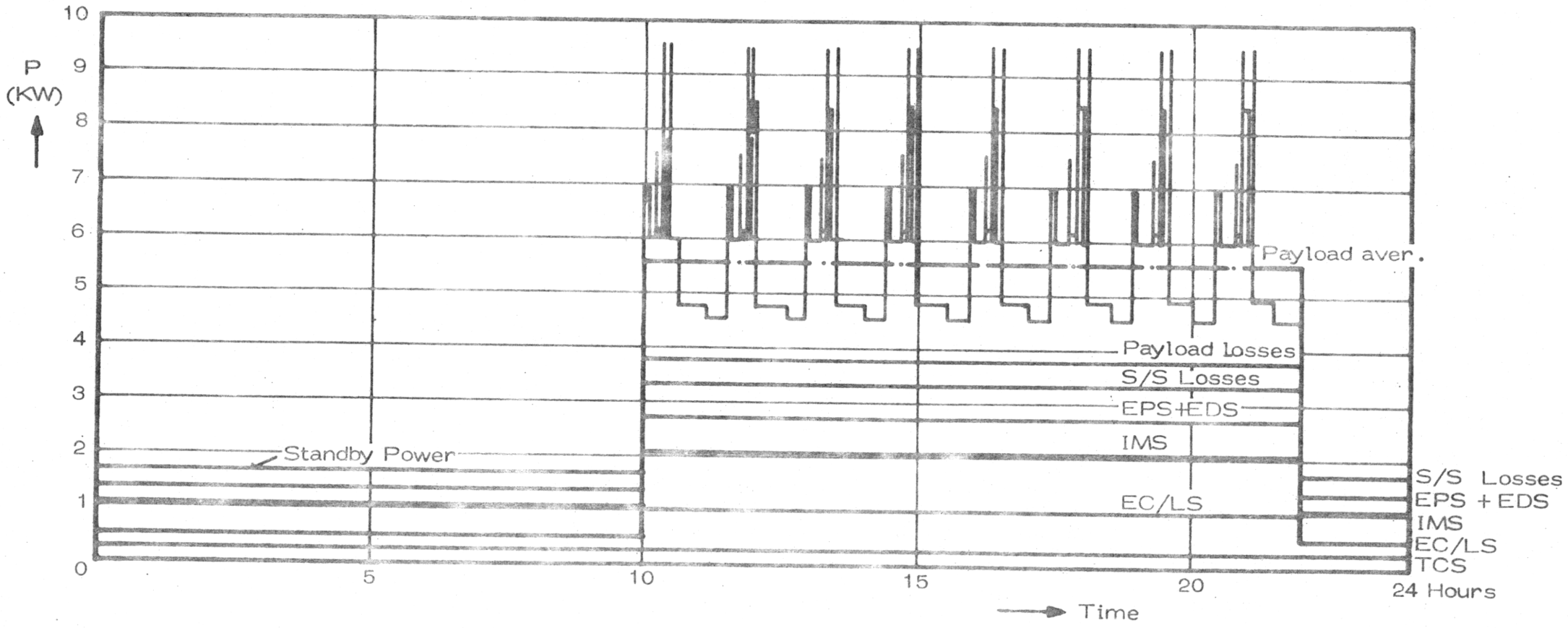
PRIORITY	ITEM	TOTAL KAU (n)	ACC. TOTAL KAU (Σn)
1	TAPE RECORDER, DIGITAL (28 Mbps)	1,010.0	1,010.0
2	OSCILLOSCOPE	171.5	1,181.5
3	VOLTMETER, AC/DC	71.9	1,253.4
4	AMPEREMETER, AC/DC	59.4	1,312.8
5	FREQUENCY METER	107.2	1,420.0
6	TV CAMERA (4)	120.0	1,540.0
7	TV MONITOR	50.0	1,590.0
8	TAPE RECORDER, VIDEO	192.4	1,182.4
9	TAPE RECORDER, ANALOG	319.6	2,102.0

COMMON PAYLOAD SUPPORT EQUIPMENT

OPTIONAL

PRIORITY	ITEM	TOTAL KAU (n)	ACC. TOTAL KAU (Σ n)
1	MICROFICHE STORAGE & RETRIEVAL	65.8	65.8
2	TAPE RECORDER, VOICE	40.0	105.8
3	POINTING PLATFORM, PALLET	3,850.0	3,955.8
4	SCIENTIFIC AIRLOCK	3,822.3	7,778.1
5	TRANSPARENT WINDOW	990.0	8,768.1
6	CAMERA, 16 MM	268.2	9,036.3
7	CONTAMINATION MONITOR, PALLET	325.0	9,361.3
8	BOOM	695.0	10,056.3
9	FREQUENCY SYNTHESIZER	244.2	10,300.5
10	FREQUENCY COUNTER	107.3	10,407.8
11	SPECTRUM ANALYZER	225.0	10,632.8
12	STORAGE GAS SYSTEM (45 KG)	220.0	10,852.8
13	CRYOGENIC STORAGE (20 KG)	1,275.0	12,127.8
14	TELEPRINTER	250.0	12,377.8
15	X - Y PLOTTER	66.0	12,443.8
16	FILM PROCESSOR	TBD	TBD

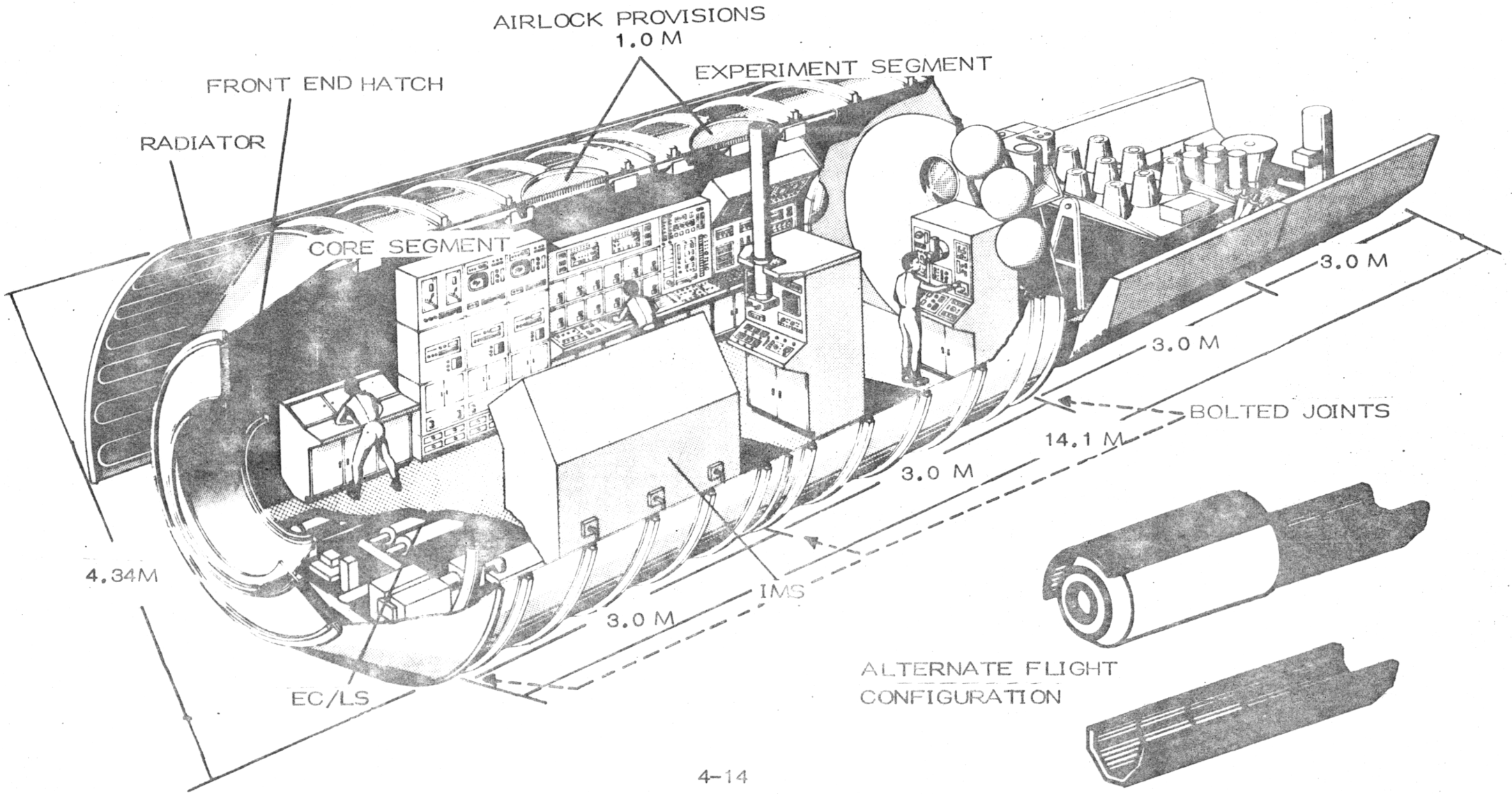
PAYLOAD B – EARTH OBSERVATION – TIME LINE



CONCLUSIONS FROM REQUIREMENTS ANALYSIS

- PREFERRED SPACELAB CONFIGURATION MUST ACCOMMODATE A WIDE RANGE OF PAYLOADS
- NO SINGLE CONFIGURATION IS ADEQUATE FOR ALL REFERENCE MISSIONS
- CONFIGURATION SHOULD PROVIDE OPTION FOR FULL INTERIOR ACCESS
- CONCEPT MUST ALLOW EXPERIMENT PRE-INTEGRATION WITHOUT FULL SPACELAB

EXTERIOR CONFIGURATION



EXTERIOR CONFIGURATION FEATURES

PRESSURIZED MODULE

- 4.34 M (14.3 FT) DIA
- NOMINALLY 2 CYLINDRICAL SEGMENTS - 3.0 M ~(10 FT) LONG EACH
- OVERALL LENGTH - 14.1 M (46.2 FT)
- FULL DIA.BOLTED JOINTS AT CYL. TO CYL. & BULKHEADS TO CYL.
- FORWARD & AFT. GROUND ACCESS HATCHES - 2 M DIA.
- RADIATOR / METEOROID SHIELD - 166 ^{o}
- CUTOUT PROVISIONS FOR ACCOMMODATING VARIOUS PAYLOAD SUPPORT EQUIPMENT
- PRESSURE BOTTLES LOCATED AFT (SAFETY & C.G.)
- STATICALLY DETERMINATE SUSPENSION SYSTEM

EXTERIOR CONFIGURATION FEATURES

PALLET

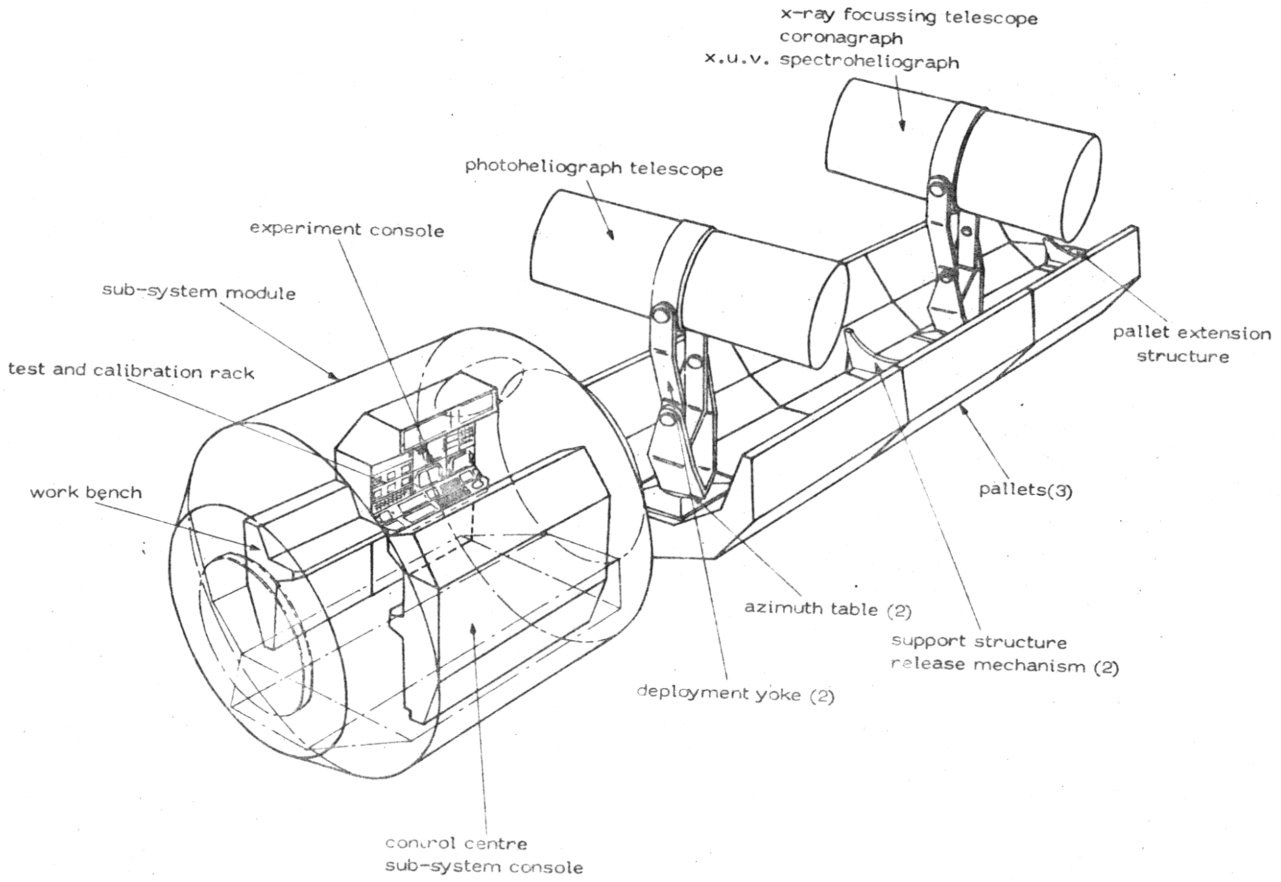
- 5 IDENTICAL SEGMENTS - 3.0 M ≈(10 FT) LONG EACH
- NOMINALLY 2 REQUIRED WITH 2 SEGMENT PRESSURIZED MODULE
- MOUNTED IN ORBITER INDEPENDENTLY FROM MODULE
- PROVIDES FOR:
    - o ELECTRICAL POWER DISTRIBUTION
    - o DATA ACQUISITION AND DISTRIBUTION
    - o THERMAL CONTROL
- CONTAINS PROVISIONS TO ADD GIMBAL PLATFORM FOR FINE POINTING OF EXPERIMENT SENSORS.

MASS BREAKDOWN

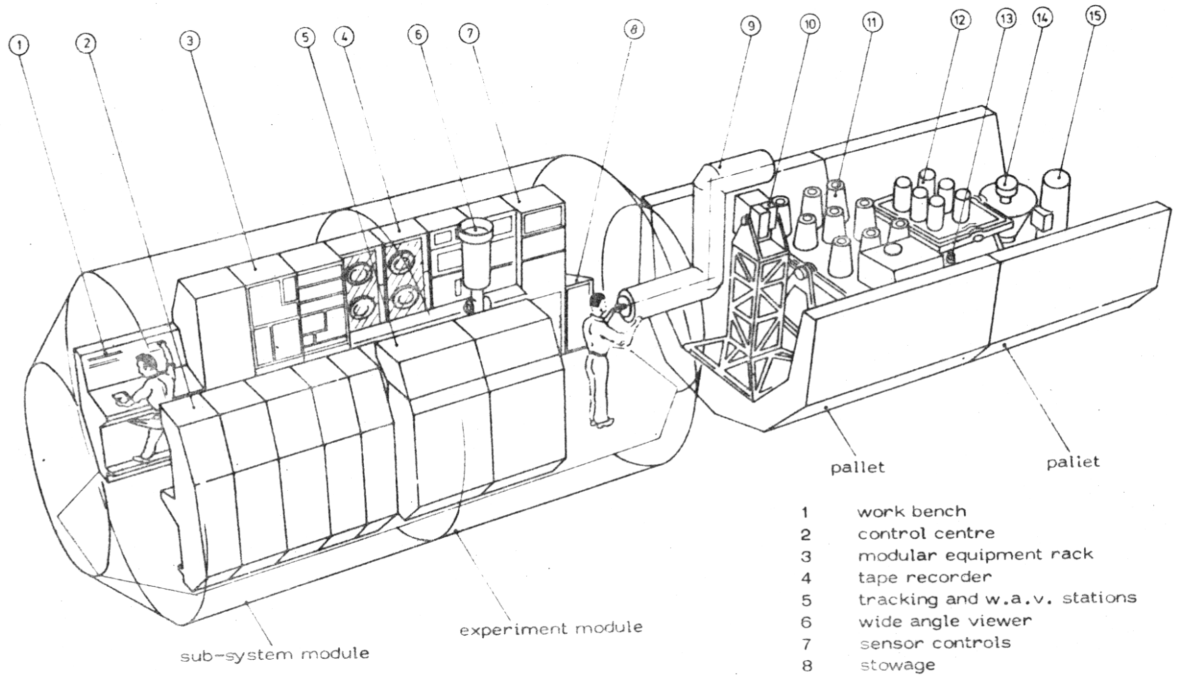
(FIGURES VALID FOR B/L CONFIGURATION : 2 MODULES/2 PALLETS)

STRUCTURE	MODULE PALLET	2.663 KG 1.346 KG
EC/LS		652 KG
TCS		842 KG
HABITABILITY		182 KG
EPS		995 KG
IMS		372 KG
EDS		645 KG
S/L WITHOUT EXPERIMENTS		7.697 KG
DESIGN TARGET		9.000 KG
AVAILABLE FOR PAYLOAD		6.803 KG

PAYLOAD ACCOMMODATION - PAYLOAD A

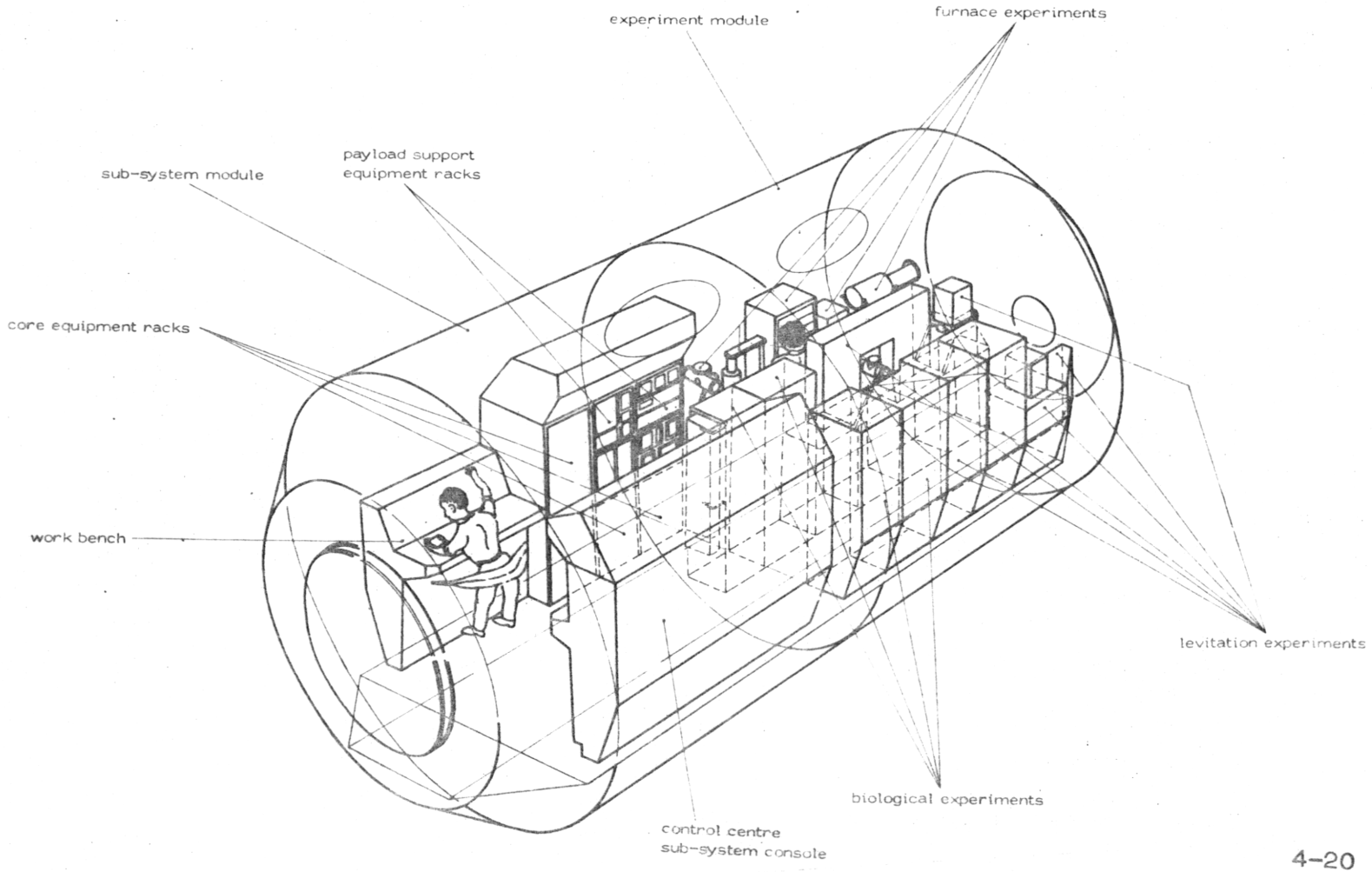


PAYLOAD ACCOMMODATION - PAYLOAD B

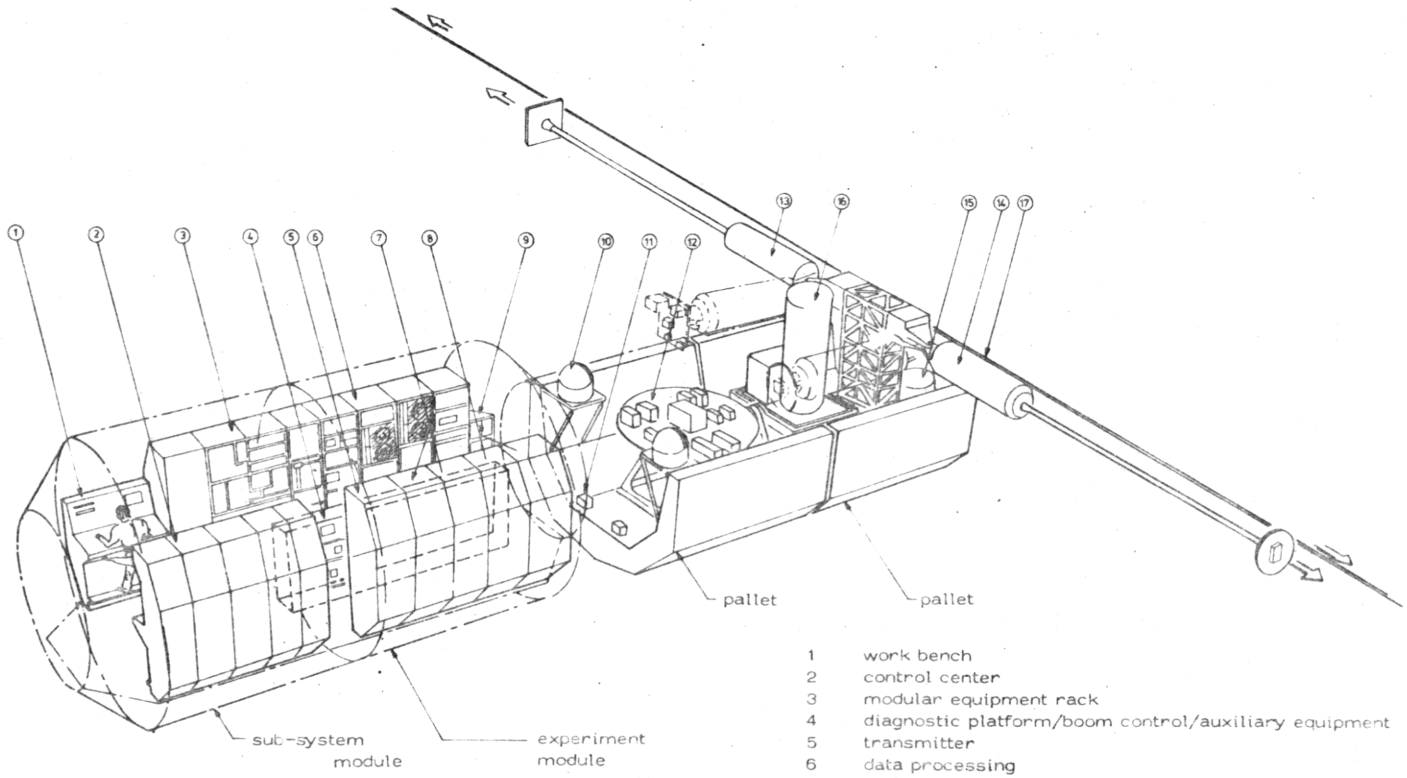


1 work bench
2 control centre
3 modular equipment rack
4 tape recorder
5 tracking and w.a.v. stations
6 wide angle viewer
7 sensor controls
8 stowage
9 tracking telescope
10 polarmeter/inferometer/pollution experiments
11 camera multispectral scannes system
12 camera system
13 spectrometers
14 ir scanner
15 radiometer

PAYLOAD ACCOMMODATION - PAYLOAD C

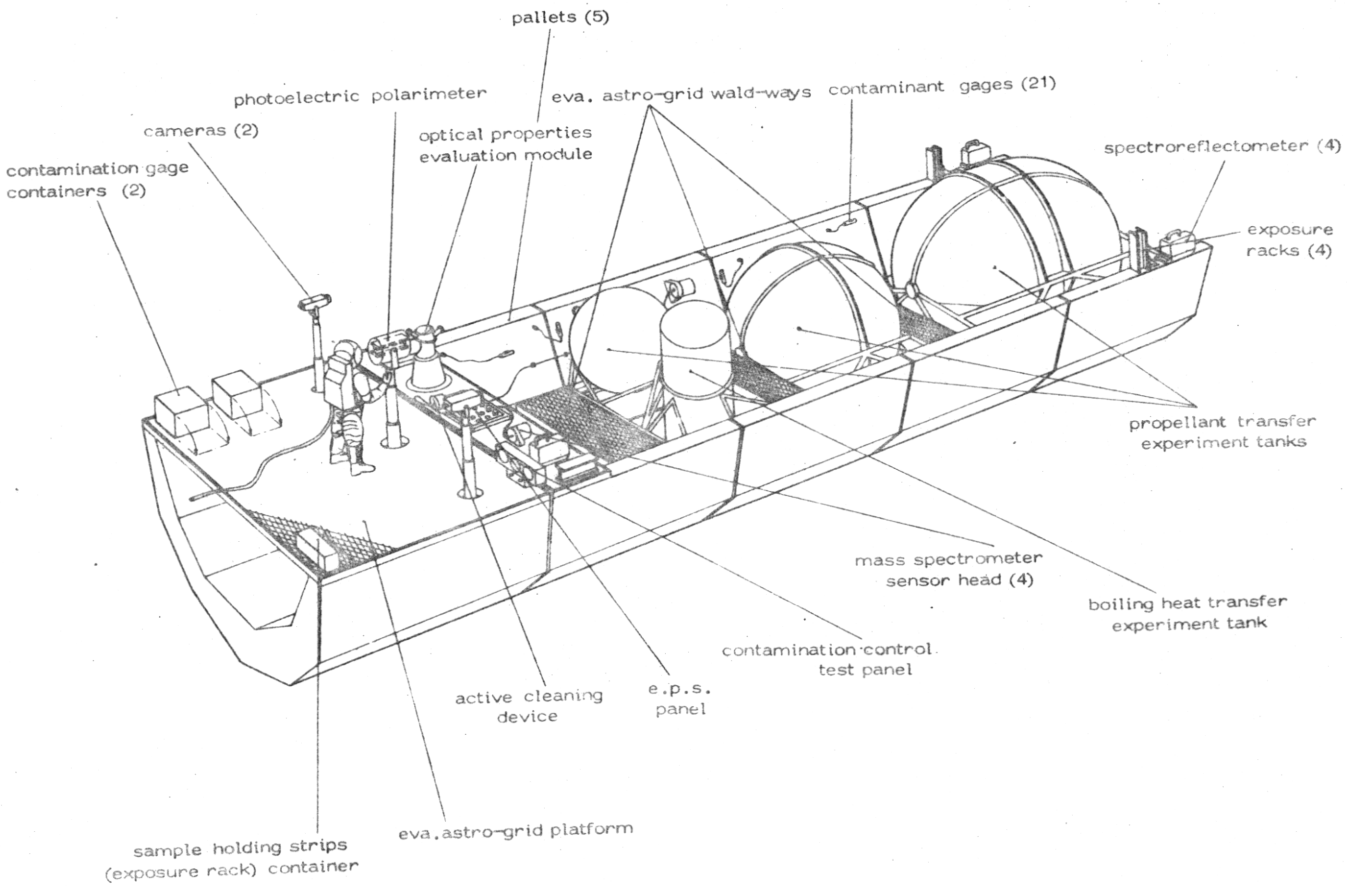


PAYLOAD ACCOMMODATION - PAYLOAD D



1 work bench
2 control center
3 modular equipment rack
4 diagnostic platform/boom control/auxiliary equipment
5 transmitter
6 data processing
7 accelerater control
8 gimballed platform control
9 auxiliary stowage
10 baloon canisters
11 canister release experiments
12 gimballed platform
13 diagnostic platform experiment
14 wake and sheath target
15 sub satellites
16 accelerometers
17 transmitter

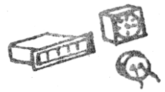
PAYLOAD ACCOMMODATION - PAYLOAD E



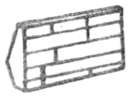
EXCHANGE OF MISSION EQUIPMENT

MODULAR CONCEPT ACCOMMODATES INTERNAL EXPERIMENT INSTALLATION BY:

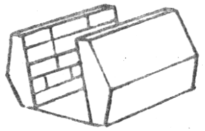
- INDIVIDUAL EQUIPMENT



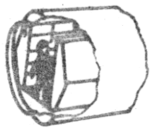
- INTEGRATED RACKS

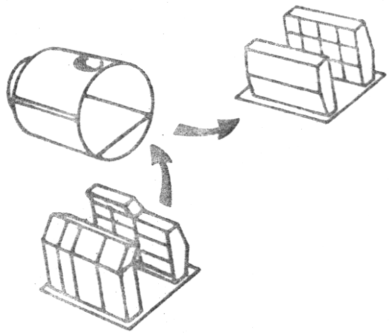


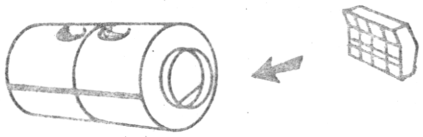
- PALLETIZED EQUIPMENT ASSEMBLY



- EXTENSION UNIT INTEGRATION







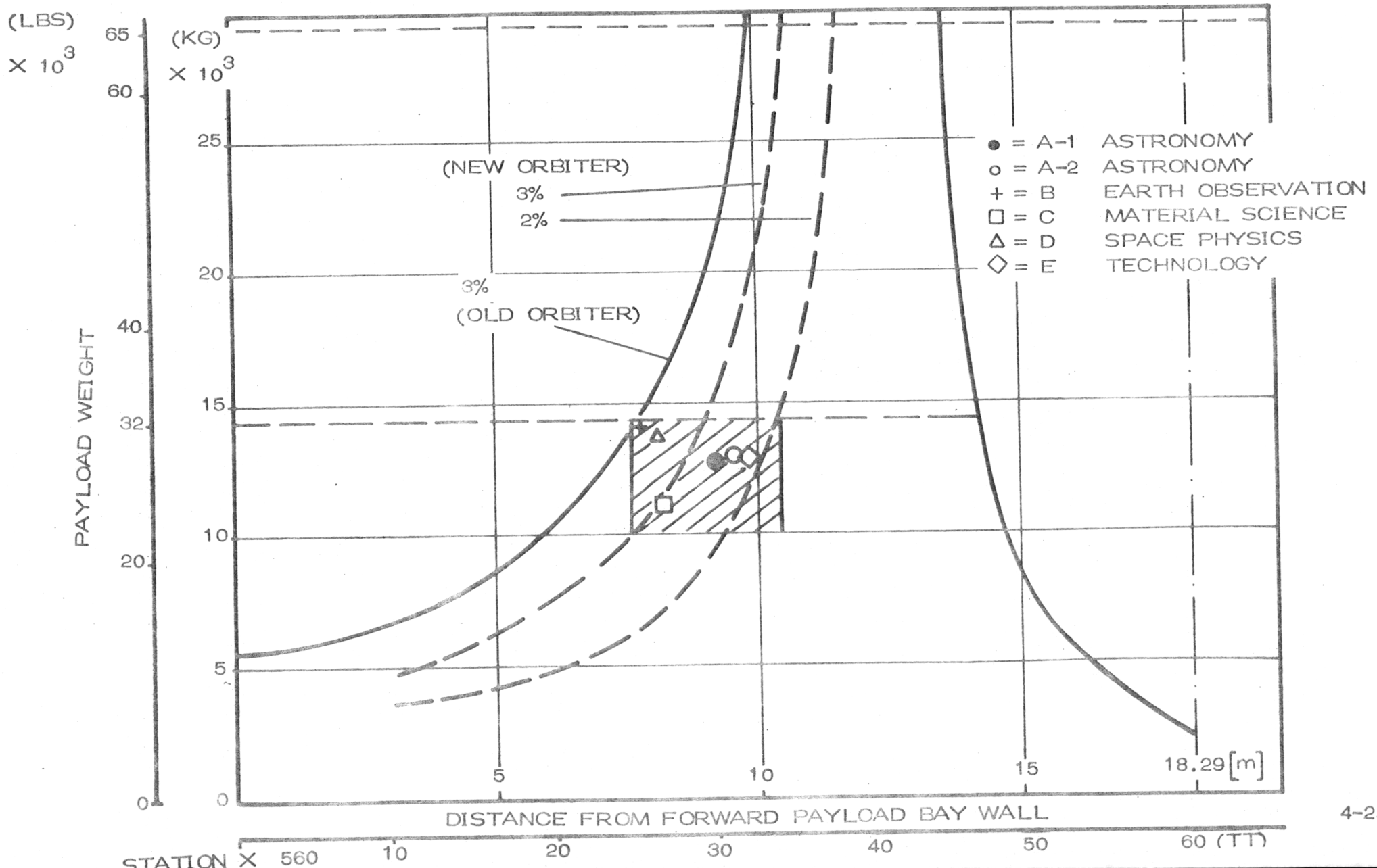
BASIS FOR C. G. CALCULATIONS

- WEIGHTS

	SPACELAB	SPACELAB + EXPERIMENTS(TOTAL)		CREW SIZE
A_1	1284 KG	A_1	12.943 KG	2
A_2	1662 KG	A_2	13.058 KG	2
B	7679 KG	B	14.321 KG	6
C	6087 KG	C	11.203 KG	3
D	7685 KG	D	13.959 KG	5
E	5428 KG	E	12.280 KG	3

- REACTANTS IN ORBITER : 820 KG
- CREW, EQUIPMENT, CONSUMABLES, SEATS, ATMOS., IN ORBITER: 310 KG/MAN
- IMS EQUIPMENT IN ORBITER: 70 KG
- DOCKING MODULE: 1225 KG
- INTEGRAL OMS; NO KITS
- USED ERNO "GROUPY 2" C.G. COMPUTER PROGRAM
  APPROX. 200 MASS ITEMS
- MOMENT ARMS ESTIMATED FROM ORBITER SKETCHES

PAYLOAD LONGITUDINAL C.G. ENVELOPE

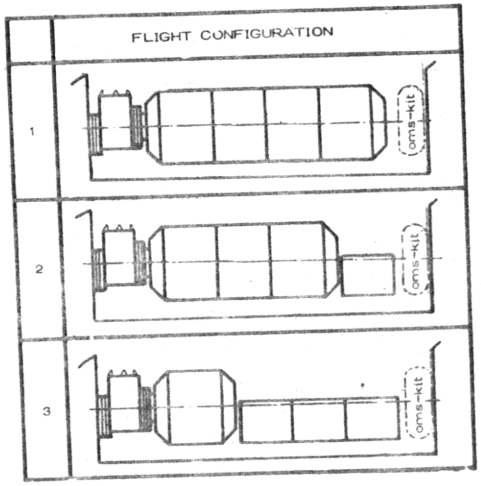


OPTIONS FOR C. G. ACCOMMODATION

- MOVE PALLETS AFT
- MOVE LAB MODULE AFT - EXTEND TUNNEL
- RE-ARRANGE ELEMENTS: PALLET - MODULE - PALLET
- ADD BALLAST AFT
- DELETE DOCKING MODULE - EXTEND TUNNEL
- MOVE EXPENDABLE FLUID TANKS AFT TO PALLET
- REDUCE CREW SIZE
- ADD THIRD MODULE

GROWTH OPTIONS

	VOLUME AVAILABLE TO EXPERIMENTS	
	PRESSURIZED	UNPRESSURIZED
1	43 (m^3) (1520 cu ft)	31 (m^3) (1100 cu ft)
2	30 (m^3) (1060 cu ft)	69 (m^3) (2430 cu ft)
3	5 (m^3) (177 cu ft)	146 (m^3) (5150 cu ft)
4	18 (m^3) (635 cu ft)	99 (m^3) (3500 cu ft)



	WEIGHT LAUNCH			
	SPACELAB W/O EXP. (APPROX.)	DOCKING MODULE	SPACELAB OVERALL (DESIGN TARGET)	CAPABILITY FOR CREW ,, EXP. CPSE & OMS-KIT-ACCOMM.
1.	10.000 (KG) (2 Power-Kits included)	1.225 (KG)	14.500 (KG) (31.972 Lbs)	3.275 (KG) (7.220 Lbs)
2.	8.600 (KG) (1 Power-Kit included)	1.225 (KG)	14.500 (KG) (31.972 Lbs)	4.675 (KG) (10.300 Lbs)
3.	7.100 (KG) (1 Power-Kit included)	1.225 (KG)	14.500 (KG) (31.972 Lbs)	6.175 (KG) (13.615 Lbs)
4.	8.200 (KG) (1 Power-Kit included)	1.225 (KG)	14.500 (KG) (31.972 Lbs)	5.075 (KG) (11.190 Lbs)

	APPLICATION
1	Missions requiring large volume (i.e. Material Science)
2	Missions requiring large volume plus external location of experiments
3	Missions requiring high altitude & inclination orbits with various number of Pallets

SUMMARY OF SPACELAB INTERFACES

CATEGORY	TYPE	PROVISIONS
SPACELAB / ORBITER	STRUCTURAL	LOAD SUPPORT
	CREW	REST; DINING; HYGIENE; WASTE MANAGEMENT
	THERMAL	RADIATOR
	DATA	PROCESSING; TIME; R.F. TRANSMISSION, MASS MEMORY
	POWER	FUEL CELL

SUMMARY OF SPACELAB INTERFACES (CONT'D)

CATEGORY	TYPE	PROVISIONS
SPACELAB / EXPERIMENT	STRUCTURAL	LOAD SUPPORT; MOUNTING PROVISIONS; STORAGE
	ELECTRICAL	DATA ACQUISITION PROCESSING STORAGE FORMATTING; POWER; CHECK OUT; CONTROLS AND DISPLAYS
	THERMAL	HEAT REMOVAL; AIR CIRCULATION & COLD PLATES
SUBSYSTEM/SUBSYSTEM	STRUCTURAL	SEGMENTED SECOND MOUNTING STRUCTURE
	ELECTRICAL	DATA BUS; INSTRUMENTATION & MONITORING; CAUTION & WARNING; DISPL. & CONTROLS; POWER BUSSES
	THERMAL	HEAT REMOVAL

SUMMARY OF SPACELAB INTERFACES (CONT'D)

CATEGORY	TYPE	PROVISIONS
MODULE/MODULE	STRUCTURAL	BOLTED JOINTS; GASKET-O-RING SEAL
	ELECTRICAL	STANDARDIZED INTERCONNECTIONS
	THERMAL	FLUID INTERCONNECT-BELLOW JOINTS
MODULE/PALLET	STRUCTURAL	INDEPENDENT; STANDARDIZED MOUNTING
	ELECTRICAL	DATA BUS; POWER; SIGNAL DISTRIBUTION
	THERMAL	FLEX. HOSE INTERCONNECTION

KEY FEATURES - MECHANICAL SUBSYSTEMS

STRUCTURE

- STATICALLY DETERMINED SUSPENSION
- INTEGRALLY MACHINED PRESS. SHELL AND PALLET
- INTERNAL STRINGERS, EXTERNAL RING FRAMES
- BOLTED JOINTS WITH GASKET O-RING SEALS
- PROVISION FOR RADIALLY MOUNTED EXP. SUPPORT EQUIPMENT

CREW HABITABILITY

- ORBITER PROVIDES CREW SERVICES
- DEDICATED SUBSYSTEM AREA
- INTEGRATED SUBSYSTEM AND EXPERIMENT CONTROL CONSOLE

ENVIRONMENTAL CONTROL/LIFE SUPPORT

- AUTONOMOUS
- GASEOUS O_2 AND N_2 SUPPLY
- CONDENSER HUMIDITY CONTROL
- LIOH USED FOR CO_2 REMOVAL
- TRACE CONTAMINANT MEASUREMENT

THERMAL CONTROL

- FIXED SPACE RADIATOR
- WATER USED FOR INTERNAL LOOP, FREON FOR EXTERNAL LOOP
- ORBITER PROVIDES SUPPLEMENTARY HEAT REJECTION

SUBSYSTEM COST SUMMARY

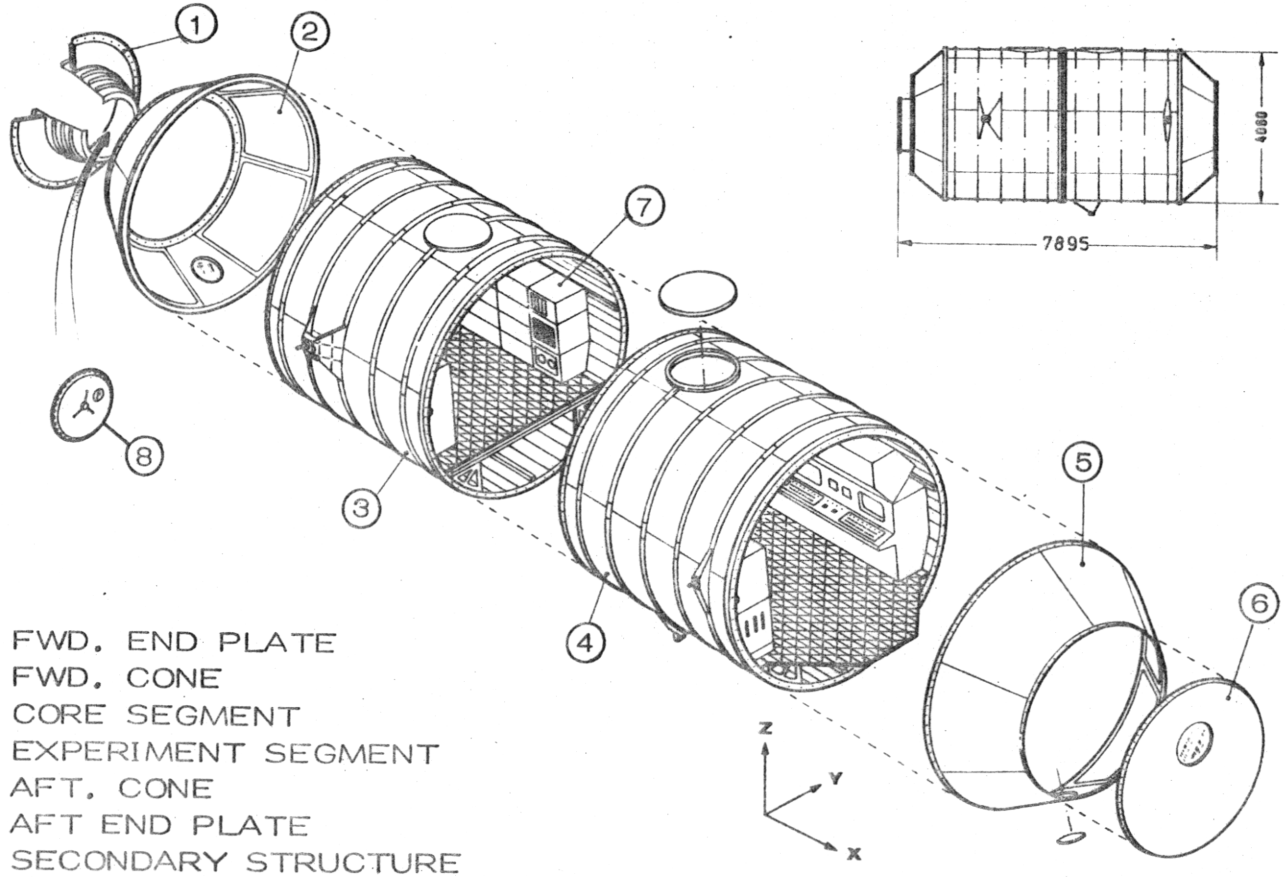
COST ESTIMATES BASED ON DETAILED DEFINITION:

1.	INFORMATION MANAGEMENT	27.2 MAU
2.	STRUCTURE- MODULE AND PALLETS	25.4 MAU
3.	ENVIRONMENTAL CONTROL/LIFE SUPPORT	18.2 MAU
4.	THERMAL CONTROL - MODULE AND PALLETS	16.7 MAU
5.	ELECTRICAL GSE	11.2 MAU
6.	ELECTRICAL POWER	6.0 MAU
7.	MECHANICAL GSE	4.7 MAU
8.	ELECTRICAL DISTRIBUTION	4.3 MAU
9.	CREW HABITABILITY AND PROTECTION	1.2 MAU
10.	ATTITUDE CONTROL	0.3 MAU

MODULE STRUCTURE DESCRIPTION

- INTERNAL LONGITUDINAL STRINGERS (INTEGRALLY MACHINED), HAT SHAPED OUTSIDE FRAMES BONDED TO CYLINDER
- INTERNAL LONGERONS RIVETED TO STRINGERS
- MATERIAL 2219 T 87 AND 2024 T 6
- TIG-WELDED BASIC STRUCTURE
- 1 G HORIZONTAL FLOOR
- SAFETY FACTORS

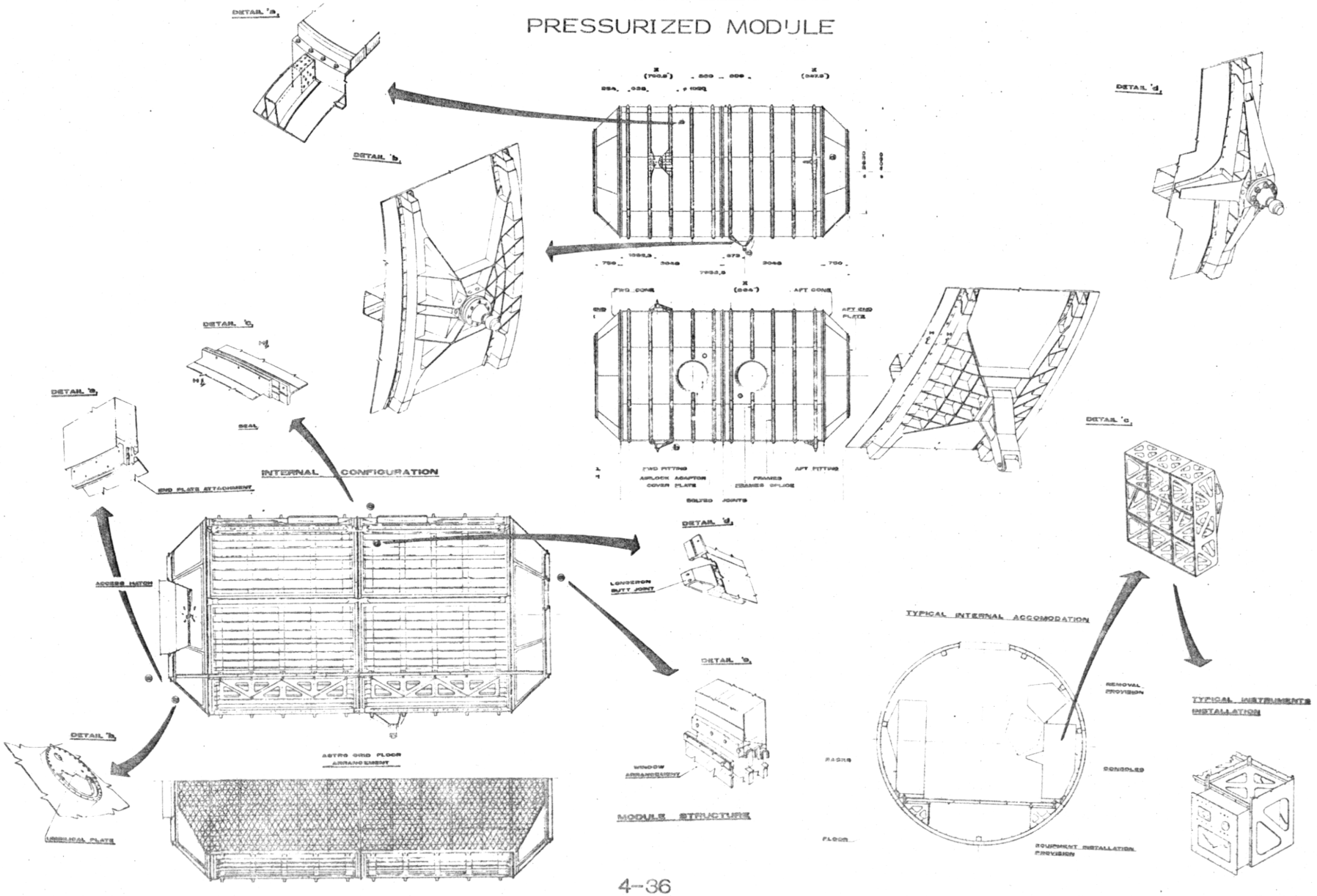
- UNPRESSURIZED STRUCTURE	1.5
- PRESSURIZED STRUCTURE AT LIMIT PRESS	1.5
- PRESSURIZED VESSELS	2.0



1 FWD. END PLATE
2 FWD. CONE
3 CORE SEGMENT
4 EXPERIMENT SEGMENT
5 AFT. CONE
6 AFT END PLATE
7 SECONDARY STRUCTURE
8 HATCH

STRUCTURAL DETAILS

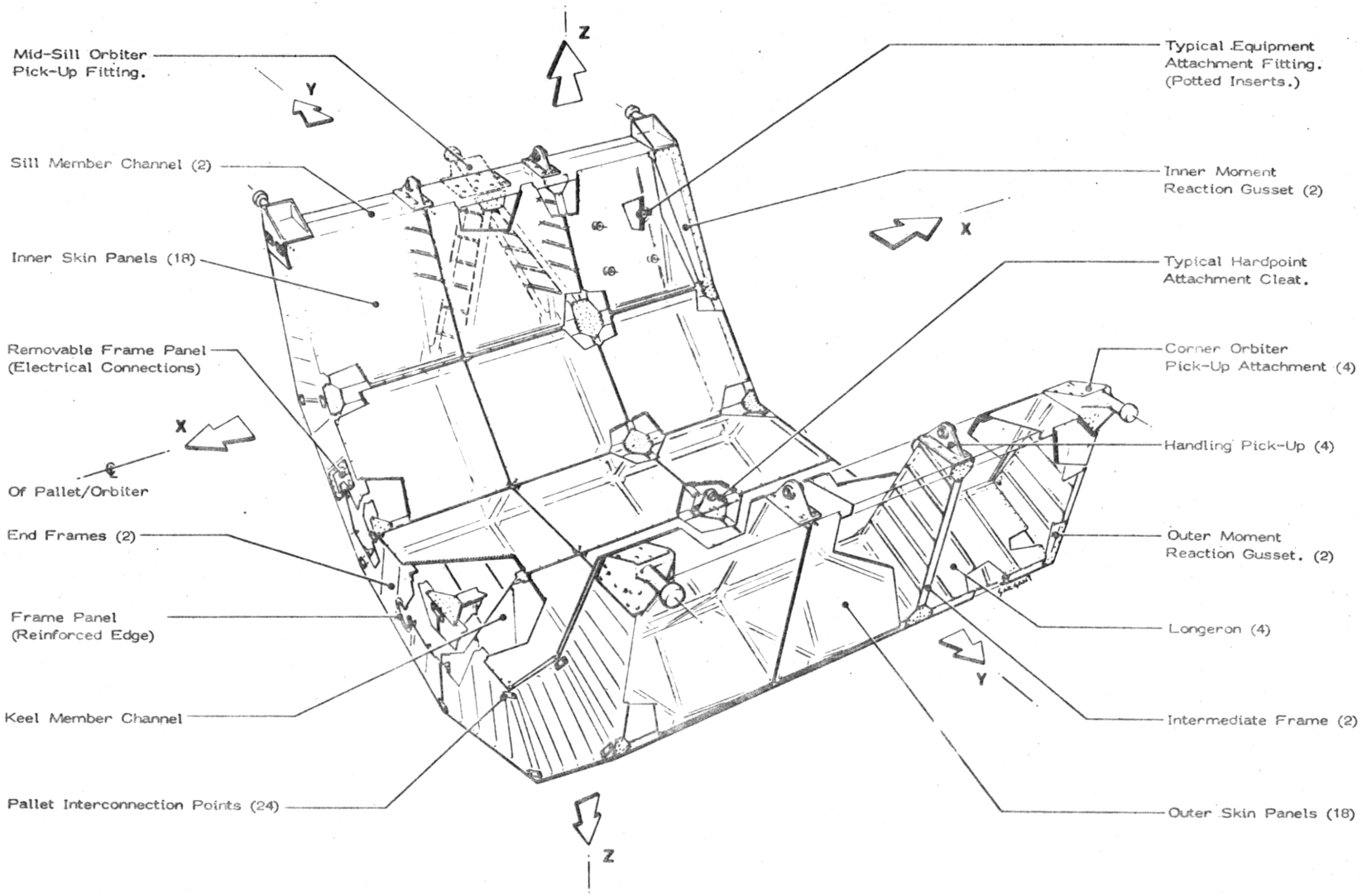
PRESSURIZED MODULE



PALLET STRUCTURE DESCRIPTION

- INTEGRALLY MACHINED FRAMES AND LONGERONS, HONEYCOMB SKIN PANELS
- MATERIAL: 2024 - T 851; 2024 - T 851/T 62; 2024-T 3/ T 42
- BOLTED ASSEMBLY OR INDIVIDUAL SUSPENSION, DEPENDING ON EXPERIMENT REQUIREMENTS
- THREE CORNER STAT. DETERMINED OR UNDETERMINED SUSPENSION DEPENDING ON DYNAMIC REQUIREMENTS

PALLET STRUCTURE



GENERAL HABITABILITY REQUIREMENTS

- PROVIDE A WORKING AREA FOR EXPERIMENTERS
  - SHUTTLE WILL PROVIDE MOST CREW HABITABILITY EQUIPMENT
- DESIGN FOR MAXIMUM HABITABILITY
- OPTIMIZE INTERIOR FOR ZERO "G" UTILIZATION WHILE GIVING HIGH CONSIDERATION TO GROUND ("1 G") MFG, CHECKOUT & TURN AROUND ACTIVITIES
- ARRANGE INTERIOR TO MINIMIZE CASUAL INTERFERENCE I.E. INTERRUPTION OF CREWMAN WHILE PERFORMING TASKS

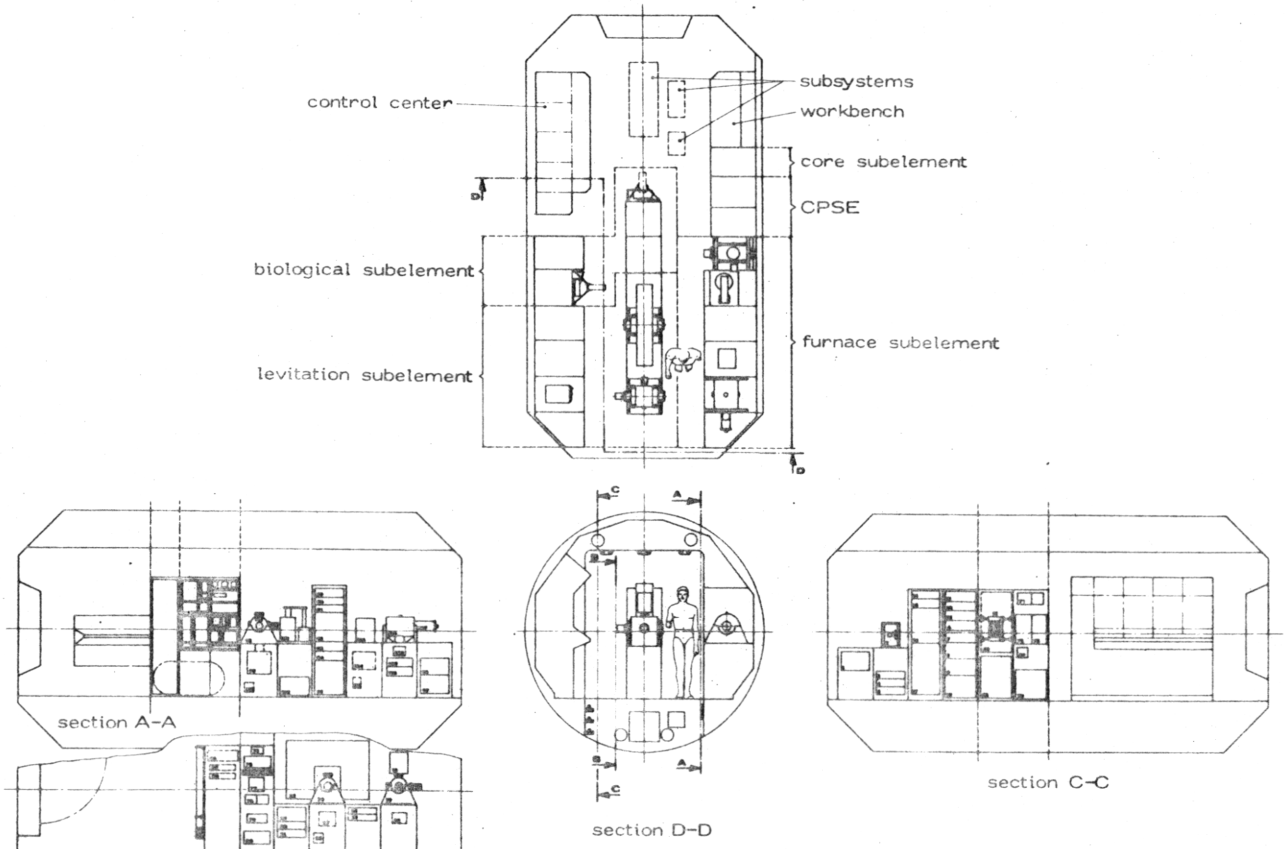
DESIGN DATA FOR CREW HABITABILITY

- PROVIDE INTERIOR INTEGRATION & PAYLOAD EQUIPMENT
- INTEGRATE MAN INTO DESIGN CONSIDERATION
- PROVIDE EQUIPMENT UNIQUELY NEEDED BY MAN

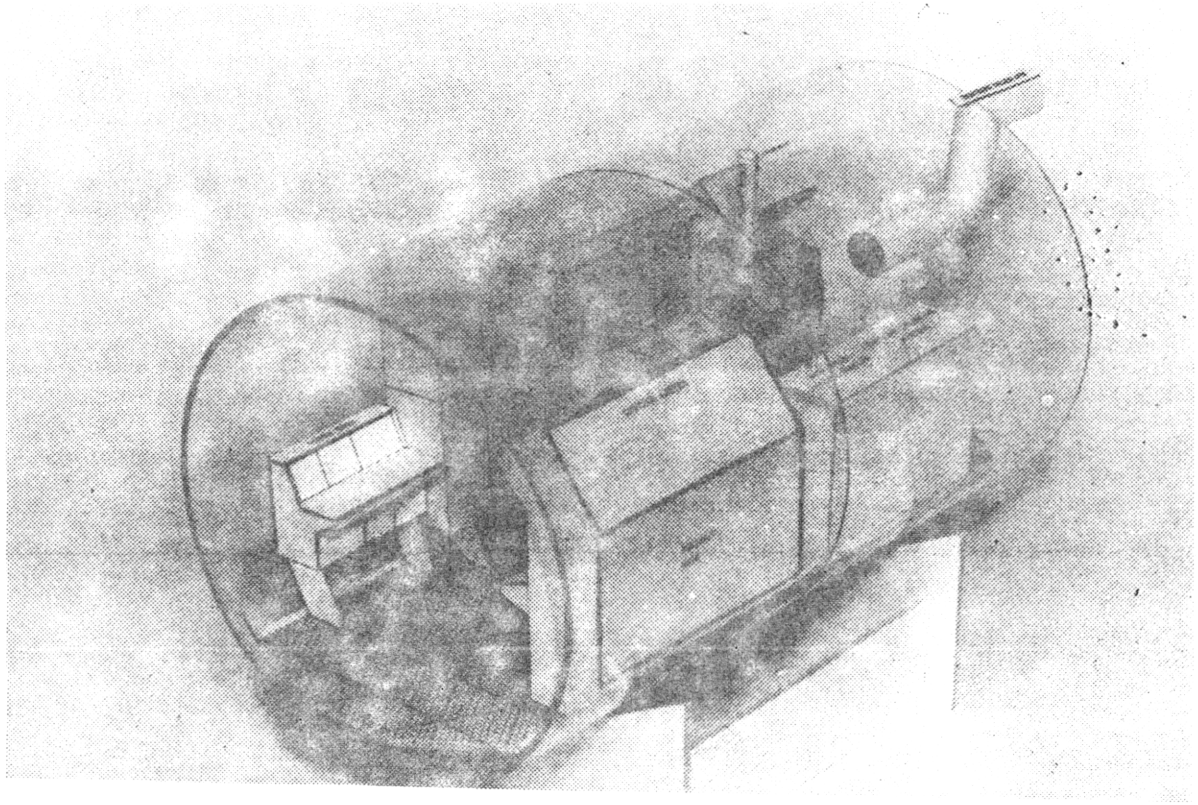
UTILIZING

- INTERIOR ARRANGEMENT DRAWINGS (INBOARD PROFILES)
- 3-DIMENSIONAL MODELS OF 1/20 SCALE
- 1/1 SCALE MOCK UPS OF MAJOR ITEMS

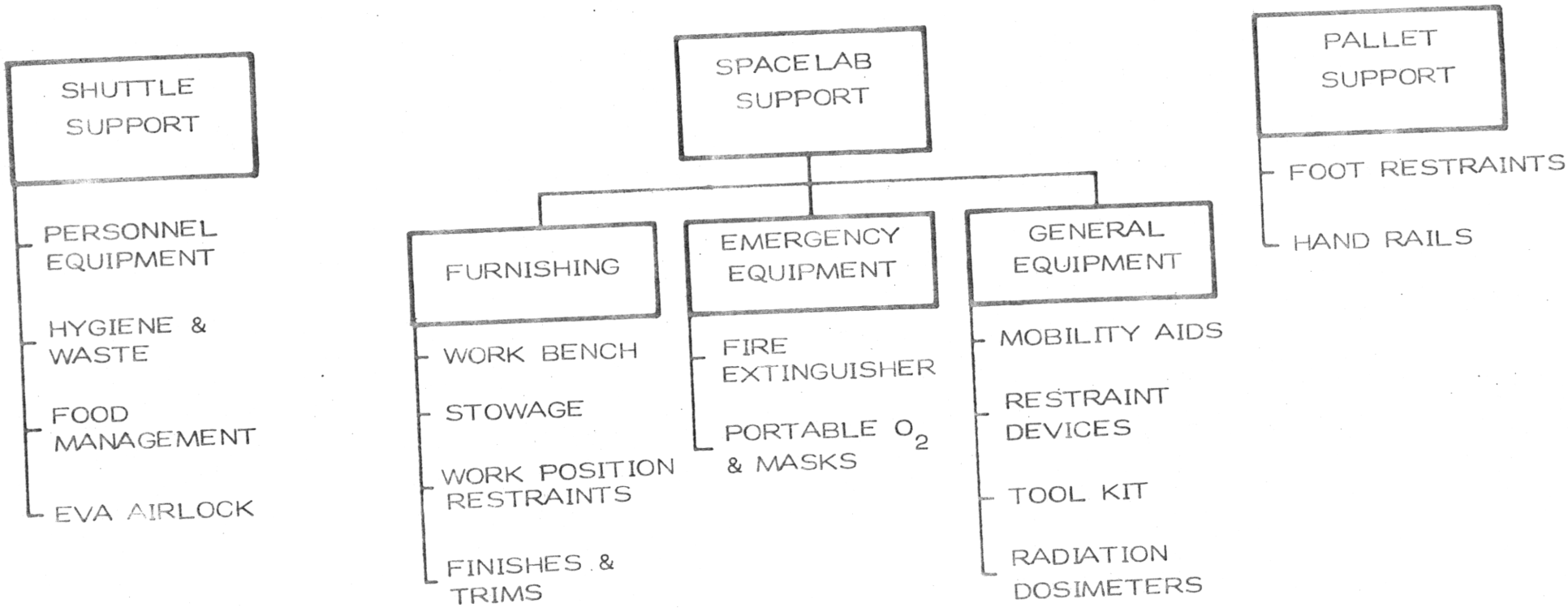
INBOARD PROFILE OF PAYLOAD "C"



1/20 SCALE MODEL



CREW HABITABILITY PROVISIONS



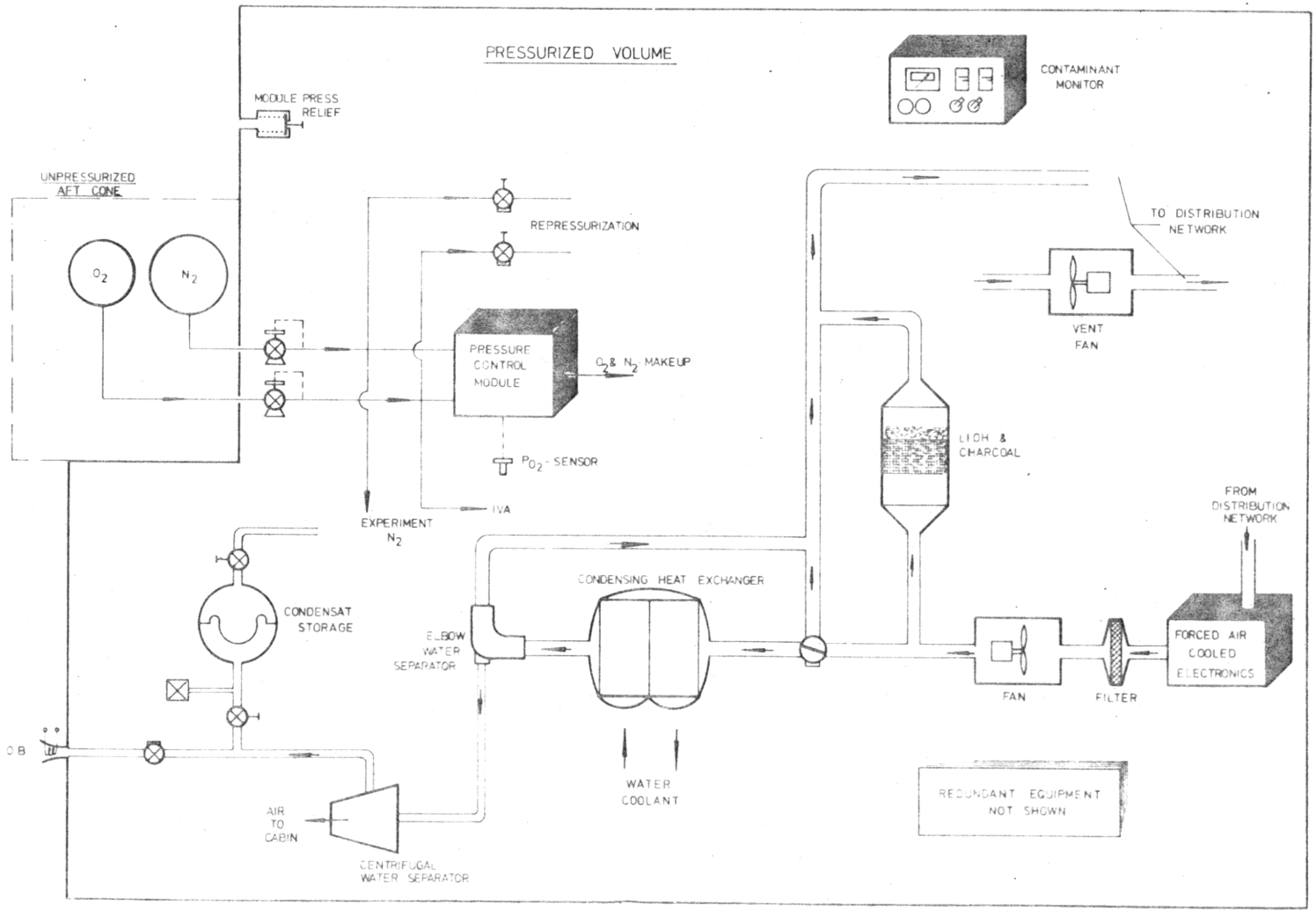
MAJOR EC/LSS REQUIREMENTS

FUNCTIONS PROVIDED BY ORBITER	FOOD, WASTE, SLEEPING & HYGIENE
ATMOSPHERE PRESSURE & COMPOSITION	COMPATIBLE WITH SHUTTLE
CONTAMINANT MONITOR	REQUIRED
AIR VELOCITIES	6 - 16 METERS/SEC
AIR TEMPERATURES	18 - 27 ^{o}C SELECTABLE
RELATIVE HUMIDITY	40 - 60 %
AIR CLEANLINESS STANDARD	CLASS 100,000
CARBON DIOXIDE LEVEL	3 mm Hg NOMINAL
	7.6 mm Hg MAXIMUM

KEY TRADES AND ANALYSES - EC/LSS

- CRYOGENIC VS GASEOUS N_2, O_2
- CARBON DIOXIDE CONTROL CONCEPT TRADE
- HUMIDITY CONTROL CONCEPT TRADE
- ATMOSPHERE RECONDITIONING COMPONENT ARRANGEMENT
- AIR COOLING CONCEPT TRADE
- EUROPEAN DEVELOPMENT VS US-HARDWARE
- PRESSURE AND CO_2 CONTROL SHUTTLE - SPACELAB INTEGRATION ANALYSIS
- TRACE GAS & ODOR CONTROL - CONTAMINANT BUILD-UP HISTORIES ANALYSIS
- COMMONALITY ANALYSIS

EC/LSS BLOCK DIAGRAM



HUMIDITY CONTROL CONCEPT TRADE SUMMARY

KEY TRADE CRITERIA	CONDENSING HEAT EXCHANGER	HYGROSCOPIC SALTS+
WEIGHT	44.8 KG	47.8 KG
VOLUME	0.077 M^3	0.064 M^3
POWER	64 WATTS	44 WATTS
COST (DDT&E/RECURRING)	MED	HIGH
TCS IMPACT	REQUIRES 5.5°C COOLANT	IMPROVES RADIATOR PERFORM.
REFURBISHMENT	MED	LOW
DEVELOPMENT RISK	LOW	HIGH
SAFETY	EXCELLENT	GOOD-TO-EXCELLENT
FLEXIBILITY	MED	HIGH
GROWTH	HIGH	LOW(EXPENDABLE WEIGHT)
COMPLEXITY	MED	SIMPLE
SELECTION	✓	

+ Li_2O SELECTED IN LOWER LEVEL TRADE

THERMAL CONTROL KEY ISSUES

- ASSESSING SPACE LAB RADIATOR CAPABILITY
- DERIVING DESIGN HEAT REJECTION LOADS
- LEVEL OF SHUTTLE SUPPORT
- DEPLOYABLE VS. FIXED RADIATORS

THERMAL CONTROL SELECTION

MISSION MODE	REQMT.	METHODS
LAUNCH AND DESCENT	1 KW MAX.	• LOOP CAPACITANCE • ORBITER SUPPORT • SUPPLEMENTAL DEVICES
ON-ORBIT	2.9 KW MIN. 6.3 KW NOM. 8.9 KW MAX	• SPACELAB AUTONOMOUS • FIXED RADIATORS • DEPLOYABLE RADIATORS • DEPLOYABLE MODULE • PALLET RADIATORS • SPACE LAB + ORBITER • ORBITER ONLY

THERMAL CONTROL SUBSYSTEM REQUIREMENTS

PAYLOAD	A	B	C	D	E
THERMAL REQMT - KW	4.75	6.3	8.9	7.5	2.86
SPACE LAB CAPACITY - KW	3.03	6.3	7.1	6.9	0
ESTIMATED ORBITER SUPPLEMENT AVAILABLE - KW	1.9-6	0-6	~6	~6	~6
MARGIN	4 TO 90%	0 TO 95%	~47%	~72%	~110%

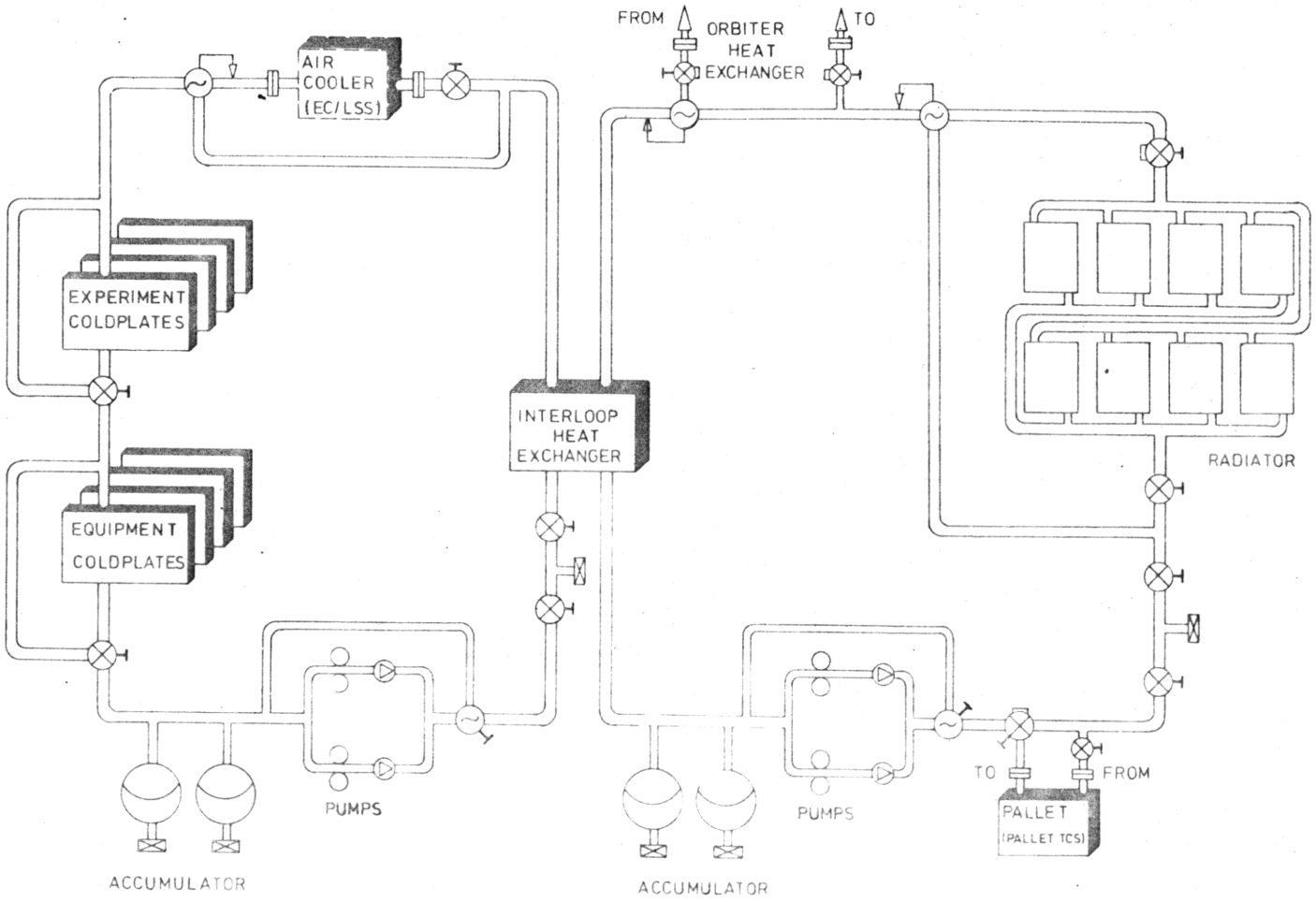
KEY TRADES AND ANALYSES - TCS

- RADIATOR AREA EXTENSION CONCEPT TRADES
- COOLANT LOOP REDUNDANCY ANALYSIS
- SUPPLIMENTAL HEAT REJECTION CONCEPT TRADES
- PALLET TCS INDEPENDENT VS MODULE DEPENDENT
- HEAT LEAK ANALYSIS - INSULATION AND RADIATOR
- METEOROID DAMAGE ANALYSIS - INSULATION AND RADIATOR
- EUROPEAN DEVELOPMENT VS US-HARDWARE
- COMMONALITY ANALYSIS

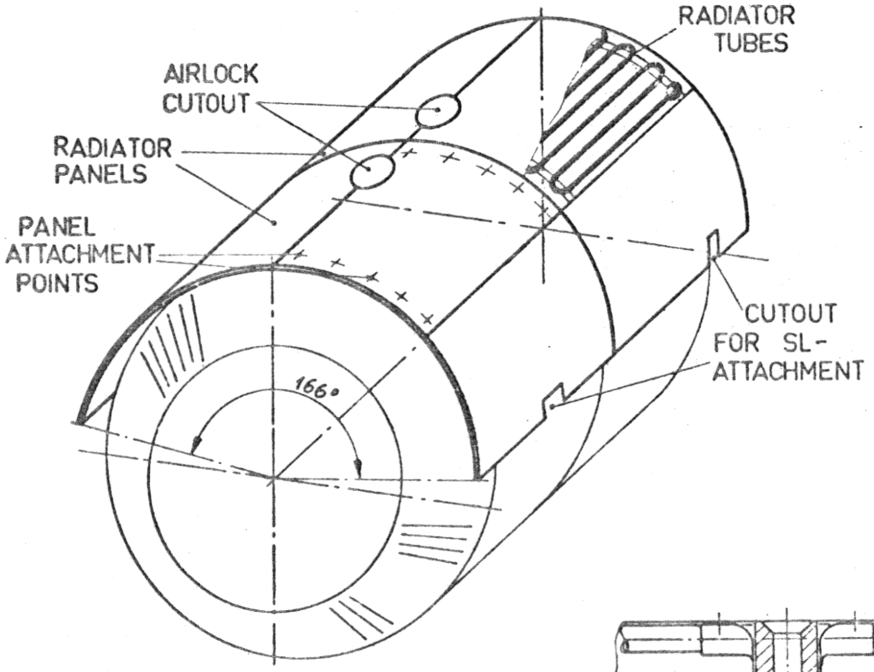
THERMAL CONTROL SUBSYSTEM DESCRIPTION

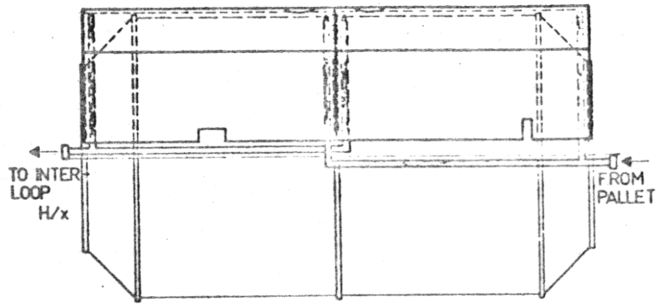
- FIXED RADIATORS
- FREON RADIATOR LOOP
- WATER INTERNAL LOOP
- THERMAL CONTROL INTERFACE WITH SHUTTLE: LAUNCH AND DESCENT, PEAK LOADS AND EMERGENCY
- PALLET USES ACTIVE AND PASSIVE ELEMENTS
- SUPPLEMENTAL HEAT REJECTION BY ORBITER

TCS BLOCK DIAGRAM

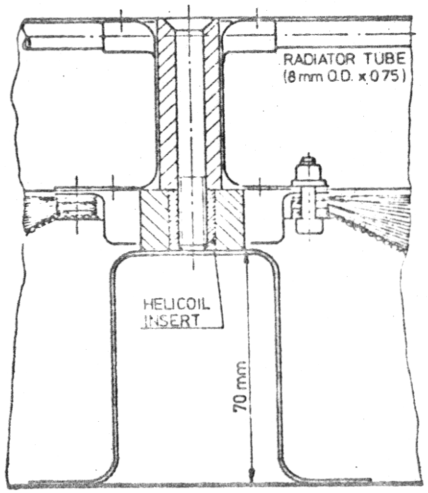


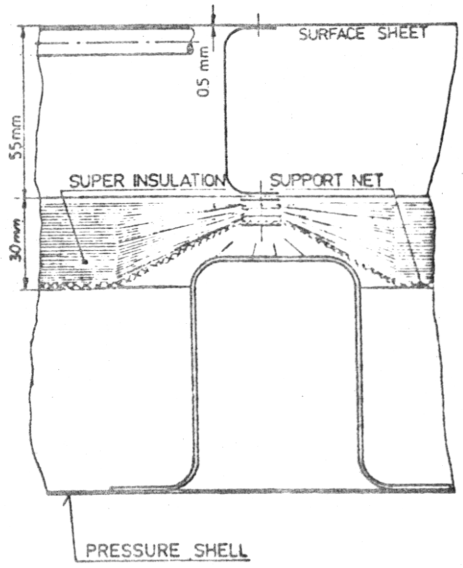
BODY MOUNTED RADIATOR CONCEPT





Body mounted Radiator (Concept 3)





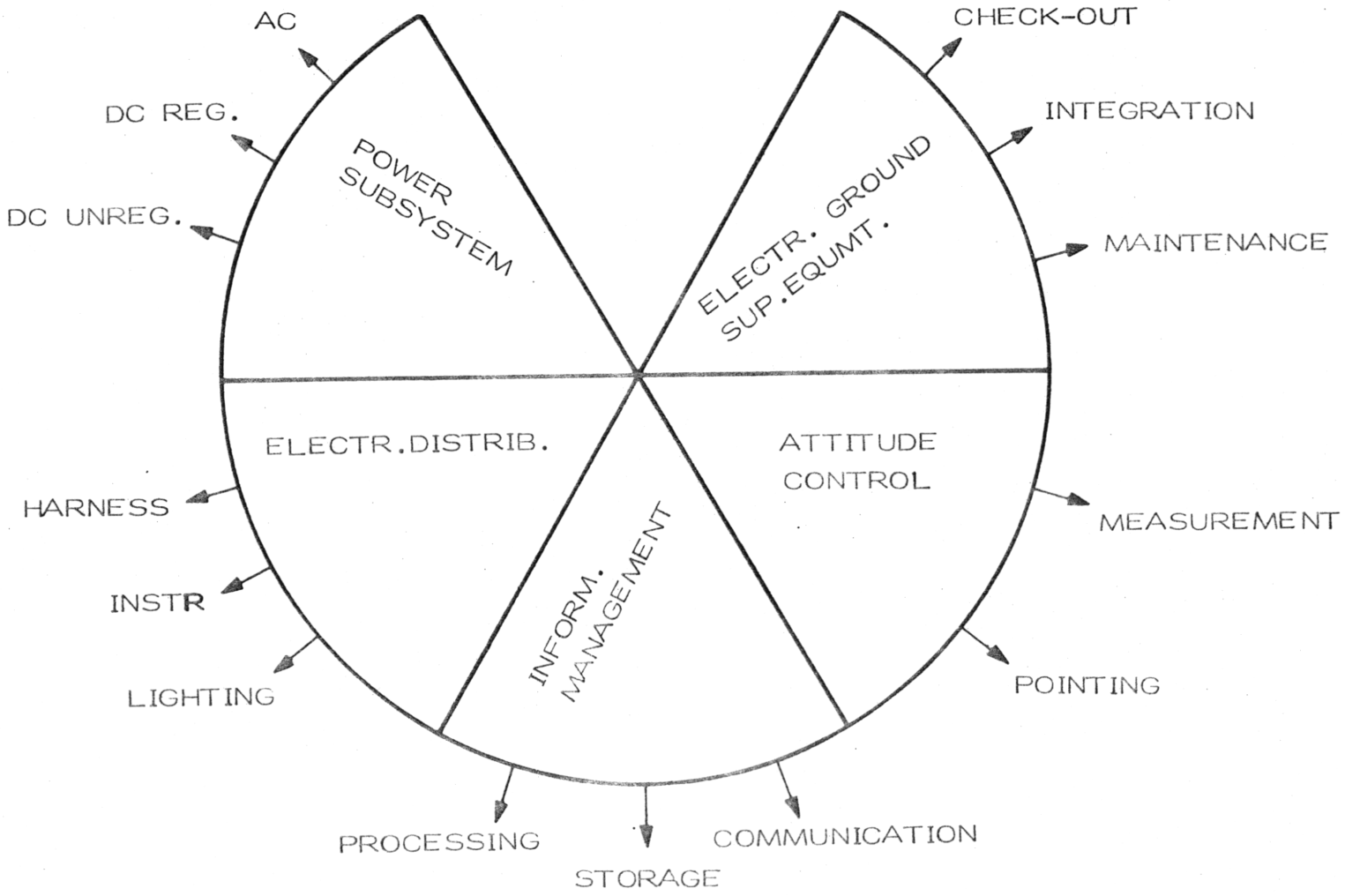
FUTURE THERMAL CONTROL ACTIVITIES

- CONFIRM ORBITER SUPPORT CAPABILITY
- RESOLVE INTERFACE CHARACTERISTICS
- VERIFY SPACELAB CAPABILITY BY COMPUTER ANALYSIS
- CONTINUE INVESTIGATION OF DEPLOYABLE RADIATORS

AGENDA

INTRODUCTION	–	PROF. G. EGGERS
STUDY OVERVIEW	–	H. HOFFMANN
STUDY APPROACH	–	K. BERGE
SYSTEM CONCEPT	–	W. WIENSS
MECHANICAL SUBSYSTEMS	–	W. WIENSS
ELECTRICAL SUBSYSTEMS	–	H. J. POSPIESZCZYK
PROGRAM CONCEPT	–	K. BERGE
PROGRAM VARIATIONS	–	K. BERGE
CONCLUSIONS & RECOMMENDATIONS	–	H. HOFFMANN

ELECTRICAL SUBSYSTEMS



KEY ISSUES OF ELECTRICAL SUBSYSTEMS

- LEVEL OF SPACELAB AUTONOMY
- DEGREE OF ACCOMMODATING PAYLOADS REQUIREMENTS
- SUBSYSTEM RELIABILITY
- USE OF FULL POWER FROM THE ORBITER
- USE OF ORBITER COMPUTER AND MASS MEMORY
- USE OF ORBITER ATTITUDE STABILIZATION CAPABILITY

POWER REQUIREMENTS VS. CAPABILITIES

PAYLOAD / POWER (KW)	A ASTRONOMY	B EARTH OBS. COM./NAV.	C MATERIAL SC. LIFE SC.	D SPACE PHYSICS	E TECHN.
REQUIRE. AV. REQUIRE. PEAK	1.11 1.43	4.80 6.50	3.90 8.70	2.76 6.33	2.06 4.00
ANALYSIS PERFORMED	1.11 1.43	1.80 5.80	2.00/1.76+ 3.72/3.28+ .72 .28	1.38/1.38+ 3.17/3.17+	2.06 4.00
SUBSYSTEMS LOSSES AV. LOSSES PEAK	2.13 0.81 0.89	2.68 1.12 2.12	2.68 1.15 1.60	2.68 1.01 1.46	1.06 3.89 6.33
TOTAL (A./P.)	4.04/4.45	5.60/10.60	7.59/11.28	6.45/10.48	3.89/6.33
AVAILABLE (FUEL CELL)	7.00/12.00	7.00/12.00	7.00/12.00	7.00/12.00	7.00/12.00
MARGIN	2.96/7.55	1.40/1.40	-0.59/0.72	0.55/1.52	3.11/5.67

+ POWER SUPPLIED IN AC AND UNREGULATED DC

ENERGY REQUIREMENTS VS. CAPABILITIES

PAYLOAD	A ASTRONOMY	B EARTH OBS. COM./NAV.	C MATER.SC. LIFE SC.	D SPACE PHYSICS	E TECHN.
REQ.OPS.TIME	24 H/D	12 H/D	24 H/D	24 H/D	24 H/D
AVAIL.OPS.TIME	24 H/D	12 H/D	19.1 H/D	24 H/D	24 H/D
ENERGY MARGIN	353 KWH	391 KWH	- 173 KWH	0 KWH	407 KWH

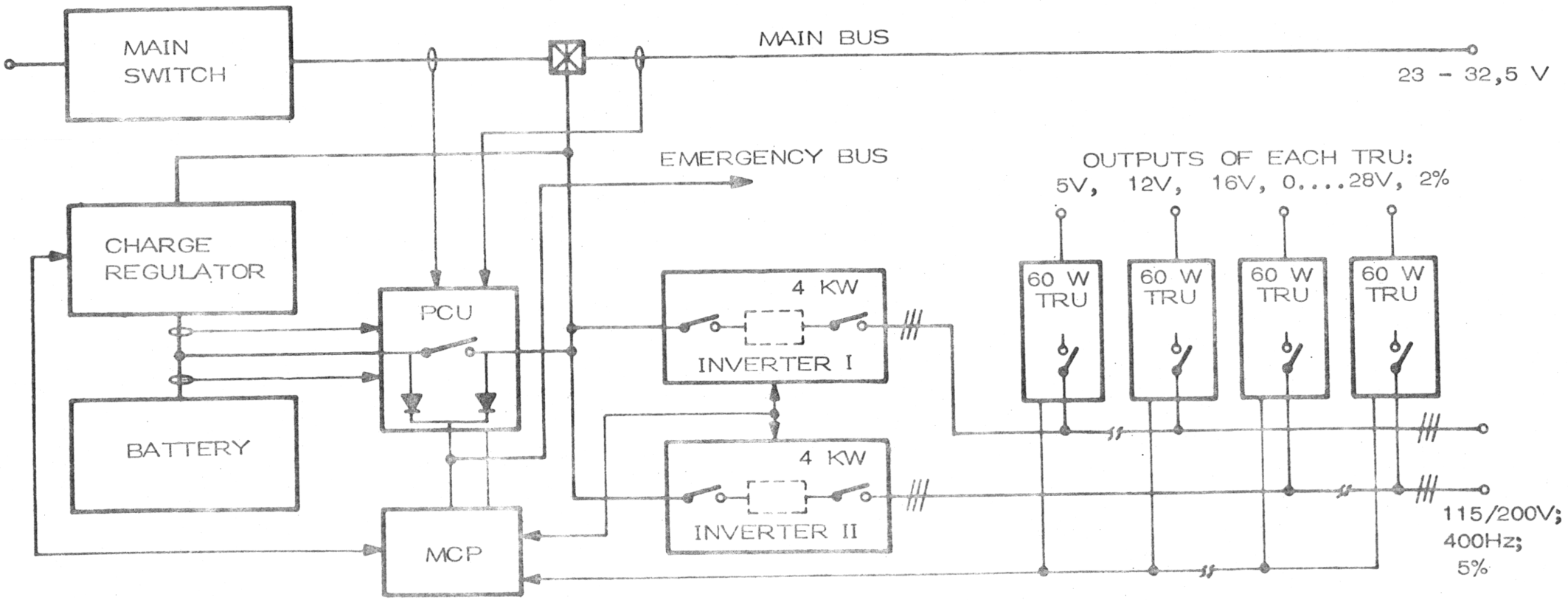
- THE SHUTTLE CARRIES ONE SET OF FUEL CELL REACTANT TANKS FOR SPACELAB
- TOTAL TIME ON ORBIT: 7 DAYS
- EXPERIMENT MISSION TIME: 6 DAYS

\+ FOR FULFILLING THE FULL TIME REQUIREMENTS A SECOND TANK SET HAS TO BE ADDED

POWER CONCLUSIONS

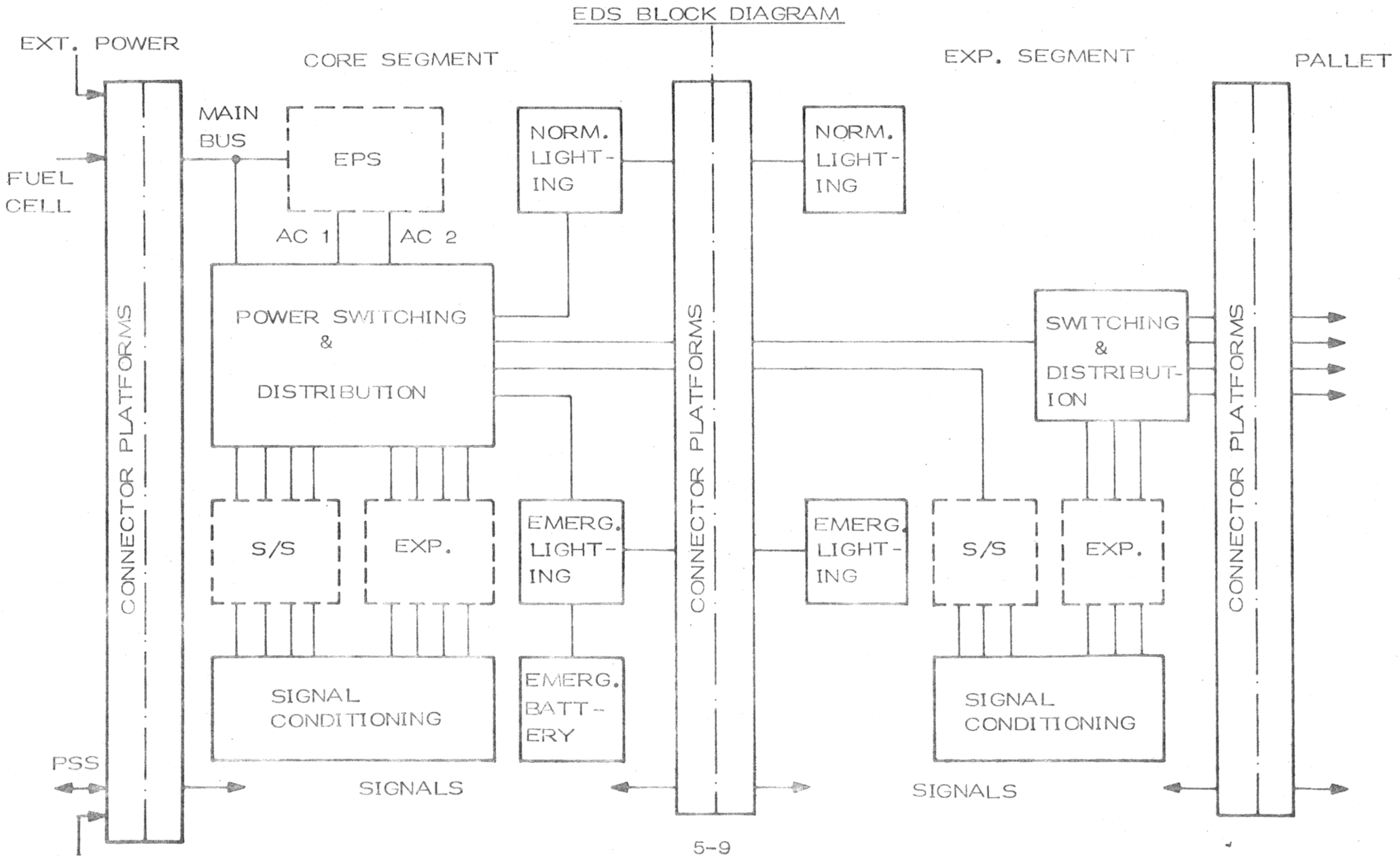
- THE OUTPUT OF ONE SHUTTLE FUEL CELL IS ADEQUATE
- ADDITIONAL REACTANTS NEEDED FOR ONE PAYLOAD
- MATERIAL SCIENCES IS THE DESIGN DRIVER

BLOCK DIAGRAM OF EPS SUBSYSTEM

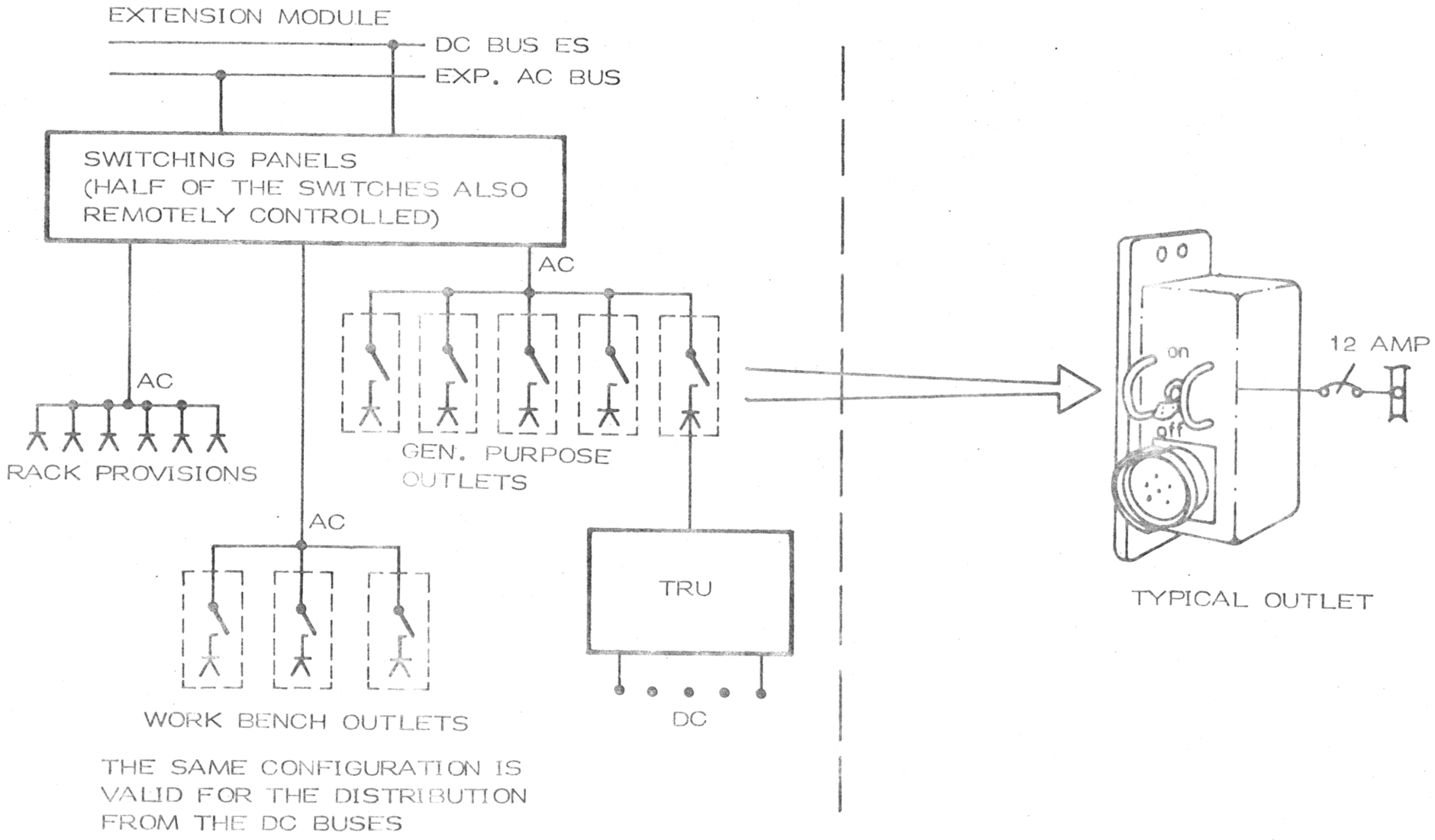


EQUIPMENT OF THE ELECTRICAL DISTRIBUTION SUBSYSTEM

	CORE SEGMENT		
	NUMBER OF UNIT	WEIGHT PER UNIT (KG)	POWER (W)
POWER SWITCHING			46
POWER DISTRIBUTION BOX	1	16	
POWER CENTRAL PANEL	1	3	
INSTRUMENTATION			32
INSTRUMENTATION BOX	1	3.5	
SENSORS	TBD	4	
HARNESS			
CABLINGS		160	
INTERCONNECTION DEVICES		40	
UMBILICALS	2	10	
MISCELLANEOUS (SUPPORTS ETC.)		25	
LIGHTING			175
CONTROL PANELS	1	1	
BATTERY	1	1.5	
LAMPS AND FIXTURES	6	2.5	
MISCELLANEOUS (SUPPORTS ETC.)		1	


EDS BLOCK DIAGRAM
EXT. POWER
CORE SEGMENT
EXP. SEGMENT
PALLET
MAIN BUS
EPS
NORM. LIGHT-ING
NORM. LIGHT-ING
FUEL CELL
AC 1
AC 2
POWER SWITCHING & DISTRIBUTION
SWITCHING & DISTRIBUT-ION
CONNECTOR PLATFORMS
CONNECTOR PLATFORMS
CONNECTOR PLATFORMS
S/S
EXP.
EMERG. LIGHT-ING
EMERG. LIGHT-ING
S/S
EXP.
SIGNAL CONDITIONING
EMERG. BATT-ERY
SIGNAL CONDITIONING
PSS
SIGNALS
SIGNALS

POWER DISTRIBUTION SCHEME FOR EXPERIMENTS



INFORMATION MANAGEMENT SUBSYSTEM

REQUIREMENTS VS. CAPABILITIES

REQUIREMENTS	CAPABILITIES
• DISPLAY AND CONTROL CONSOLE	• MAIN CONSOLE IN SPACE LAB (TWO OPERATORS) – IMS EQUIPMENT ACCOMMODATED AT PAYLOAD SPECIALIST STATION (PSS)
• CAUTION AND WARNING	• INDEPENDENT OF COMPUTER AND DATA BUSES – AUDIBLE AND VISUAL INDICATION IN SPACE LAB AND AT PSS
• RECORDING	• 25 KBPS RECORDER FOR MAINTENANCE AND SPECIAL PURPOSES – PROVISION FOR CPSE RECORDER
• DOWN – LINK	• 25 KBPS CONTINUOUSLY – UP TO 5 HOURS/DAY 256 KBPS OR ANALOG SIGNAL (UP TO 5 MHZ) – VOICE ON REQUEST

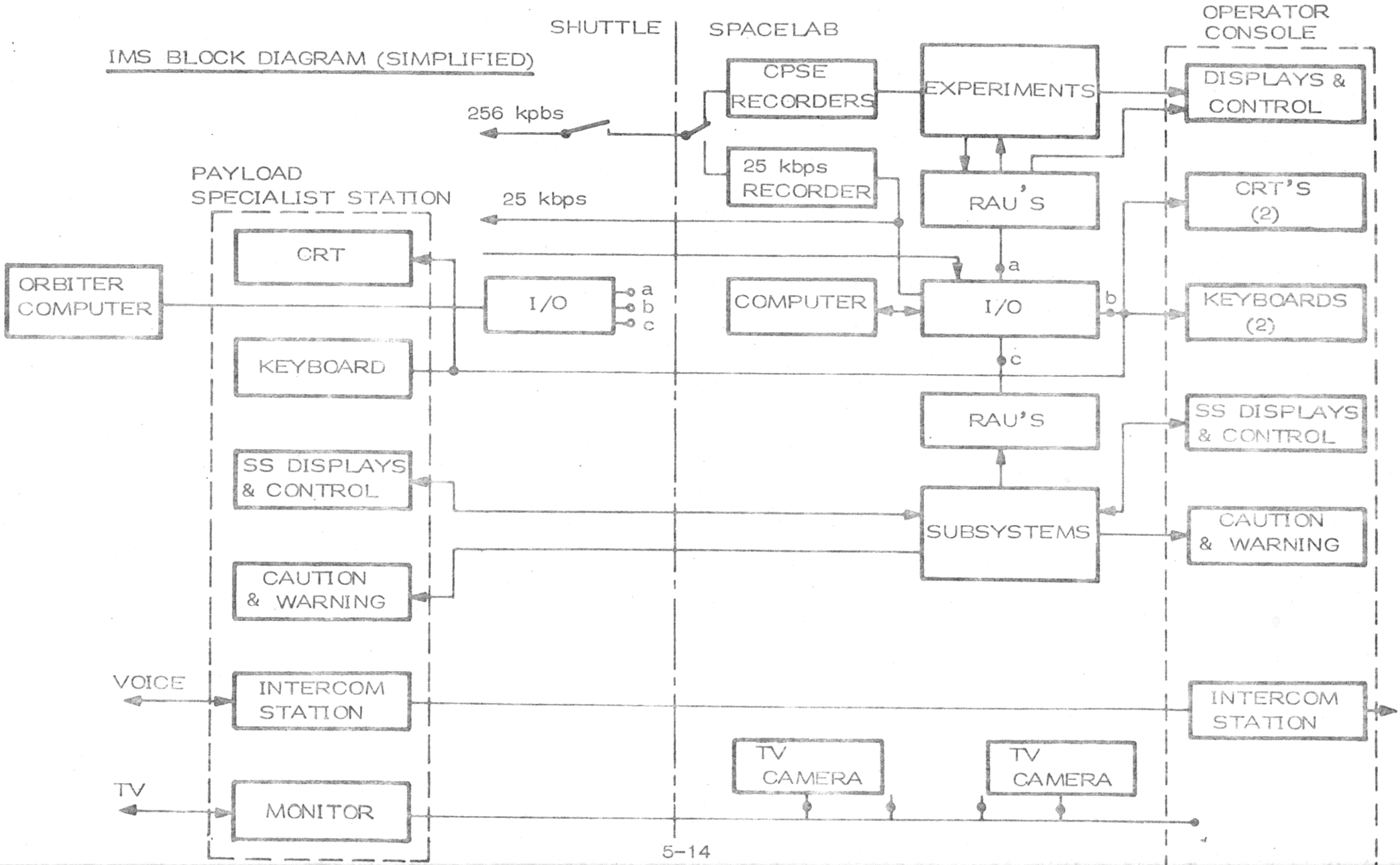
IMS REQUIREMENTS VS. CAPABILITIES (CONT'D)

REQUIREMENTS	CAPABILITIES
• UP - LINK	• COMMAND AND CONTROL FOR EXPERIMENTS - VOICE ON REQUEST
• CLOSED CIRCUIT TV	• TWO TV CAMERAS AND ONE MONITOR - PROVISIONS FOR ADDITIONAL MONITOR AND CAMERAS
• ON-BOARD CHECK-OUT	• PROCESSING OF ENGINEERING DATA OF S/S AND EXP. (LIMIT CHECKS, TRENDS ETC.) - FAILURE IDENTIFICATION AND ISOLATION
• DATA PROCESSING	• TELEMETRY AND DISPLAY FORMAT GENERATION - ATTITUDE, TIME ETC. CODE CONVERSION - EXPERIMENT SEQUENCING AND CONTROL - GENERAL PURPOSE PROCESSING FOR EXP.
• DATA ACQUISITION AND DISTRIBUTION	• STANDARDIZED REMOTE ACQUISITION UNITS - SEPARATE BUSES FOR SUBSYSTEMS AND EXPERIMENTS

IMS MAIN TRADES AND ANALYSES

TRADES AND ANALYSES	CONSIDERATIONS	B2	B3
• DATA ACQUISITION	• COMPUTER CONFIG. – BUSES – CREW STATIONS	×	×
• COMPUTER SELECTION	• SHUTTLE VS. EUROPEAN COMPUTER – AVAILABILITY AND COSTS – SOFTWARE	×	×
• AUTONOMY (COMPUTER, MASS MEMORY, RECORDER ETC.)	• INTERFACE TO SHUTTLE – FUNCTIONS OF EGSE	×	×
• AUTOMATION	• FAIL-SAFE COMPUTERS AND BUSES – SELF-TEST AND RECONFIGURATION – COMPLEX SOFTWARE	×	
• BUS CONCEPTS	• INTERFACES (I/O, COMPUTER, RAU'S) – FLEXIBILITY	×	×
• SOFTWARE	• REQUIREMENTS – FLEXIBILITY – USE	×	×

IMS BLOCK DIAGRAM (SIMPLIFIED)



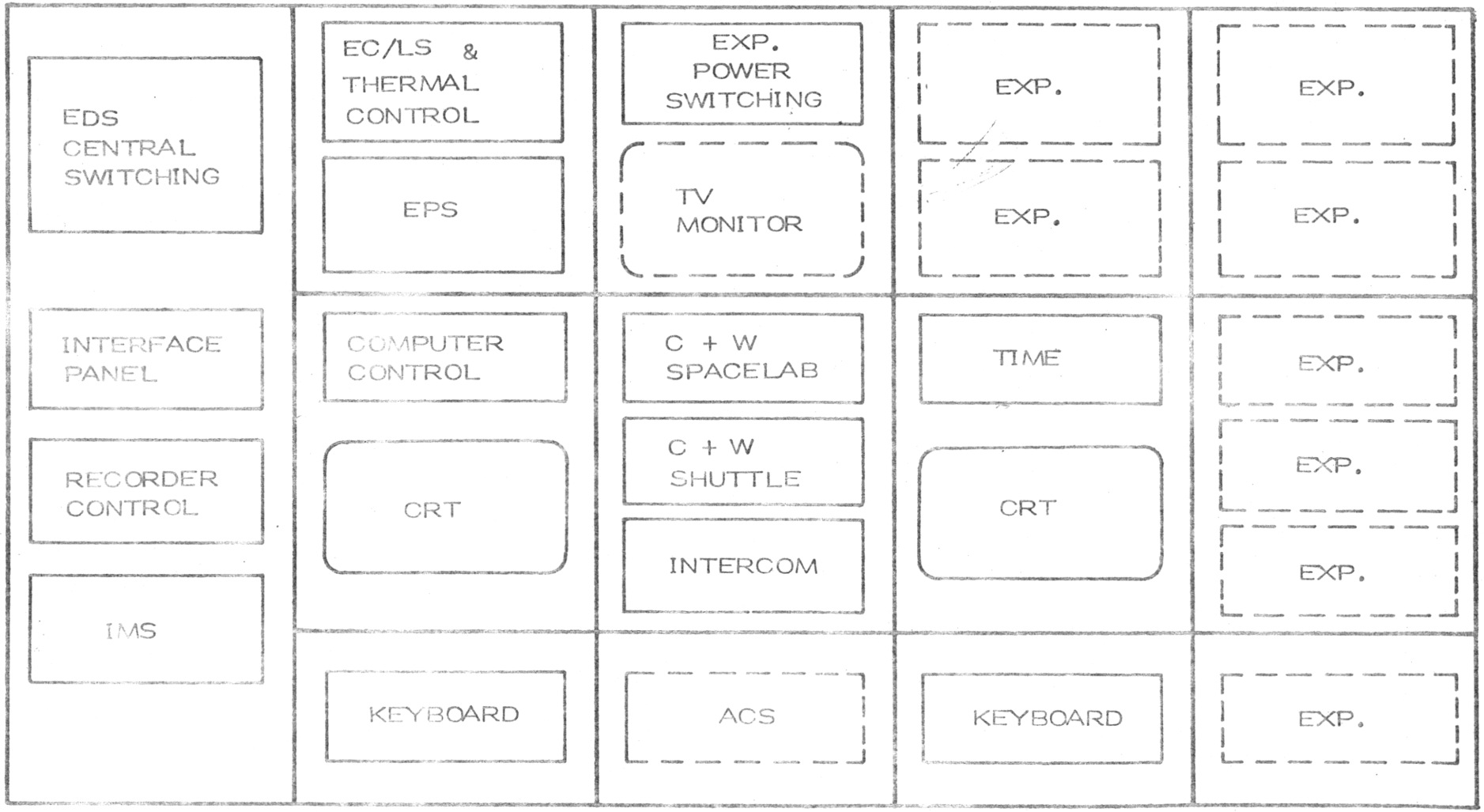
IMS EQUIPMENT CHARACTERISTICS

- 20 REMOTE ACQUISITION UNITS (RAU's)
  - 29 ANALOGUE IN
  - 64 DISCRETES IN
  - 16 DISCRETES OUT
- 2 I/O CONTROLLER
  - DATA BUS CONTROL
  - DIRECT MEMORY ACCESS (DMA)
  - AUXILIARY INTERFACES
- 1 COMPUTER
  - COMMONALITY WITH ORBITER
  - 16 BIT WORD LENGTH
  - 48 K WORDS CAPACITY
  - 2 MICROSECONDS ADD-TIME
- 3 KEYBOARDS (1 IN SHUTTLE, 2 IN SPACELAB)
  - NUMERIC
  - FUNCTION KEYS
- 3 CRT's
  - 15 INCH TYPE
- 2 TV CAMERAS
  - ONE INCH BLACK AND WHITE VIDICON
  - AUTOMATIC LIGHT LEVEL CONTROL
- 2 COMPUTER CONTROL PANELS
  - COMMONALITY WITH ORBITER
  - INITIATES PROGRAM LOADING, ETC.
- 2 IMS CONTROL AND DISPLAY PANELS
  - PROVIDES SWITCHING FOR ALL RAU's
  - DISPLAYS STATUS OF IMS
- 2 CAUTION AND WARNING PANELS
  - LIGHT AND TONE WARNING
  - ADUSTABLE LIMITS
- 1 RECORDER CONTROL PANEL
  - MODE SWITCHING

SHUTTLE SUPPORT TO IMS

- MASS MEMORY FOR COMPUTER PROGRAMS (150 K WORDS)
- SHUTTLE COMPUTER DEDICATED FOR BACK-UP
- SHUTTLE COMPUTER FOR PALLET-ONLY MODE
- ONE TERMINAL DELIVERS
  - TIMES (GMT, MISSION TIME)
  - ATTITUDE DATA
  - UPLINK DATA FOR EXPERIMENTS
- PCM INTERLEAVER - 25 KBPS FOR TELEMETRY
- WIDEBAND DOWNLINK - 256 KBPS OR ANALOGUE SIGNAL UP TO 5 MHZ
- UP - AND DOWN-LINKS FOR VOICE
- PANEL ACCOMMODATION AT THE PAYLOAD SPECIALIST STATION

OPERATING CONSOLE CONCEPTUAL LAYOUT



ACS DESIGN CONCEPT

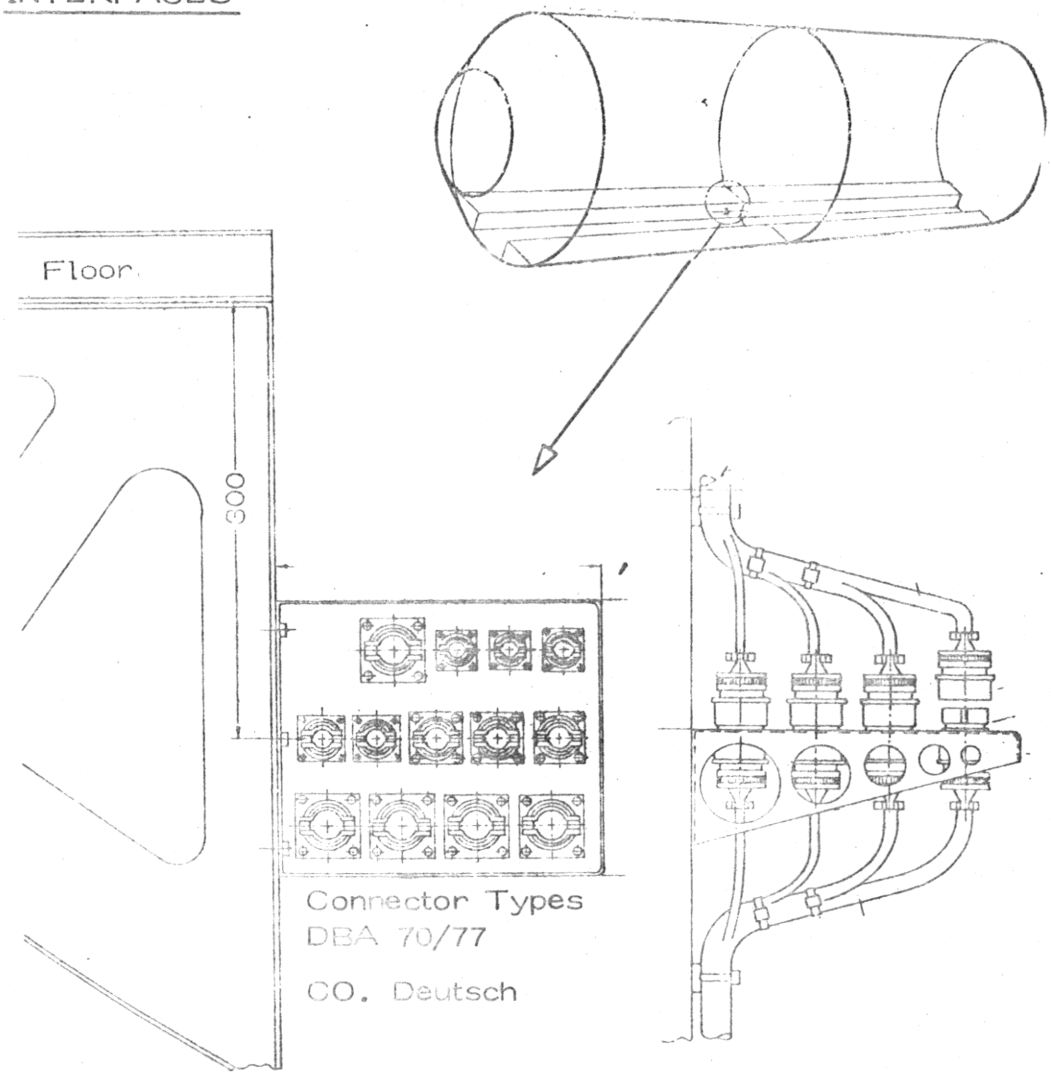
- USE OF SHUTTLE RCS
- PERFORMANCES
  - ATTITUDE ACCURACY: $\pm$ 0.1° (LIMIT CYCLE)
  - ATTITUDE RATES: $\pm$ 0.01°/SEC

- SHUTTLE IDENTICAL ATTITUDE MEASUREMENT PACKAGE IN THE NEAR OF THE EXPERIMENTS

- OPTION
- USE OF SHUTTLE RCS AS BIAS, GIMBALLED CAN FOR EXPERIMENT SENSORS
- PERFORMANCES
  - ATTITUDE ACCURACY: $\pm$ 20 arc sec
  - LOAD CAPABILITY UP TO 3000 KG PER CAN
  - SENSORS SUPPLIED FOR SUN, STAR, EARTH AND MAGNETIC FIELD REFERENCE

INTERFACES

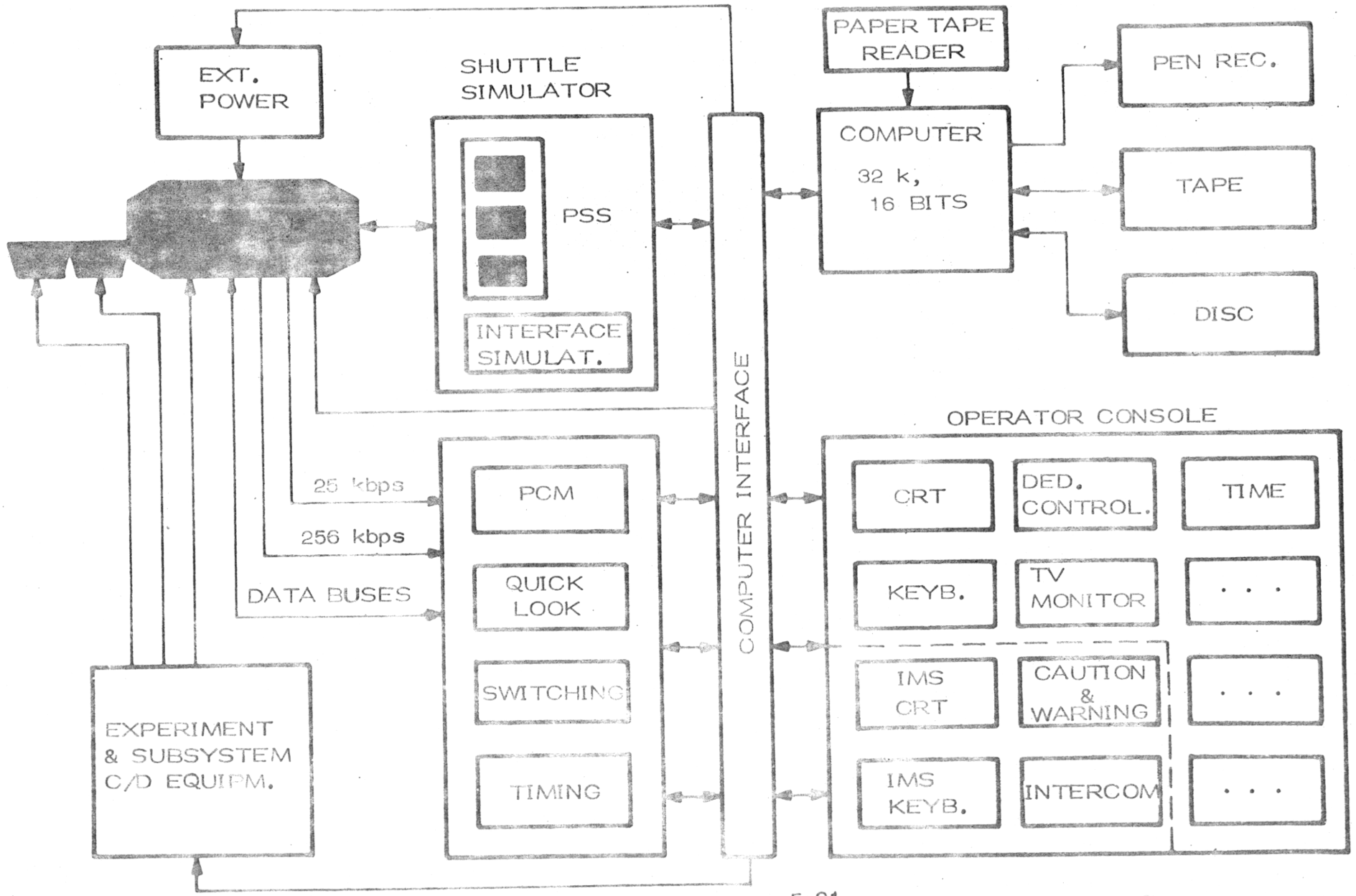
- SPACELAB / SHUTTLE
- SUBSYSTEM / EXP.SEGMENT
- SEGMENT / PALLET
  - EL.POWER
  - SIGNALS
  - BUSES
  - TV
  - VOICE



KEY FUNCTIONS OF ELECTRICAL GROUND SUPPORT EQUIPMENT (EGSE)

- AUTOMATIC SPACE LAB SYSTEM TESTS WITH
  - ENGINEERING MODEL FOR DEVELOPMENT
  - PROTOTYPE FOR QUALIFICATION
  - FLIGHT UNIT FOR ACCEPTANCE
  - FLIGHT UNIT FOR EXPERIMENT INTEGRATION
  - FLIGHT UNIT FOR MAINTENANCE POST-FLIGHT
- FUNCTIONS FOR SYSTEM TESTS
  - SIMULATION OF ORBITER FUNCTIONS AND INTERFACES
  - SIMULATION/STIMULATION OF SUBSYSTEMS AND EXPERIMENTS
  - CONTROL OF S/S AND EXP. C/O EQUIPMENT
  - ACQUISITION, PROCESSING, DISPLAY AND STORAGE OF DATA
- ON-PAD CHECK-OUT
- SPACELAB SIMULATION FOR ORBITER AND EXPERIMENTS

EGSE PRINCIPLE BLOCK DIAGRAM



EGSE DESIGN CONCEPT

- DATA ACQUISITION
  - PCM DATA DECOMMUTATION AND QUICK LOOK
  - SWITCH MATRIX (TLM, BUSES, TIMING, STATUS ETC.)
- PROCESSING AND RECORDING
  - 32K, 16 BIT COMPUTER
  - MAGNETIC TAPES, DISC
  - STRIP CHART RECORDER, TELEPRINTER
  - PAPER TAPE READER
- OPERATOR CONSOLE
  - IMS PARALLEL CRT, KEYBOARD, CAUTION AND WARNING
  - DEDICATED CONTROLS, CRT, KEYBOARD, TIME DISPLAY ETC.
- ORBITER SIMULATION
  - PAYLOAD SPECIALIST STATION
  - FUEL CELL AND SIGNAL INTERFACES;
- SPACELAB SIMULATOR
  - SIMULATION OF PHYSICAL INTERFACES FOR ORBITER AND EXPERIMENTS

SUMMARY OF RESOURCES AVAILABLE TO EXPERIMENTS

- VOLTAGES FOR AC: 115/200V $\pm$ 5%, 400 Hz
  FOR DC: 0 ÷ 28 V, 5V, $\pm$ 12 V, $\pm$ 16 V
  MAIN BUS: 23 ÷ 32.5 VDC
- POWER 3.6 KW DC AVERAGE, 8.6 KW DC PEAK
  OR OR
  2.9 KW AC AVERAGE, 6.9 KW AC PEAK
  - FLEXIBLE POWER DISTRIBUTION
  - ADAPTABILITY TO ALL EXPERIMENT STATIONS
- LIGHTING
- SAFETY
  - TV COVERAGE OF ANY AREA
  - INTERCOMMUNICATION INTERNAL AND TO GROUND
  - CAUTION AND WARNING
- DATA DOWN-LINK
  - 20 KBPS CONTINUOUSLY
  - 256 KBPS OR UP TO 5 MHZ APPR. 5 H/DAY

SUMMARY OF RESOURCES AVAILABLE TO EXPERIMENTS (CONT'D)

- DATA UPLINK
  - 2 KBPS PER STATION PASS
- DATA ACQUISITION AND DISTRIBUTION
  - 10 REMOTE ACQUISITION UNITS
  - 29 ANA. AND 64 DISCR. INPUTS PER UNIT
  - 16 DISCR. OUTPUTS PER UNIT
  - SIGNAL CONDITIONING
- FUNCTIONS
  - CHECKOUT
  - DISPLAY AND MONITORING (2 CRT'S)
  - SEQUENCING
  - GEN. PURPOSE PROCESSING (4K, 16 BIT WORDS)
  - RECORDING (25 KBPS COMPUTER FORMATTED)

SUMMARY OF RESOURCES AVAILABLE TO EXPERIMENTS (CONT'D)

- MISCELLANEOUS
  - PANEL ACCOMMODATION IN OPERATOR CONSOLE
  - TIME DISPLAY
  - ATTITUDE INFORMATION
- ATTITUDE CONTROL
  - PROVISIONS FOR ATTITUDE MEASUREMENT PACKAGE AT THE EXPERIMENTS
  - OPTIONAL GIMBALLED CAN WITH SENSOR PACKAGE
- GROUND SUPPORT
  - STANDARDIZED STIMULI/SIMULI SIGNALS
  - COMPUTER CONTROL OF C/O EQUIPMENT
  - GEN. PURPOSE EQUIPMENT FOR TEST AND MAINTENANCE

AGENDA

INTRODUCTION	–	PROF. G. EGGERS
STUDY OVERVIEW	–	H. HOFFMANN
STUDY APPROACH	–	K. BERGE
SYSTEM CONCEPT	–	W. WIENSS
MECHANICAL SUBSYSTEMS	–	W. WIENSS
ELECTRICAL SUBSYSTEMS	–	H. J. POSPIESZCZYK
PROGRAM CONCEPT	–	K. BERGE
PROGRAM VARIATIONS	–	K. BERGE
CONCLUSIONS & RECOMMENDATIONS	–	H. HOFFMANN

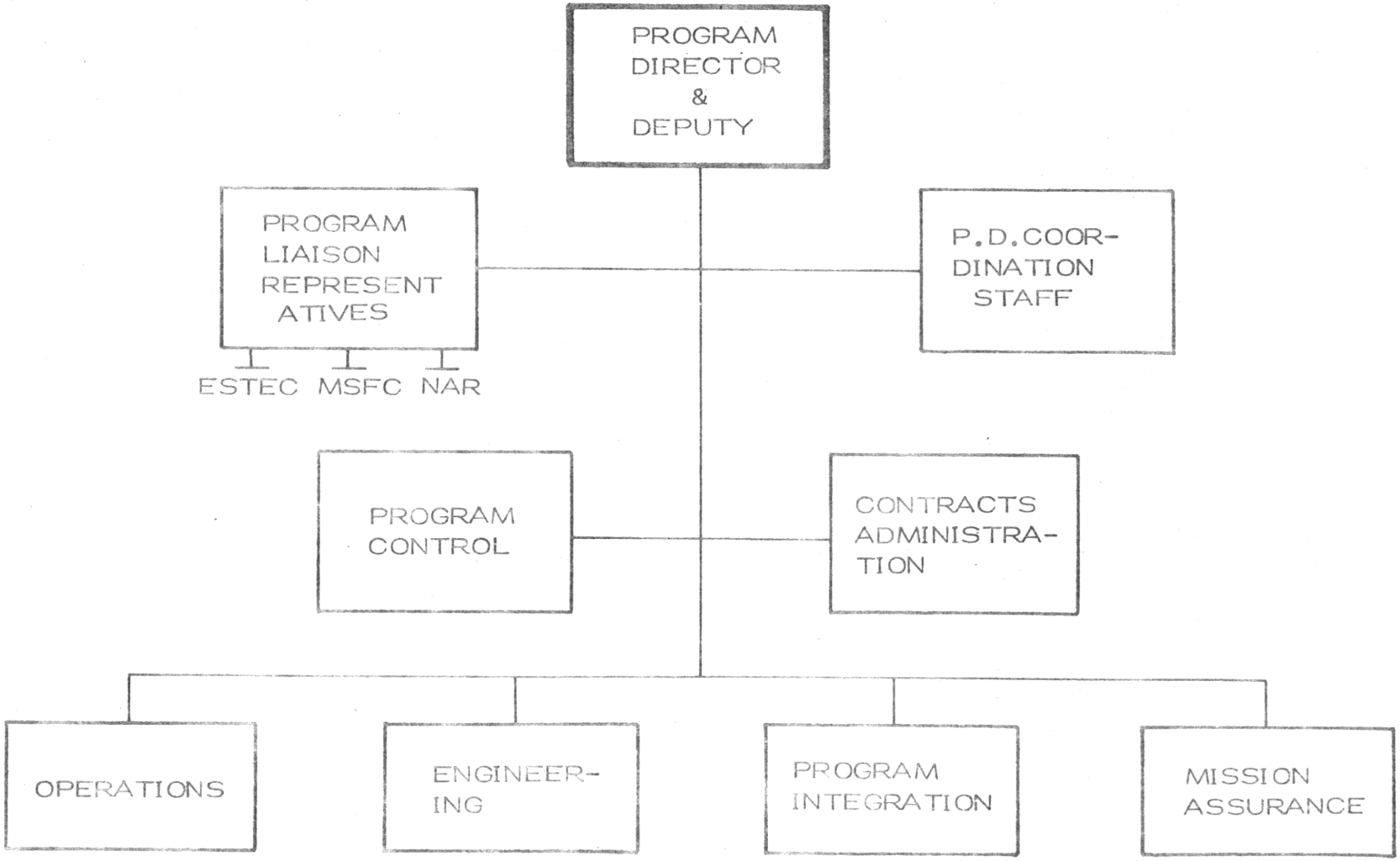
MANAGEMENT OF THE PROGRAM IN PHASE C & D

- ERNO RAUMFAHRTTECHNIK WILL MANAGE THROUGH HIS TEAM SEVEN EUROPEAN COCONTRACTORS HAVING SUBSYSTEM RESPONSIBILITY

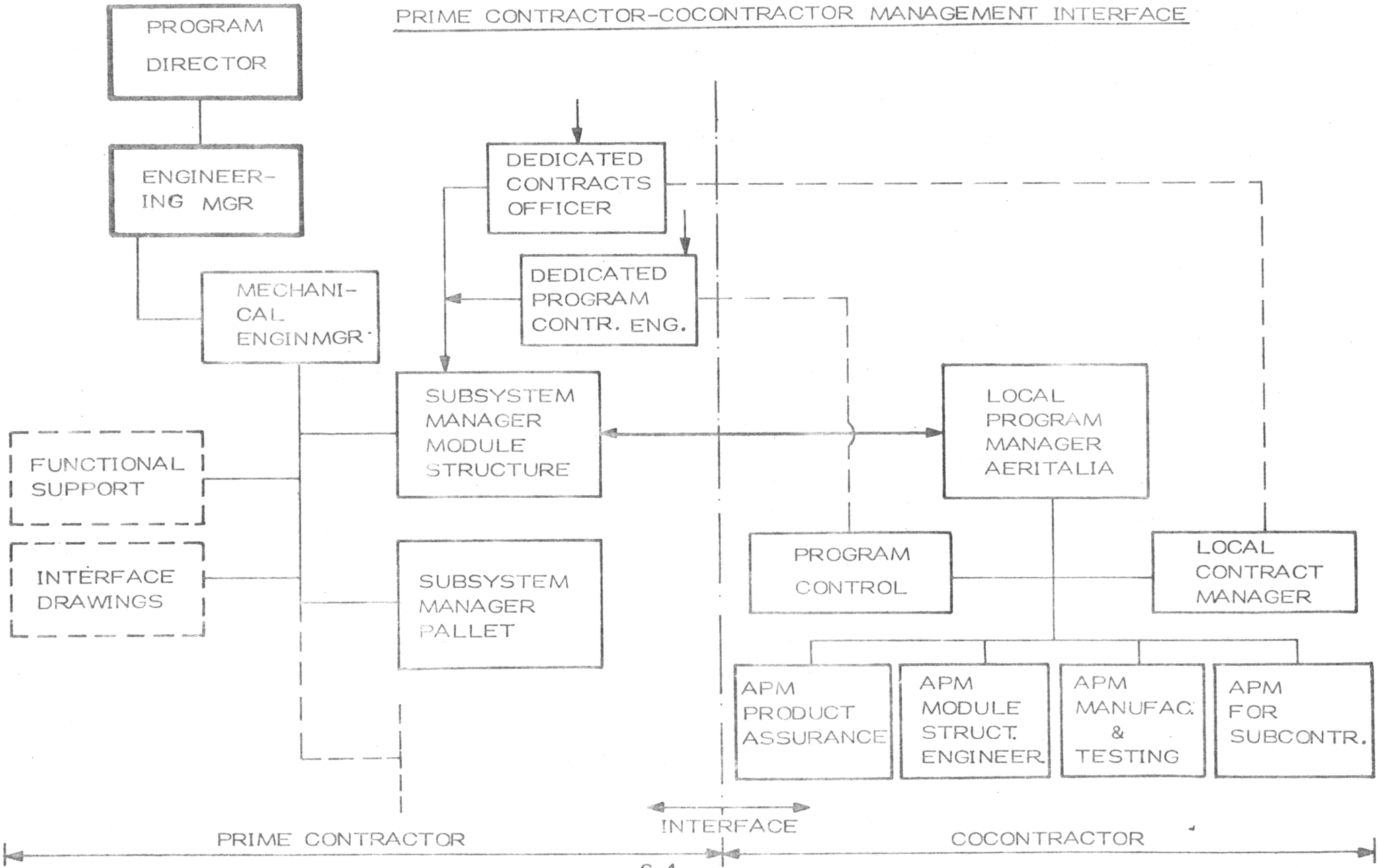
- THE COCONTRACTORS WILL HAVE FURTHER SUBCONTRACTORS AND SUPPLIERS

THE PRIMECONTRACTORS TEAM WILL HAVE THE OVERALL MANAGEMENT AND SYSTEM ENGINEERING RESPONSIBILITY AND WILL BE THE PRIMARY CONTACT TO ESRO/ESTEC AND THROUGH THEM TO NASA.

PRIME CONTRACTORS ORGAINZATION



PRIME CONTRACTOR-COCONTRACTOR MANAGEMENT INTERFACE



MANAGEMENT FEATURES

- CLEARLY DEFINED RESPONSIBILITY BETWEEN PRIME CONTRACTOR AND CO-CONTRACTOR AND OTHER SUBCONTRACTORS

- ERNO'S TOTAL MANAGEMENT AND ENGINEERING TEAM WILL HAVE:

  - ERNO RESIDENT ENGINEERS WILL BE LOCATED AT COCONTRACTORS FACILITIES
  - ERNO LIAISON ENGINEERS WILL BE LOCATED AT ESTEC, MSFC, NAR, WHERE REQUIRED
  - ACCOMMODATIONS FOR ESTEC/NASA PERSONNEL AT ERNO WILL BE AVAILABLE

- SUPPORT IN MAN-RELATED AREAS AND PAYLOAD ACCOMMODATION WILL BE AVAILABLE THROUGH MDAC AND TRW SYSTEMS

PROGRAM DEVELOPMENT SCHEME

THE RECOMMENDED PROGRAM HAS BEEN OBTAINED THROUGH AN ITERATIVE PROCESS CONSIDERING:

- SCHEDULE CRITICALITY
- COST CRITICALITY
- TEST ARTICLES SHARING
- FEEDBACK FROM TEST RESULTS

IT MEETS THE PRIMARY OBJECTIVES OF:

- DELIVERS A FULLY QUALIFIED FLIGHT SPACLE LAB BY EARLY 1979.
- DELIVERS NON-FLIGHT SPACE LAB FOR OPERATIONAL SUPPORT (PROTOTYPE)
- DELIVERS OPERATING EQUIPMENT FOR ABOVE
- RETAINS AN ENGINEERING MODEL CAPABILITY IN EUROPE
- ACCOMPLISH PROGRAM FOR 175 M.A.U.

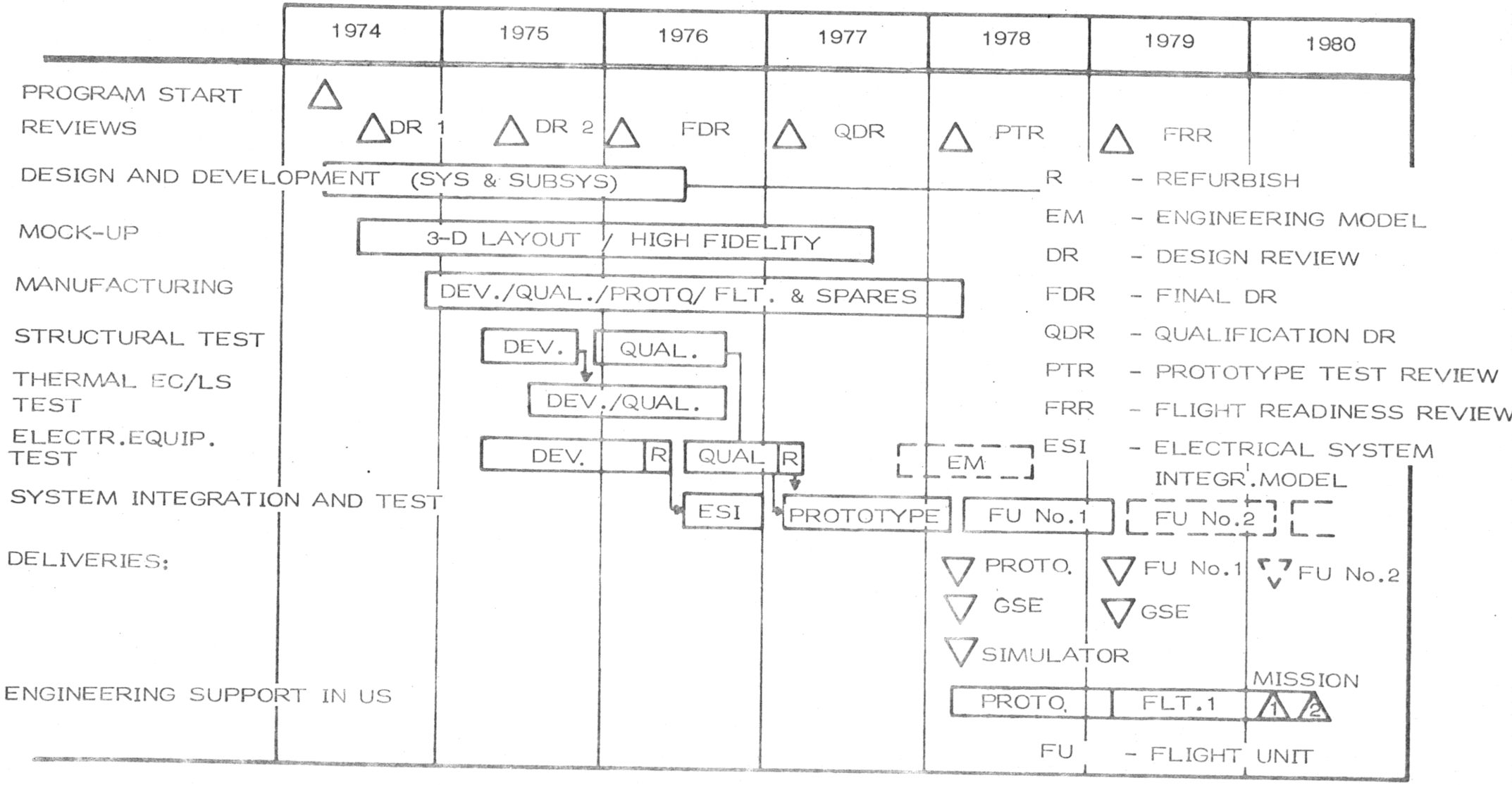
DEVELOPMENT PROGRAM CHARATERISTICS

- FLIGHT UNIT DELIVERED IN 59 MONTHS WITH GSE
- THIS SCHEDULE PERMITS:
  - FULL USE OF TEST ARTICLES
  - GOOD FEED BACK OF TEST RESULTS
  - GOOD BALANCE OF PARALLEL AND SERIES ACTIVITIES
    - SUBSYSTEM DEVELOPMENT IS IN PARALLEL
    - INTEGRATION OF ENGR.SYS.INTEGR.MODEL, PROTO, FLIGHT UNIT ARE IN SERIES (ONE CREW)
    - CORE & EXP.SEGMENT & PALLET INTEGRATED IN PARALLEL
    - FINAL SPACELAB INTEGRATION IN SERIES
  - REDUCED NEED FOR GSE & FACILITIES
- NON FLIGHT SPACELAB FOR OPERATIONAL SUPPORT DELIVERY 1 YEAR BEFORE FLT.UNIT WITH LAUNCH SUPPORT EQUIPMENT

DEVELOPMENT PROGRAM CHARACTERISTICS CONT'D

- COMPLIMENT OF HARDWARE REDUCED WITHOUT JEOPARDIZING QUALITY OF TEST RESULTS
  - UNITS FOR QUAL, PROTO, FLIGHT & SPARES MEET DOC.8 REQ.
  - GSE REDUCED BY 1 SET
  - ENGINEERING MODEL DELETED BY INCREASING USE OF PROTO - TYPE (DELIV. TO U.S.)
- ESSENTIALLY COMPLIANT WITH ESRO/NASA LEVEL 1 SPACELAB "GUIDELINES AND CONSTRAINTS FOR PROGRAM DEFINITION"
- MEETS BASIC PROGRAM OBJECTIVES OF SPACE LAB DOC. 8
- MAKES FULL USE OF EUROPEAN CAPABILITY
  - BY CONCENTRATING DESIGN QUALIFICATION AT UNIT AND SUBSYSTEM LEVELS - EXISTING FACILITIES CAN BE USED
  - EXISTING PRODUCTION METHODS & EQUIPMENT USED

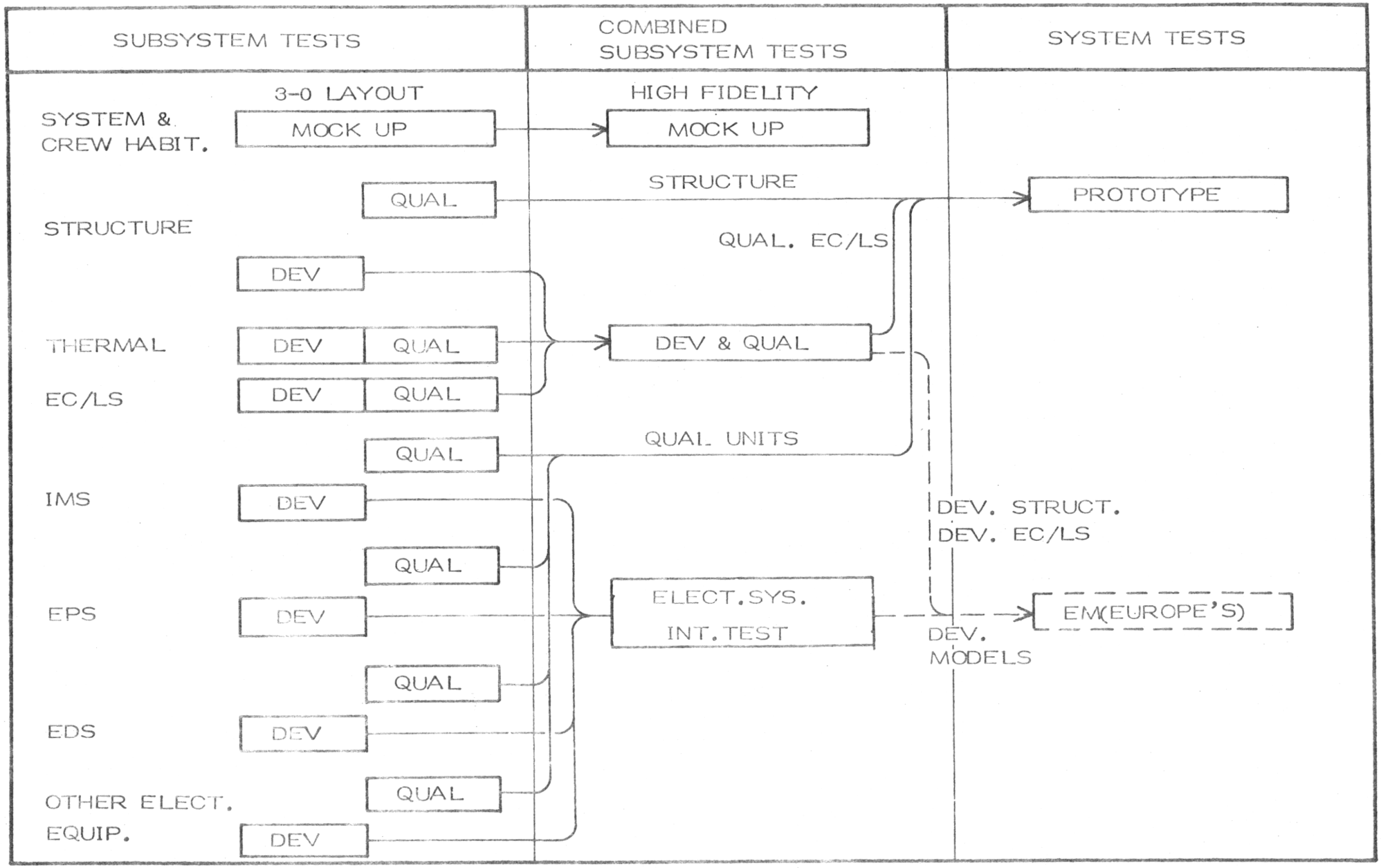
RECOMMENDED PROGRAM SCHEDULE

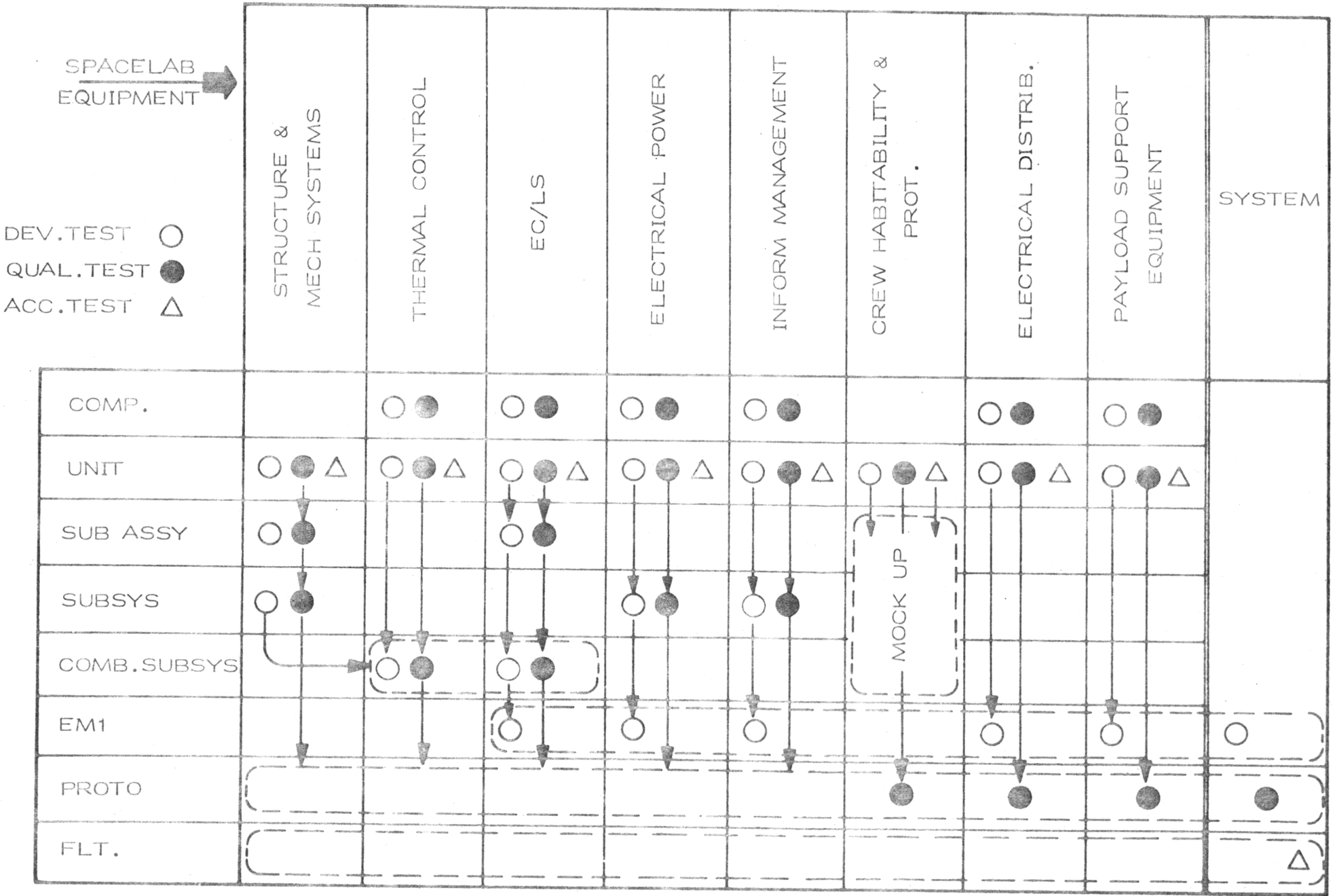


MAJOR TEST ARTICLES

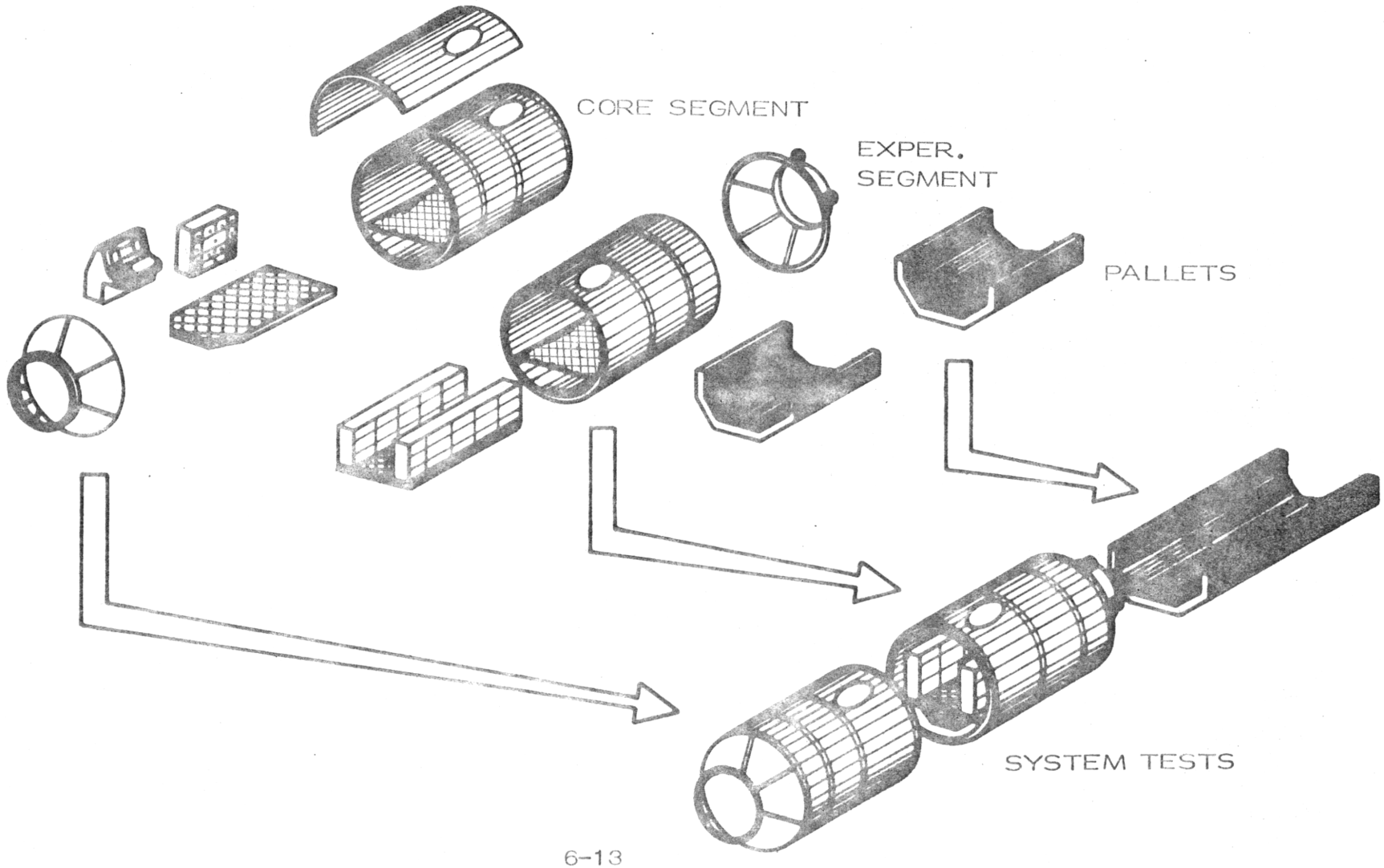
MOCK UP	FULL SCALE 3-D SYSTEM ENGINEERING TOOL, USED FOR CREW HABITABILITY SUBSYSTEM DEVELOPMENT. PROGRESSIVELY TRANSFORMED TO HIGH-FIDELITY MOCK UP
STRUCTURAL TEST ARTICLES	TWO FULL SIZE 6 METER MODULES (DEV. AND QUAL.) STATIC AND DYNAMIC TESTING - NON DESTRUCTIVE
EC/LS AND THERMAL TEST ARTICLE	FULLY FUNCTIONAL COMBINED SUBSYSTEMS FOR DEV. & QUAL. INSTALLED IN DEV. STRUCTURAL MODULE
ELECTRICAL SYSTEM INTEGRATION TEST ARTICLE	FULLY FUNCTIONAL ELECTRICAL SYSTEM INSTALLED IN SECONDARY STRUCTURE. MADE UP FROM DEV. MODELS
PROTOTYPE	FLIGHT CONFIGURATION SPACELAB MADE UP USING QUAL. UNITS INSTALLED IN QUAL. STRUCTURAL MODULE

TEST ARTICLE UTILIZATION

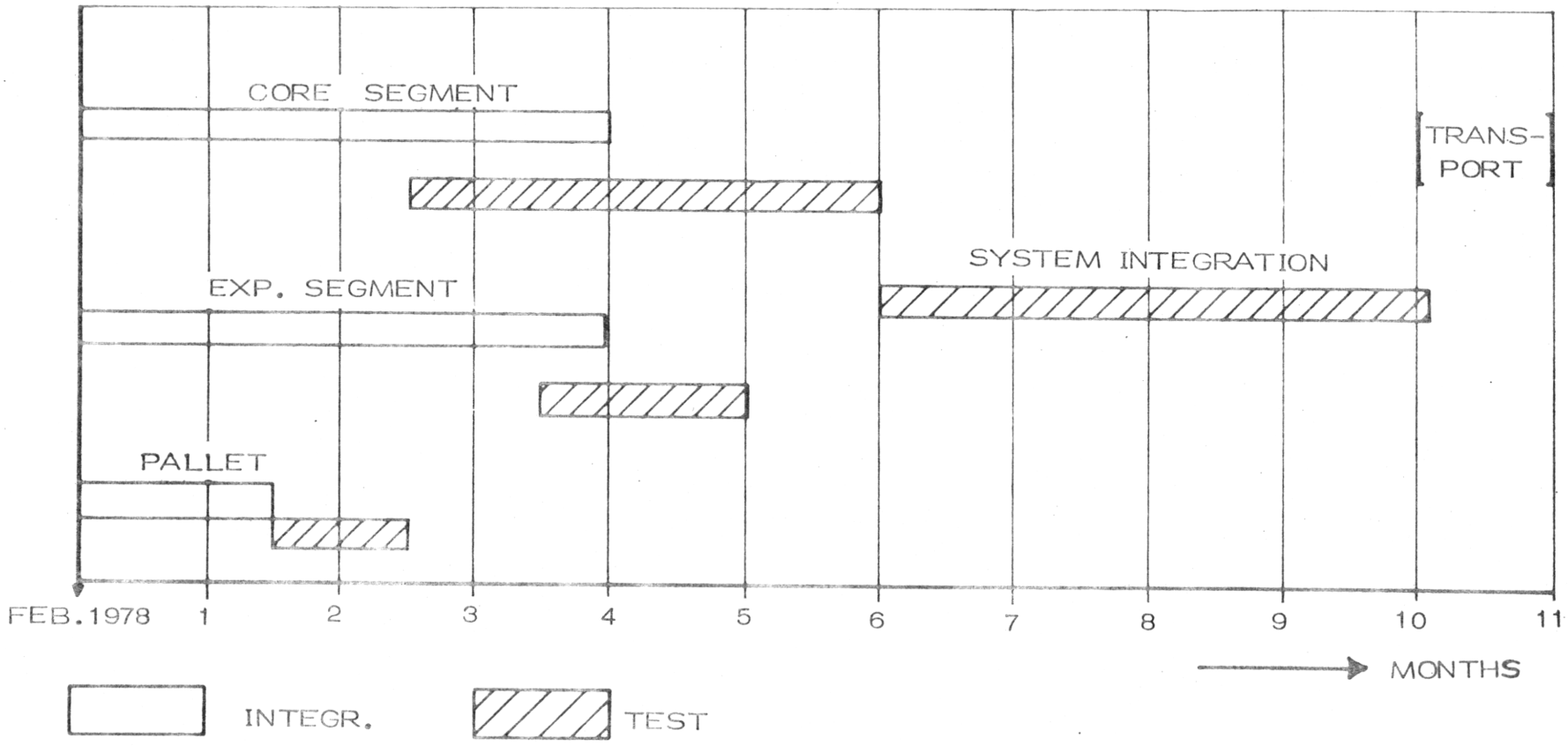



SPACELAB EQUIPMENT
DEV.TEST
QUAL.TEST
ACC.TEST
STRUCTURE & MECH SYSTEMS
THERMAL CONTROL
EC/LS
ELECTRICAL POWER
INFORM MANAGEMENT
CREW HABITABILITY & PROT.
ELECTRICAL DISTRIB.
PAYLOAD SUPPORT EQUIPMENT
SYSTEM
COMP.
UNIT
SUB ASSY
SUBSYS
COMB.SUBSYS
EM1
PROTO
FLT.
MOCK UP

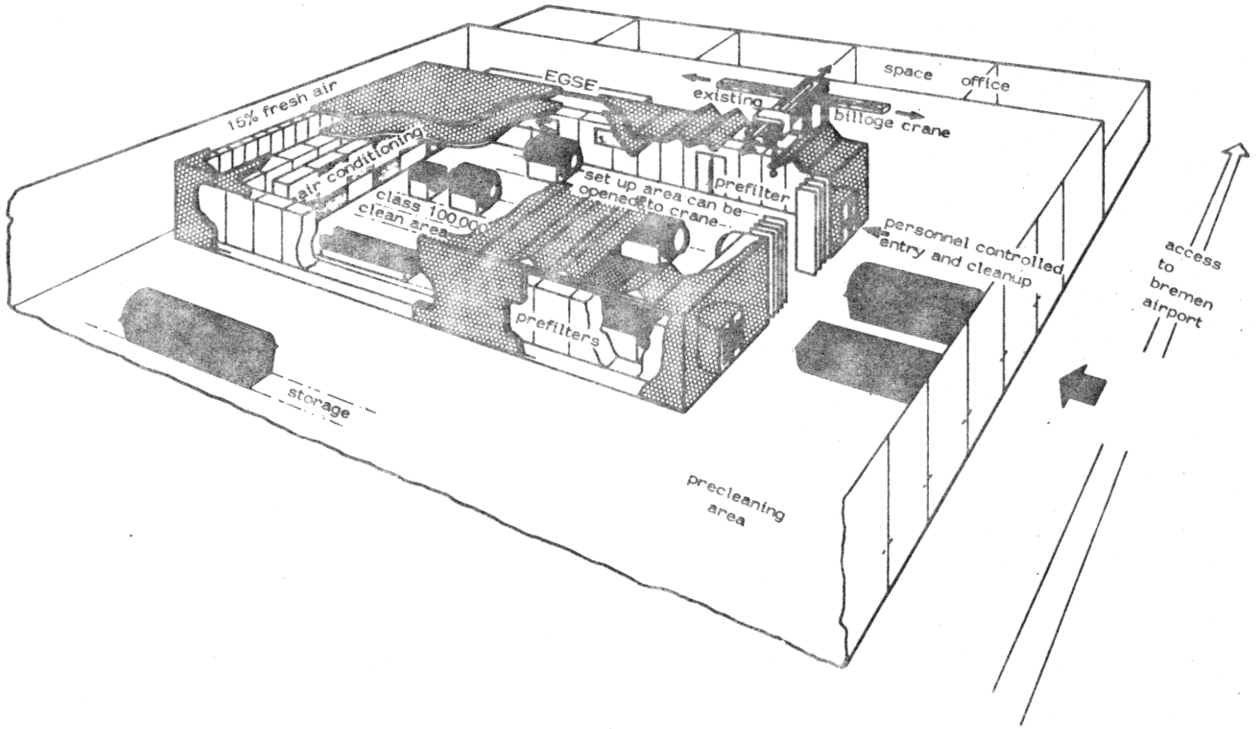
INITIAL INTEGRATION



TYPICAL INTERGRATION SCHEDULE



INTEGRATION FACILITIES OF VFW-FOKKER



TRANSITION TO PRODUCTION AND EXPANDED OPERATIONS

- MANUFACTURING PROCEDURES, TOOLING ETC. DIRECTLY APPLICABLE
- EXPAND EXISTING GSE IN EUROPE TO FULL SET FOR PRODUCTION
- LOGISTICS PLAN ADAPTS DIRECTLY TO EXPANDING OPERATIONS AND NEW LOCATIONS
- OPTIMIZE DECISION MILESTONE (PROCUREMENT AND WORK FORCE)

OPERATIONAL PHASE

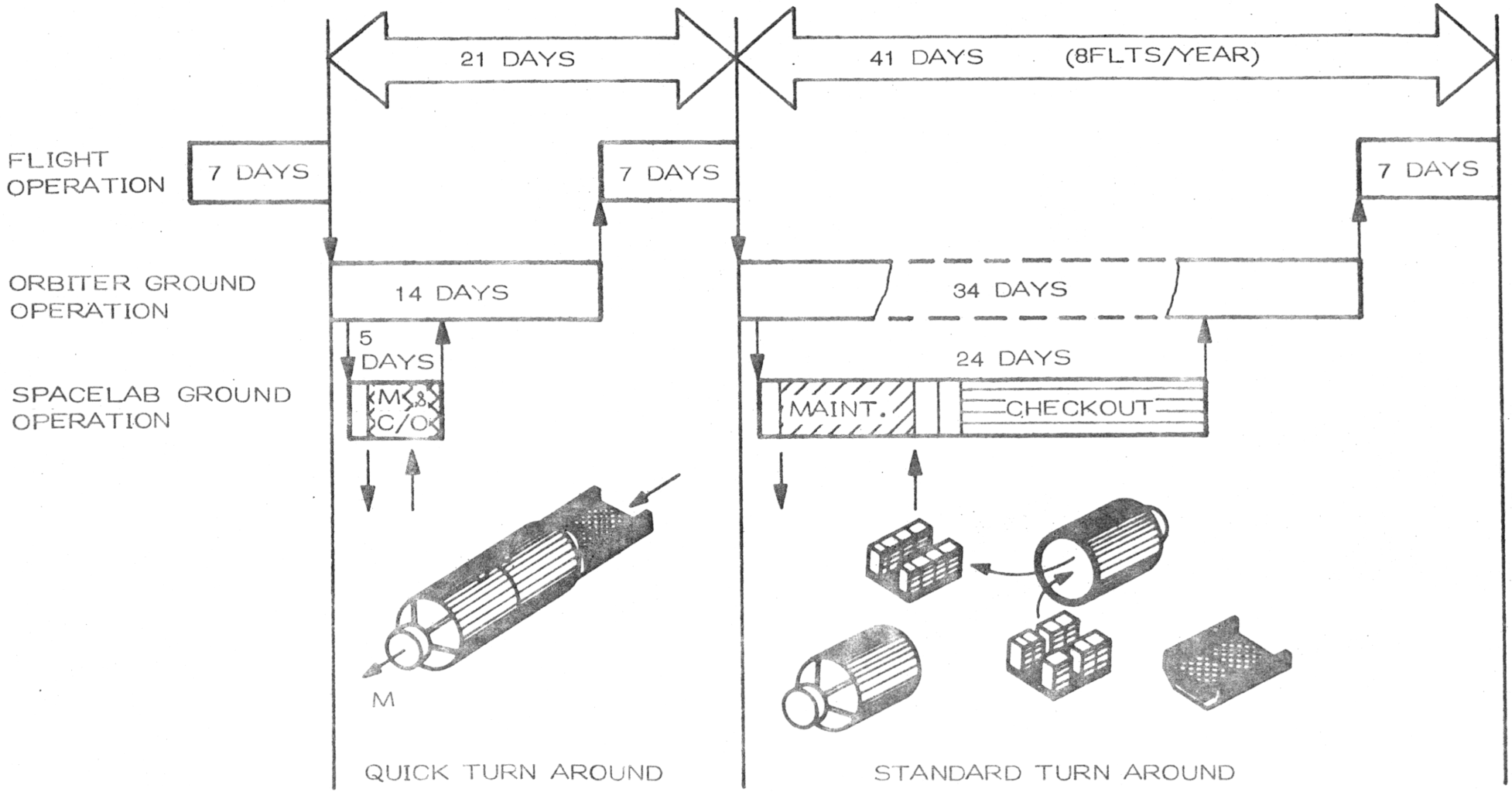
- SYSTEM ANALYSIS AND CONCEPTUAL CONSIDERATIONS OF THE SPACE LAB SYSTEM HAVE BEEN GUIDED BY LOW OPERATIONAL COST OBJECTIVES

  - THE MODULAR CONCEPT RESPONDS TO THIS REQUIREMENT

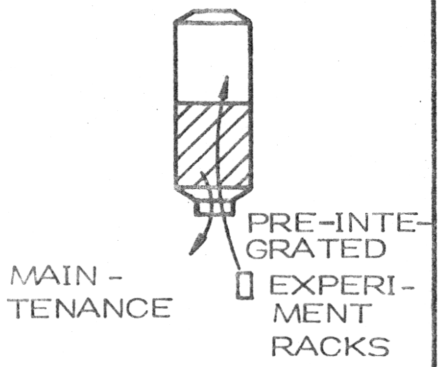
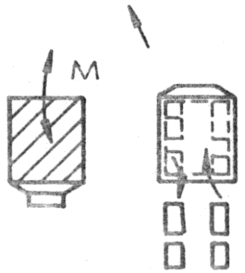
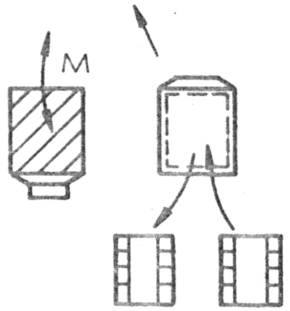
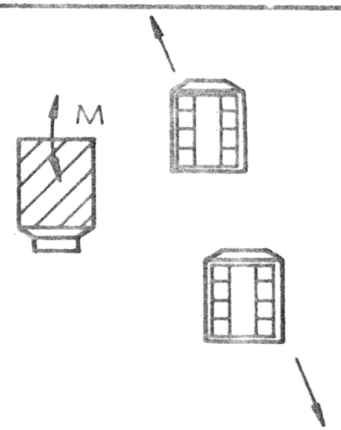
    - DEDICATED EXPERIMENT SEGMENTS CAN BE INTEGRATED WHILE SPACE LAB IS IN ORBIT

    - EXPERIMENT PALLET STRUCTURES CAN ALSO BE USED FOR INTEGRATION INSTEAD OF EXPERIMENT SEGMENTS

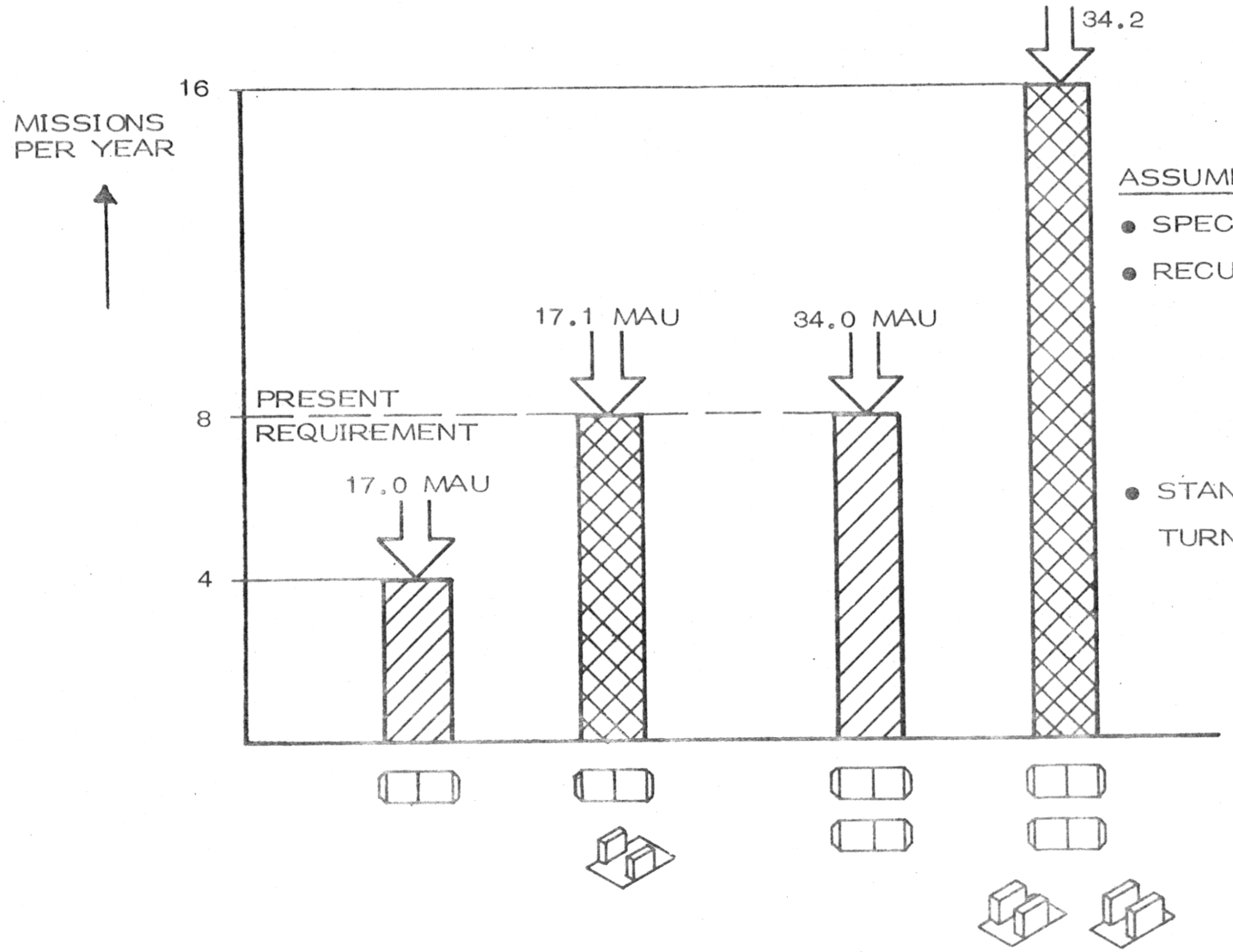
SPACE LAB OPERATION



FLEXIBILITY OF OPERATIONS

I	II	III	IV
			
QUICK TURN AROUND • MINOR EXCHANGE • MINIMUM MAINTEN. • USE ON-BOARD C/O	**INTERMEDIATE TURN AROUND** • MED EXCHANGE • NORMAL MAINT. • USE EGSE OR OBC/O	**STANDARD TURN AROUND** • FULL EXCHANGE • MINIM. TO NORMAL MAINT. • USE EGSE OR OBC/O	

MISSION SEQUENCE IN RELATION TO NECESSARY HARDWARE



ASSUMPTIONS

- SPEC. PAYLOAD MISSION
- RECURRING COSTS
  - 2 MODULE = 17 MAU
  - 1 SEC. STRUCTURE = 0.1 MAU

  (EXCLUDED: SPARES & GSE)
- STANDARD SPACELAB
  TURN AROUND : 24 DAYS

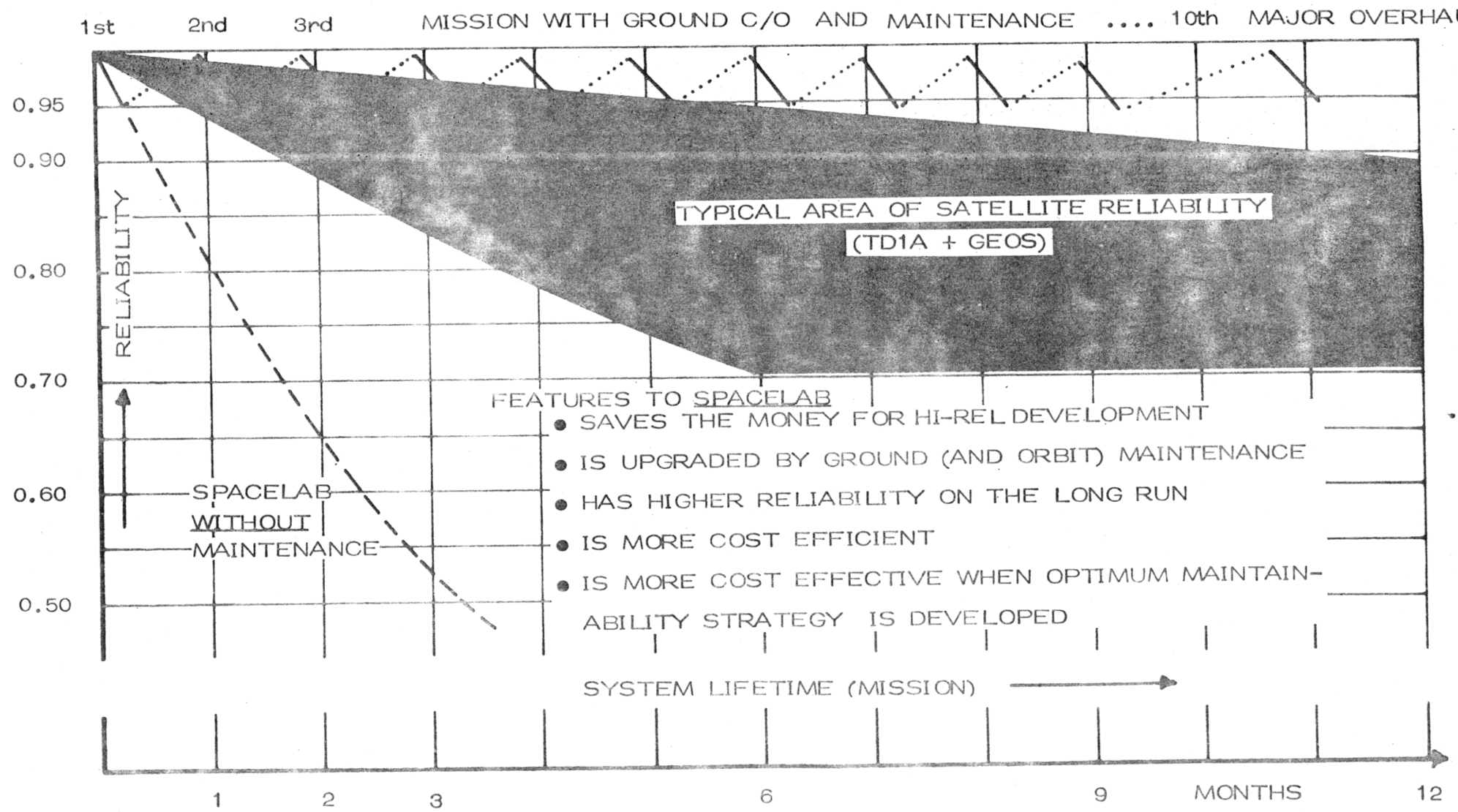
MISSION ASSURANCE FEATURES

- CONTRAST TO EUROPEAN SATELLITE TASKS

ESRO SATELLITE PROJECTS	MISSION DURATION (YEARS)	SPECIFIED RELIABILITY	SYSTEM "MTBF" (YEARS)
TD 1 A	0,5	0,70	1.5
COS B	1	0,85	6
GEOS	2	0,80	9
ECS(CONC.)	7	0,70	20
SPACELAB:	7 DAYS +)	0.95	0,5

DESIGN CRITERIA	COMPONENT QUAL. LEVEL	ENVIRON - MENTAL QUALIFICATION	USEFUL LIFE	SAFETY PROVISIONS
SATELLITE PROJECTS	ALL-HIRED	ASSY AND/OR S/S + SYSTEM PROTO	MISSION DURATION	GROUND PREP. ONLY
SPACELAB	CAM TOLERABLE	ASSEMBLY OR S/S LEVEL	50 +) MISSIONS/OR 5 YEARS	GROUND, LAUNCH & ORBIT

SPACELAB MISSION ASSURANCE FEATURES



RELIABILITY APPORTIONMENT & ESTIMATES

SUBSYSTEM	INITIAL APPORTIONMT. (EARLY B2)	1st ESTIMATE	SELECTED IMPROVEMENTS
STRUCTURE /MECHANICAL	0.995	0.9997	
THERMAL CONTROL	0.997	0.989	
EC/LS	0.994	0.986	0.989
ELECTRICAL POWER	0.993	0.994	0.9964
ELECTRICAL DISTRIBUTION	0.997	0.997	
INFORMATION MANAGEMENT	0.990	0.958	0.995
ON BOARD CHECK-OUT	0.997	0.990	
COMMON SUPPORT EQUIPMENT	0.997	0.975	0.985
CREW HABITABILITY & PROTECTION	0.997	0.999	
ATTITUDE MEASUREMENT & CONTROL	0.998	1.0	
RESULT:	0.955	0.892	0.941
MARGIN:	0.995		
SPACE LAB RELIABILITY:	GOAL 0.95	PRESENT ESTIMATE 0.94	

RELIABILITY APPORTIONMENT PROCEDURE

- INITIAL APPORTIONMENT TO MEET 0.95 GOAL WAS MADE
- RESULTING ESTIMATE WAS 0.89 BEING IN LINE WITH 175 MAU

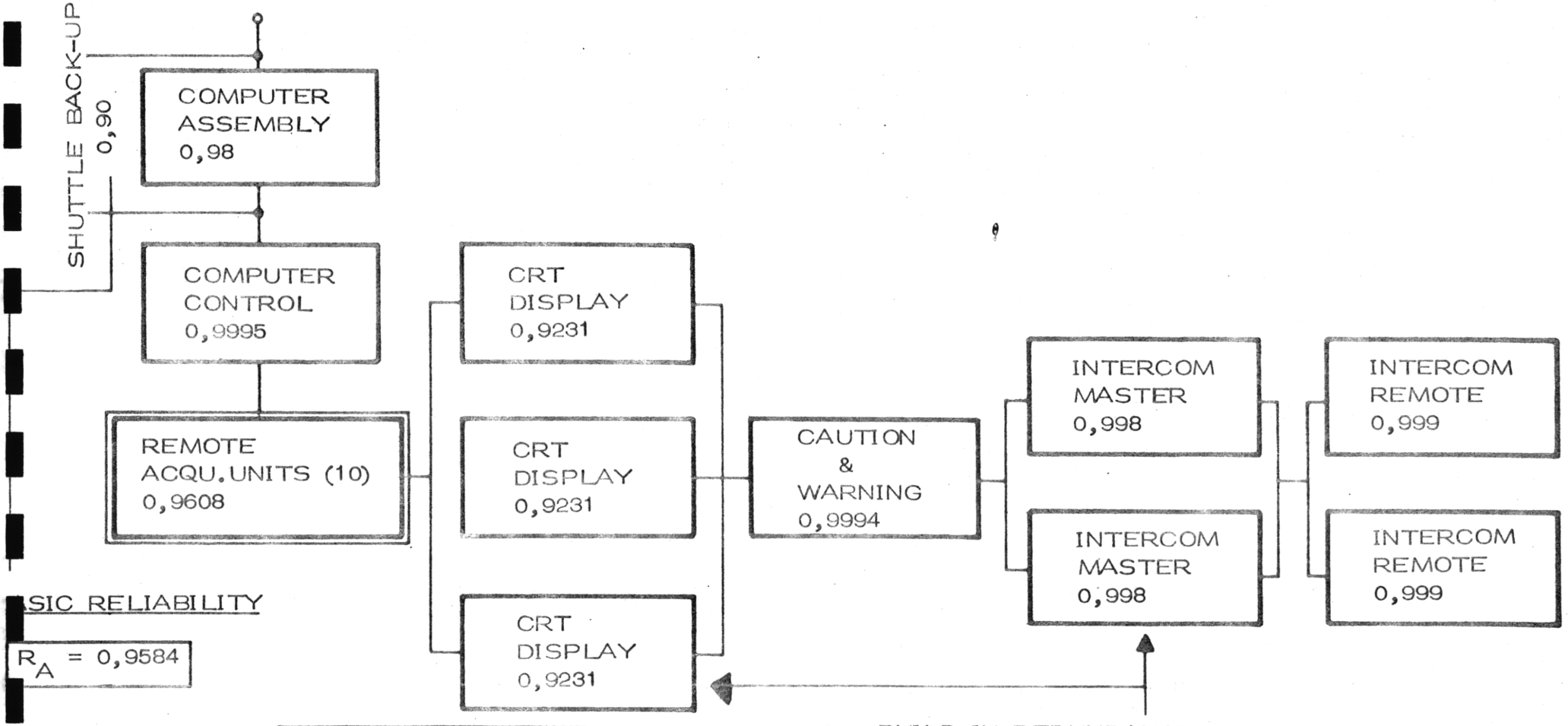
QUESTION: HOW TO ARRIVE TO 0.95?

- BY ADDITIONAL REDUNDANCY
- BY ON BOARD MAINTENANCE WITH SELECTED SPARES

THE ON BOARD MAINTENANCE APPEARS TO BE THE MOST COST EFFECTIVE WAY.

WE USED THIS ON: EPS, IMS, TCS, CPSE AND ARRIVED TO 0.94 WITHIN 175 MAU

EXAMPLE : IMS MAINTENANCE



BASIC RELIABILITY

$R_A = 0,9584$

RAU SPARE FOR ON BOARD MAINTENANCE

$R_\Sigma = 0,9954$
COST ~ 50 K.A.U.

PROGRAM COST ESTIMATING PROCESS

- STUDY APPROACH ESTABLISHED EARLY:
  - WBS
  - COSTING GUIDELINES & GROUND RULES
  - FORMATS
  - COSTING METHODS

- COSTING METHODS APPLIED:
  - "BOTTOM UP" - USED FOR FINAL ESTIMATES
    - o TECHNICAL AND PROGRAM DEFINITION
    - o ESTIMATE OF MANPOWER
    - o ESTIMATE OF MATERIAL, TRAVEL, ETC.
  - "TOP DOWN" - USED FOR EARLY PROGRAM STREAMLINING AND CHECK OF FINAL ESTIMATE
    - o APPLIES CER's TO FLIGHT HARDWARE
    - o ESTABLISH 1st UNIT RECURRING COST
    - o FACTORIZE TO COST TOTAL PROGRAM

SPACELAB PROGRAM COST BREAKDOWN

RECOMMENDED CONCEPT

ESTEC WBS NO.	ITEM	COST IN MAU	
1000	PROGRAM MANAGEMENT	17.71	10.6%
2000	PRODUCT ASSURANCE	10.75	6.5%
3000	SYSTEM ENGINEERING	22.70	13.7%
4000	DESIGN DEVELOPMENT	66.67	40.25%
5000	PROTOTYPE	14.00	8.4%
6000	FLIGHT UNIT	22.03	13.3%
7000	SPARES	3.24	1.9%
8000	GSE	8.20	4.9%
9000	OPERATIONS	0.30	0.2%
0000	TOTAL COST	165.60	
	CONTRACTORS FEE	9.88	5.9%
	TOTAL PRICE ESTIMATE	175.48	

BASIC ASSUMPTIONS FOR THE 175 MAU PRICE ESTIMATE

- THE PROGRAM AND THE RELATED ESTIMATES HAVE BEEN STRUCTURED FOR SUCCESS
  - ANY INDUSTRIAL RISK ASSUMPTIONS HAVE BEEN EXCLUDED (NON-RISK ESTIMATE)
- THE PROGRAM HAS BEEN STRUCTURED ALONG THE GEOGRAPHICAL DISTRIBUTION KNOWN TODAY IN RELATION TO THE MANAGMENT CONCEPT AND TO THE MAJOR TASK ALLOCATIONS. CHANGES WILL BE SENSITIVE TO THE 175 MAU ESTIMATE.
- PRICE LEVEL MID 1973
- VALIDITY OF A 59 MONTH SCHEDULE

RECOMMENDED CONCEPT

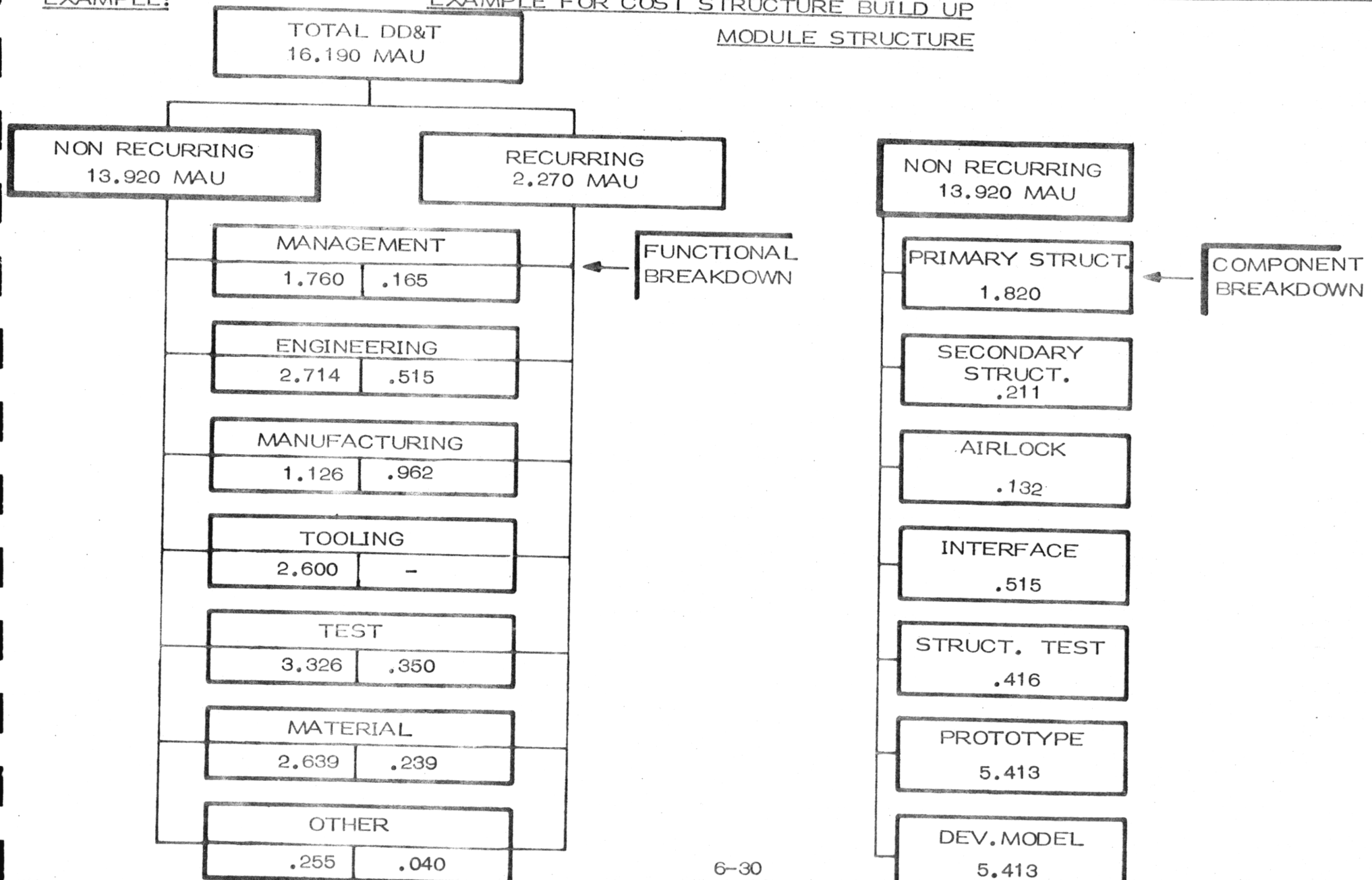
PROGRAM COST BREAKDOWN
NO PROFIT INCLUDED

- SPACE LAB PROGRAM — 165,599 MAU
  - MANAGEMENT & ENGINEERING — 40,712 MAU
  - DESIGN, DEVELOPMENT AND TEST — 88,867 MAU
    - INTEGRATION — 21,181 MAU
    - STRUCTURE — 16,881 MAU
    - EC/LS+ TCS — 19,424 MAU
    - IMS — 18,461 MAU
    - EPS+EDS — 4,717 MAU
    - GSE — 8,197 MAU
  - PRODUCT ASSURANCE — 10,752 MAU
  - FLIGHT UNIT — 22,032 MAU
    - ASSEMBLY & C/O — 5,066 MAU
    - STRUCTURE — 4,164 MAU
    - EC/LS+TCS — 5,259 MAU
    - IMS — 3,759 MAU
    - EPS+EDS — 1,684 MAU
    - CPSE — 2,100 MAU
  - SPARES — 3,236 MAU

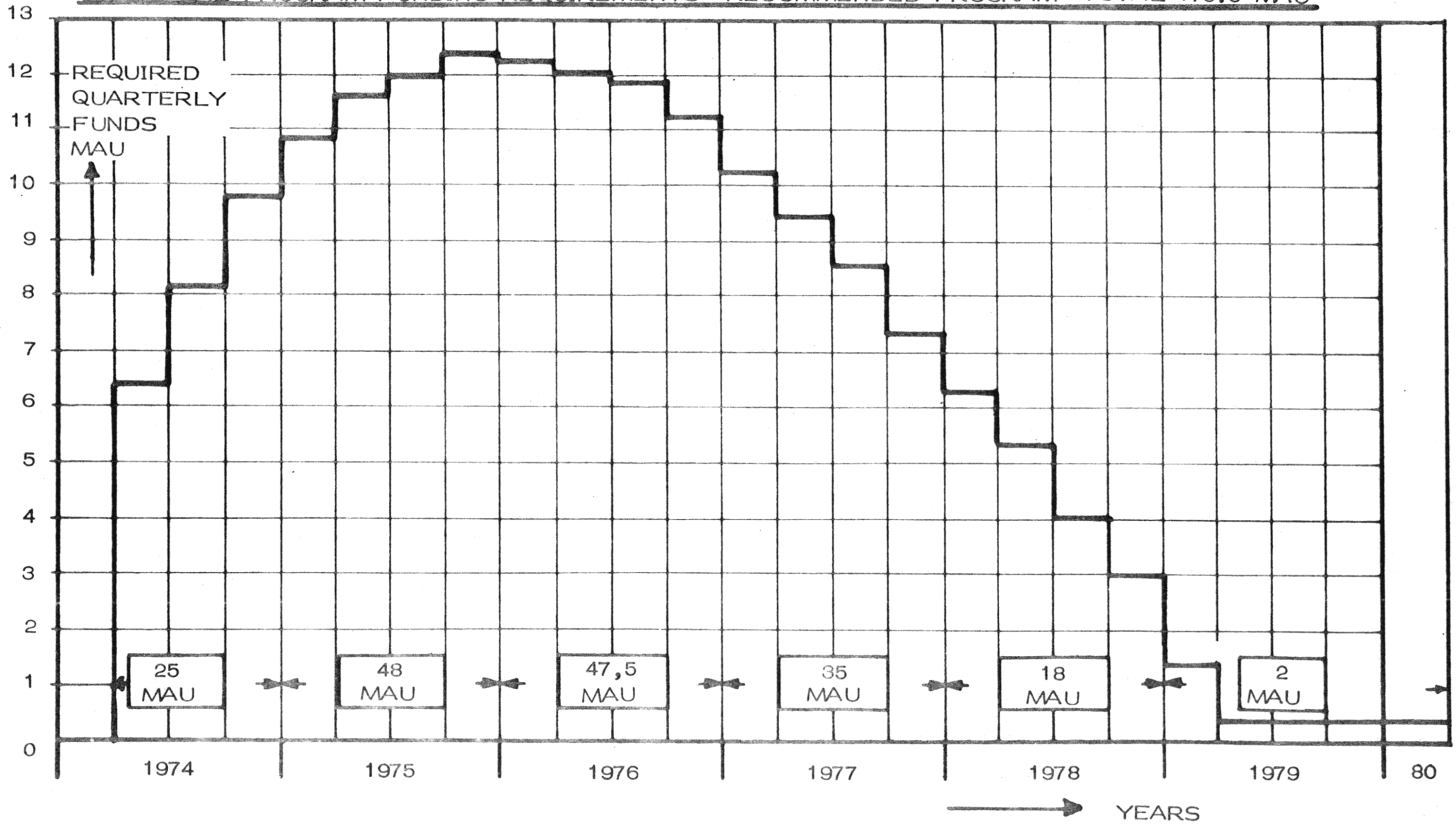
62 M/m.

EXAMPLE:

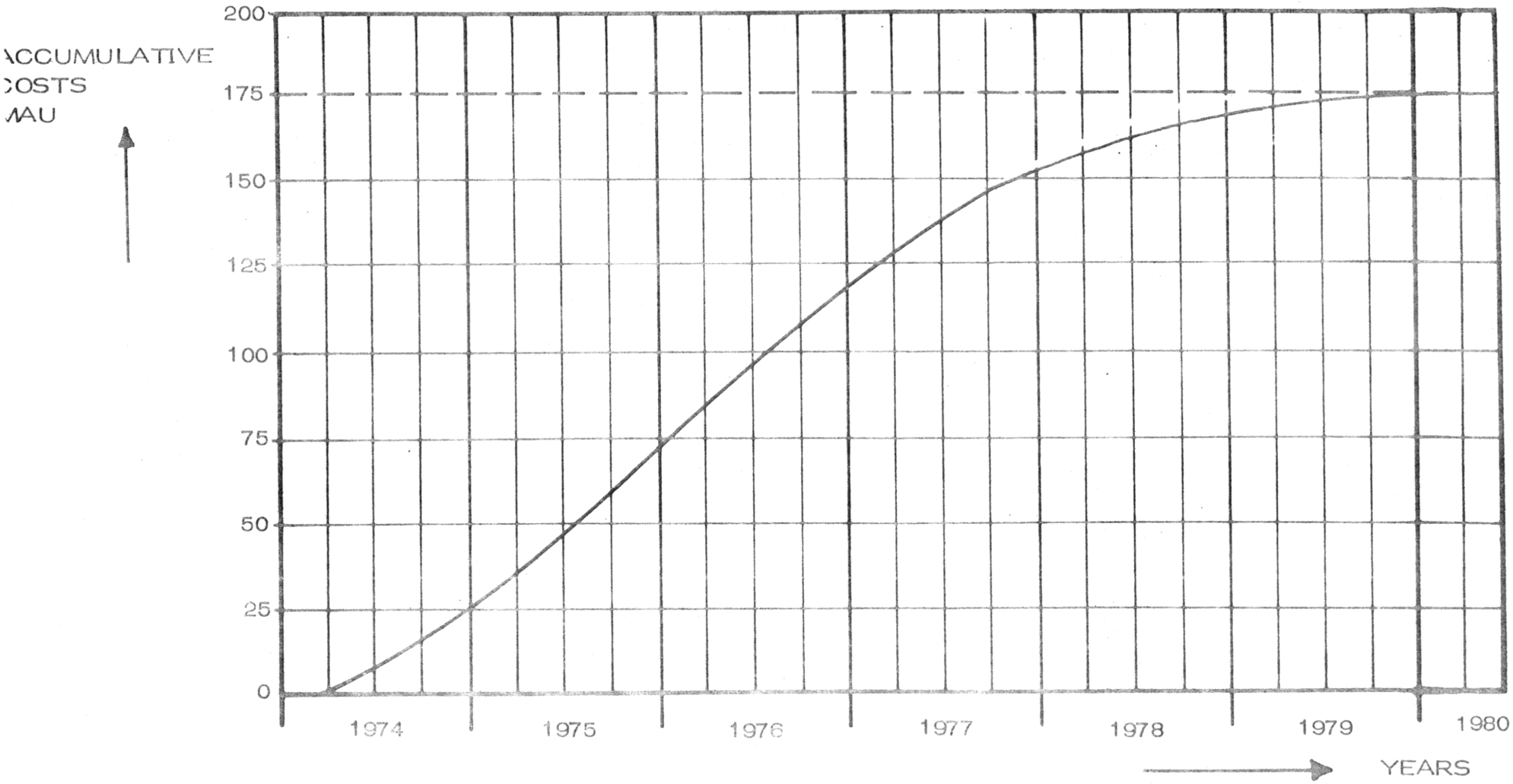
EXAMPLE FOR COST STRUCTURE BUILD UP



SPACE LAB PROGRAM FUNDING REQUIREMENTS: RECOMMENDED PROGRAM TOTAL 175.5 MAU



SPACE LAB PROGRAM ACCUMULATIVE COSTS
RECOMMENDED PROGRAM



PRIME COST-AFFECTING FACTORS

ESTIMATED COSTS ARE PRIMARY SENSITIVE TO:

- CONCEPT DEFINITION DEVIATIONS
  - o AUTONOMY FROM SHUTTLE
  - o PAYLOAD SUPPORT CAPABILITY
  - o RELIABILITY & SAFETY REQUIREMENTS
- TEST PROGRAM VARIATIONS AND HARDWARE QUANTITY VARIATIONS
  - o ENGINEERING MODELS
  - o DEVELOPMENT/QUAL. TEST ARTICLES
  - o MGSE & EGSE
- PROGRAM SCHEDULES ADJUSTMENTS
- USA VS. EUROPEAN HARDWARE PROCUREMENT
- PROGRAM MANAGEMENT AND CONTROL

AGENDA

INTRODUCTION	-	PROF. G. EGGERS
STUDY OVERVIEW	-	H. HOFFMANN
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CONCLUSIONS & RECOMMENDATIONS	-	H. HOFFMANN

SPACELAB PROGRAM VARIATIONS ANALYSES

- PAYLOAD ACCOMMODATION
- SPACELAB AUTONOMY VS. ORBITER SUPPORT
- EUROPEAN VS. US PROCUREMENT
- OTHER DESIGN &REQUIREMENT VARIATIONS
- SPACELAB PROGRAM-LEVEL VARIATIONS

PAYLOAD ACCOMMODATION VARIATIONS

VARIATION	FEATURES	DELTA COST (MAU)
1. 3 MODULE CONFIGURATION	INCREASES INTERNAL VOLUME	+ 7.00
2. 4 MODULE CONFIGURATION	INCREASES INTERNAL VOLUME	+ 14.00
3. SUPPORT SATELLITE DEPLOYMENT & SERVICING	ADDS BOOMS & MANIPULATORS	+ 6.80
4. DELETE BOLTED END JOINTS	REDUCES MODULAR FLEXIBILITY	- 0.10
5. USE SIMPLIFIED PALLET	REDUCES AVAILABLE VOLUME, LIMITS INSTALLATION OPTIONS	- 1.47
6. PROVIDE ADDITIONAL POWER	ADDS FUEL CELL AND REACTANTS	+ 16.00
7. PROVIDE SPACELAB DEPLOYMENT MECHANISM	INCREASES FIELD OF VIEW OPTIONS; RADIATOR EXPOSURE	+ 30.00
8. INCREASE IMS CAPABILITY	VARIOUS ITEMS - SEE LIST	+ 5.30

AUTONOMY VARIATIONS

VARIATIONS	FEATURES	DELTA COST (MAU)
1. ADD DEPLOYABLE RADIATOR	INCREASES SPACELAB THERMAL CONTROL CAPACITY ON-ORBIT	+ 11.00
2. MAKE EC/LS NON-AUTONOMOUS	USE ORBITER FOR ATMOSPHERE AND CONTROL, CO_2 REMOVAL, HUMIDITY AND TEMPERATURE CONTROL, TRACE CONTAMINANT REMOVAL	- 13.00
3. MAKE IMS AUTONOMOUS	ADDS MASS MEMORY. ADDS COMPUTER FOR PRIMARY USE IN "PALLET-ONLY" MODE. REQUIRES BACK-UP COMPUTER FOR SPACELAB MODE	+ 2.95
4. PROVIDE AUTONOMOUS POWER	ADDS FUEL CELL AND REACTANTS TO SPACELAB; REQUIRES MORE THERMAL CONTROL CAPACITY	+ 23.00
5. PROVIDE AUTONOMOUS ATTITUDE REFERENCE	INCLUDED ON "OPTIONAL COMMON PAY-LOAD SUPPORT" EQUIPMENT LIST	+ 13.60

INFORMATION MANAGMENT VARIATIONS

VARIATION	FEATURES	DELTA COST (MAU)
1. ADD EXPERIMENT COMPUTER	PROVIDES MORE DATA PROCESSING CAPACITY	+ 0.20
2. PROVIDE GRAPHIC DISPLAY	ADDS DATA EVALUATION FLEXIBILITY	+ 0.80
3. INCREMENTAL PLOTTER	COMPUTER DRIVEN-FOR HARD COPY GRAPHICS	+ 0.70
4. STIMULI EQUIPMENT	INCREASES EXPERIMENT COMMAND CAPABILITY	+ 0.15
5. HARD COPY PRINTER	PRINTS COMPUTER ALPHA-NUMERIC OUTPUTS	+ .05
6. READ/WRITE MEMORY	PROVIDES READ/WRITE MASS MEMORY FOR EXPERIMENTER PROGRAMS	+ 0.85
7. INCREASE DATA BUS CAPACITY	PROVIDES 10 MBPS DATA HANDLING CAPABILITY	+ 2.50
8. DESIGN FOR TDRS	REDUCES ON-BOARD STORAGE REQUIRED	+ 0.01
9. DELETE 1 CRT AND KEYBOARD	REDUCES EXPERIMENTER ACCESS TO DISPLAYS	- 0.14
10. DELETE PCM RECORDER	ORBITER PROVIDES RECORDING OF FAILURE DATA	- 0.08

PROCUREMENT VARIATIONS

VARIATION	FEATURES	DELTA COST (MAU)
1. DEVELOPMENT EUROPEAN COMPUTER INSTEAD OF US PURCHASE	INCREASES EUROPEAN TECHNOLOGY & MAY AFFECT SCHEDULE	+ 0.94
2. DEVELOPE T.V. CAMERA INSTEAD OF U.S. PURCHASE	INCREASES U.S. PROCUREMENT	+ 0.49
3. DEVELOPE T.V. MONITOR INSTEAD OF U.S. PURCHASE	INCREASES U.S. PROCUREMENT	+ 0.26
4. DEVELOPE SCIENTIFIC AIRLOCK IN U.S. INSTEAD OF EUROPE	INCREASES U.S. PROCUREMENT	- 2.1

OTHER DESIGN AND REQUIREMENT VARIATIONS

VARIATION	FEATURES	DELTA COST (MAU)
1. INCREASE RELIABILITY	RELIABILITY INCREASE TO 0.96 REQUIRES ADDED ON-BOARD SPARES	+ 1.50
2. DECREASE RELIABILITY	DECREASE TO 0.89 BY REDUCTION IN ON-BOARD SPARES	- 0.09
3. USE NASA EGSE	NASA "ACE" EGSE OFFERS INCREASED CAPABILITY -EXISTING HARDWARE	- 2.00
4. DESIGN FOR DEPRESSURIZED OPERATION	PERMITS PLANNING OR INADVERTANE DEPRESSURIZATION WITHOUT DAMAGE	+ 18.00
5. DESIGN FOR ON-BOARD MAINTENANCE	ADDS MODULARITY, ACCESS, TEST POINTS. OPERATIONAL FLEXIBILITY	+ 12.00
6. CONTAMINANT SENSING EXTERNAL	REQUIREMENT NOT MET. PROVIDED UNDER "OPTIMAL COMMON PAYLOAD SUPPORT"	+ 1.50
7. MGSE VARIATIONS	NUMEROUS ITEMS	SEE LIST
8. INCREASE EGSE CAPABILITY	ADDS DIAGNOSTIC CAPABILITY. ADDS COMPUTER CAPACITY AND SOFTWARE FOR MORE FUNCTIONS	+ 12.00
9. SIMPLIFICATION OF PALLET DESIGN	USES A DIFFERENT DESIGN APPROACH DECREASING PAYLOAD INTEGRATION FLEXIBILITY	- 1.47

PROGRAM VARIATIONS WHEN DESIGN FIXED

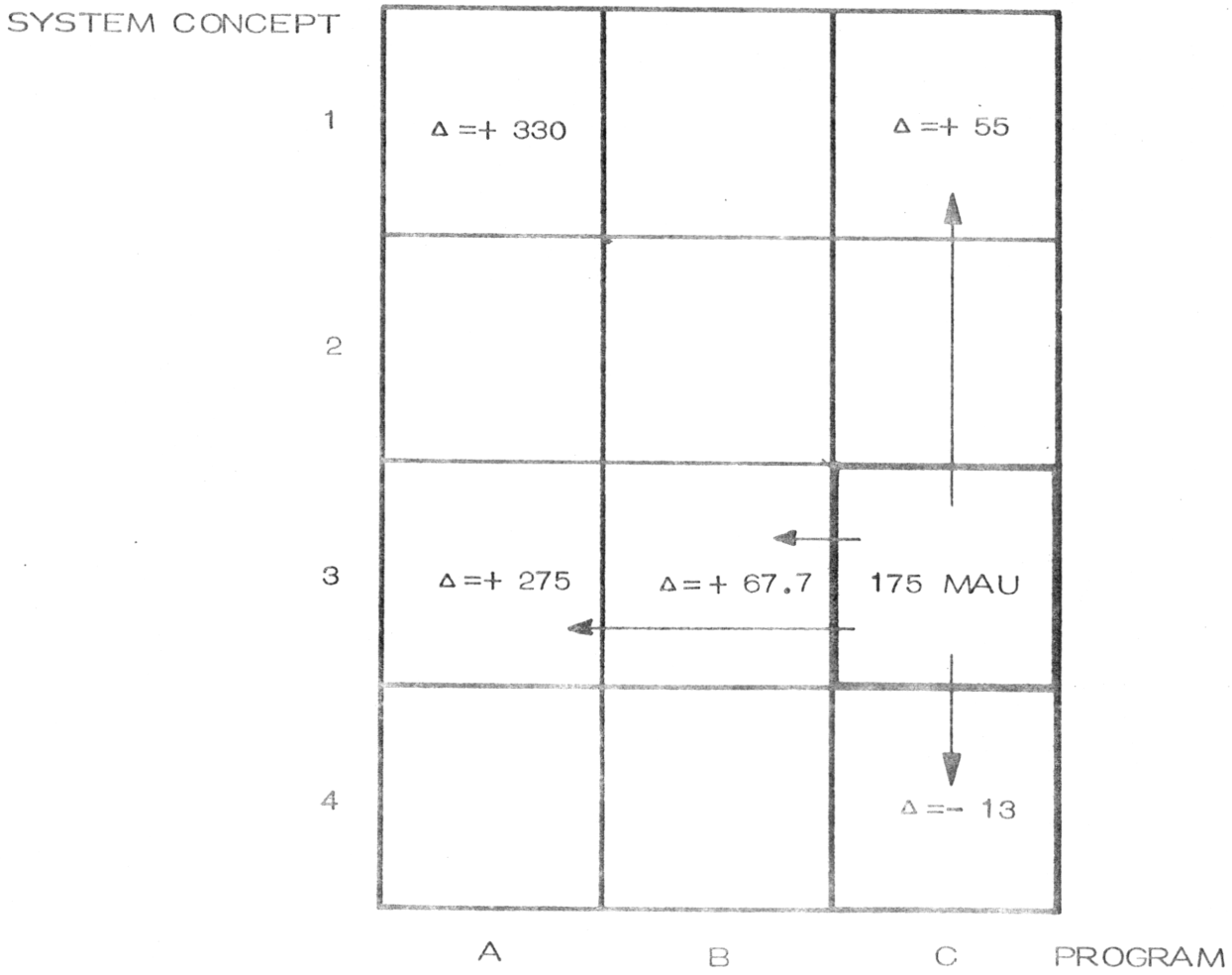
PROGRAM	PROGRAM CONTENT	DELTA COST (MAU)
A	FULLY COMPLIANT WITH DOC. 8 REQUIREMENTS • SPECIFIED QUANTITIES • 56 MONTHS TO FLIGHT UNDER DELIVERY	+ 275
B	FULLY COMPLIANT WITH ESRO/NASA LEVEL 1 REQUIREMENTS • QUANTITIES REDUCED BY BETTER UTILIZATION • 59 MONTHS TO FLIGHT UNIT DELIVERY • SHARING OF TEST ARTICLES	+ 67.7
C	ESSENTIALLY COMPLIANT WITH ESRO/NASA LEVEL 1 REQUIREM REQUIREMENTS • QUANTITIES REDUCED BY DEFERRED ACTIVATION OF SECOND LAUNCH SITE • 59 MONTHS TO FLIGHT UNIT DELIVERY • SHARING OF TEST ARTICLES • DELIVERY PROTOTYPE TO US IN LIEU OF EM • CONCENTRATES TESTING AT SUBSYSTEM LEVEL	175 REFERENCE PROGRAM

MGSE VARIATIONS

VARIATION	FEATURES	DELTA COST (MAU)
1. REDUCE QUANTITY OF CAGES AND DOLLIES	AFFECTS OPERATIONS TIMELINES AND FLEXIBILITY	- 0.12
2. HANDLING TROLLEY	ADDS LAUNCH AREA HANDLING EQUIP. IN NASA EQUIP. UNAVAILABLE	+ 0.30
3. MODULE/PALLET HOIST	ADDS CAPABILITY TO HOIST COMBINED SPACE LAB AND PALLETS	+ 0.17
4. TRANSPORTATION CONTAINER	ADDS TRANSPORTATION CONTAINER FOR COMBINED SPACE LAB AND PALLETS	+ 0.80
5. LOADING PLATFORM	FOR AIR TRANSPORTATION. IF RENTAL IS NOT AVAILABLE	+ 0.13

SYSTEM DESIGN/PROGRAM MATRIX

TOTAL PROGRAM COST



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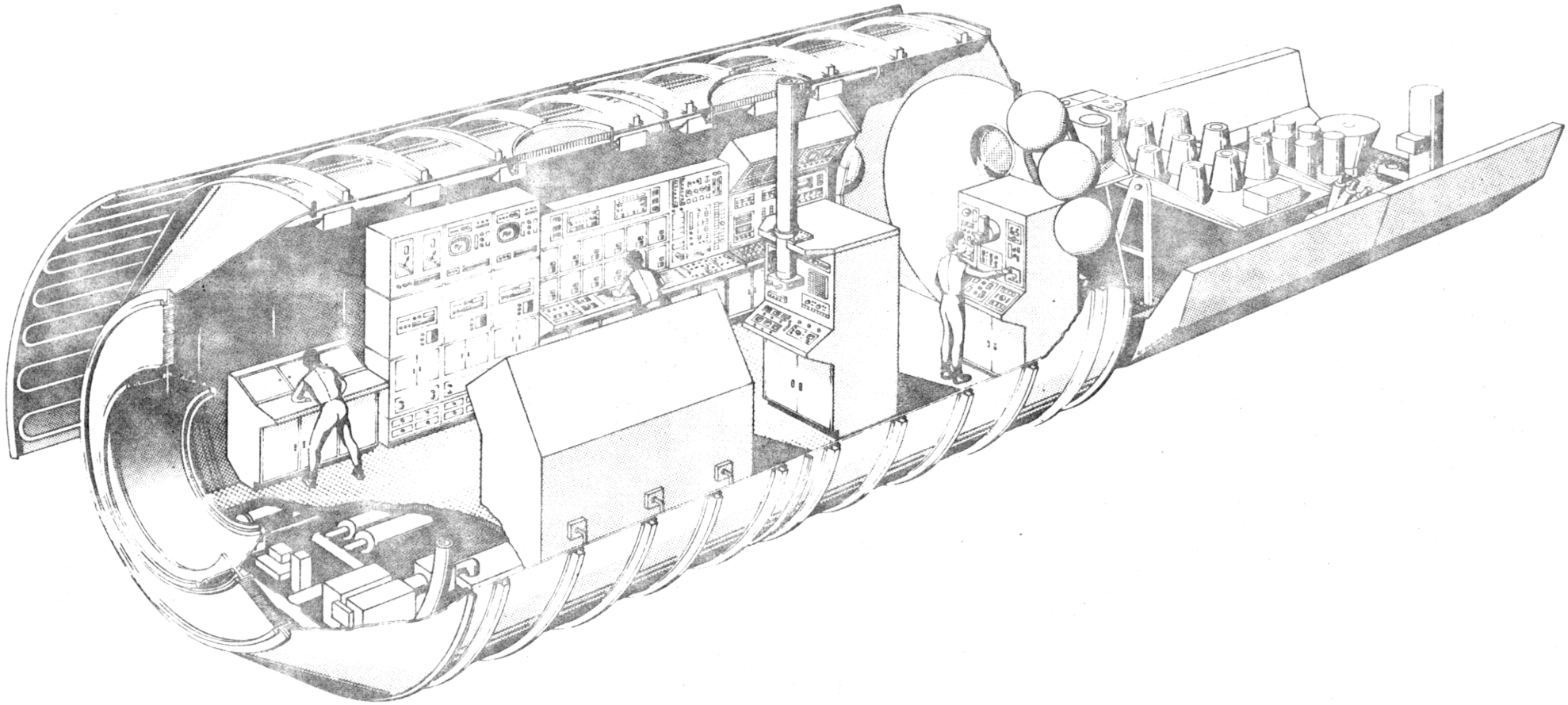
THE RECOMMENDED SPACELAB



SPACELAB PHASE B2 SUMMARY & CONCLUSIONS

- 175 MAU EUROPEAN SPACELAB PROGRAM IS FEASIBLE
- PROGRAM COSTS ARE MOST SENSITIVE TO:
  - QUANTITIES OF TEST & DELIVERABLE ARTICLES
  - DEGREE OF UTILISATION OF HARDWARE, FACILITIES, & PERSONNEL
- MODULAR CONCEPT IS CLEARLY PREFERABLE
- SPACELAB AUTONOMY VS. ORBITER SUPPORT ISSUE REQUIRES CONTINUED EFFORT
- OUR SPACELAB TEAM IS DEDICATED TO ACCOMPLISHING THE PROGRAM OBJECTIVES WITHIN THE TARGET COST

MAJOR TASKS FOR THE NEXT PHASE

- CONTINUE CONFIGURATION ANALYSES TO ACCOMMODATE ANTICIPATED CHANGES IN CUSTOMER REQUIREMENTS
- CLARIFY THE INTERFACES WITH THE ORBITER AND THE RESOURCES AVAILABLE BEFORE ORBITER DESIGN FREEZE
- PERFORM PRELIMINARY DESIGN AND PREPARE CAREFULLY ALL PROGRAM ASPECTS BEFORE ENTERING PHASE C&D.
- CONTROL THE COSTS CAREFULLY TO REMAIN WITHIN THE 175 MAU BUDGET FOR THE FINAL PRICE OFFER