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Impact of Lunar and Planetary Missions on the Space Station

EAGLE
ENGINEERING, INC.

CONTRACT NO. NAS9-17176

PRELIMINARY REPORT
SEPTEMBER 21, 1984
REPORT NO. 84-85B

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IMPACT OF LUNAR AND PLANETARY MISSIONS

ON THE SPACE STATION

PREPARED FOR

PLANETARY EXPLORATION DIVISION ,

JOHNSON SPACE CENTER

BY EAGLE ENGINEERING

REPORT NUMBER **84-85B**

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DRAFT 30 MINUTE PRESENTATION

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IMPACT OF LUNAR AND PLANETARY MISSIONS ON THE SPACE STATION

PREPARED FOR
PLANETARY EXPLORATION DIVISION ,
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TASK DEFINITION

LUNAR BASE MISSIONS

- O LUNAR BASE CONCEPTUAL DEFINITION
- O LUNAR ACTIVITIES LOGISTICS
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- O SPACE STATION ELEMENTS REQUIRED
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- O PLANETARY MISSION SCENARIOS
- O SPACE STATION ELEMENTS REQUIRED
- O SPACE STATION FUNCTION
- O PHASED PLAN
- O UNCERTAINTIES IMPACT

LUNAR OPERATIONS IMPACTS

- O THE IMPACT OF THE LUNAR BASE ON THE SPACE STATION IS ONE OF SCALE - FLIGHT OPERATIONS MUST BE DONE MORE FREQUENTLY, WITH LARGER VEHICLES

PRIOR TO LUNAR OXYGEN PRODUCTION: EVERY TWO MONTHS FLIGHT OPERATIONS ARE:

- O ONE UNMANNED LAUNCH VEHICLE (ULV) TANKER LAUNCH OF LOX/LH_2 TO SS (100 M. TONS)
- O ONE SHUTTLE AFT CARGO CARRIER (ACC) LAUNCH WITH PAYLOADS, LUNAR LANDERS, CREWS, ETC
- O AT THE SPACE STATION - TWO OTV'S, THE LANDER AND PAYLOAD(S) ARE CHECKED OUT & MATED INTO A STACK. THE OTV'S & LANDER ARE FUELED WITH LOX/LH_2
- O THE LUNAR MISSION IS FLOWN AND THE OTV'S (PLUS MANNED MODULE ON MANNED SORTIES) RETURN TO SPACE STATION FOR DOCKING AND RECOVERY

AFTER LUNAR O_2 PRODUCTION STARTS, FLIGHT OPERATIONS INCLUDE:

O TWO TANKER LAUNCHES

PLUS

O TWO STS LAUNCHES

FOR EVERY

O THREE LUNAR MISSIONS

LUNAR OPERATIONS IMPACTS

SPACE STATION HARDWARE

- O HANGERING AND STORAGE FOR 4 OPERATIONAL OTV'S
- O GANTRY'S FOR PREPARING TWO STACKS SIMULTANEOUSLY OF 2 OTV'S PLUS LUNAR LANDER, PLUS CARGOS (UP TO 3 ELEMENTS). STACKS WILL BE 30 TO 40 M (100 TO 135 FT) IN LENGTH & UP TO 15 M WIDE
- O PROPELLANT DEPOT WITH CAPACITY OF AT LEAST 2 TANKER LOAD UNITS OF 100 M TONS EACH
- O EQUIPMENT TO FUEL FROM DEPOT - 2 OTVS PLUS LANDER WHILE MATED IN STACK FOR DEPARTURE. 98 M TONS LOX/LH_2 TOTAL PER MISSION
- O ADDITIONAL HABITABILITY MODULE FOR HOUSING 2 TO 4 EXTRA SPACE STATION CREW AND TEMPORARY BILLETING FOR 4 TO 6 TRANSIENT LUNAR BASE PERSONNEL
- O 2 OMVS FOR FLIGHT SUPPORT

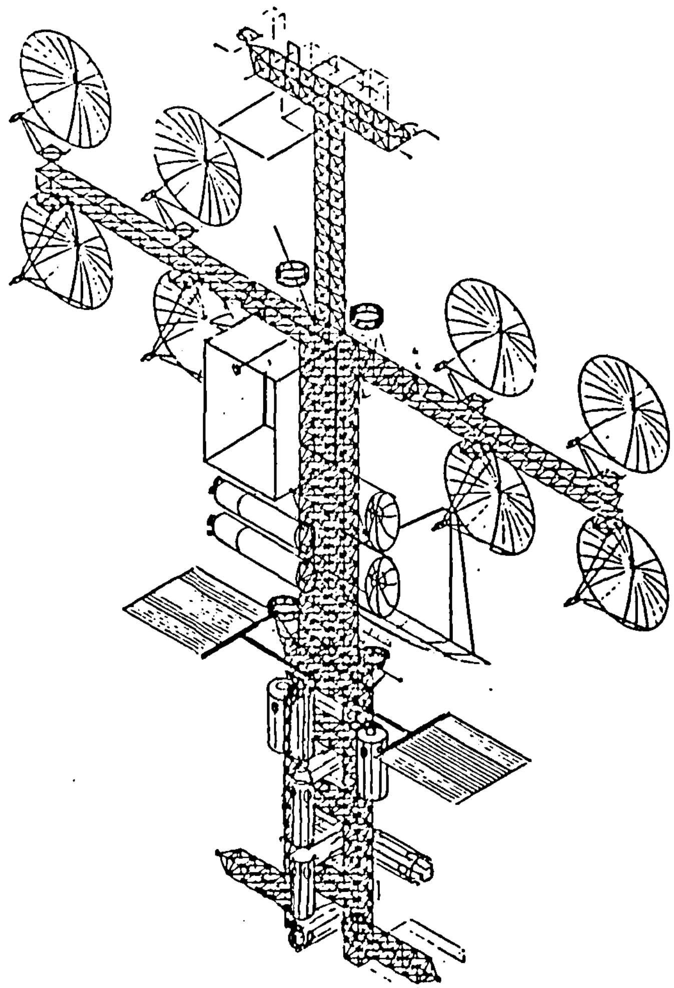
SPACE STATION MANPOWER: EACH SIXTY DAYS THE SPACE STATION MUST PROVIDE FACILITIES AND MANPOWER FOR:

- O TRAFFIC CONTROL
  - RENDEZVOUS/DOCKING ACTIVITIES - 1 TANKER, 1 SHUTTLE, 1 AFT CARGO CARRIER PAYLOAD, 2 OTV'S
  - 1 LUNAR DEPARTURE
  - 1 DEPOT ELEMENT REMOVAL FOR DEORBIT
- O VEHICLE CHECKOUT, MAINTENANCE AND REPAIR
  - 2 OTV SORTIES
  - 6 OMV SORTIES (4 DOCKING, 1 STACK DEPARTURE, 1 EMPTY DEPOT DEPARTURE FOR DEORBIT INITIATION)
  - 1 SET OF LUNAR VEHICLES & PAYLOADS (E-LANDER, OMM, E-LLMM/ASCENT, COMMON MODULE)
- O STACK ASSEMBLY AND FUELING SEQUENCE

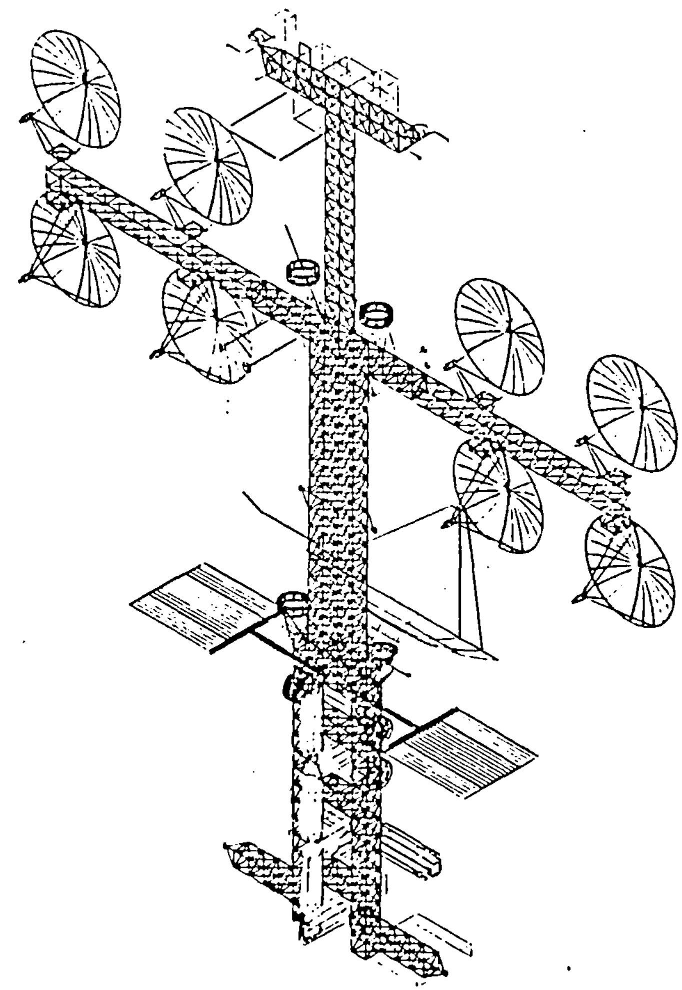
PLANETARY MISSIONS IMPACTS ON THE SPACE STATION

REQUIREMENTS	MARS SAMPLE RETURN	KOPFF SAMPLE RETURN	CERES SAMPLE RETURN	MERCURY ORBITER	TITAN PROBES/ SATURN ORBITER
o SPACE STATION HARDWARE REQUIRED					
NO. OF OTVs EXPENDED (NOT RETURNED)	Ø	1	1	Ø	1
NO. OF OTV REFURB. KITS	1	2	2	1	1
GANTRY TO STACK TWO STAGES		YES	YES		
CHECKOUT EQUIP. FOR TWO STAGE STACK		YES	YES		
QUARANTINE MODULE	YES	YES	YES		
ADDITIONAL POWER, KW	5	5	5		
ADDITIONAL THERMAL CONTROL, NO. OF STANDARD MODULES	1	1	1		
o SPACE STATION MANHOURS REQUIRED					
OTV REFURBISHMENT	52	1Ø3	1Ø3	52	52
AEROBRAKE REMOVAL		21	21		21
OTV/PAYLOAD INTEGRATION & C/O	11	21	21	11	11
FUEL, RELEASE, AND LAUNCH	24	36	36	24	24
RENDEZ/RETRIEVE OTV USING OMV	12	12	12	12	
SHUTTLE RENDEZ/PAYLOAD REMOVAL	2	2	11	2	2
ULV PROPELLANT DELIVERY	7	17	18	7	1Ø
SAMPLE RETRIEVAL USING OMV	8	8	8		
SAMPLE ANALYSIS & SHIPMENT	24	16	16		
TOTAL MISSION MANHOURS	138	235	246	1Ø5	118

SPACE STATION



Impact



No Impact

LUNAR & PLANETARY STUDY

GROUNDRULES & ASSUMPTIONS

1. THE SPACE STATION CAN STORE AND TRANSFER LOX AND LH_2 TO THE ORBITAL TRANSFER VEHICLE (OTV) IN ORBIT.

2. AEROBRAKING WILL BE A MATURE TECHNOLOGY AND IS INCORPORATED IN THE OTV DESIGN.

3. THE OTV WILL USE LOX/LH_2 PROPELLANT.

4. ISP = 460 SEC WITH 1% START/STOP LOSSES YIELDING EFFECTIVE ISP = 455.4 SEC.

5. ALL STAGES, LUNAR LANDERS, ETC., WILL BE LOX/LH_2 UNLESS STRONGLY CONTRAINDICATED.

   EXCEPTION - EXPENDABLE ASCENT STAGE WILL USE STORABLES.

6. BOIL OFF RATE FOR CRYOGENIC STAGES IS 55 KG/DAY OF LH_2 PER STAGE.

7. CARGO UNITS FOR THE LUNAR BASE WEIGH A MAXIMUM OF 18 METRIC TONS.

8. THE LUNAR ORBIT SERVICE STATION WT = 35 M TONS. IT CAN STORE AND TRANSFER LH_2 AND LOX IN ORBIT. ON-ORBIT RE-REFRIGERATION CAPABILITY FOR CRYOGENICS IS ASSUMED.

9. OTV ELEMENTS CAN BE "STACKED" I.E. USED AS TWO IDENTICAL STAGES, ONE STAGING BEFORE THE OTHER IGNITES.

10. LUNAR SURFACE STORAGE, TRANSFER (INTO LANDERS), AND RE-REFRIGERATION OF CRYOGENICS BOTH LOX AND LH_2 IS ASSUMED AFTER O_2 PRODUCTION COMMENCES.

LUNAR & PLANETARY STUDY

GROUNDRULES & ASSUMPTIONS
(CONTINUED)

11. MAJOR MAINTENANCE OF THE LANDER IS AVAILABLE EITHER AT THE LUNAR BASE OR AT THE LUNAR ORBIT SERVICE STATION.

12. FOR THE PURPOSE OF THIS STUDY: LUNAR O_2 WILL BECOME AVAILABLE AFTER DELIVERY OF THE PRODUCTION PLANT TO LUNAR SURFACE. THIS O_2 WILL BE USED IN THE REUSABLE LUNAR LANDER, BUT DELIVERY OF LUNAR O_2 TO EARTH ORBIT WILL NOT BE EXAMINED IN THIS STUDY.

13. THE OTV WILL BE SIZED TO PERFORM ANY OF THREE REFERENCE MISSIONS:

    A. DELIVER 9 M TONS TO GEOSYNCHRONOUS ORBIT, RETURNING EMPTY USING A SINGLE STAGE.

    B. DELIVER 6 M TONS ROUND TRIP TO GEOSYNCHRONOUS ORBIT, USING A SINGLE STAGE.

    C. DELIVER 18 M TONS PAYLOAD PLUS A LUNAR LANDER (SIZED TO LAND THE PAYLOAD) TO LUNAR ORBIT, USING TWO OTV STAGES IN TANDEM. BOTH OTV STAGES ARE RETURNED TO THE SPACE STATION.

14. THE SAME OTV'S (WITH A KICK STAGE WHERE APPROPRIATE) CAN BE USED FOR THE PLANETARY MISSION. ALTERNATE EXPENDABLE STAGES (SUCH AS CENTAUR) CAN ALSO BE CONSIDERED. WHERE FEASIBLE, OTV STAGES ARE RECOVERED.

15. THE SPACE STATION ALTITUDE = 500 KM (270 N MI).

16. LUNAR OPERATIONS WILL NOMINALLY HAVE A LAUNCH WINDOW EVERY NINE DAYS.

LUNAR & PLANETARY STUDY

GROUNDRULES & ASSUMPTIONS
(CONTINUED)

17. LUNAR ORBIT OPERATIONS WILL BE AT 200 KM LUNAR ALTITUDE (109 NAUT. MI.).

18. LUNAR BASE WILL BE NEAR EQUATORIAL ($\pm$ 4°).

19. AFTER STAGE 1 BURNOUT OF OTV, SECOND STAGE COASTS AROUND (NEARLY) TO PERIGEE BEFORE IGNITION TO MINIMIZE G-LOSSES (2 BURN OPTION).

20. PROPELLANT TRANSFER TO R-LEM TAKES PLACE ON LUNAR SURFACE-H_2 TANK IS LANDED INTACT AND STORED ON THE SURFACE FOR REFRIGERATION AND PUMPING.

21. <u>NO</u> LUNAR ORBIT SERVICE STATION IS ASSUMED.

22. LOX/LH_2 MIXTURE RATIOS OF 7:1 ARE USED FOR ALL LUNAR LANDERS.

23. AFT CARGO CARRIER ON SHUTTLE EXTERNAL TANK IS ASSUMED AND USED.

24. SHUTTLE DERIVED-UNMANNED LAUNCH VEHICLES (ULV) NEEDED AND ASSUMED FOR PROPELLANT TANKERS. LAUNCH 100 METRIC TON LOX/LH_2 TO SPACE STATION PER FLIGHT.

25. LAUNCH COST ESTIMATES (1984 DOLLARS) ULV -$133 MILLION/LAUNCH
STS -$100 MILLION/LAUNCH

LUNAR BASE DESCRIPTION

THE FINISHED LUNAR BASE CONSISTS OF:

0 5 HABITABILITY MODULES

0 5 RESEARCH UNITS

- GEO-CHEMICAL LABORATORY
- CHEMICAL/BIOLOGY LABORATORY
- GEO-CHEMICAL/PETROLOGY LABORATORY
- PARTICLE ACCELERATOR
- RADIO TELESCOPE

0 3 PRODUCTION PLANTS (PRECEEDED BY PILOT PLANTS)

- OXYGEN PLANT
- CERAMICS PLANT
- METALLURGY PLANT

0 2 SHOPS

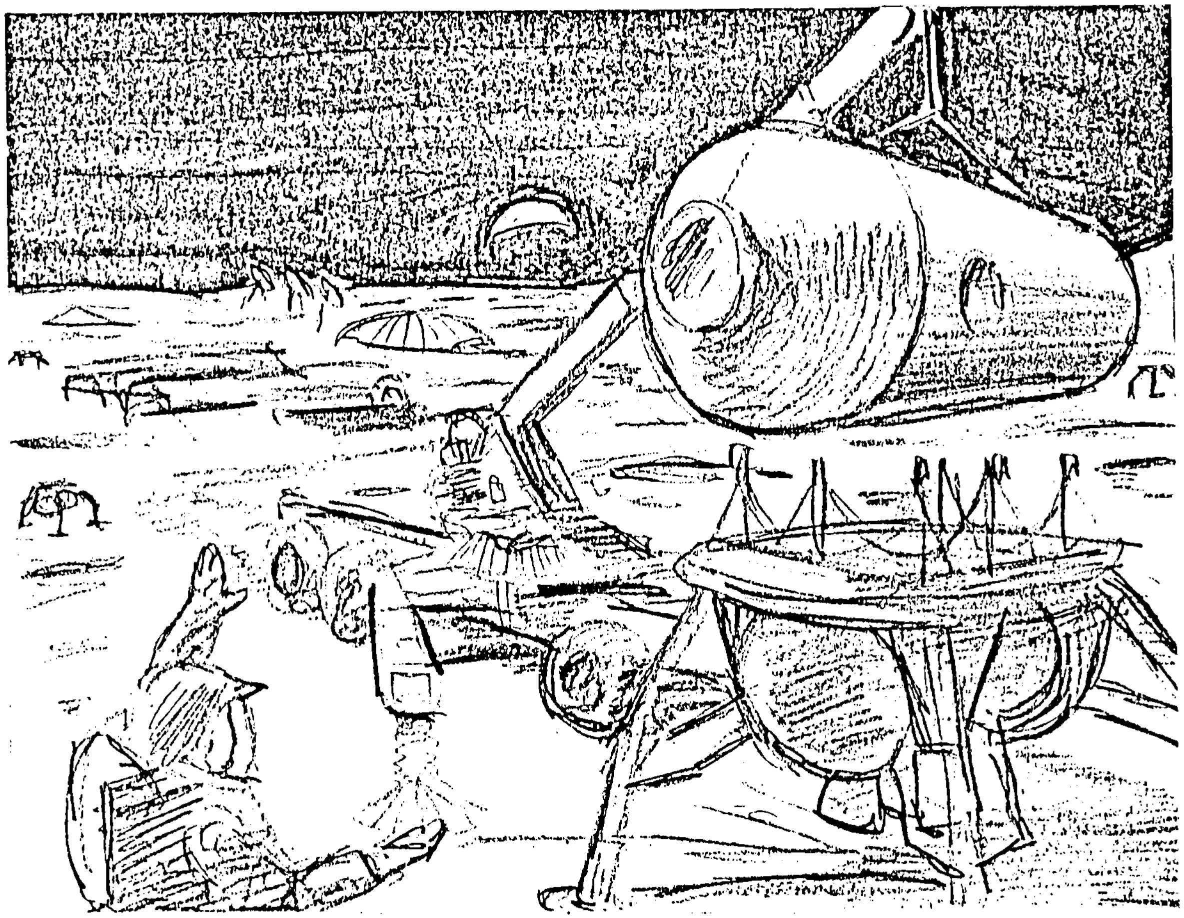
0 3 POWER UNITS

0 1 EARTHMOVER/CRANE

0 3 MOBILITY UNITS W/ TRAILERS

0 18 PERMANENT PERSONNEL

ALL ASSEMBLED OVER A 10 YEAR BUILD-UP PERIOD



UNLOADING MODULE ON LUNAR SURFACE

PAINTING TO BE SUPPLIED

LUNAR BASE BUILD-UP SCHEME

O FIRST 8 YEARS - UNMANNED EXPLORATION & MAPPING

O BASE BUILD-UP STARTS IN 2005

- 1ST YEAR - HABITAT POWER UNIT, CRANE, & 1 LABORATORY DELIVERED-UNMANNED
  - 2 MANNED SORTIES FLOWN TO PREPARE BASE-ALL RETURN

- 2ND YEAR - MOBILITY UNIT & O_2 PILOT PLANT DELIVERED-2 MORE MANNED SORTIES SMALL PERMANENT CREW STAYS

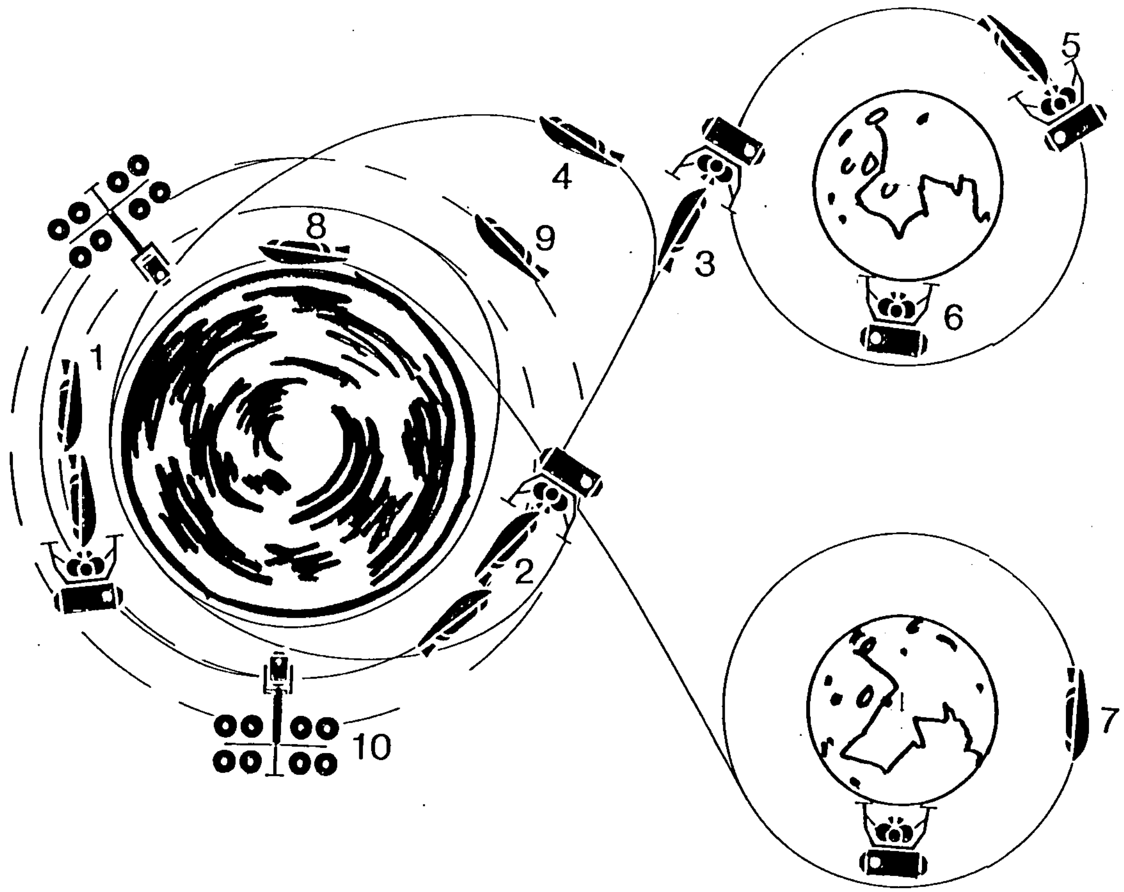
- 3RD YEAR - 1 MORE LAB & MISC. EQUIPMENT DELIVERED-UNMANNED
  - 3 MANNED SORTIES, ENTIRE CREW OF ONE MISSION STAYS SO THAT PERMANENT CREW HAS A LAUNCH VEHICLE ON SURFACE

- 4TH YEAR - OPERATIONAL OXYGEN PRODUCTION PLANT DELIVERED, REUSABLE LANDER/ LAUNCHER (R-LEM) DELIVERED & BECOMES OPERATIONAL

- 5TH YEAR THROUGH 10TH YEAR - HEAVY FLIGHT SCHEDULE TO DELIVER REMAINDER OF BASE ELEMENTS, SLACKING OFF AS TO 6 MANNED CREW ROTATION SORTIES PER YEAR AS BASE APPROACHES FULL GROWTH - MATURE BASE BY 10TH YEAR.

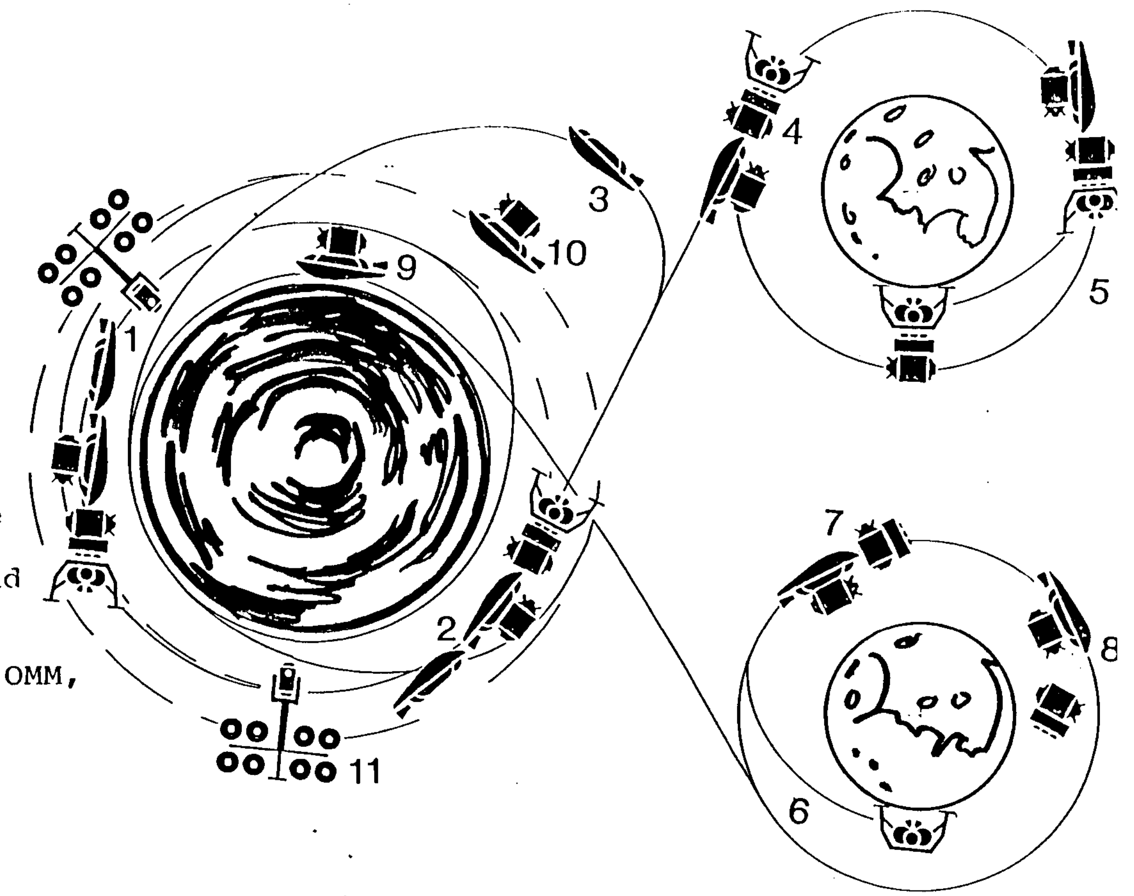
LUNAR SCENARIO, EXPENDABLE LANDER

1. Stack departs SS
2. First stage burn
3. Second stage burn
4. First stage returns to SS
5. Circularized in lunar orbit
6. Expendable lander places Common Module on lunar surface
7. Second stage returns to Earth
8. Aerobraking
9. Circularized above SS orbit
10. Second stage returns to SS

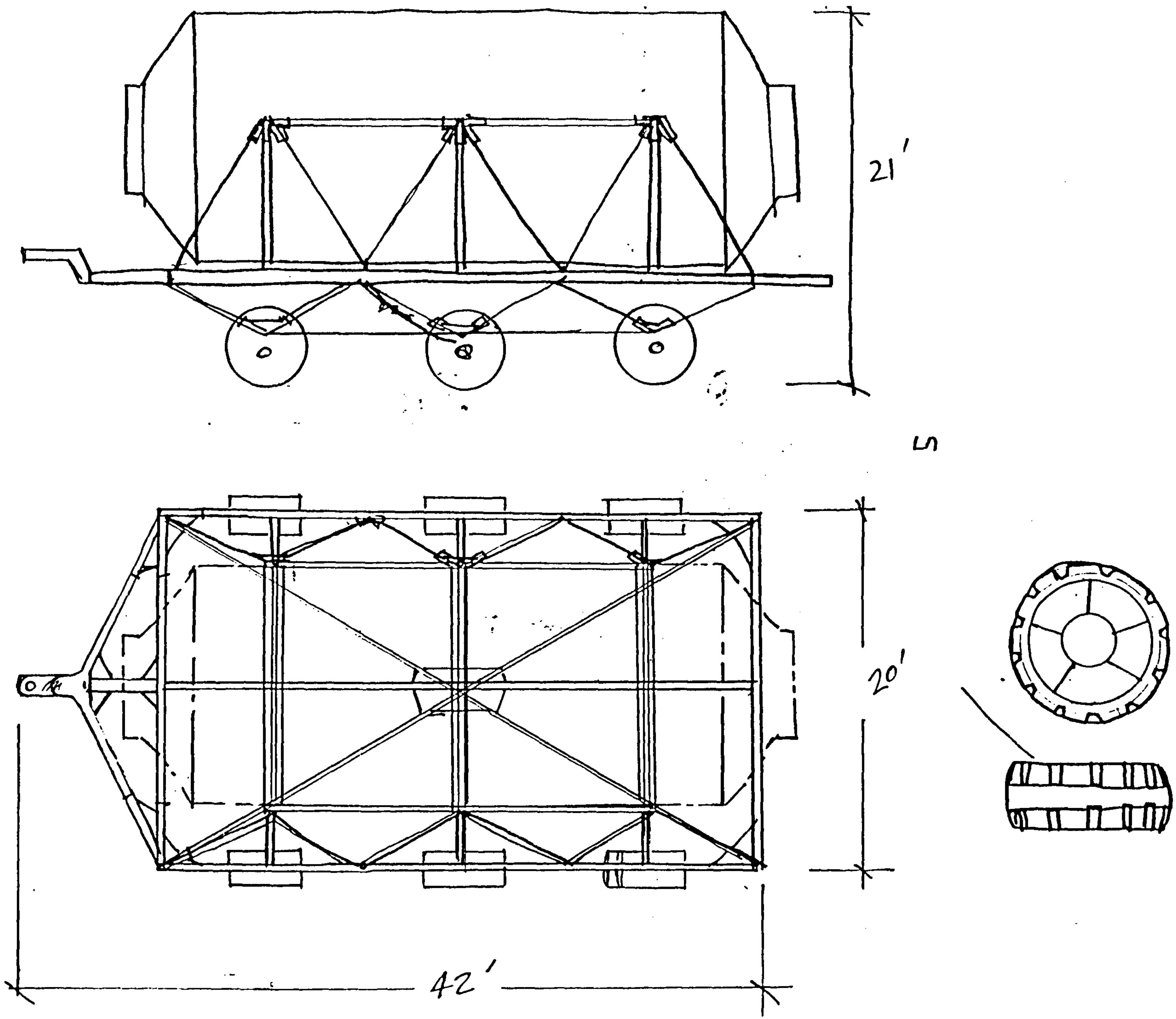


LUNAR SCENARIO, MANNED MISSION

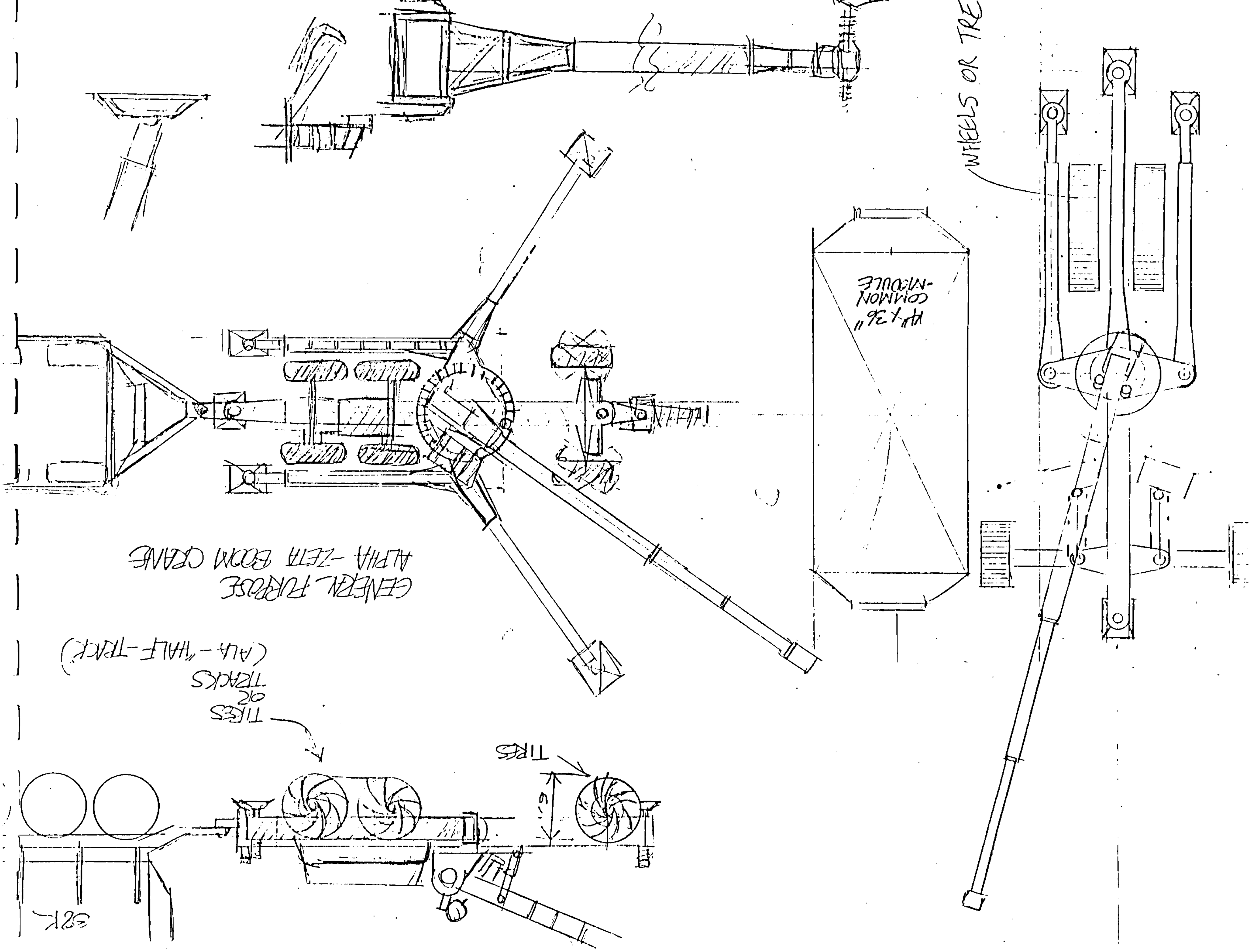
1. Stack departs SS
2. Trans-lunar injection burn
3. First stage returns to SS
4. Second stage, lander, and manned module insert into lunar orbit
5. Lander descends
6. Ascent module departs lunar surface
7. Ascent module rendezvous with second stage
8. Second stage returns to earth with OMM, ascent module discarded
9. Aerobraking
10. Circularization above the SS orbit
11. Rendezvous with SS



COMMON MODULE AND TRAILER - DRAFT SKETCH



LUNAR CRANE - DRAFT SKETCH

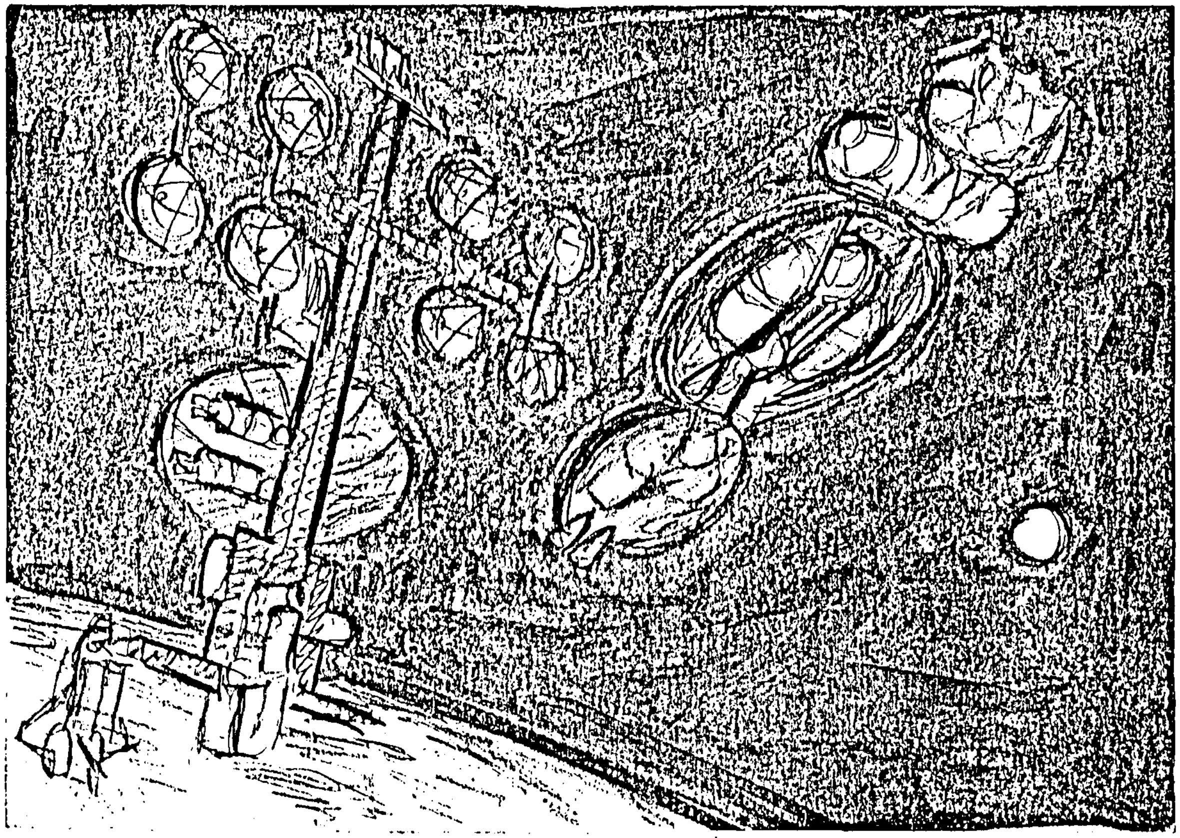


LUNAR SPACE TRANSPORTATION SYSTEM

STS ELEMENTS	ELEMENT DESCRIPTION	ELEMENT FUNCTION AND DESIGN GOALS
BASE ELEMENT COMMON MODULE	LENGTH = 11 M. ; DIAMETER = 4.6 M. WEIGHT =17.5 M.TON	COMMON LUNAR HOUSING AND/OR LABORATORY UNIT
E-LANDER	DIAMETER = 8.2 M. ; HEIGHT = 7 M. WEIGHTS: BURN OUT = 3.8 M.TON USABLE PROPELLANT = 13.6 M.TON LOX/LH2 PROPELLANT	EXPENDABLE LUNAR LANDER DESIGNED TO DELIVER 17.5 M.TON TO LUNAR SURFACE
LUNAR LANDING MANNED MODULE (LLMM)	LENGTH = 3.6 M. ; DIAMETER = 2.6 M WEIGHT = 3.25 M.TON (WITH 4 CREW)	MODULE TO CARRY CREW OF 4 TO LUNAR SURFACE, AND RETURN -- LIMITED LIFE SUPPORT --NOT REUSED--
E-LAUNCHER	DIAMETER = 3.6 TO 5 M. HEIGHT = 2 M. WEIGHTS: BURN OUT = 2.6 M.TON USABLE PROPELLANT = 5 M.TON PUMP FED, STORABLE PROPELLANT	EXPENDABLE LAUNCHER TO CARRY LLMM PLUS .5 TON PAYLOAD FROM LUNAR SURFACE TO LUNAR ORBIT
OTV MANNED MODULE (OMM)	LENGTH = 2.6 M. ; DIAMETER = 3 M. WEIGHT = 5.5 M.TON (WITH 4 CREW)	CREW MODULE FOR OTV, TO CARRY PERSONNEL FROM ORBIT TO ORBIT -SHIRT SLEEVE EVIRONMENT ---REUSABLE---
AEROBRAKING ORBITAL TRANSFER VEHICLE (AOTV)	DIAMETER = 12.2 M. (AERO SHIELD) LENGTH = 5 M. WEIGHTS : BURN OUT = 7.Ø M.TON USABLE PROPELLANT = 42 M.TON LOX/LH2 PROPELLANT	OTV SIZED TO DELIVER 35 M.TON TO LUNAR ORBIT AND RETURN EMPTY USING TWO OTVs BOTH RETURNED BY AEROBRAKING -- REUSABLE--

LUNAR SPACE TRANSPORTATION SYSTEM

STS ELEMENTS	ELEMENT DESCRIPTION	ELEMENT FUNCTION AND DESIGN GOALS
REUSABLE LUNAR LANDER/LAUNCHER (R - LEM)	DIAMETER = 10 M. ; HEIGHT = 7 M. WEIGHTS: BURN OUT = 5.2 M.TON USABLE PROPELLANT = 30 M.TON LOX/LH2 PROPELLANT	LUNAR BASED VEHICLE FOR TRANSPOR[illegible] FROM LUNAR SURFACE TO LUNAR ORBIT AND BACK - USING LUNAR PRODUCED OXYGEN. DESIGNED FOR 17.5 TON PL DOWN, 0 UP -- OR -- 14 TON PL DOWN, 7 TON UP. - A 5 TON TANK OF LH2 IS ALSO CARRIED DOWN ON EACH LANDING
REUSABLE LUNAR LANDING MANNED MODULE (R - LLMM)	LENGTH = 5 M. ; DIAMETER = 2.6 M. WEIGHT = 5 M.TON (WITH 6 CREW)	LUNAR BASED MANNED MODULE FOR US[illegible] WITH R-LEM; NORMAL CREW 6, MAX 1[illegible]
LARGE OMM	LENGTH = 4 M. ; DIAMETER = 3 M. WEIGHT = 8 M.TON (WITH 6 CREW)	LARGER OMM REPLACEMENT; FOR ORBITAL TRANSPORT OF CREWS IN MATURE LUNAR BASE OPERATIONS NORMAL CREW 6, MAX. 10
H2 TRANSFER TANK	VOLUME = 57 CU.M. WEIGHTS : EMPTY WT.=1 M.TON FULL WT.= 5 M.TON	TANK OF LIQUID HYDROGEN FUEL FO[illegible] R-LEM (WITH LUNAR O2) - ONE DELIVERED TO LUNAR SURFACE STORAGE EACH FLIGHT
----------------	---- LAUNCH VEHICLES ---	-------------------------
SHUTTLE (STS)	PL TO SPACE STATION = 25 M.TON	REUSABLE LAUNCH VEHICLE FOR VALUABLE CARGOS AND PERSONNEL
SHUTTLE/AFT CARGO CARRIER (STS-ACC)	PL TO SPACE STATION = 22 M.TON	SHUTTLE WITH A CARGO COMPARTMEN[illegible] ON AFT END OF EXTERNAL TANK -FOR OVERSIZE CARGOS-
SHUTTLE DERIVED UNMANNED LAUNCH VEHICLE (SD-ULV)	USABLE LOX/LH2 TO SPACE STATION = 100 M.TON	UNMANNED LAUNCHER DESIGNED USIN[illegible] SHUTTLE ELEMENTS,--USED FOR LAUNCHING LOX/LH2 PROPELLANT T[illegible] ORBITAL STORAGE DEPOT



AOTV STACK DEPARTING SPACE STATION

WITH COMMON MODULE

PAINTING TO BE SUPPLIED

AOTV

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OTV SCHEDULED MAINTENANCE OPERATIONS

Duration	Operation	Crew	Manhours
DURATION 1 DAY	REMOVE AND REPLACE FUEL CELL/BATTERY	2 PEOPLE	5:40 MANHOURS
DURATION 2 DAYS	REMOVE AND REPLACE ENGINE	4 PEOPLE	65:30 MANHOURS

OTV UNSCHEDULED MAINTENANCE OPERATIONS

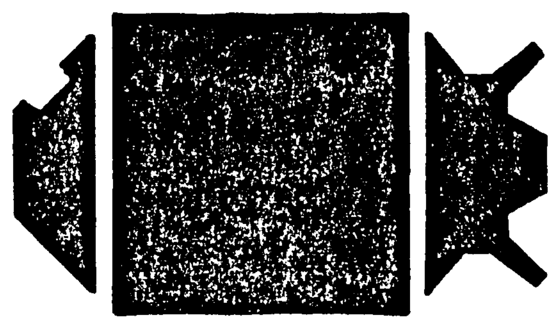
Duration	Operation	Crew	Manhours
DURATION 1 DAY	REMOVE AND REPLACE AVIONICS MODULE	2 PEOPLE	5:30 MANHOURS
DURATION 1 DAY	REPAIR AEROBRAKE	4 PEOPLE	26:20 MANHOURS
DURATION 2 DAYS	REMOVE AND REPLACE TANK MODULE	4 PEOPLE	58:15 MANHOURS

OTV TURNAROUND OPERATIONS

NORMAL OTV TURNAROUND

DURATION 4 DAYS | 2 PEOPLE | 69:40 MANHOURS

- O RETRIEVAL AND CAPTURE
- O SAFING
- O BERTHING
- O INSPECTION
- O REMOVE AND REPLACE ACS MODULES
- O SYSTEMS TEST
- O PAYLOAD INTEGRATION
- O TRANSFER PROPELLANT
- O PRELAUNCH
- O LAUNCH

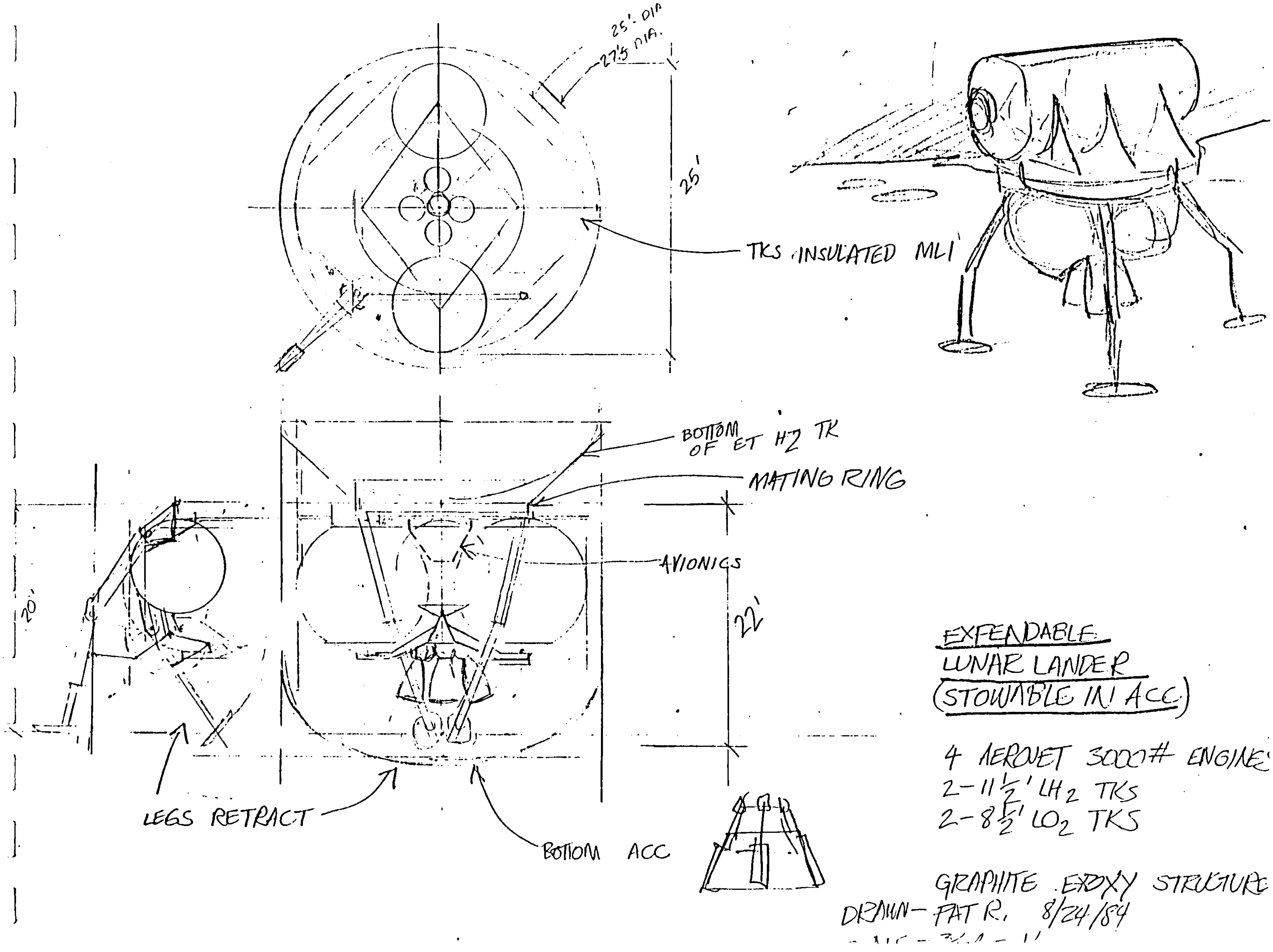


OMM

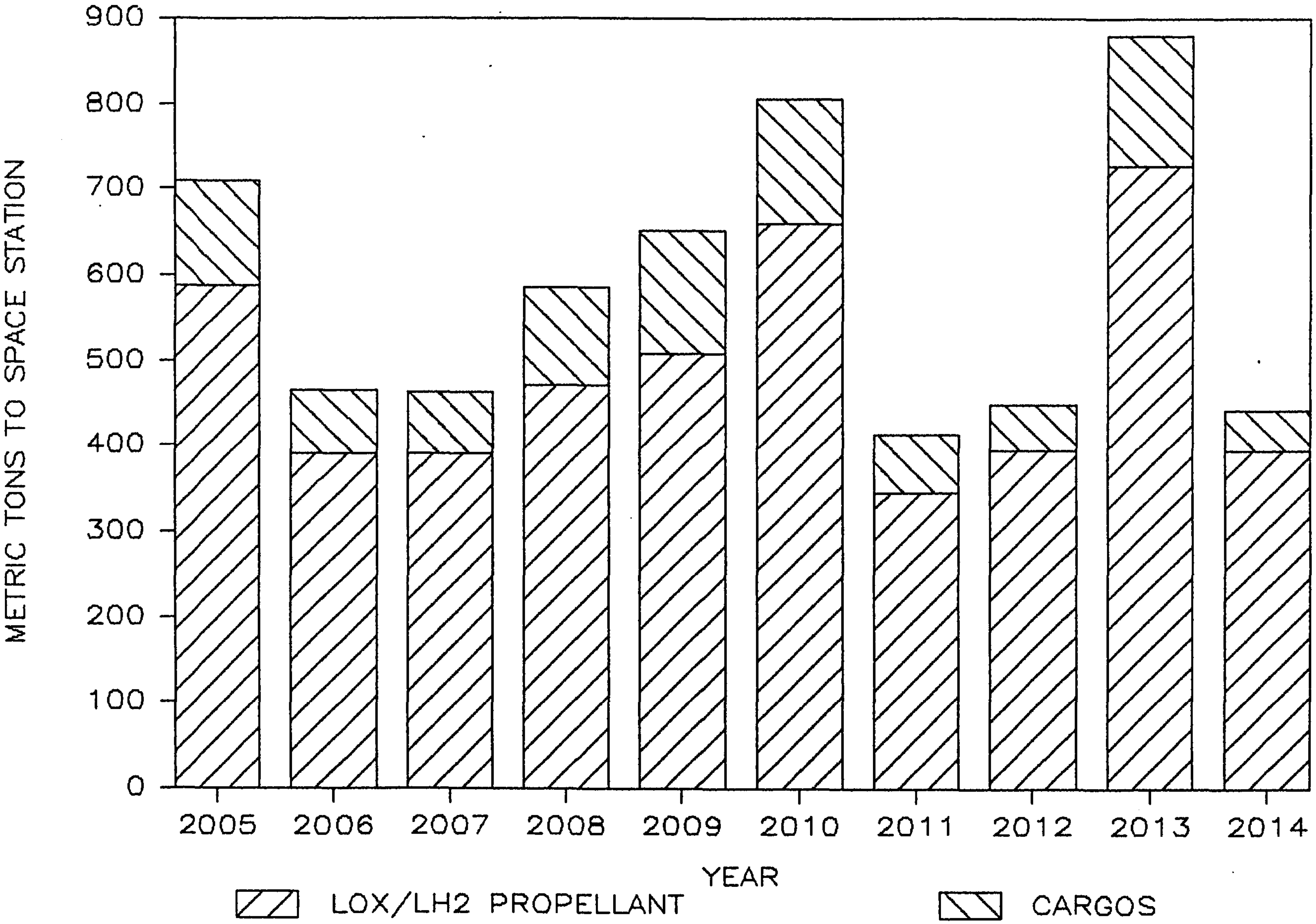
OTV MANNED MODULE

DETAILED SKETCH TO BE SUPPLIED

EXPENDABLE LANDER - DRAFT SKETCH



LUNAR BASE LAUNCH REQUIREMENTS



DETAILED LAUNCH MANIFEST AND LUNAR MISSION SCHEDULE

MONTH	LAUNCH NO.	TYPE	CARGO MANIFEST	CARGO WT. M.TON	LUNAR FLIGHT NO.	FLIGHT TYPE
			------------- YEAR 2005 --------------			
JAN	5-1	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
FEB	5-2	STS-ACC	E-LANDER,+BASE ELEMENT #1	21	L5-1	UNMANNED DELIVERY
MARCH	5-3	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
APRIL	5-4	STS-ACC	E-LANDER,+BASE ELEMENT #2	21	L5-2	UNMANNED DELIVERY
MAY	5-5	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
JUNE	5-6	STS-ACC	E-LANDER,+BASE ELEMENT #3	21	L5-3	UNMANNED DELIVERY
JULY	5-7	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
AUG	5-8	STS-ACC	E-LANDER,+BASE ELEMENT #4	21	L5-4	UNMANNED DELIVERY
SEPT	5-9	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
OCT	5-10	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+OMM,+4 CREW	20	L5-5	MANNED SORTIE
NOV	5-11	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
DEC	5-12	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+OMM,+4 CREW	20	L5-6	MANNED

DETAILED LAUNCH MANIFEST AND LUNAR MISSION SCHEDULE

MONTH	LAUNCH NO.	TYPE	CARGO MANIFEST	CARGO WT. M. TON	LUNAR FLIGHT NO.	FLIGHT TYPE
			------------- YEAR 2006 -------------			
JAN	6-1	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
FEB	6-2	STS-ACC	E-LANDER,+BASE ELEMENT #5	21	L6-1	UNMANNED DELIVERY
MARCH						
APRIL	6-3	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
MAY	6-4	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+4 CREW,+2 TON P.L.,+ 4 TON OF AOTV ELEMENTS	20	L6-2	MANNED SORTIE
JUNE						
JULY	6-5	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
AUG	6-6	STS-ACC	E-LANDER,+BASE ELEMENT #6	21	L6-3	UNMANNED DELIVERY
SEPT						
OCT	6-7	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
NOV	6-8	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+4 CREW,+2 TON P.L.,+ 4 TON OF AOTV ELEMENTS	20	L6-4	MANNED SORTIE
DEC						

DETAILED LAUNCH MANIFEST AND LUNAR MISSION SCHEDULE

MONTH	LAUNCH NO.	TYPE	CARGO MANIFEST	CARGO WT. M. TON	LUNAR FLIGHT NO.	FLIGHT TYPE
			------------- YEAR 2007 --------------			
JAN	7-1	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
FEB	7-2	STS-ACC	E-LANDER,+BASE ELEMENT #7	21	L7-1	UNMANNED DELIVERY
MARCH						
APRIL	7-3	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
MAY	7-4	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+4 CREW,+2 TON P.L.,+ 4 TON OF AOTV ELEMENTS	20	L7-2	MANNED SORTIE
JUNE						
JULY	7-5	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
AUG	7-6	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+4 CREW,+2 TON P.L.,+ 4 TON OF AOTV ELEMENTS	20	L7-3	MANNED SORTIE
SEPT						
OCT	7-7	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
NOV	7-8	STS-ACC	E-LANDER,+E-LLMM/ASCENT,+4 CREW,+2 TON P.L.,+ R-LLMM	21	L7-4	MANNED SORTIE
DEC	7-9	STS-ACC	R-LEM ELEMENTS,+SECOND R-LLMM,+H2 TANK	10		
	7-10	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		

DETAILED LAUNCH MANIFEST AND LUNAR MISSION SCHEDULE

MONTH	LAUNCH NO.	TYPE	CARGO MANIFEST	CARGO WT. M.TON	LUNAR FLIGHT NO.	FLIGHT TYPE
			------------- YEAR 2008 -------------			
JAN	8-1	STS-ACC	E-LANDER,+BASE ELEMENT #8	21	L8-1	UNMANNED DELIVERY
FEB	8-2	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
MARCH	8-3	STS-ACC	E-LANDER,+BASE ELEMENT #9	21	L8-2	UNMANNED DELIVERY
APRIL	8-4	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
	NOTE--- LUNAR CREW DELIVERED TO SPACE STATION ON SCHEDULED RESUPPLY STS LAUNCH					
MAY					L8-3	MANNED SORTIE
JUNE	8-5	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
JULY	8-6	STS	2 H2 TANKS,+ 18 TONS OF LUNAR CARGO, + 4 CREW	21	L8-4	MANNED SORTIE
AUG	8-7	SD-ULV	LOX/LH2 PROPELLANT SUPPLY UNIT	100		
	NOTE--- LUNAR CREW DELIVERED TO SPACE STATION ON SCHEDULED RESUPPLY STS LAUNCH					
SEPT					L8-5	MANNED SORTIE
OCT	8-8	STS	2 H2 TANKS,+ 18 TONS OF LUNAR CARGO, + 4 CREW	21		
NOV					L8-6	MANNED SORTIE
DEC						

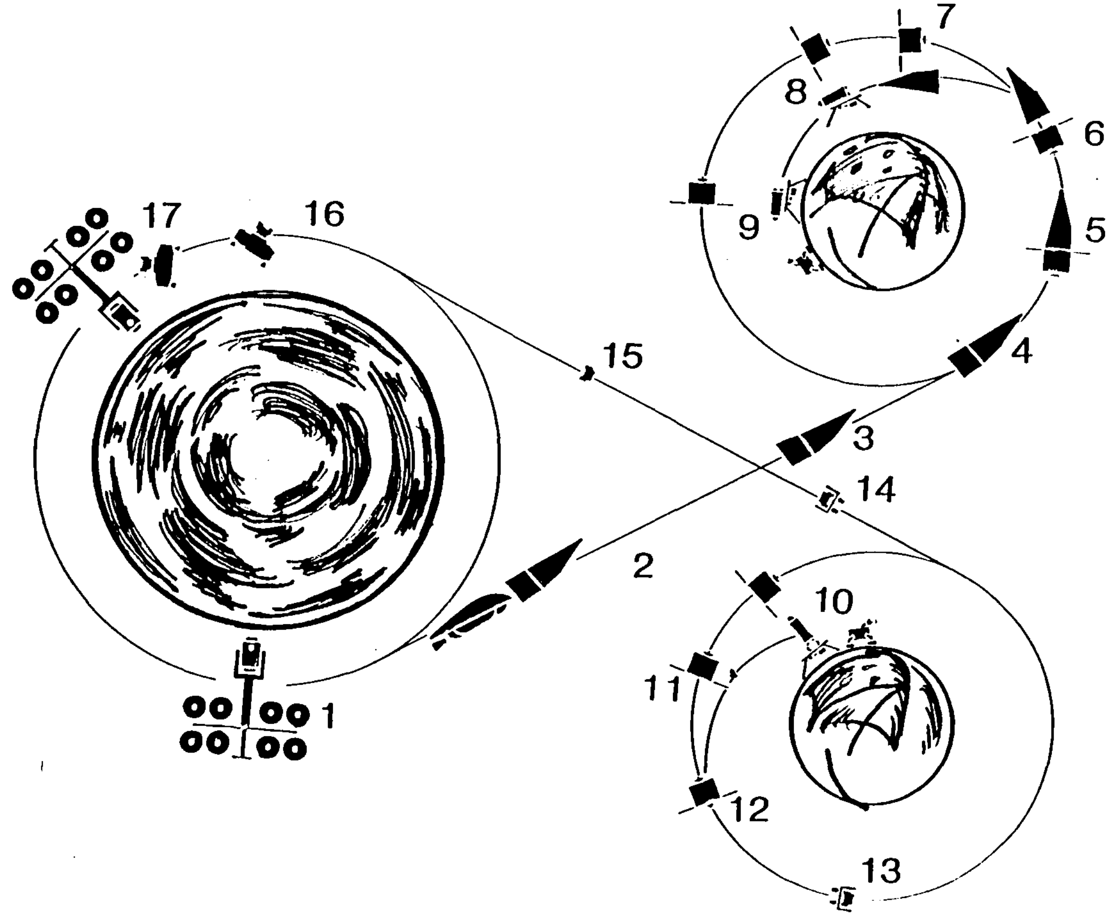
COMMENTS AND CONCLUSIONS

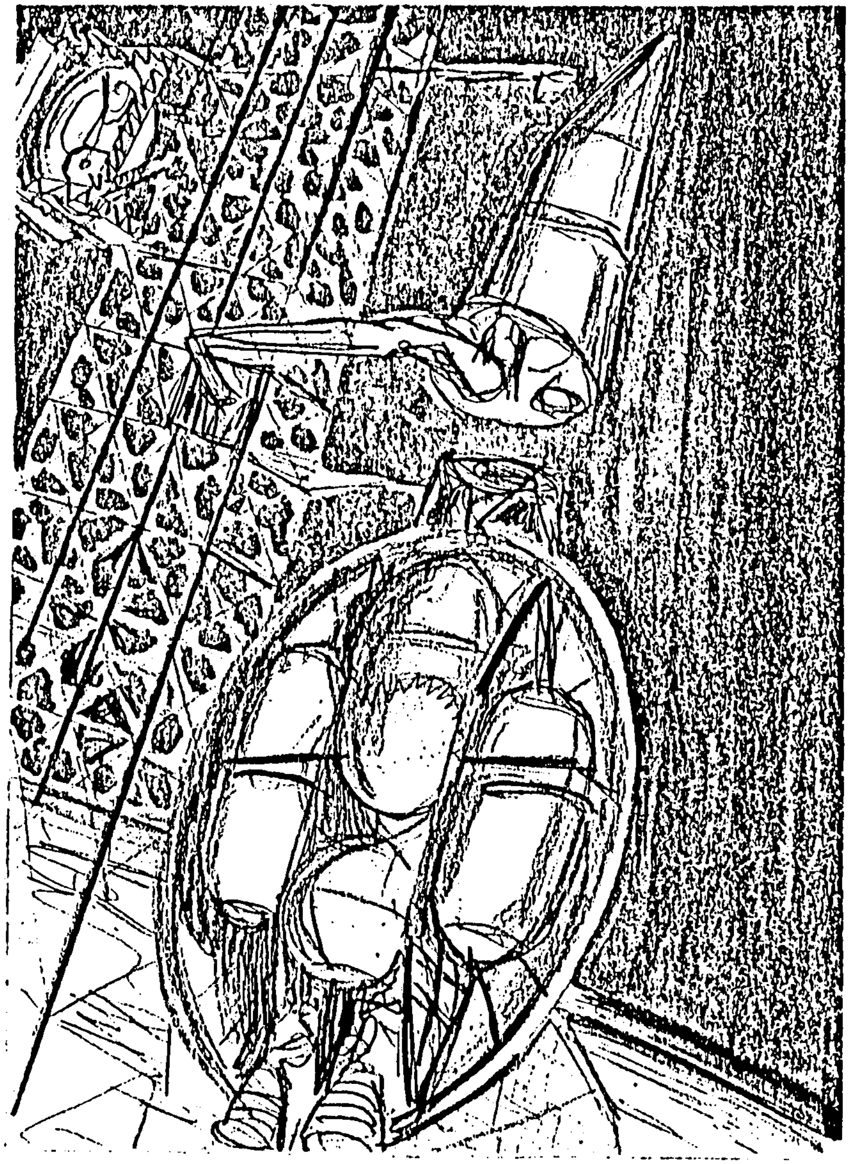
LUNAR BASE BUILD-UP AND OPERATIONS

- O THE LUNAR INITIATIVE REQUIRES HEAVY UTILIZATION OF THE SPACE STATION AS AN OPERATIONS CENTER AND TRANSPORTATION DEPOT
- O STORAGE, MAINTENANCE, AND OPERATIONS OF PERMANENT AND TRANSIENT TRANSPORTATION SYSTEM ELEMENTS REQUIRE EXTENSIVE HANGERS, GANTRYS, AND SHOP AREAS, PLUS 2 TO 4 ADDITIONAL SPACE STATION CREW MEMBERS
- O ADDITIONAL PERSONNEL MODULE(S) WILL BE NECESSARY FOR ENLARGED SS CREW PLUS 4 TO 6 TRANSIENTS (25% OF TIME)
- O LARGE OTV'S WITH MULTI-STAGING CAPABILITY ARE REQUIRED
- O ULV TANKER LAUNCHES ARE REQUIRED TO ACHIEVE REASONABLE LAUNCH RATES - PROVIDES LAUNCH COST SAVINGS OF $1.5 BILLION/YEAR COMPARED TO NSTS ALONE.
- O LUNAR TRANSPORTATION OPERATIONS ARE FAIRLY INTENSE BUT ENTIRELY PRACTICABLE. REQUIRES ONE LAUNCH PER MONTH, ONE LUNAR FLIGHT EVERY 2 MONTHS

MARS SAMPLE RETURN SCENARIO

1. Stack Leaves S.S.
2. Trans-Mars Injection
3. Trans-Mars Voyage
4. Aerocapture/Mars Orbit Insertion
5. Jettison Orbiter Aeroshell
6. Lander and Orbiter Separate
7. Lander Enters Mars Atmosphere
8. Landing on Mars
9. Collect Samples
10. Launch from Mars
11. Rendezvous Maneuvers
12. Rendezvous with Orbiter
13. Trans-Earth Injection
14. Trans-Earth Voyage
15. Earth Orbit Insertion
16. Rendezvous with OMV
17. Return to S.S.





MARS SAMPLE RETURN

SPACE STATION CHECKOUT

PAINTING TO BE SUPPLIED

CERES OR KOPFF SAMPLE RETURN SCENARIO

1. 2 OTVs, MMII, 2 Samplers, and EOC leave SS

2. First stage separates and returns to SS

3. Second stage and spacecraft enroute to comet/asteroid

4. Spacecraft surveying asteroid/comet

5. Landers on surface, Spacecraft orbiting

6. Spacecraft recovers samples and departs for Earth

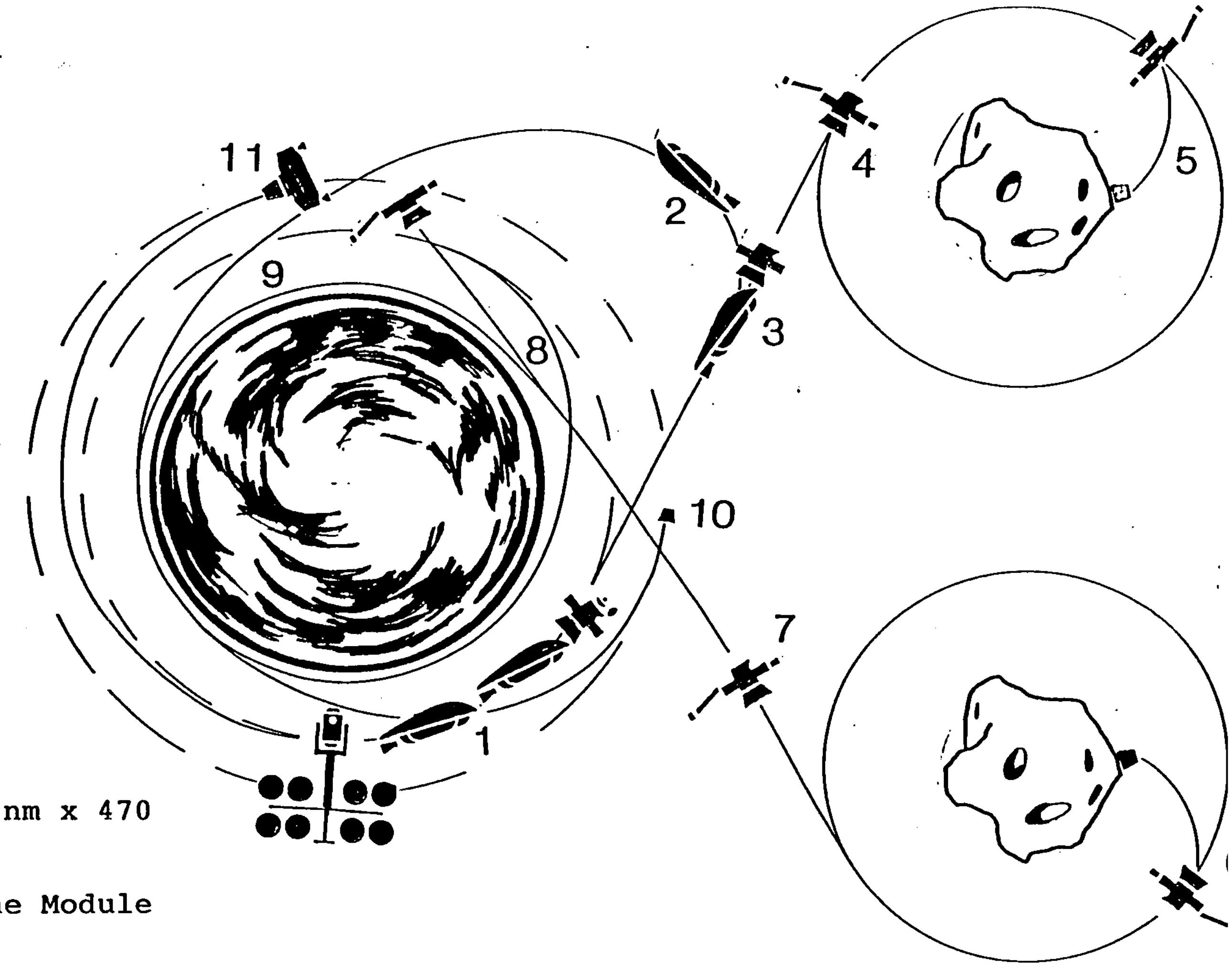
7. MMII and EOC enroute to Earth

8. MMII and EOC separate

9. EOC aerobrakes

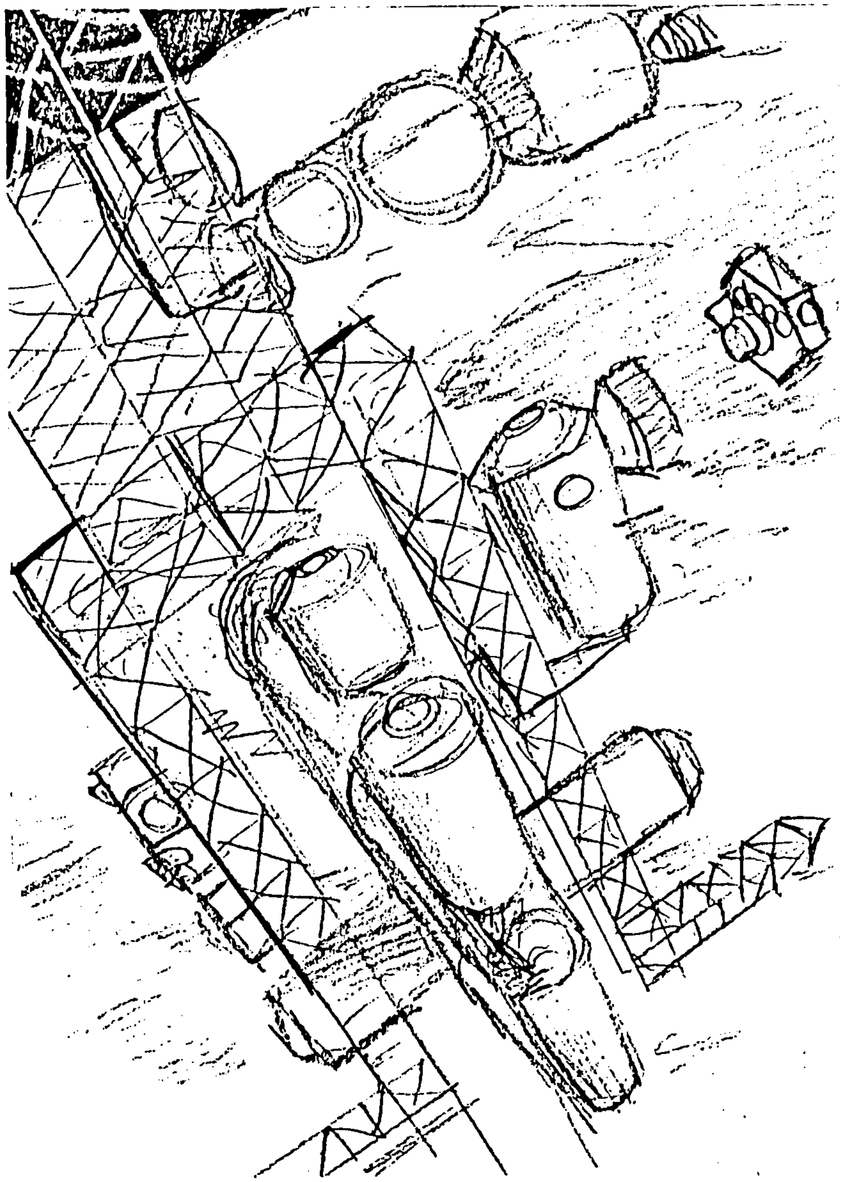
10. EOC circularization burn, 470 nm x 470 nm final orbit

11. OMV retrieves EOC to Quarantine Module



CERES STACK

DETAILED SKETCH TO BE SUPPLIED



OMV RETURNS SAMPLE TO QUARANTINE MODULE

PAINTING TO BE SUPPLIED

GLOVE BOX INSIDE QUARANTINE MODULE

SKETCH TO BE SUPPLIED

MERCURY ORBITER SCENARIO

SKETCH TO BE SUPPLIED

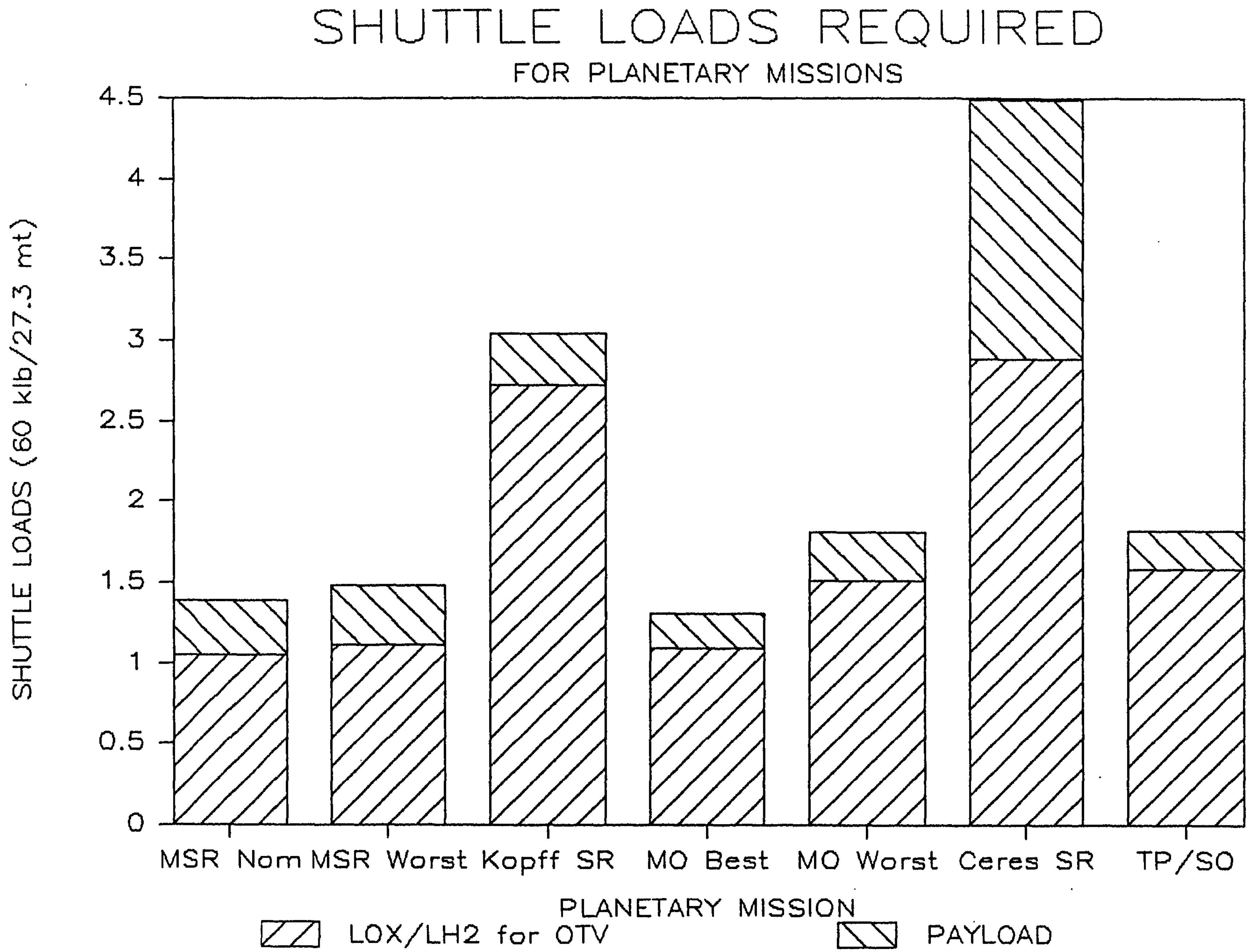
TITAN PROBES/SATURN ORBITER SCENARIO

SKETCH TO BE SUPPLIED

PLANETARY MISSIONS PERFORMANCE SUMMARY

	C3	TYPE OF OTV*	PAYLOAD OUT OF LEO	LEO TOTAL DEPARTURE MASS	OTV PROPELLANT LOAD	PROPELLANT + PAYLOAD (LIFT REQ.)
	(KM/SEC)^2		METRIC TONS	METRIC TONS	METRIC TONS	METRIC TONS
MARS SAMPLE RETURN	9.Ø	1 STAGE REUSABLE	8.89	43.53	27.41	36.31
KOPFF SAMPLE RETURN	8Ø.7	2 STAGE, 1ST STAGE RETURNS	8.38	91.76	71.Ø8	79.46
CERES SAMPLE RETURN	9.9	2 STAGE, 1ST STAGE RETURNS	43.57	131.24	75.42	118.99
MERCURY ORBITER	18.7	1 STAGE REUSABLE	5.63	41.Ø2	28.46	34.Ø8
TITAN PROBES/ SATURN ORBITER	5Ø.5	1 STAGE EXPENDABLE	6.34	52.9Ø	41.3Ø	47.65

* ISP = 455.4 SEC., ALL STAGES HAVE A TOTAL PROPELLANT CAPACITY OF 4Ø METRIC TONS, A = 3,731 KGMS, B = .Ø785. STAGES THAT DO NOT RETURN HAVE THE AEROBRAKE REMOVED.


SHUTTLE LOADS REQUIRED
FOR PLANETARY MISSIONS
SHUTTLE LOADS (60 klb/27.3 mt)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
MSR Nom
MSR Worst
Kopff SR
MO Best
MO Worst
Ceres SR
TP/SO
PLANETARY MISSION
LOX/LH2 for OTV
PAYLOAD

COMMENTS AND CONCLUSIONS

PLANETARY MISSIONS

- THE IMPACT OF THE PLANETARY MISSIONS STUDIED ON THE SPACE STATION IS NOT LARGE WHEN COMPARED TO THE LUNAR BASE
- A QUARANTINE MODULE MAY BE DESIRABLE FOR SAMPLE RETURNS
- THE KOPFF AND CERES MISSIONS REQUIRE THE CAPABILITY TO STACK AND CHECKOUT TWO STAGE OTVS
- 2 TO 7 MANWEEKS OF ON-ORBIT WORK, DEPENDING ON THE MISSION COMPLEXITY, WILL BE REQUIRED OF THE CREW OF THE STATION TO LAUNCH A MISSION
- WITH THE POSSIBLE EXCEPTION OF QUARANTINE MODULE WORK, DEDICATED CREW WILL NOT BE REQUIRED

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