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SPACE TRANSFER VEHICLE CONCEPTS AND REQUIREMENTS

NAS8-37856

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FOREWORD

This report, prepared by Martin Marietta Corporation, is submitted to George C. Marshall Space Flight Center, National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC), Alabama, in response to the DR-5 requirements of contract NAS8-37856, Space Transfer Vehicle Concept and Requirements. It is the DR-5 identified in Data Procurement Document No. 709.

APPENDIX A

90-DAY STUDY CONCEPT DEFINITION

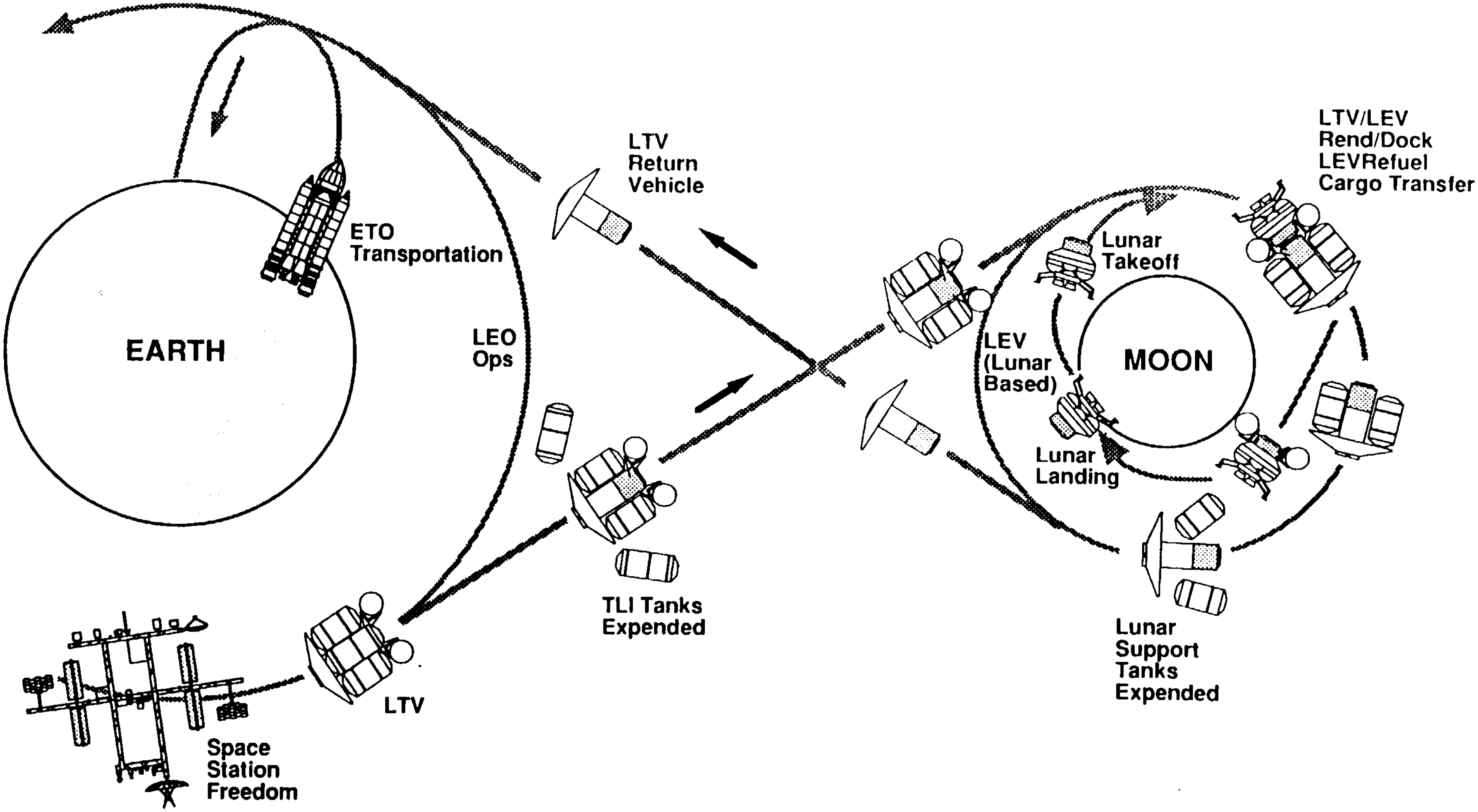
This appendix describes the work that was performed to define the Lunar transfer vehicle and Lunar excursion vehicle which were part of the "Report of the 90-Day Study on Human Exploration of the Moon and Mars." A detailed concept definition of both vehicles including overall dimensions, mass properties, subsystem definition, and operational flight sequences is contained herein. These data were presented at Interim Review #1 in December 1989.

1.0 MISSION SCENARIO

The steady-state Lunar mission scenario for the 90-day study is depicted in Figure 1.0-1. In this scenario, two separate vehicles, a Lunar transfer vehicle (LTV) and a Lunar excursion vehicle (LEV) are utilized to deliver cargo and crew to the Lunar surface. In the steady-state scenario shown, propellant is delivered to Space Station Freedom using the Earth to Orbit (ETO) Transportation System. After undergoing any required refurbishment and attachment of propellant tanks delivered from Earth, the LTV leaves Space Station Freedom with crew and/or cargo. The translunar injection (TLI) tanks are expended after the TLI burn. The LTV then performs a Lunar orbit insertion (LOI) burn. Once the LTV is in low Lunar orbit (LLO), the LEV acsends from the Lunar surface for rendezvous and docking with the LTV. After completing the docking maneuver, crew and/or cargo along with propellant is transferred to the LEV from the LTV. Once the LEV is fueled and has its crew and cargo, the vehicles separate and the LEV prepares for descent to the Lunar surface. The LTV propellant tanks for supplying fuel to the LEV are then expended and the LTV prepares for return to Space Station Freedom. The LTV engines are retracted, doors in the aerobrake are closed, and the LTV performs a transearth injection (TEI) burn. After the aeropass maneuver, the LTV performs a rendezvous maneuver with Space Station Freedom. The LEV remains on the Lunar surface until the LTV returns months later.

2.0 LTV/LEV CONCEPT DEFINITION

Figure 1.0-1 Lunar Mission Scenario - Steady State



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The LTV/LEV stacked configuration as shown in Figure 2.0-1 is approximately 23 m in total length. The configuration consists of the LTV and the LEV along with their respective crew cabs and cargo. The LTV is a stage and a half concept with 4 expendable drop tanks. There are two separate crew cabs, one on the LTV and one on the LEV. Cargo along with propellant must be transferred from the LTV to the LEV.

2.1 LTV CONFIGURATION

The basic LTV configuration shown in Figure 2.1-1 consists of a rigid 13.7 m aerobrake and a core vehicle that consists of a propulsion module and a lunar transit crew cab. Drop tank attach structure and feedlines are mounted to the core vehicle.

The aerobrake as shown in Figure 2.1-2 is a 13.7 m (45 ft) diameter rigid structure composed of composite materials and covered with advanced Shuttle-type thermal protection system tiles. A 7.6 m (25 ft) preassembled core with the engine nozzle doors, mechanisms, and tiles installed is delivered to orbit attached to the LTV. The outside periphery of the aerobrake (eight equal segments) is assembled at Space Station Freedom. The aerodynamic pressure environment, TPS (FRCI-12) thicknesses, and weight summary for the aerobrake are shown. The TPS for the aerobrake is tailored into four bands corresponding to the pressure and aeroheating regions. Total dry weight for the aerobrake is slightly over 2 t.

The core vehicle illustrated in Figure 2.1-3 is an integrated structure which includes the propulsion module, the transit crew cab, and the aerobrake attachment structure. The core is an integrated structure to reduce on orbit assembly times and structural weight. The basic core structure consists of a composite shell of graphite/epoxy with eight (8) longerons designed to transfer and distribute engine thrust loads and TLI and LLO tank loads. The longerons are equally spaced at 45° around the core. The engines are mounted on a set of crossbeams which intersect the shell (and longerons) at 0, 90, 180, and 270°. Auxiliary support/stabilizing beams run from each side of the engine mount beams to the other 45° spaced longerons. The aerobrake support is a trussed structure. The crew cab is built into the basic core unit but can be removed and replaced with a skirt of equal structural support. Ring frames are spaced at major interface locations to support drop tank and cargo attachment, with intermediate stiffening rings spaced as required to maintain structural rigidity along the core shell.

Figure 2.0-1 LTV/LEV Configuration

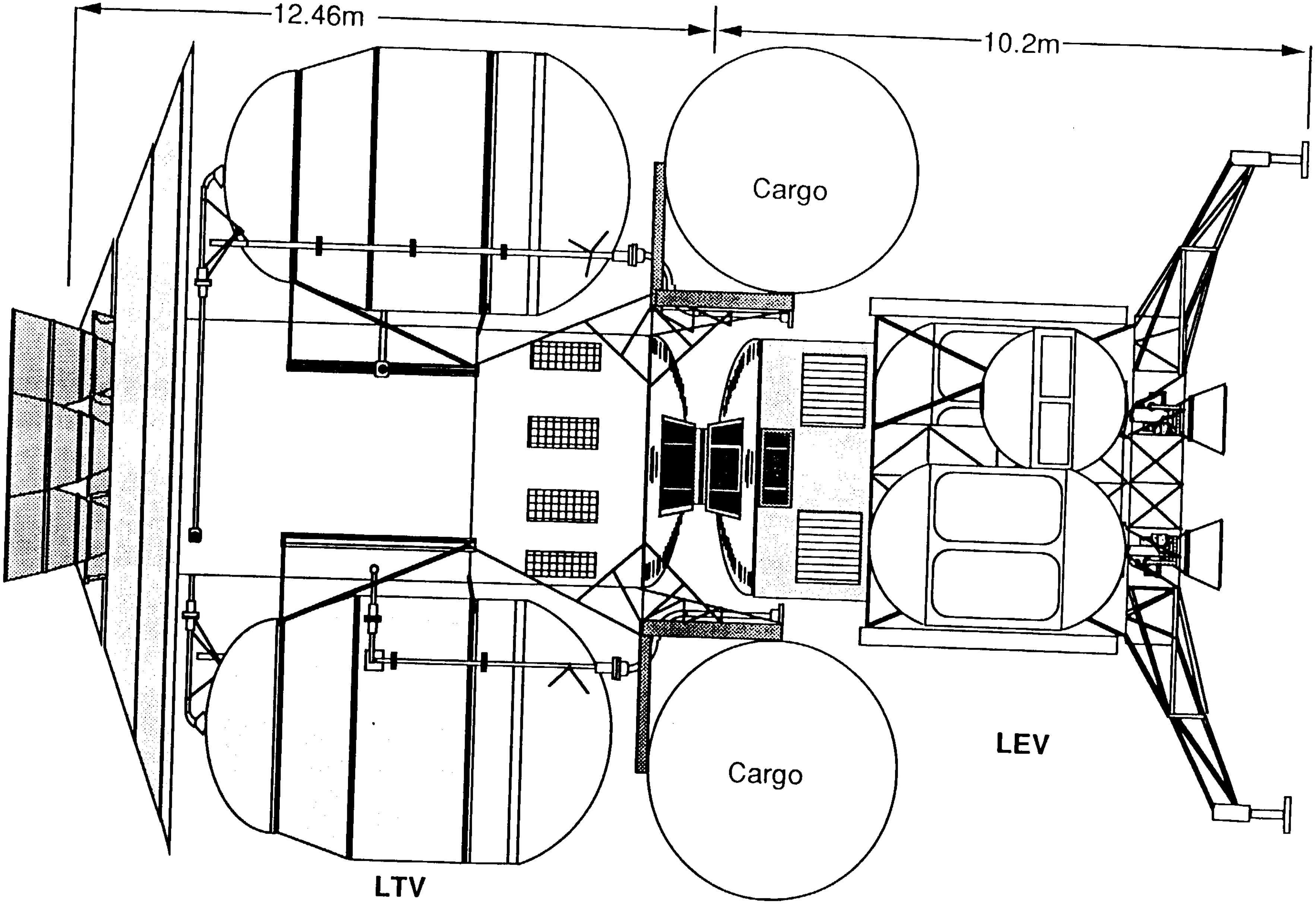

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Figure 2.1-1 LTV Core Configuration

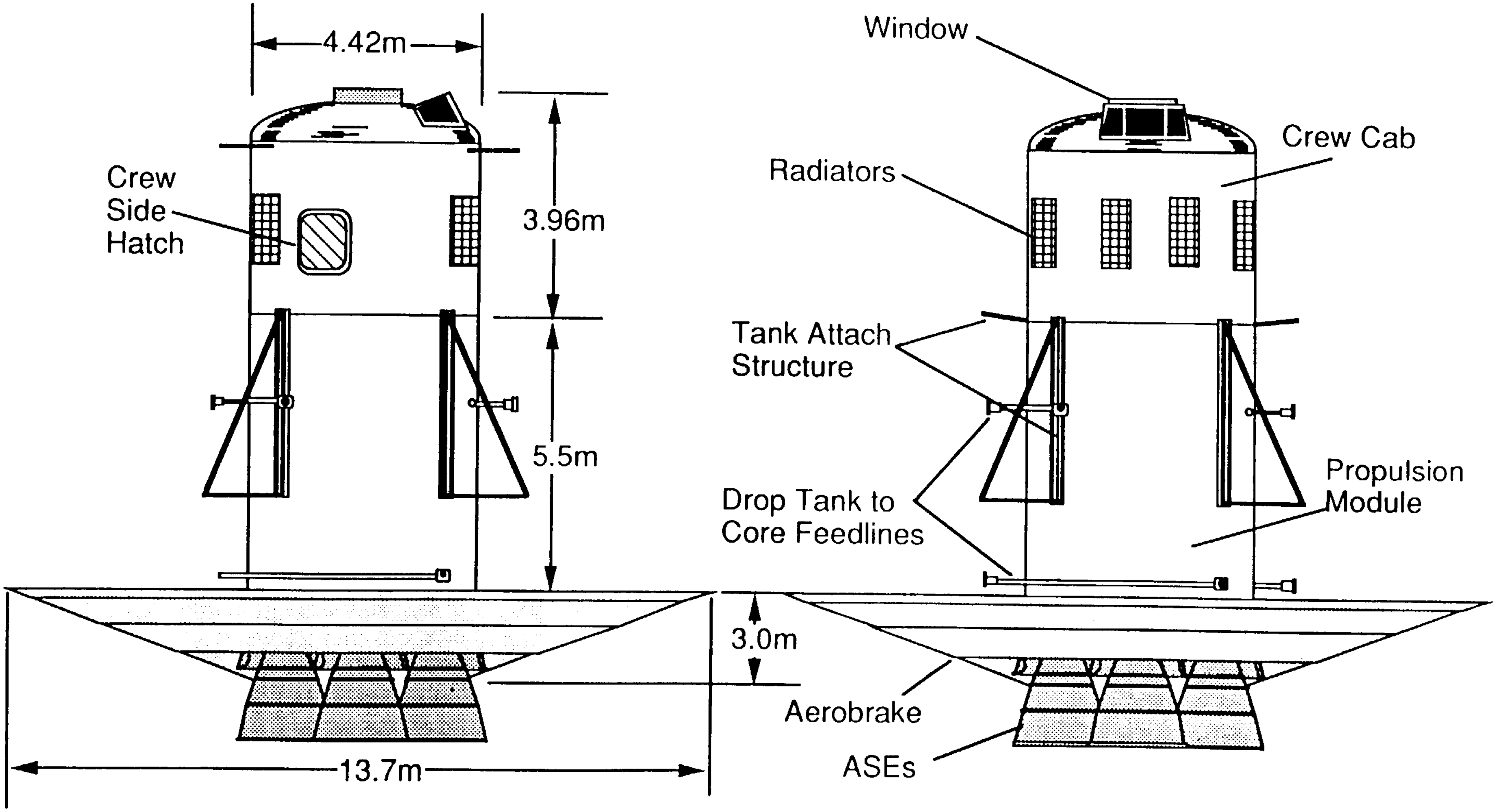
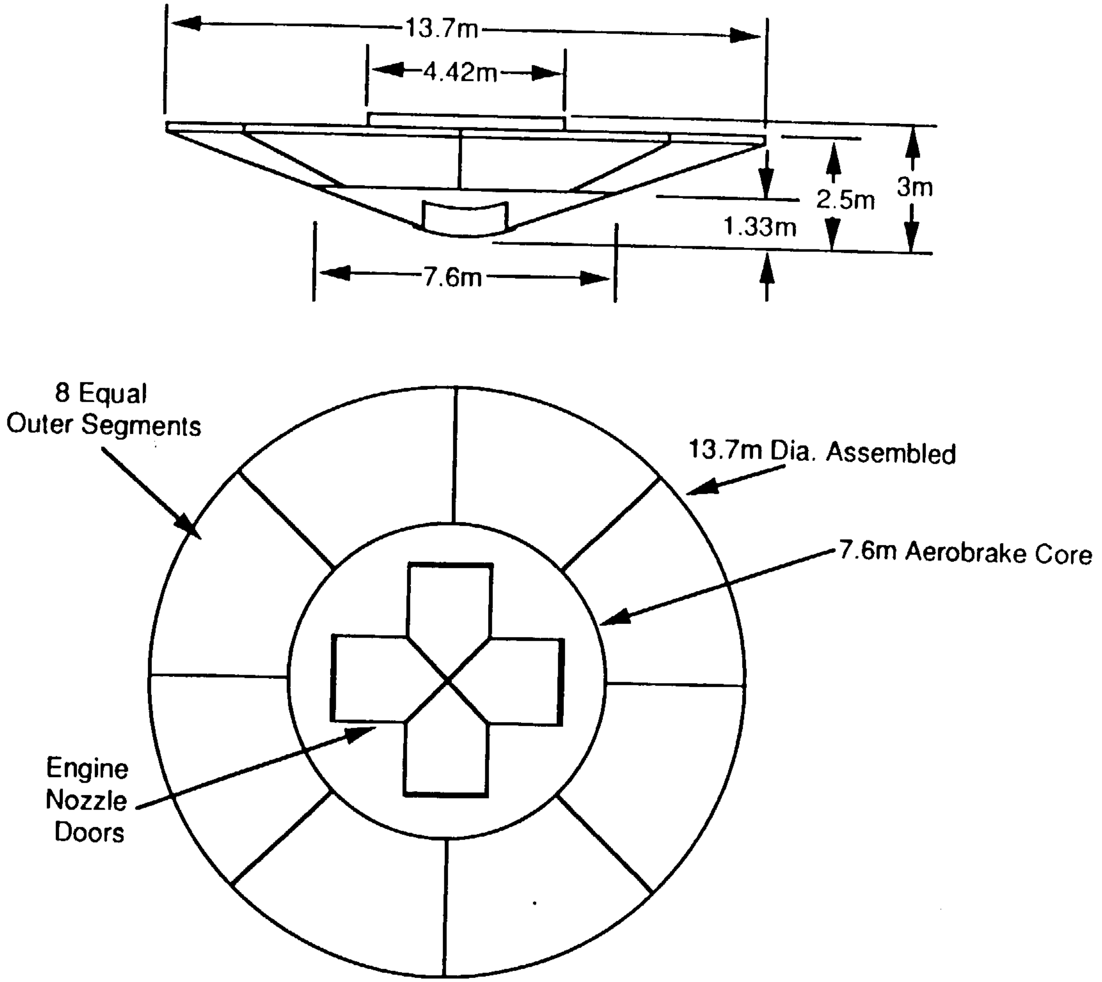


Figure 2.1-2 Aerobrake Overview

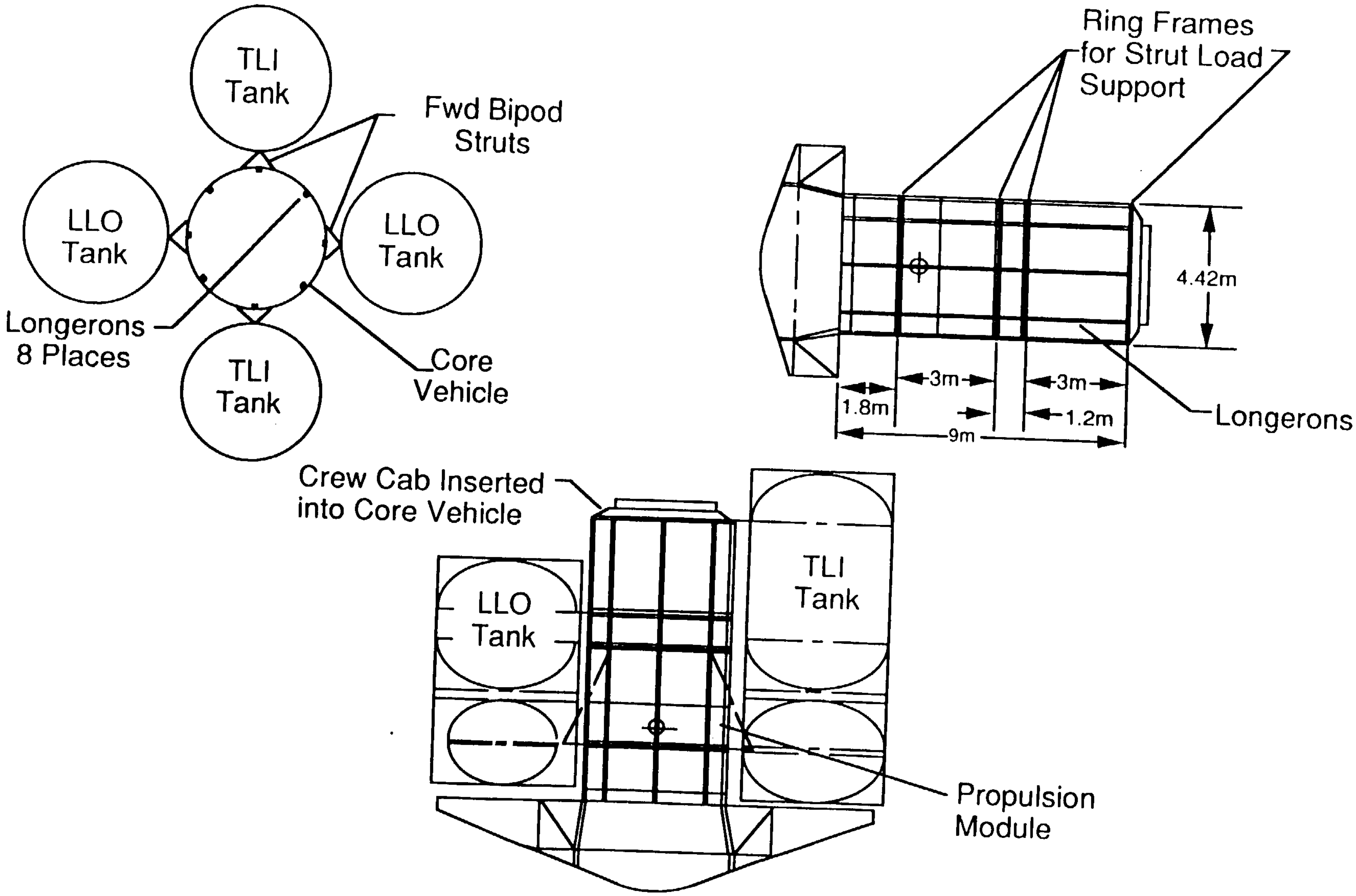


Weight Summary (t)	
Ribs & Struts	.59
Honeycomb	.66
TPS	.46
Mechanism	.11
Contingency	.27
Total	2.08

Pressure Distribution	
r = 0	134 psf
r = 11.1'	121 psf
r = 16.5'	107 psf
r = 20.6'	94 psf
r = 22.5'	87 psf

TPS Distribution (FRCI-12)	
r = 0 to 11.1'	.75"
r = 11.1' to 16.5'	.65"
r = 16.5' to 20.6'	.55"
r = 20.6' to 22.5'	.45"

Figure 2.1-3 Core Vehicle



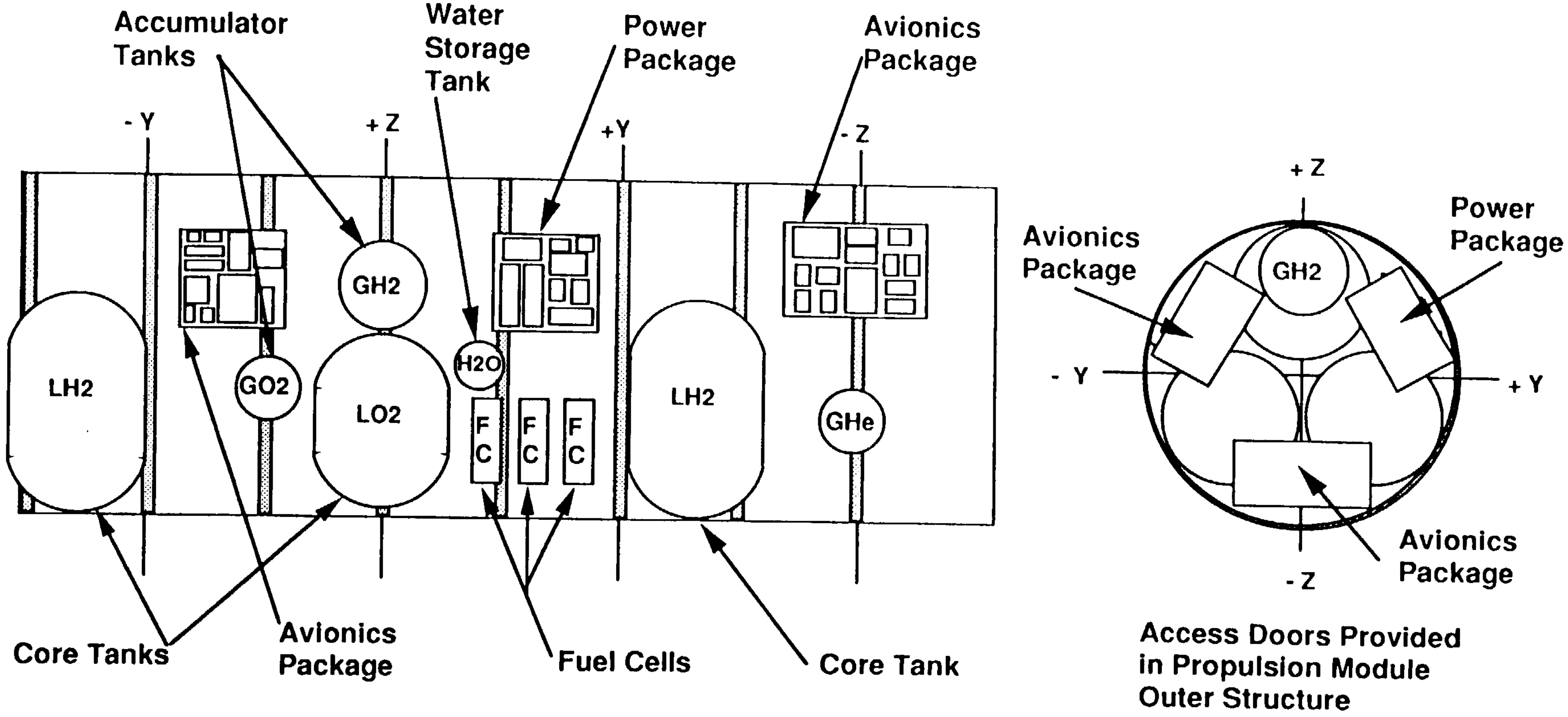
The core propulsion module, approximatley 5.5 meters in length and 4.42 meters in diamter, includes core propellant tanks, plumbing, other subsystem equipment, and 4 advanced space engines (20,000 lbs thrust each). The three core propellant tanks (1 LO2 and 2 LH2) contain approximately 7 t of propellant. The 2 LO2 tanks are 1.9 m in diameter and 2.46 m in length. The LH2 tank is the same diameter but 3.15 m in length. The relative location for the various LTV subsystems are shown in Figure 2.1-4. The avionics is packaged in two avionics bays and electrical distribution is located above the fuel cells. The accumulator tanks for GH2 and GO2 are located near the LO2 tank. LN2 for crew ECLSS support is contained inside the crew cab. Access doors are provided in the core vehicle outer structure to allow for repairs and maintenance of equipment.

Figure 2.1-5 shows the TLI tanks with their LH2 and LO2 feedline connections mounted to the LTV core vehicle. The LLO tanks are mounted in a similar manner. This plan view indicates the position of the drop tanks around the core vehicle. Each TLI tank is 10.4 m long by 4.42 m in diamter and contains separate oxygen and hydrogen tanks connected by an intertank. Total propellant capacity of each TLI tank is 44.6 t. The two TLI tanks are expended after the TLI burn on the way to the moon. Each LLO tank is about 7 m in length and 4.42 m in diameter and contains separate oxygen and hydrogen tanks. Total propellant capacity of each LLO tank is 22.3 t. The LLO tanks are expended after rendezvous/docking with the LEV and transferring propellant in LLO. Both the TLI and LLO tanks are delivered to Space Station Freedom for each mission using expendable ETO transportation.

The lunar transit crew cab, approximately 4 meters long and 4.42 meters in diameter, contains a side hatch for alternate crew egress/ingress as well as a standard Space Station Freedom berthing ring for attachment to Station. A window on the top of the crew cab allows viewing of the rendezvous/docking procedure while radiators provide thermal heat rejection.

Cargo is attached to the LTV as shown in Figure 2.1-6 utilizing the cargo support racks mounted above the LLO tanks. Also shown is the propellant transfer lines used for transferring propellant from the LTV to the LEV. Details of the cargo and propellant transfer will be discussed in a later section of this document. Preliminary mass properties of the LTV are shown. The total dry weight of the vehicle is slightly over 22 t with the crew module and drop tanks making up the majority of the weight.

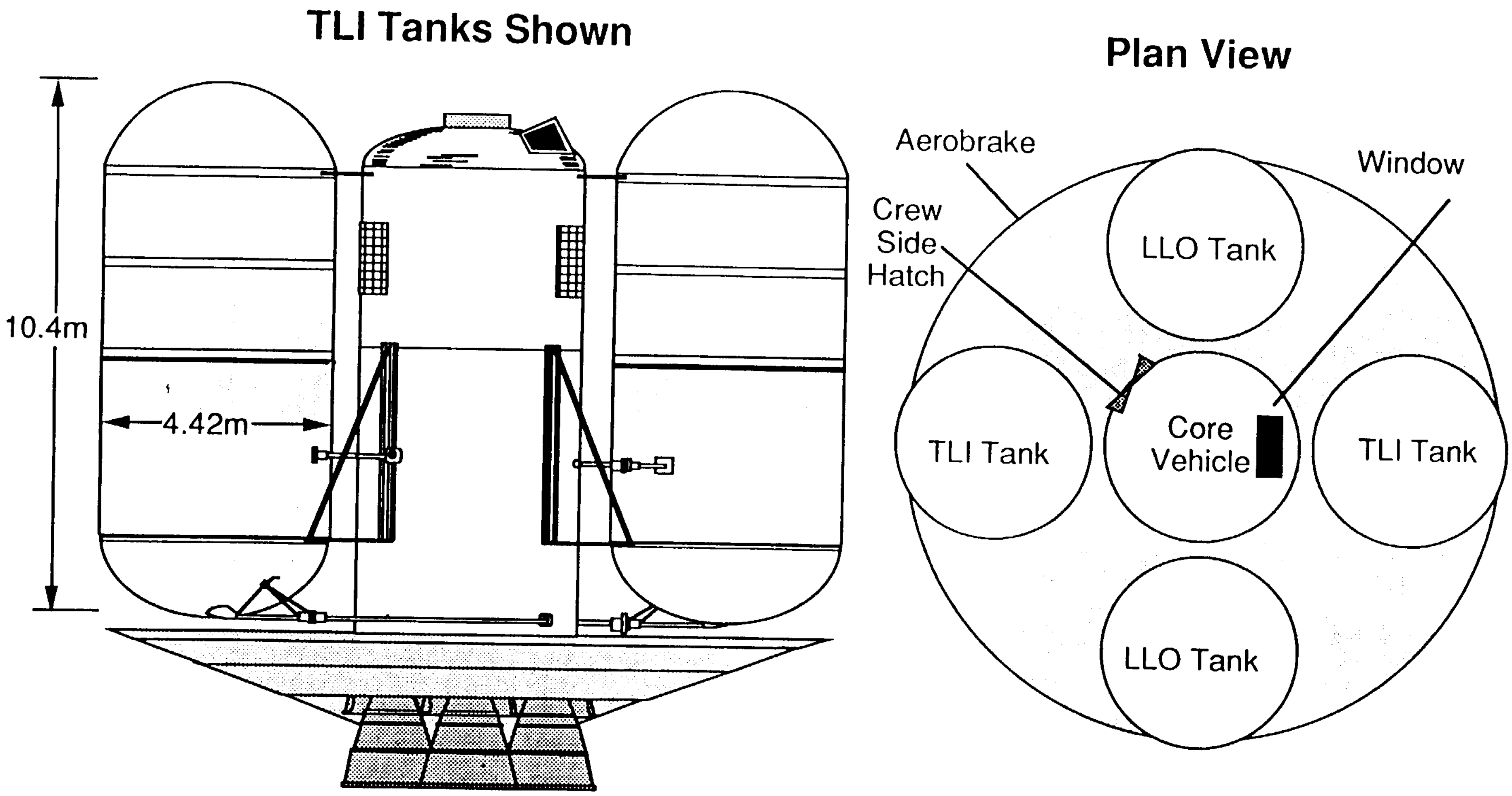
Figure 2.1-4 Equipment Layout in Propulsion Module



Access Doors Provided in Propulsion Module Outer Structure

Interfaces to Crew Cab
- Power
- Avionics
- Water
- Oxygen Supply Line

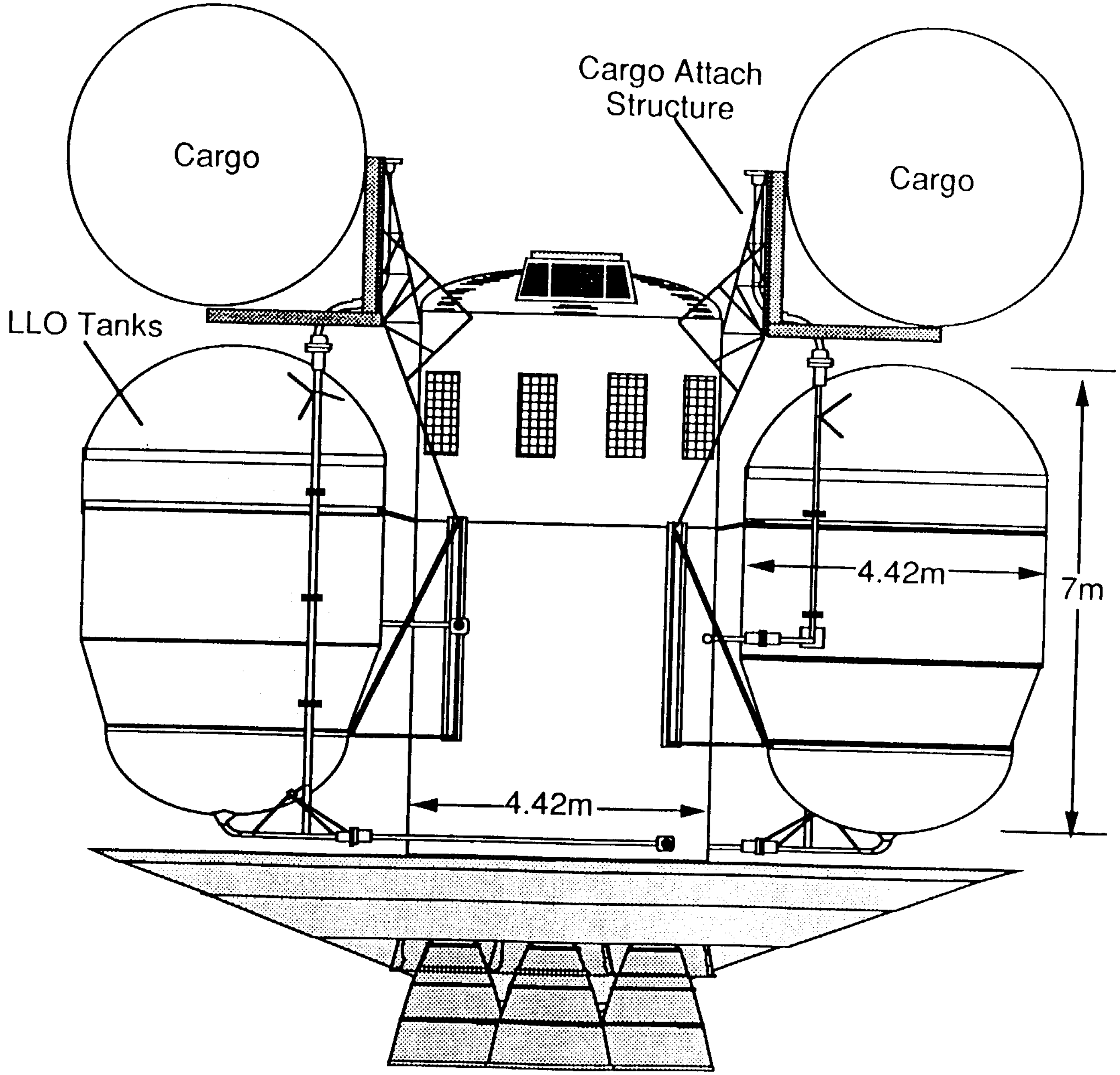
Figure 2.1-5 LTV Tank Configuration



TLI Tanks Shown

Plan View

Figure 2.1-6 LTV Configuration with Cargo



Mass Properties Summary	(t)
Structure	1.00
Drop Tanks	6.50
Core Propulsion	.97
Main Engines	1.24
RCS	.14
GN&C	.12
C&DM	.26
Power	.45
Thermal Control	.15
Aerobrake	1.81
Crew Module	6.63
Contingency	2.89
Total Dry Weight	22.16

The LTV return configuration is depicted in Figure 2.1-7. The LTV is shown just before the aeropass maneuver begins. The 4 engine nozzles have been retracted and the aerobrake doors have been closed and sealed. The doors will remain closed until the vehicle has returned to Space Station Freedom. 15% of the propellant in the propulsion module core tanks remain for RCS maneuvers around Space Station Freedom. The aerobrake is sized for a 10° angle of attack and 20° wake angle. The cg of the vehicle during the aeropass maneuver is situated inside the propulsion module.

2.2 LEV CONFIGURATION

Side views of the LEV configuration are shown in Figure 2.2-1. The LEV consist of four advanced space engines, 4 landing legs, propellant tanks and support structure, subsystem equipment, the lunar crew cab, and the cargo transfer structure. The overall dimensions are 11.8 m from landing leg to landing leg and 10.2 m from the lunar surface to the top of the crew cab.

The lunar crew cab is 2.9 m high by 4.42 m in diameter. The lunar crew cab is smaller than the transit cab due to the limited stay in the lunar cab, only during the short descent/ascent to/from the lunar surface and for limited hours on the lunar surface. A window located in the top of the crew cab provides viewing for rendezvous/docking with the LTV and a side window provides viewing for landing operations on the lunar surface. Real time fiber optic imaging may be required to alleviate the problem of large cargo blocking the field of view of the landing legs. A crew side hatch provides egress/ingress on the lunar surface and radiators provide thermal heat rejection.

The core of the LEV contains subsystem equipment along with four propellant tanks (2 LO2 and 2 LH2) that hold 22.4 t of propellant. The LO2 tanks are almost spherical, 2.4 m by 2.5 m. The LH2 tanks are 2.8 m in diameter and 4.6 m long. Since propellant is transferred from the LTV, these four tanks are not structurally designed for wet launch but they do have multi-layer insulation for orbital boiloff reduction. The four ASEs (20,000 lbs thrust each) have no nozzle extensions and are approximately 1.3 m from the lunar surface after landing. The cargo transfer structure is located on either side of the core tanks and allows the cargo to be lowered directly to the lunar surface.

Figure 2.1-7 LTV Return Configuration

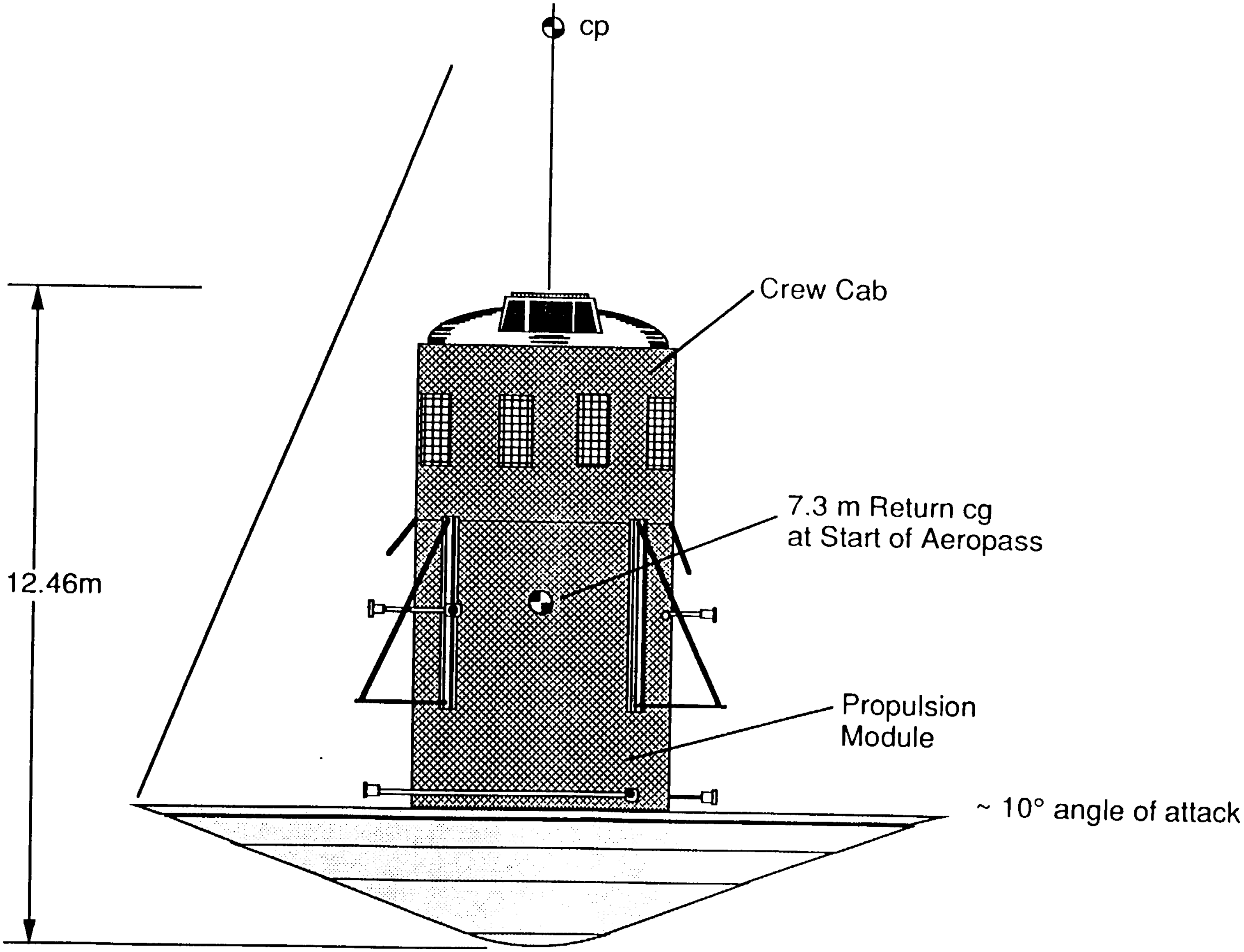


Figure 2.2-1 LEV Configuration

Side Views

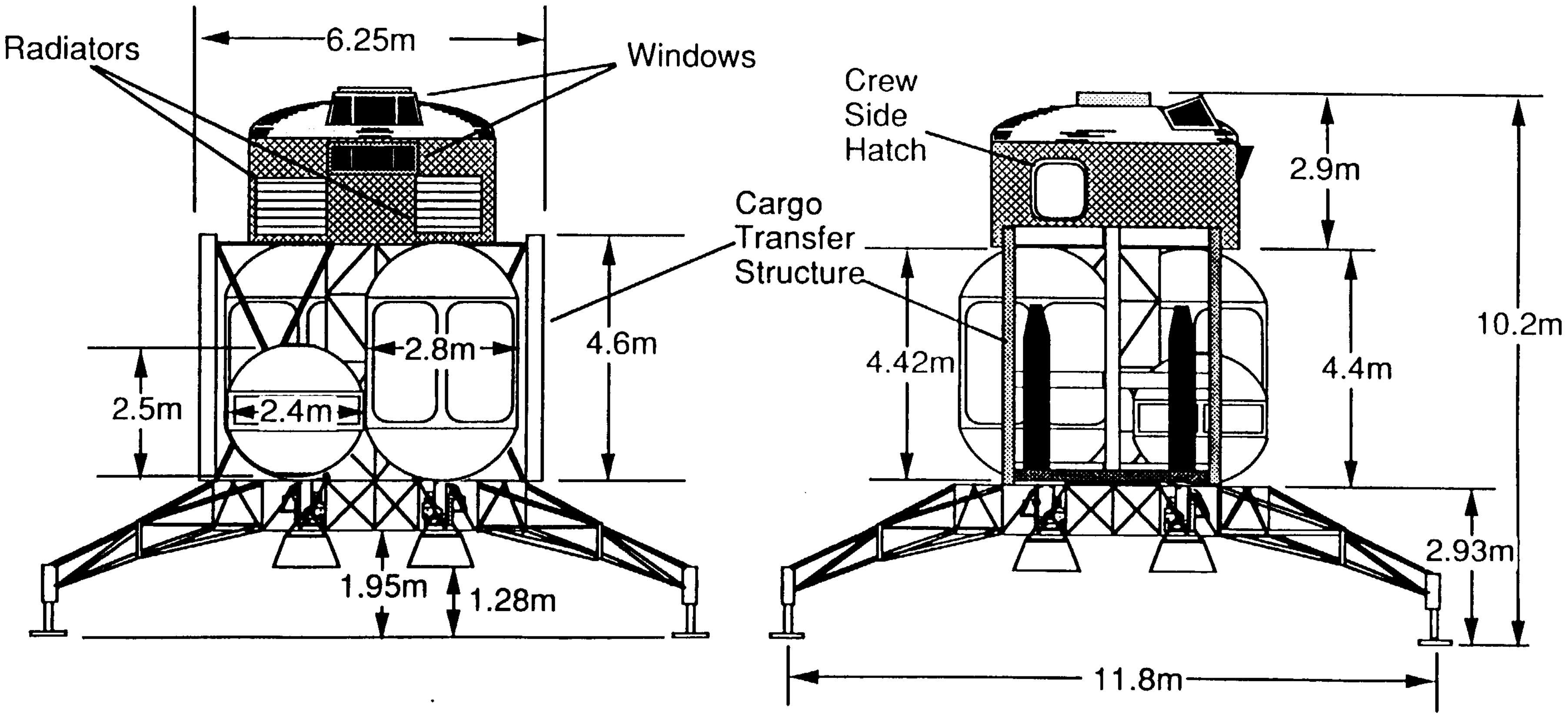


Figure 2.2-2 shows a plan view of the LEV, the opposite side view of the LEV, and a preliminary mass properties summary of the vehicle. The position of the crew cab and windows, propellant tanks, and cargo mechanism is shown along with the 16.8 m diagonal spacing between the landing legs. Total dry weight of the LEV is about 9.2 t with the crew cab about one third of the total dry weight. The LEV configuration with cargo is illustrated in Figure 2.2-3. The chart illustrates how the cargo is attached to the cargo transfer mechanism and can be lowered directly to the lunar surface between the landing legs for cargo less than 6.1 m in total length.

2.3 SUBSYSTEM DEFINITION

2.3.1 Aerobrake

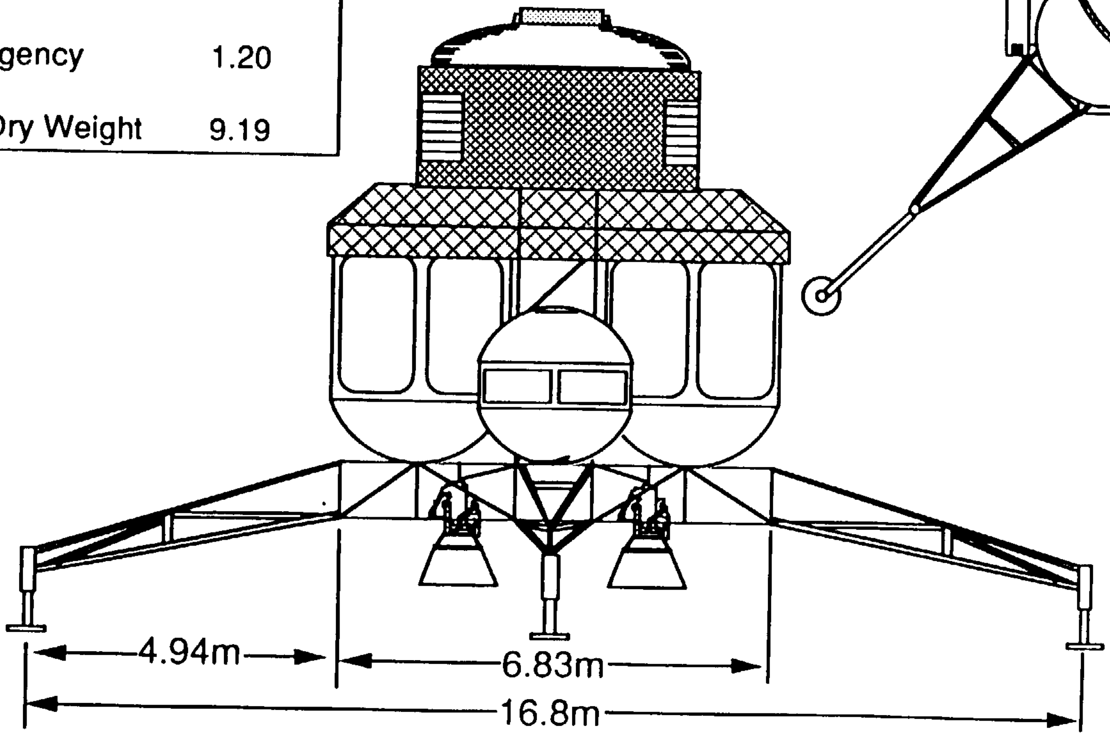
A detailed view of the aerobrake is shown in Figure 2.3.1-1. The aerobrake is a rigid spherical sector-truncated cone composed of composite graphite/polyimide structure and honeycomb panels and covered with advanced Shuttle-type thermal protection system tiles (FRCI-12). The honeycomb outer panels are foam with aluminum facesheets (4 layers of .005 inch). The thin shell surface is supported by radial ribs that extend outward from a 7.6 m (25 ft) diameter central spherical core to a 13.7 m (45 ft) peripheral ring. Radial ribs are spaced at the panel interfaces and at the center of each outer panel. Circumferential stiffening rings are placed at the 7.6 m diameter and at the 13.7 m diameter locations. 16 support struts that extend from the core to the outer panels (2 per panel) also provide additional support. An isometric view of the aerobrake structure is shown in Figure 2.3.1- 2. The 16 radial ribs, the 2 circumferential stiffening rings, and the 16 support struts are shown along with the core support structure and engine support structure.

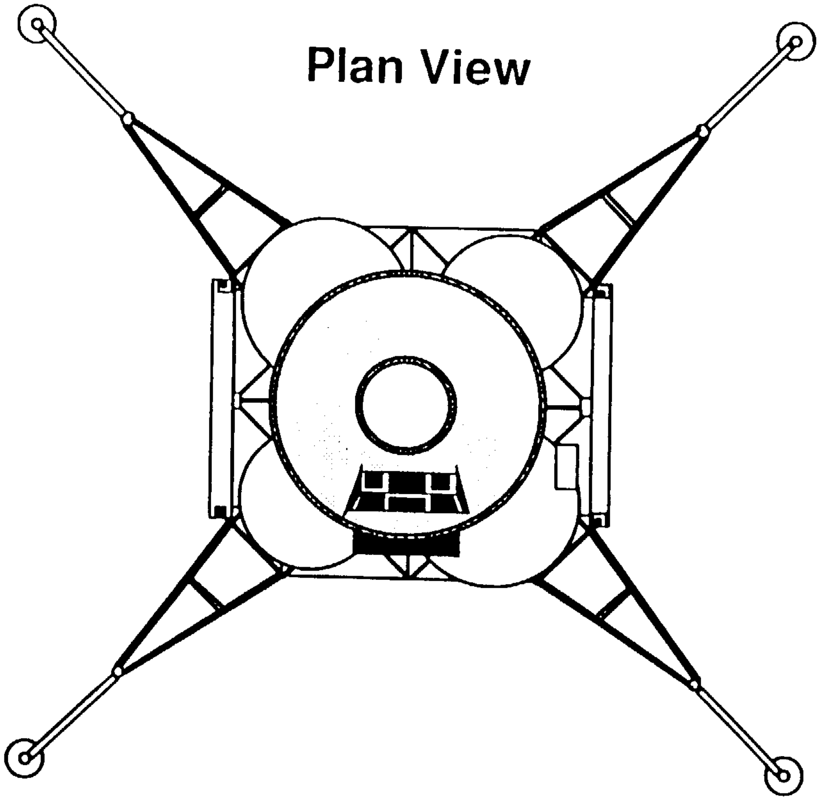
Four, five-sided, pentagon-shaped doors as illustrated in Figure 2.3.1-3 provide openings for the 72" engine bells/nozzles plus clearance and misalignment tolerances. The doors open toward the outside of the aerobrake and remain open during all but the final aeropass operations. To open, the doors translate slighly outward (straight up motion) before being rotated about a hinged interface to preclude interference with the aerobrake TPS. Small motors designed to be fail-op, fail-op, fail-safe are used to drive the translation and hinge mechanisms. Operations are reversed for closure. The pentagon shape allows the doors to be supported by an aerobrake cap member running crosswise between the engines. Each door also contains a locking mechanism which fastens the door to the aerobrake cap member to preclude any tendancy of the door to open

Figure 2.2-2 LEV Configuration

Mass Properties Summary (t)	
Structures	1.66
Propellant Tanks	.44
Propulsion	.32
Main Engines	1.08
RCS	.14
GN&C	.14
C&DM	.26
Power	.47
Thermal Control	.35
Crew Cab	3.13
Contingency	1.20
Total Dry Weight	9.19

16





Plan View

Figure 2.2-3 LEV Configuration with Cargo

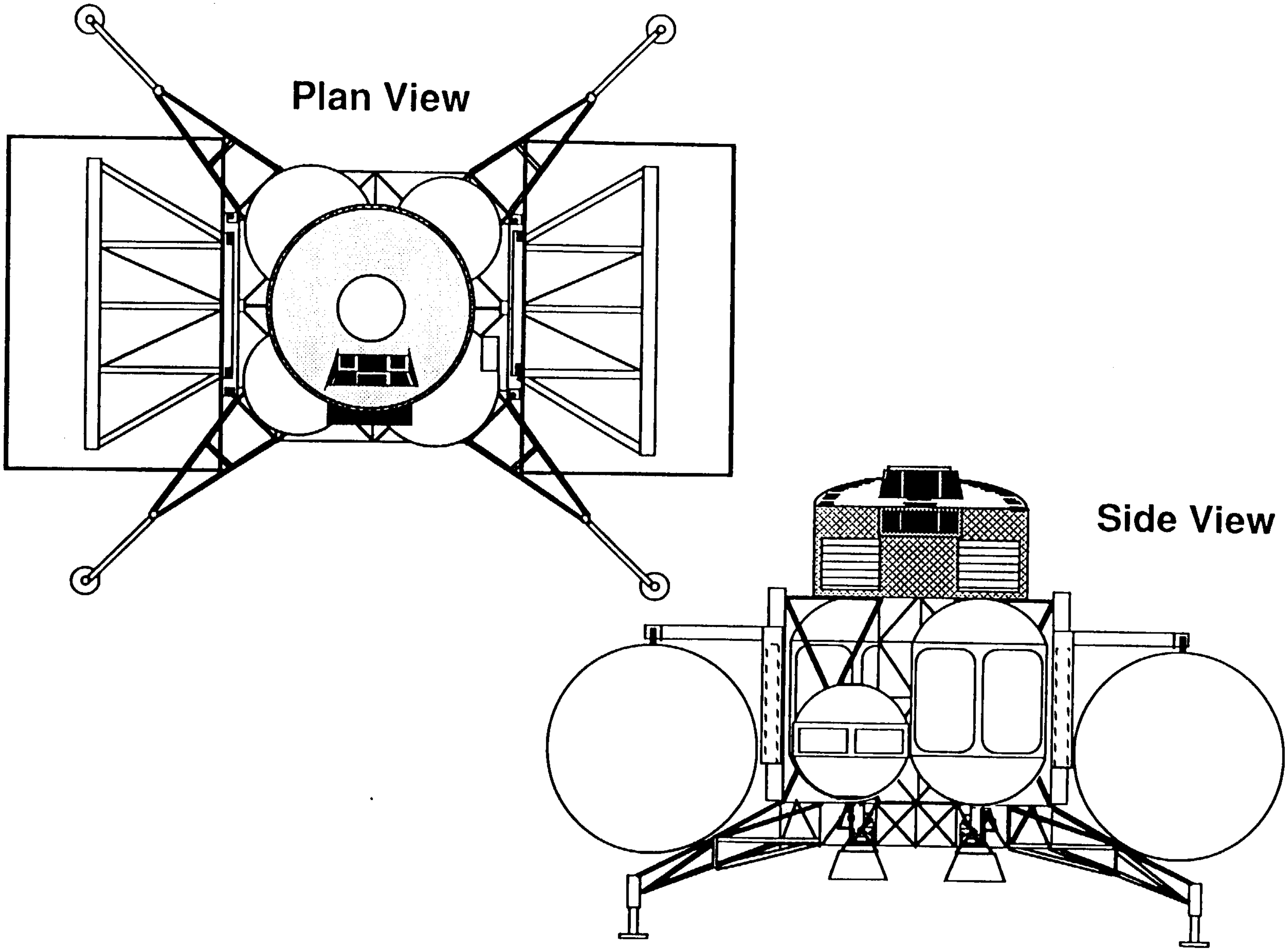


Figure 2.3.1-1 Aerobrake Details

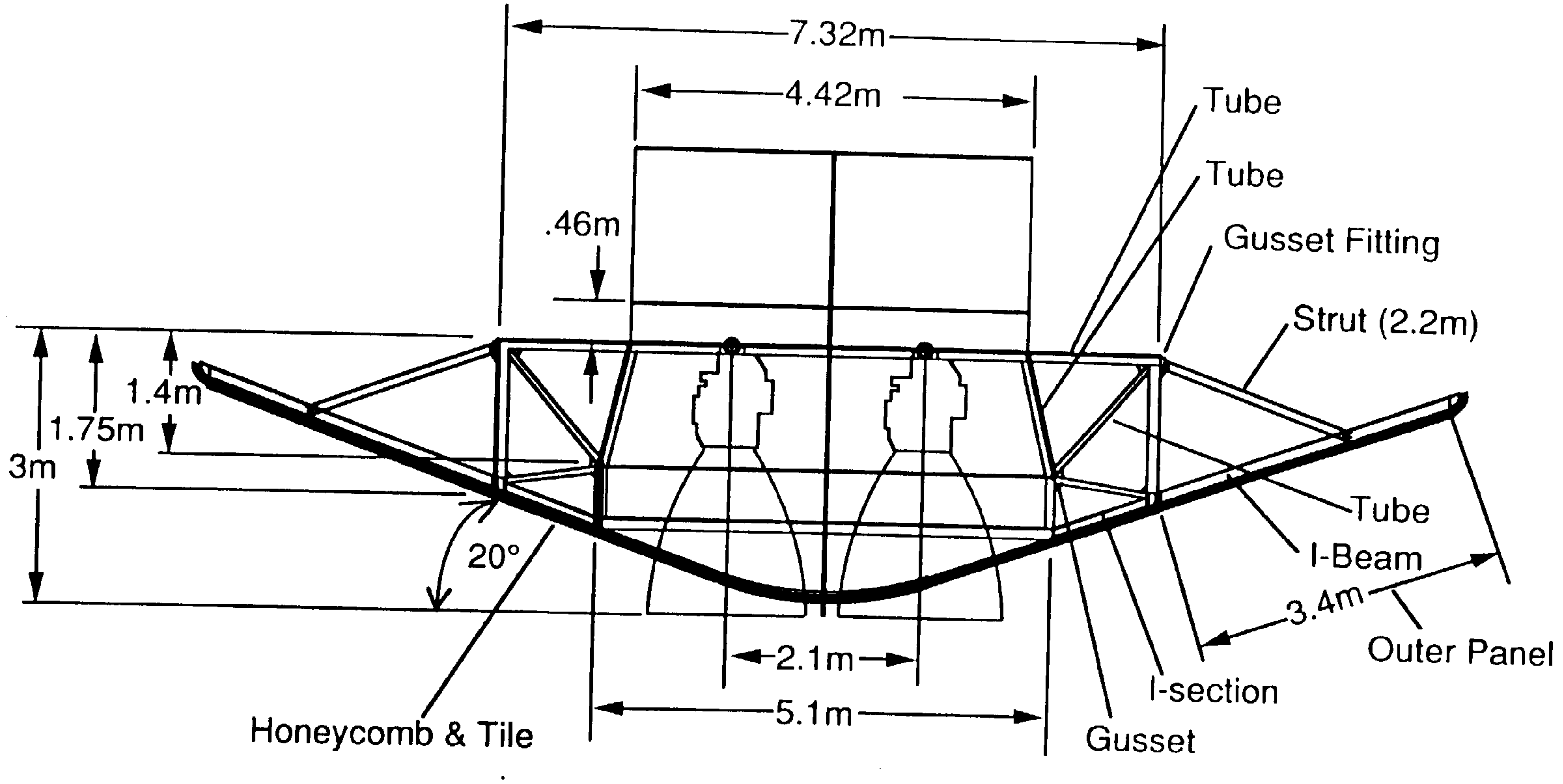


Figure 2.3.1-2 Aerobrake Details

Isometric View

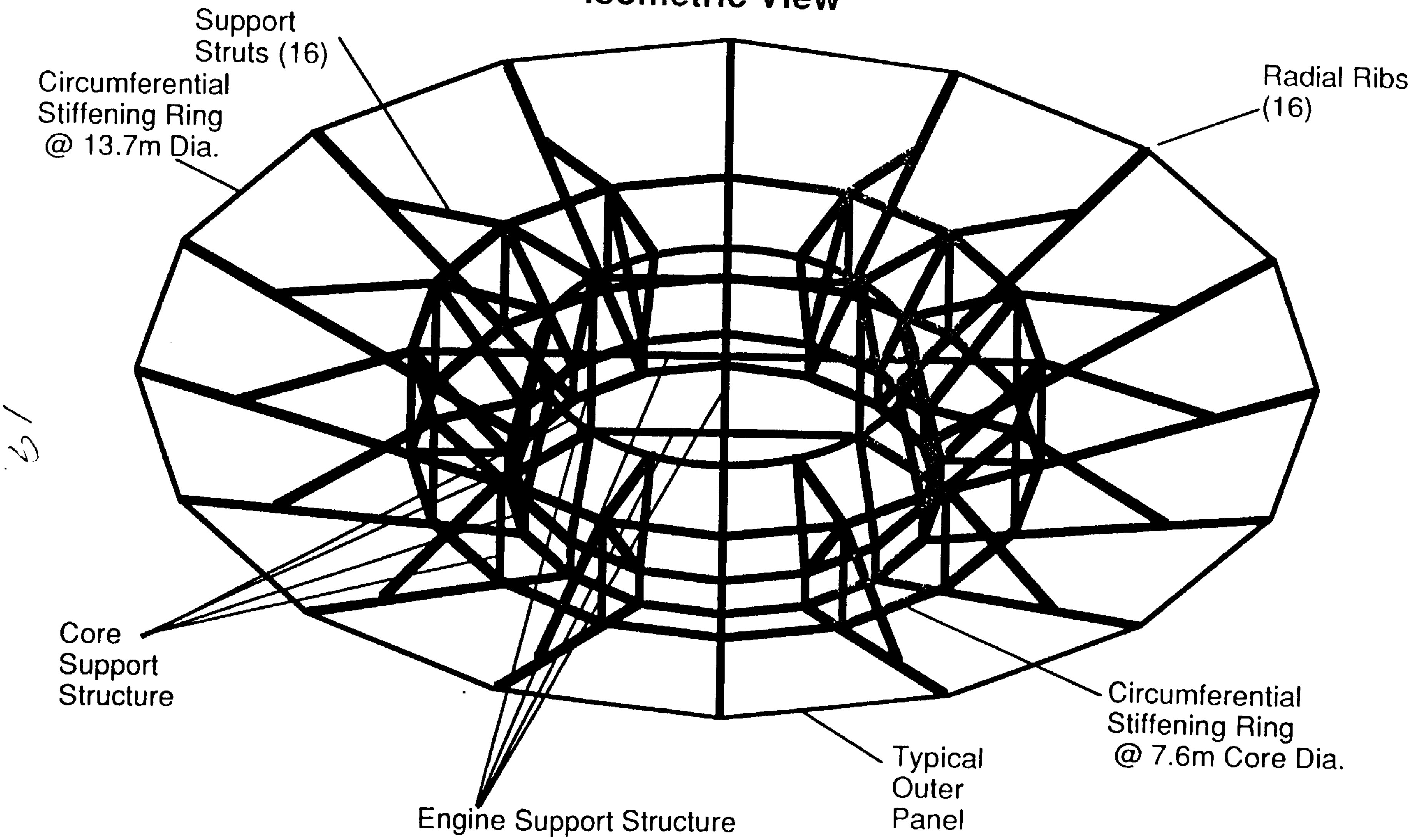
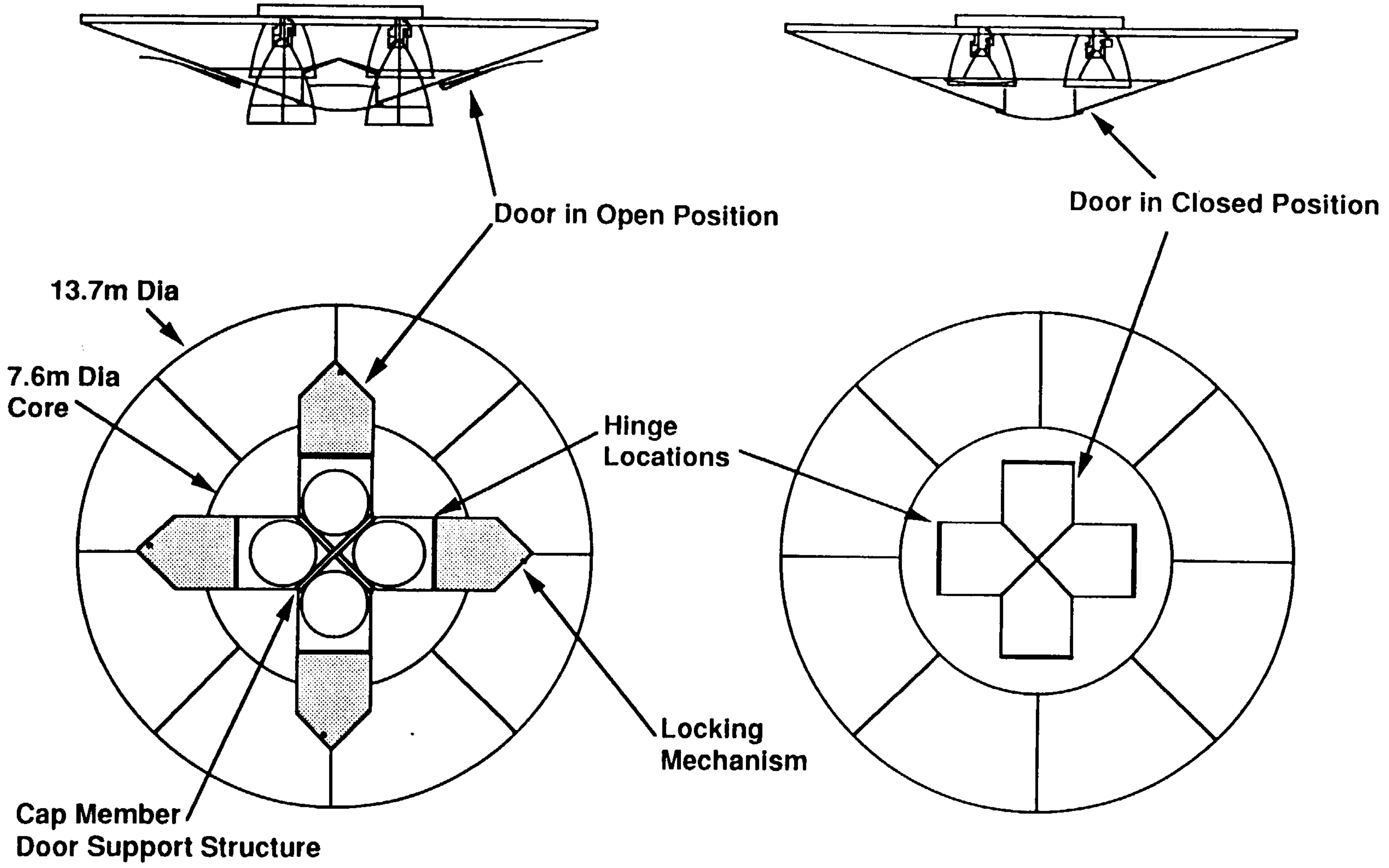


Figure 2.3.1-3 Aerobrake Door Details



during the aeropass operations. Provisions are included for emergency closure utilizing EVA-suited personnel if door mechanisms fail. As an option, the doors could be translated slightly outward (straight up motion), then slid back along the outside of the brake utilizing guide rails on the inside of the brake.

As illustrated in Figure 2.3.1-4, the eight outer aerobrake segments are attached to the aerobrake central core with the aid of Space Station Freedom robotics. The central core is attached to a daisy-wheel type structure and is rotated to allow attachment of each segment. The first of the eight panels has three radial ribs for support – one rib in the center of the panel and a rib on each side of the panel to provide support for the second and eighth segment. Panels two through seven are common and have two ribs each – one rib in the center of the panel and one rib on the side to provide support for the panel that attaches to it. The eighth and final panel to be attached has only one rib in the center since it is supported by the ribs on panels one and seven. Each outer segment will have been prefitted on the ground and clearly numbered to ensure a matched fit at station. The eight segments are snapped into place utilizing robotics. Each segment has shear pins/blades which fit into receiving lugs on the aerobrake central core and adjacent segments. These self-locking devices, spaced approximately one foot apart, minimize the need for EVA support to attach the segments. After each segment is attached to the central core with the shear pins, support struts must be attached on the backside of the aerobrake between the segment and the central core. The struts provide the necessary structural support for attaching the next panel as well as providing support during aeropass operations. The struts are attached to the individual segments and are pinned to the central core after initial segment attachment. EVA inspection of the assembled aerobrake may be required to ensure all panels are secured and locked in place.

An optional assembly technique for the aerobrake utilizes folded, deployable structure as shown in Figure 2.3.1-5. The structural ribs of each of the eight outer segments would be folded back against the central core of the aerobrake (toward the vehicle) in the ETO transportation mode using a hinged mechanism at the central core interface. The backside support struts would be prepinned to the central core and folded along with the ribs. The structural ribs of the segments would then be deployed (motor driven) and locked in place once the vehicle is at the station minimizing the EVA requirement. The backside support struts would then be pinned to the ribs using robotics. The segment panels would then be attached to the extended rib/strut configuration with self-locking devices using the station robotics. Inspection and verification of the assembled aerobrake could be performed by EVA suited crewmen. As an option to the above configuration,

Figure 2.3.1-4 Aerobrake Assembly

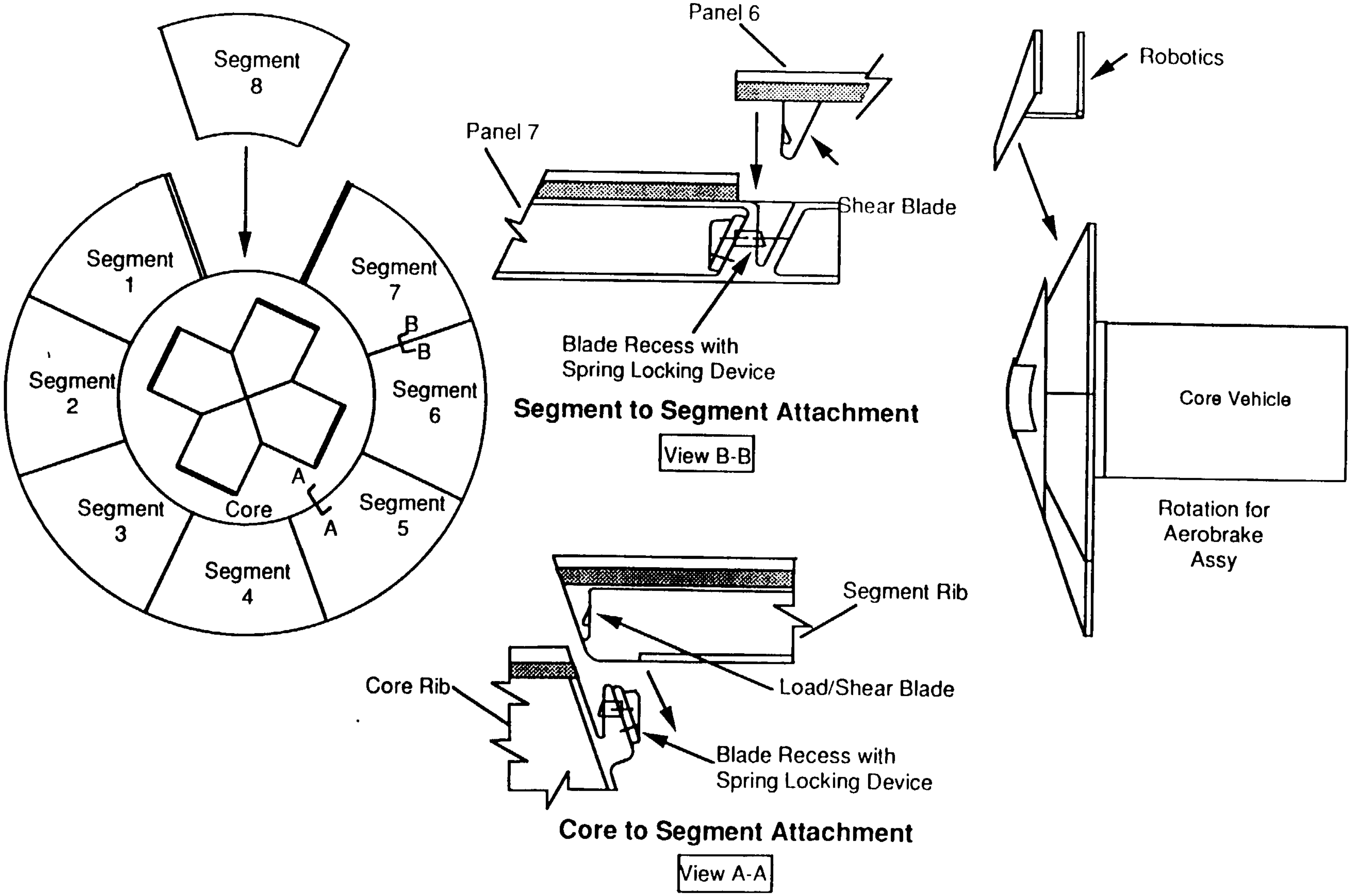


Figure 2.3.1-5 Aerobrake Assembly - Folded Structure

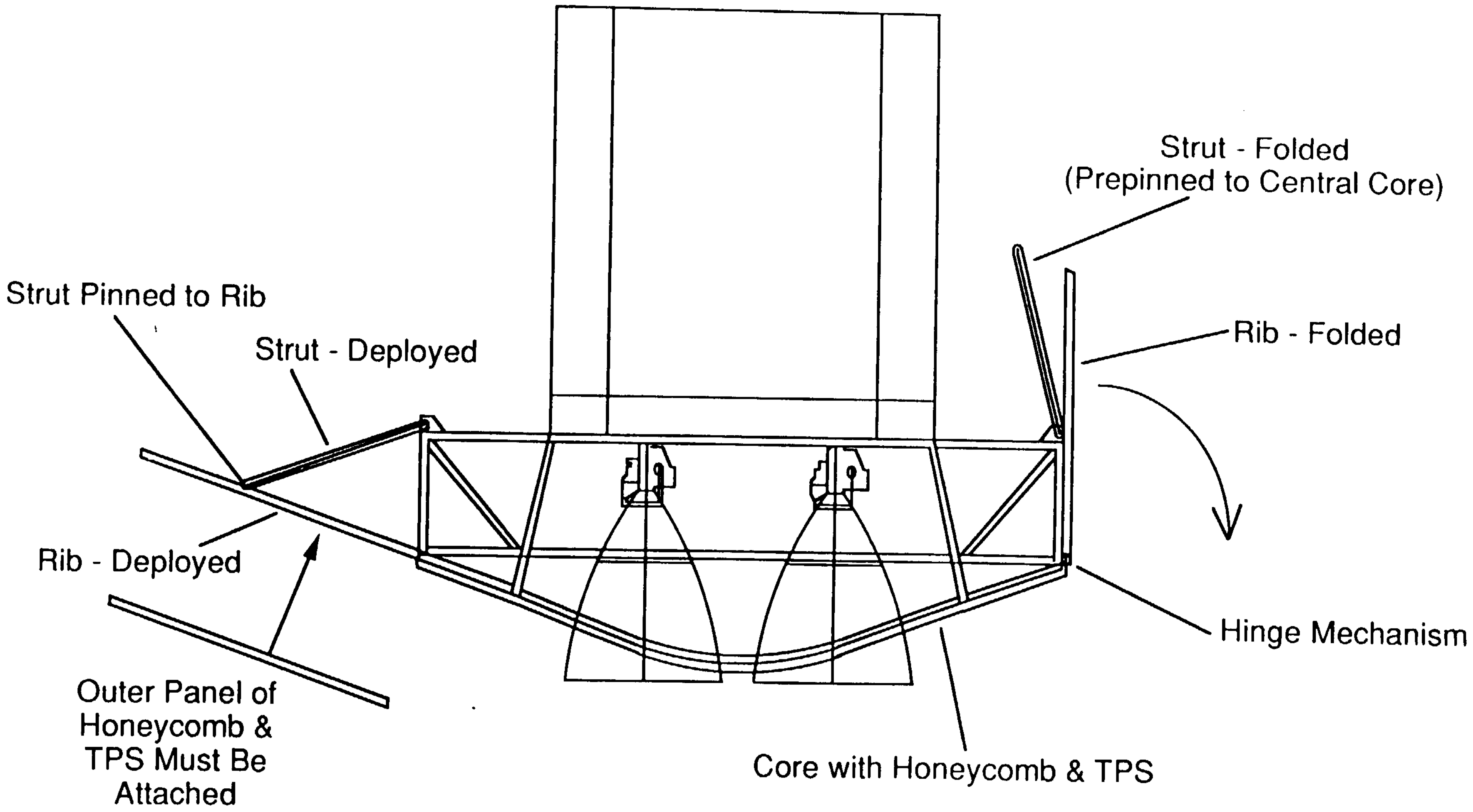
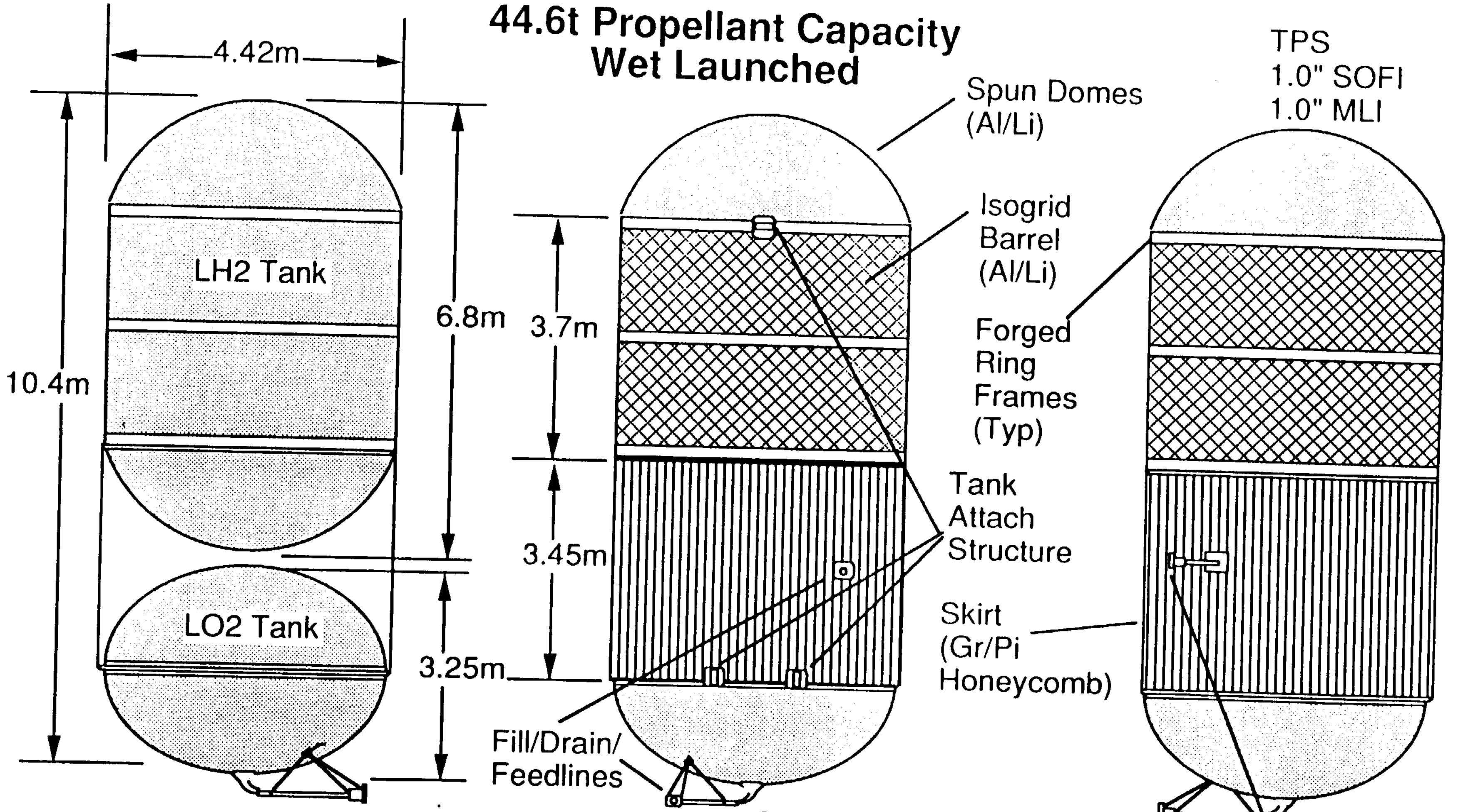


Figure 2.3.2-2 TLI Drop Tank Configuration

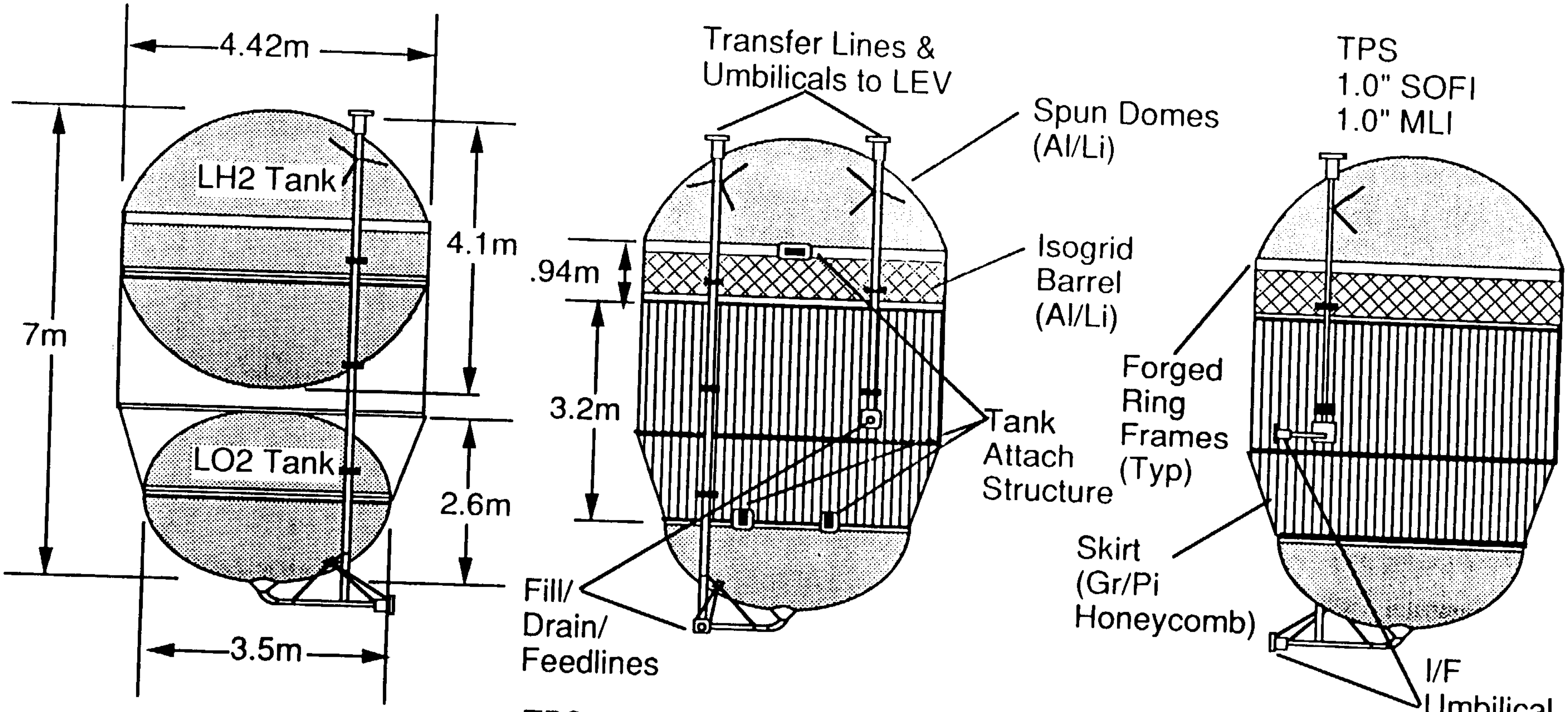


TPS	.49
Structure	.84
Propulsion	.29
Contingency	.24

Total Dry Weight 1.87t

Figure 2.3.2-3 LLO Drop Tank Configuration

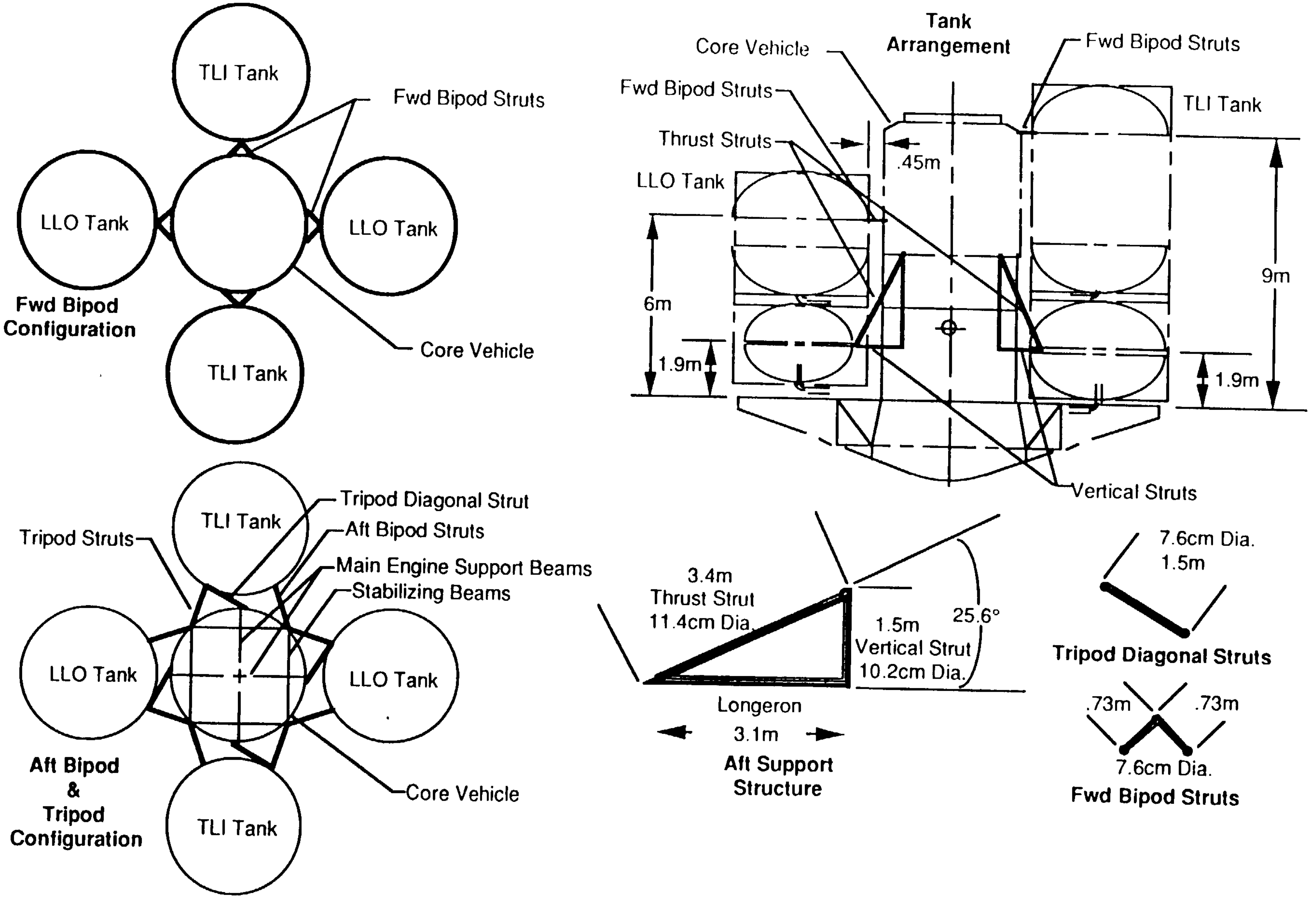
22.3 t Propellant Capacity
Wet Launched



TPS	.32
Structure	.79
Propulsion	.51
Contingency	.24

Total Dry Weight 1.87t

Figure 2.3.2-1 Drop Tank Support Structure



26

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the backside support struts could be jointed and prepinned to the panel ribs and central core. The struts could be automatically deployed and locked in place along with the structural ribs. This would require struts that are complex two-piece configurations, and they would be somewhat heavier than the one-piece versions described above. Segment panels could be attached in the same manner as described above.

2.3.2 Drop Tanksets

As shown earlier in Figure 2.1-5, the LTV configuration consists of four drop tanksets (2 TLI tanksets and 2 LLO tanksets). These tanksets contain all the propellant required to perform the lunar mission (that needed by both the LTV and LEV). The tanksets are delivered wet to Space Station Freedom using ETO transportation. Once at Station, they are structurally attached to the LTV and fluid connections are made in preparation for the lunar mission. Propellant is routed from these tanksets through the LTV core tanks to the engines. Propellant for the LEV is contained in the LLO tanksets. The TLI tanksets are expended after the early TLI burn and the LLO tranksets are expended in LLO after the propellant has been transferred to the LEV.

The drop tanksets are mounted to the core vehicle in similar fashion as the ET/Orbiter attachment which is a three-point mount – two aft and one forward. Details of the tankset attachment is shown in Figure 2.3.2-1. One aft support is a tripod, making it fixed, while the other two mounts are bipods. The aft bipod permits lateral pivot motion and the forward bipod allows fore/aft motion. The aft bipod and tripod structure is attached to the LTV core vehicle and mated to the drop tanks at the LO2 tank ring frames. The forward bipod structure is attched to the LTV core vehicle and mated to the drop tanks at LH2 tank ring frames near the end of the tank. After structural mate is complete, fluid connections are made. The drop tankset/core vehicle propellant interfaces (two per tank) are located at two aft umbilical assemblies adjacent to, but separated from the two aft structural interfaces. The disconnects contain shutoff valves that are closed prior to retraction of the umbilical assembly.

The TLI drop tankset consists of an LH2 tank, an intertank, and a LO2 tank with corresponding feedlines and umbilicals. The tankset shown in Figure 2.3.2-2 is designed to be launched wet in the ETO transportation system. The LH2 tank has aluminum-lithium spun domes and an isogrid barrel section. The intertank is a graphite/polyimide honeycomb structure. The LO2 tank has aluminum-lithium spun domes with a forged ring center frame. The TPS consists of

1.0" of SOFI for prelaunch boiloff reduction and one inch of MLI for on orbit boiloff control on both tanks. The diameter of the TLI tankset is 4.42 m and the overall length is 10.4 m. Each TLI tankset contains a total of 44.6 t of propellant which is utilized during the TLI burn. Preliminary dry weight of the TLI tankset is shown as 1.87 t.

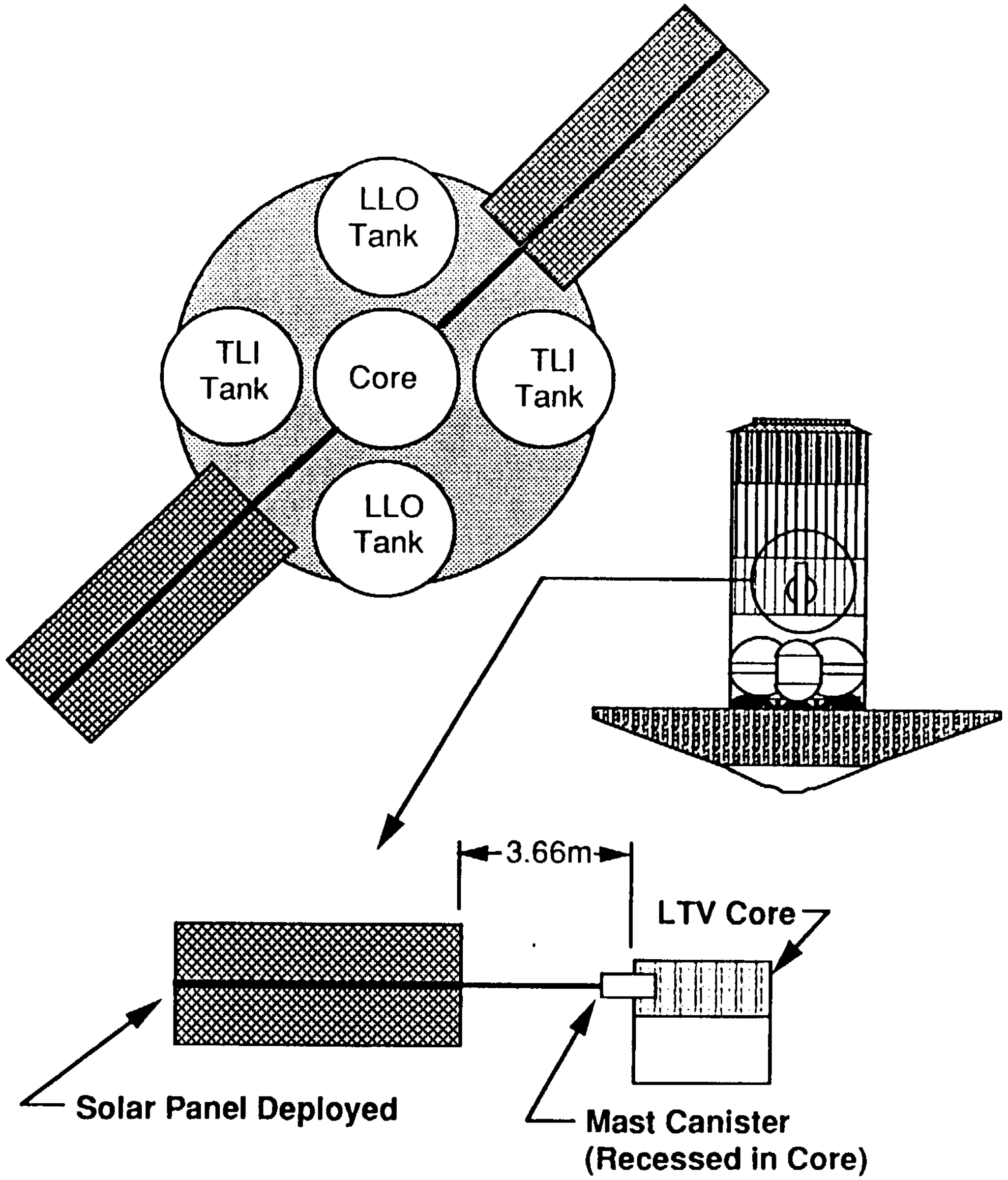
The LLO drop tankset as shown in Figure 2.3.2-3 is very similar to the TLI tankset with an LH2 tank, an intertank, and a LO2 tank. The LLO and TLI tanksets have similar TPS and are constructed with similar materials and manufacturing techniques. However, the LLO tankset not only has feedlines and umbilicals to the LTV core vehicle but also has transfer lines and umbilicals to fill the LEV. The diameter of the LLO tankset is 4.42 m at the LH2 tank diameter but tapers to 3.5 m at the LO2 tank location. Overall length is 7 m. Each LLO tankset contains 22.3 t of propellant which is utilized for the LLO burn and for supplying the LEV. The LLO tankset weights are similar to those of the TLI tankset because of the additional transfer lines to the LEV and the addition of a full communication device in each tank for propellant transfer.

2.3.3 Power

The LTV baseline power system utilizes current STS fuel cells which are significantly improved from the ones used for Apollo missions. These STS units are lighter (91kg) and produce 6 to 8 times more power (7 kW average) which results in fewer units and more efficient packaging. The fuel cells are packaged in the LTV skirt region and utilize propellant boiloff for fuel (450kg of H2 and O2 in 3 days). Water is produced as a byproduct (660 L in 3 days) and could be piped to the crew cab.

On long duration missions, solar arrays are required for power supply. The solar arrays as illustrated in Figure 2.3.3-1 must be extended out at least 12 feet from the core vehicle to clear the drop tanks and avoid shadowing from the tanks. Shadowing from overhead cargo may require further extension of the arrays. The arrays and masts are stored in a 6 foot long cannister recessed into the side of the core vehicle to prevent interference problems during ETO transportation. Batteries are also required for backup power supply when the arrays are not deployed. Fuel cells offer distinct advantages over solar arrays for short duration lunar missions in areas of weight, packaging, dependability, and eliminating the need for batteries. A weight comparison for the LTV power system with fuel cells and with solar arrays is provided.

Figure 2.3.3-1 Power System Solar Arrays vs Fuel Cells



Fuel Cell Power System	
Components	**Weights (t)**
Fuel Cells (3)	.27
Accumulator Tanks	.05
Water Storage Tank	.01
Total	.33

Solar Array Power System	
Components	**Weights (t)**
Solar Arrays (2)	.29
Mast Assembly (2)	.33
Drive Mechanism (2)	.01
Deployment Controller	.01
Charge Controller (5)	.01
Batteries (5)	.13
Total	.78

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2.3.4 Propulsion

The TLI tankset propulsion schematic shown in Figure 2.3.4-1 indicates the various subsystems on the TLI tanksets. Gaseous helium was baselined as the tank pressurization systems. The LH2 and LO2 feedlines are also used for fill, drain, and purge as well as for feed for the engines. Each tank has a propellant outlet device and a propellant utilization probe. The LLO tankset propulsion schematic shown in Figure 2.3.4-2 indicates the various subsystems on the LLO tanksets. Each tank will have a full communication device for propellant transfer from the tanks to the LEV during lunar orbit. The transfer will be accomplished using cryo pumps. Gaseous helium was baselined as the tank pressurization systems. The LH2 and LO2 feedlines are capable of transferring propellant to the LTV and LEV and are also used for fill, drain, and purge.

As shown in the cross feed schematic in Figure 2.3.4-3, propellant is transferred from the drop tanksets to the core tanks before being routed to the engines. The cross feedline from the drop tanks to the core vehicle tanks is shown. The system is split into two zones taking propellant from one TLI and LLO tankset. The interfaces are set up so that there is no left or right tankset requirement. The zoning allows for equal propellant flow and reduces the required amount of linear feedline. Figure 2.3.4-4 shows the overall location of the subsystems for the LTV core tanks. The LO2 and LH2 cross feed system from the drop tanksets are connected to the core tanks to ensure that the LTV will always have propellant in case of mission abort. Gaseous helium is used for tank pressurization. GO2 and GH2 is used to fuel the reaction control system as well as providing fuel to the fuel cells.

A trade study was conducted to determine the effect of different numbers and thrust levels of engines for the LTV. With only one or two engines, the thrust to weight ratio is very low and the vehicle incurs large gravity losses. As the number of engines increase, the gravity losses approach zero. For 20,000 lb thrust ASEs, the breakeven point is somewhere around 5 engines. However, another parameter that had to be considered if a common engine was to be used on the LTV and LEV was the throttling ratio of the engine. Based on an LEV throttling ratio constraint of 20:1, 4 engines (20,000 lb thrust ASEs) are required for the LEV. Therefore, based on gravity losses and throttling requirements, 4 ASE (20,000 lb thrust each) were baselined for both the LTV and LEV.

Figure 2.3.4-1 TLI Tank Propulsion Schematic

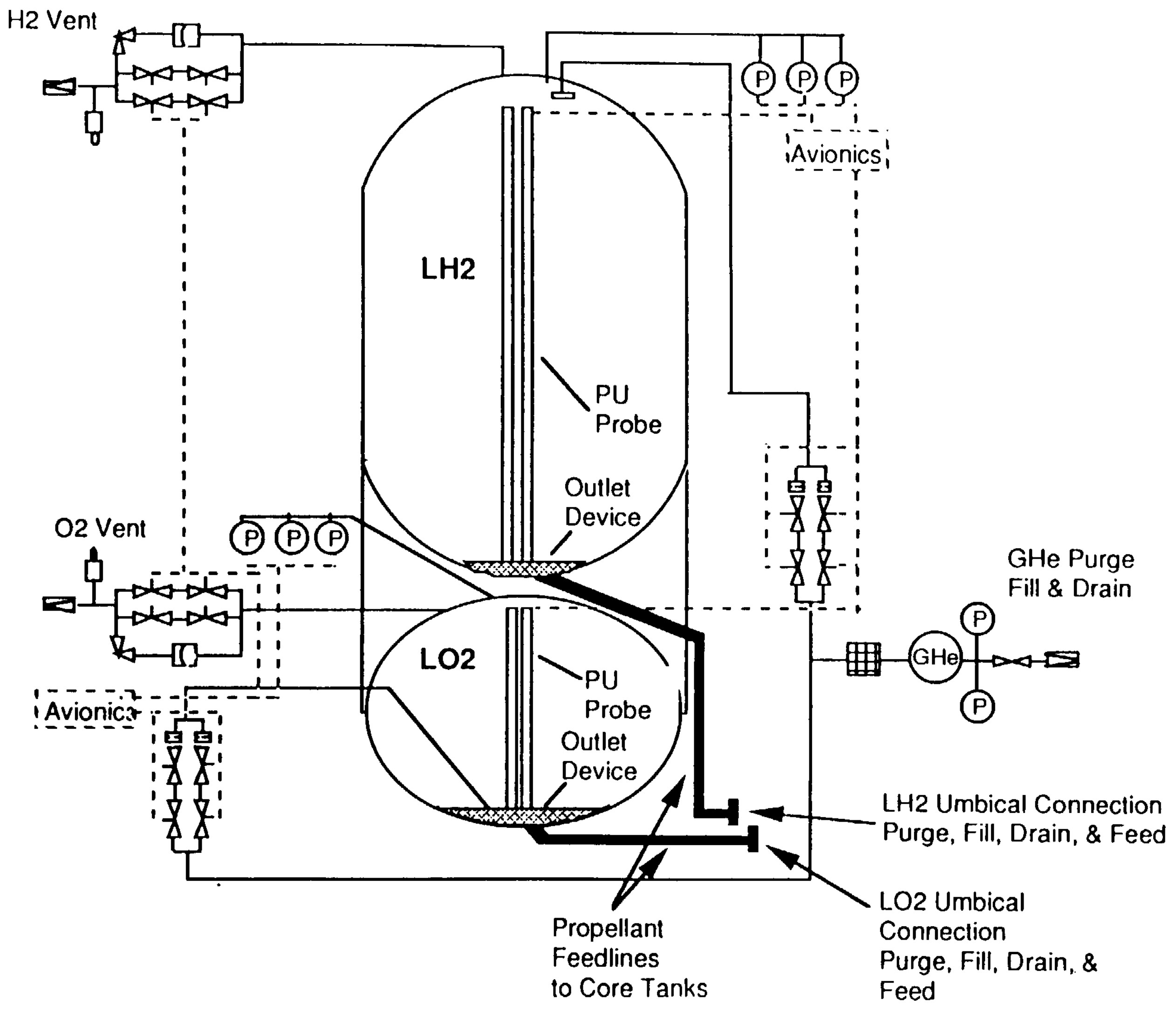


Figure 2.3.4-2 LLO Tank Propulsion Schematic

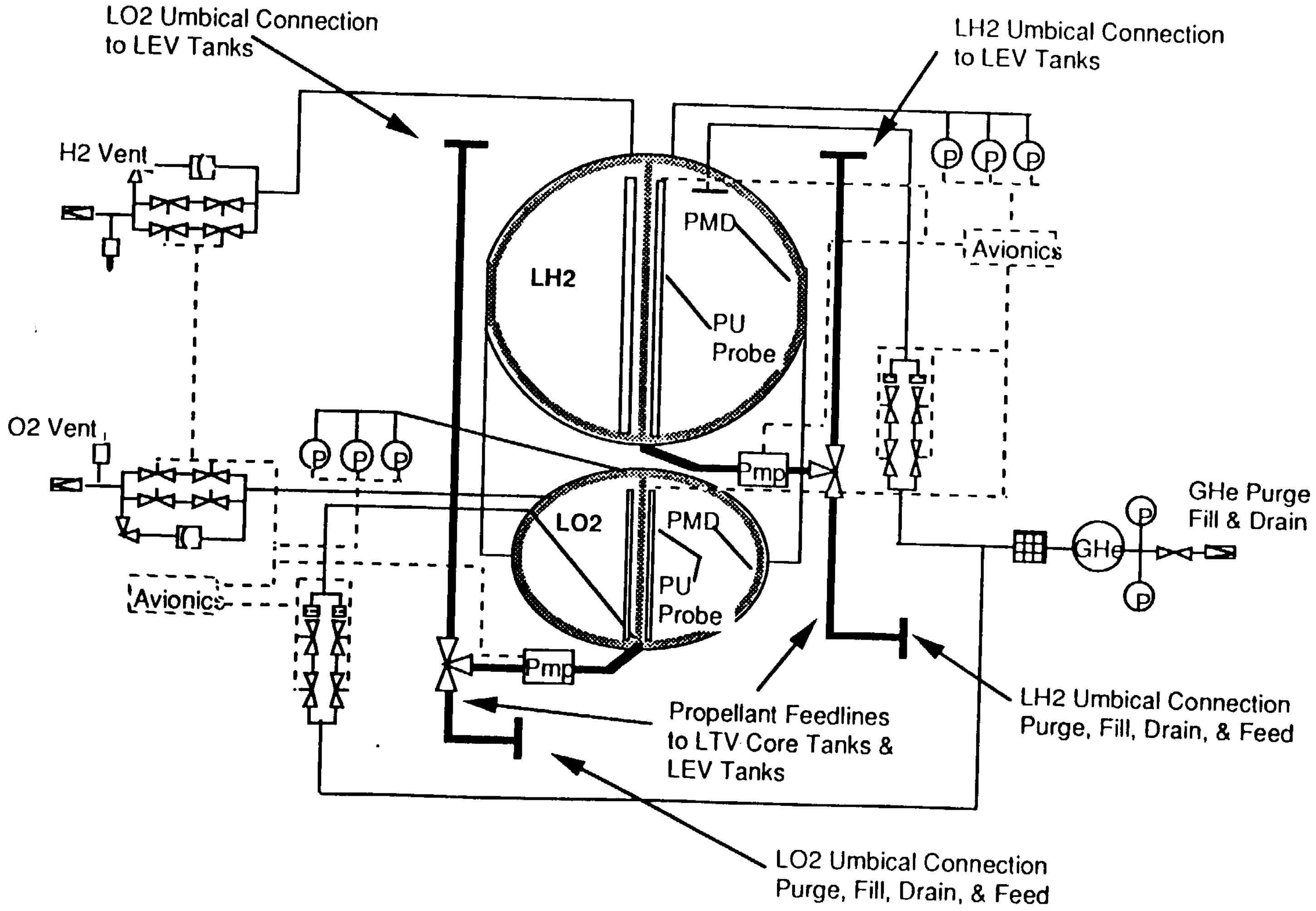


Figure 2.3.4-3
Cross Feed Schematic from Drop Tanks to Core Tanks

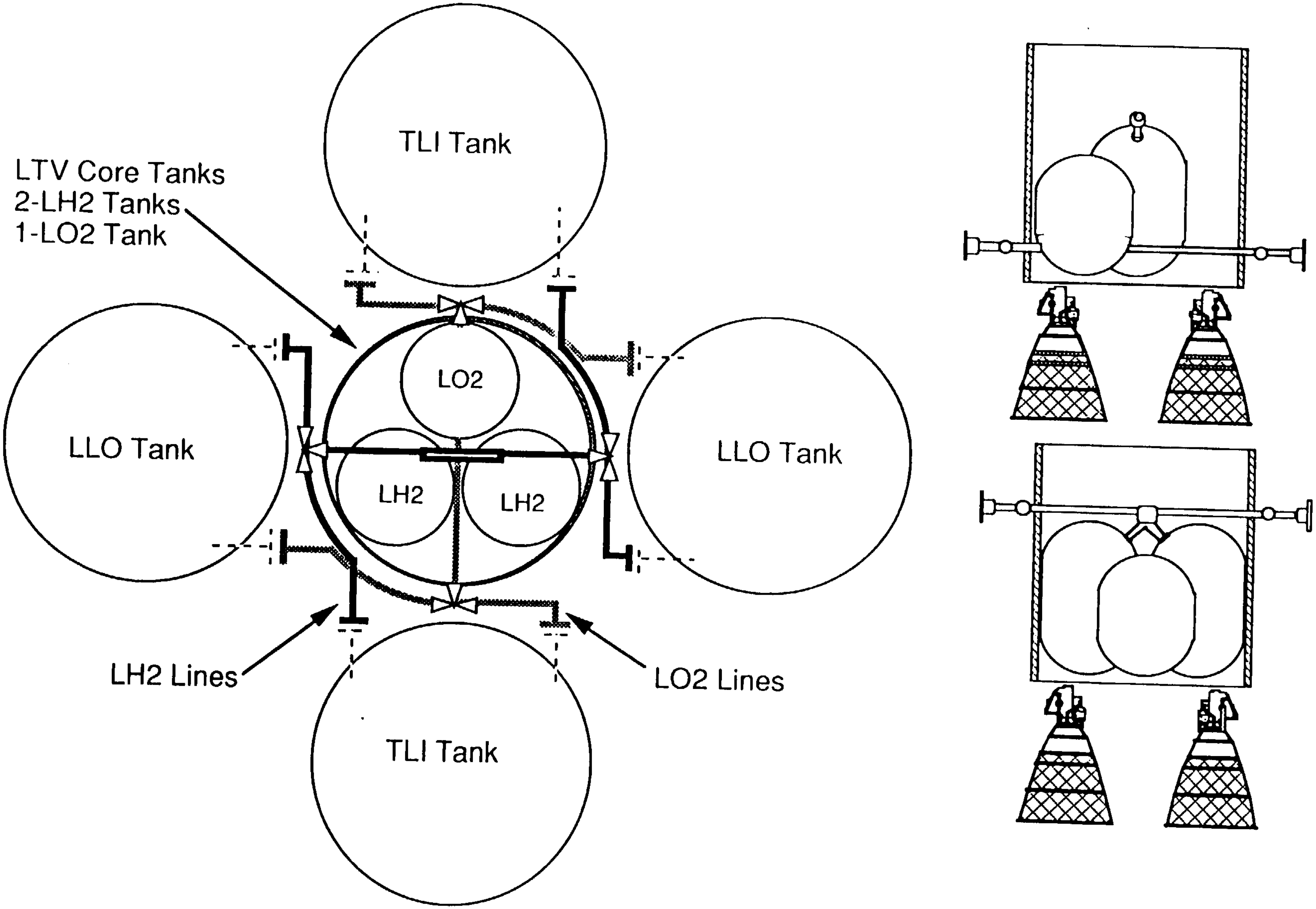
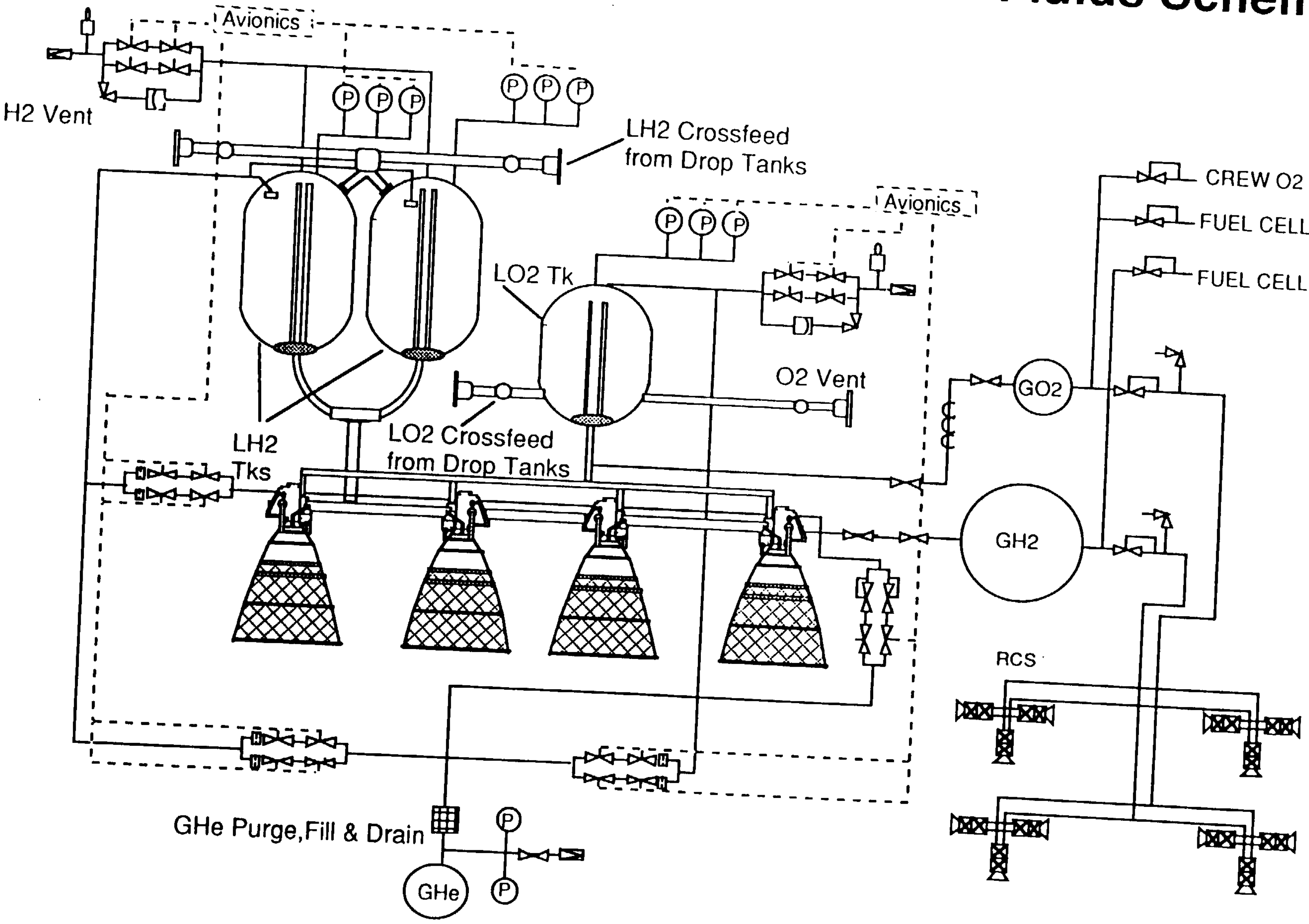


Figure 2.3.4-4 Core Tanks Propulsion and Fluids Schematic



A trade study was performed to evaluate preliminary insulation concepts for the LTV TLI and LLO drop tanksets. The analysis focused on the LH2 tanks since they represent the worst case for boiloff. Ground performance for various insulation configurations were determined simulating the conditions inside the ETO transportaion vehicle which was assumed to be continuously purged with gaseous nitrogen while on the launch pad. Various thicknesseses of Spray-On-Foam-Insulation (SOFI) were analyzed. As expected, the boiloff rate was minimized as the SOFI thickness increased. However, since the insulating effect of the SOFI is marginal on orbit, minimizing the SOFI thickness is desirable. Based on External Tank experience and a review of Shuttle Centaur requirements, 2.54 cm of SOFI was baselined for both the TLI and LLO tanksets. The on orbit boiloff was estimated for three configurations of multi-layer insulation (MLI) varying from 1.3 cm to 5.0 cm in thickness. Since a combination of SOFI and MLI will be required on the tanks for ground and on orbit thermal control, the total weight penalty of insulation and boiloff was calculated for various SOFI/MLI combinations. Assuming a thirty day on orbit period before the mission begins, the combination of 2.54 cm of SOFI and 2.54 cm of MLI provided the lowest weight penalty and was baselined for the tanksets.

A trade study was also performed to evaluate the insulation concepts required for the LEV core tanks while on the lunar surface and on orbit. As stated earlier, the LH2 tanks were examined since they represent the worst boiloff. Various thicknesses of MLI, ranging from 1.3 cm to 10 cm were evaluated. The lunar surface conditions represented the worst case thermal environment for the LEV core tanks, particularly during the lunar cycle. Shading of the tanks during the lunar day is desirable to limit the boiloff. Only passive insulation concepts were considered, but further reductions in boiloff could be realized if active cooling such as mechanical refrigeration or a vapor-cooled shield were added. Based on the analyses, an insulation configuration of 5.0 cm of MLI was chosen as the baseline insulation concept for the LEV core tanks. This insulation concept will provide an LH2 boiloff of approximately 0.25% per day while on the lunar surface and 0.10% per day while on orbit.

2.3.5 Other Subsystems

The various subsystems for both the LEV and LTV are shown in Figure 2.3.5-1. Except for the automated landing system on the LEV, commonality exists between vehicles for all subsystem components. All subsystems are man-rated, redundant, fault tolerant (configured to be

Figure 2.3.5-1 LTV/LEV Subsystem Description

LTV/LEV SUBSYSTEM COMMONALITY

REACTION CONTROL SYSTEM

Accumulator Tanks
Thrusters
Valves & Lines
Conditioning Units

GUIDANCE, NAVIGATION & CONTROL

Flight Controller
IMU Processor
Thrust Controller
GPS/Deep Space Receiver
Rendezvous & Docking Radar System
Collision Advoidance System

ELECTRICAL POWER

Fuel Cells
Radiators
Residual H_2O System
Reactant Tanks (LH_2 & LO_2)
Power Distribution & Management
Valves & Lines

COMMUNICATION & DATA HANDLING

GPS/Deep Space Antenna System
STDN/TDRS Transponder
20W RF Power Amp
S-Band RF System
VHF System
Ku Band System
Video & Imaging Processor System
Data Processing and Storage System
TDRSS
Health & Instrumentation Monitoring System
Central Computers

LEV UNIQUE SUBSYSTEM

Automatic Landing System

fail op, fail op, fail safe) to ensure crew safety. A more detailed listing of these subsystem components were generated to determine mass properties.

3.0 ON ORBIT OPERATIONS

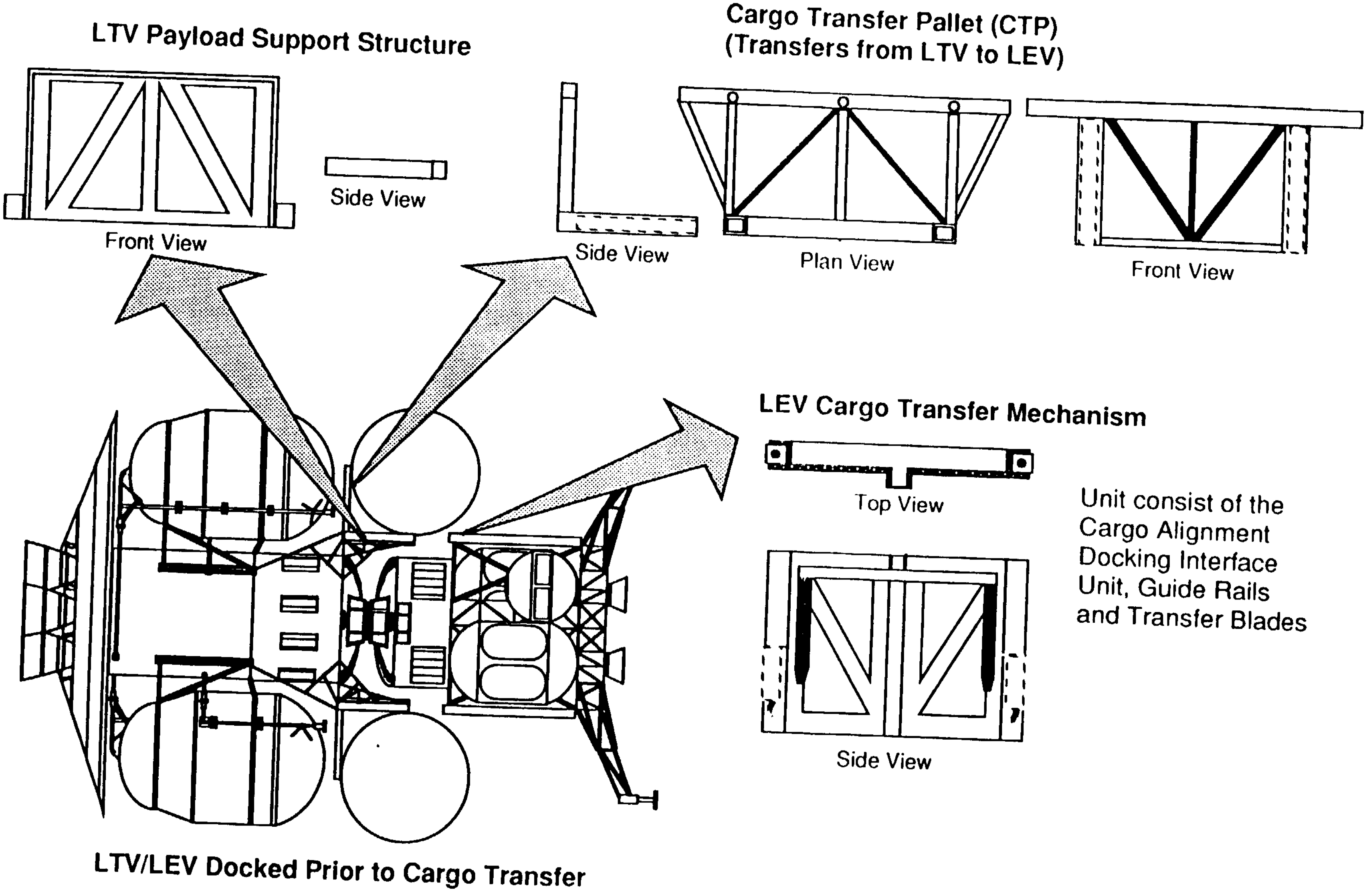
3.1 CARGO TRANSFER

During steady state operations, cargo is delivered via the ETO transporation system and attached to the LTV at Space Station Freedom. The LEV is waiting on the lunar surface for the LTV to arrive in LLO. The LEV will then ascend from the surface and rendezvous and dock with the LTV in LLO. The cargo on the LTV must be autonomously transferred from the LTV to the LEV for delivery to the lunar surface.

Cargo is mounted to the LTV as shown in Figure 3.1-1 via a cargo transfer pallet which consist of a "L" shaped structure housing the cargo pick up points. A payload support structure on the LTV has guide rails built into it to seat the cargo transfer pallet (CTP) and automatically lock the CTP into place. Cargo transfer between the LTV and LEV is achieved by using a mechanism similar to a forklift mounted on the LEV. The forklift type blades engage the payload support structure which releases the mounting pins holding the cargo to the LTV and locks the cargo to the blades.

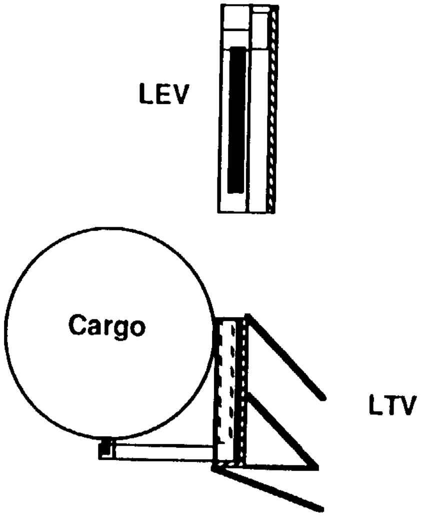
Figure 3.1-2 illustrates the cargo transfer sequence between the two vehicles in LLO. Cargo is mounted to the cargo transfer pallet. The CTP with cargo is then mounted into the payload support structure on the LTV. The cargo transfer pallet is held in place with latching pins that automatically activate via a tripping mechanism when the CTP is seated. Sensors will indicate that the pins are seated. After the docking maneuvers between the LTV and LEV are completed at LLO, the cargo transfer operation is instituted when the cargo alignment docking interface (CADI) unit, is raised from the LEV and mates with the payload support structure. The alignment device consist of two tapered pins that mate into the respective receptacles on the payload support structure. Once the alignment is made, the two forklift type blades are raised from the LEV on guide rails and engage the CTP. This action releases the mounting pins holding the CTP to the payload support structure and locks the CTP to the blades. The blades then retract down the guide rails to the LEV. The CADI unit is then undocked and lowered back to the LEV completing the transfer sequence.

Figure 3.1-1 Cargo Transfer Components

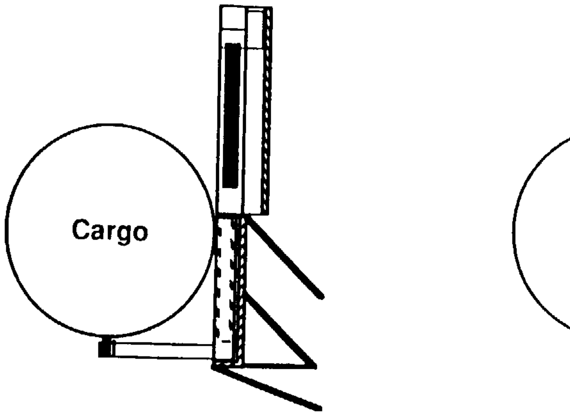


Unit consist of the Cargo Alignment Docking Interface Unit, Guide Rails and Transfer Blades

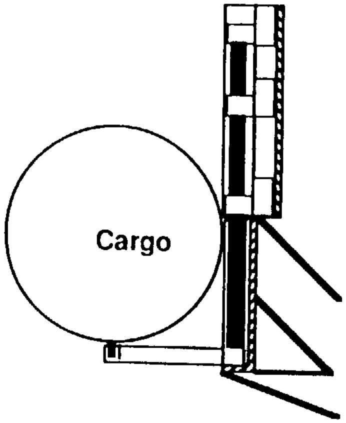
Figure 3.1-2 LTV/LEV Cargo Transfer Sequence



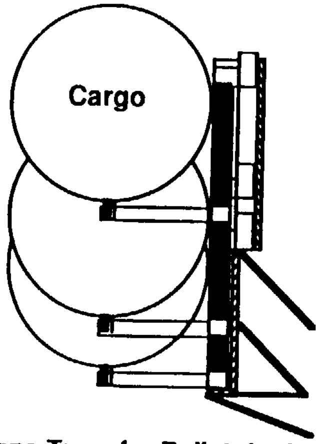
1 - LTV & LEV Docked and Cargo Transfer begins.



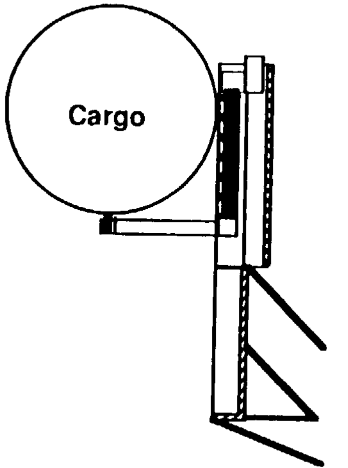
2 - LEV Cargo Transfer Mechanism mated to the LTV Cargo Support Rack.



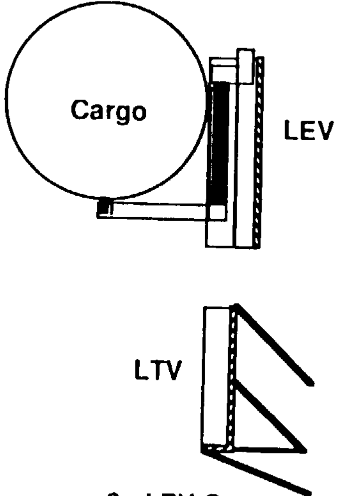
3 - The Cargo Transfer Blades engaging the Cargo Transfer Pallet



4 - Cargo Transfer Pallet, locked to Cargo Transfer Blades and translated back to the LEV



5 - Cargo transfer completed



6 - LEV Cargo Transfer Mechansim undocks from LTV Cargo Support Rack and retracted

3.2 PROPELLANT TRANSFER

During steady state operations, propellant is delivered in the TLI and LLO tanksets via the ETO transporation system and attached to the LTV at Space Station Freedom. The steady state mission scenario is the same as that described in the cargo transfer operation. The LEV core tanks are essentially empty of propellant once the LEV and LTV have docked. Propellant in the LLO tanksets on the LTV must be autonomously transferred from the LTV to the LEV core tanks to provide propellant for the LEV to continue its mission.

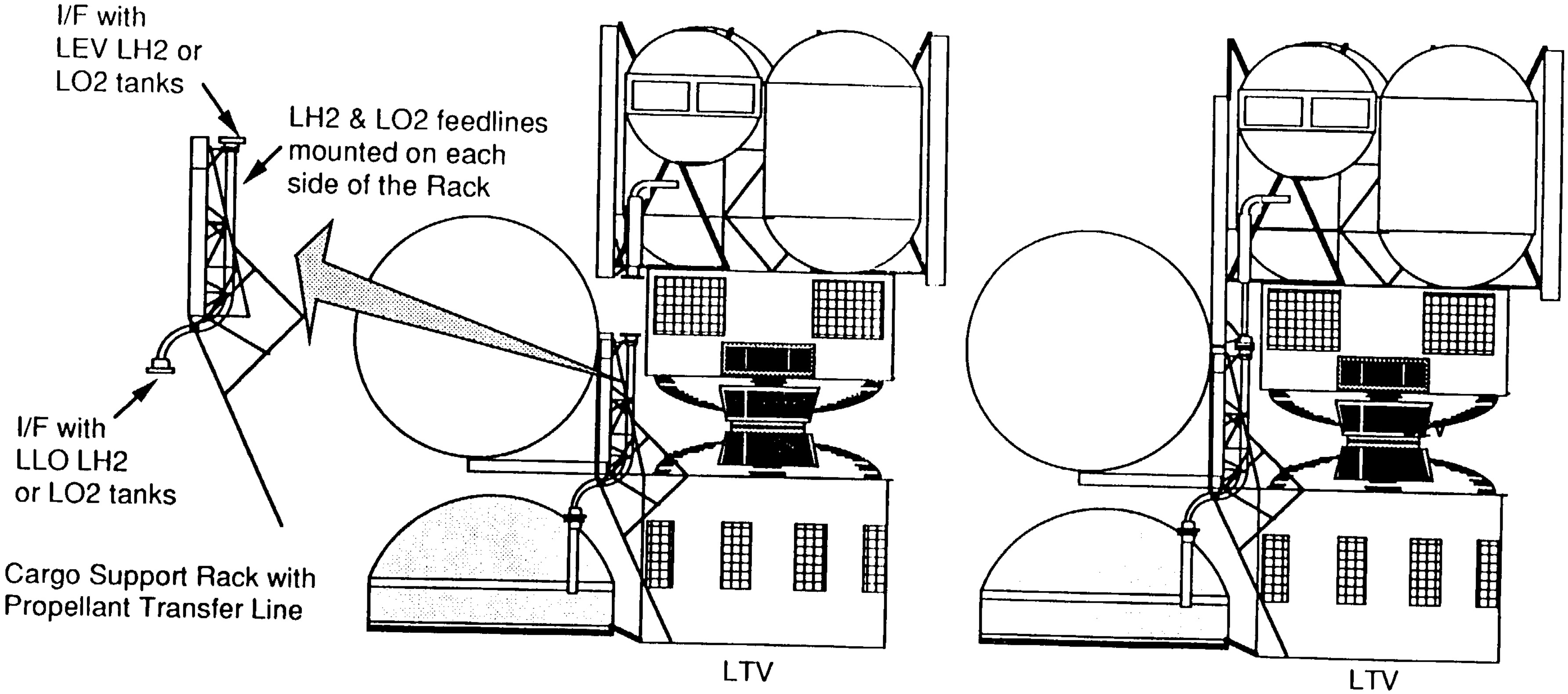
Figure 3.2-1 illustrates the propellant transfer operation that is taking place in conjunction with the cargo transfer operation. In order to transfer propellant from the LLO tanksets to the LEV, interface feedlines (LO2 and LH2) are mounted in the cargo support rack. After the vehicles are docked, the cargo transfer mechanism extends from the LEV and mates with the cargo support rack. This allows the LEV crossfeed to extend using a series of internal bellows and connect with the LO2 and LH2 interfaces on the cargo support rack. Propellant is then transferred using the cryo pumps located in the LLO tanksets. The connecting sequence is reversed once the propellant has been transferred.

3.3 CARGO UNLOADING ON LUNAR SURFACE

Cargo unloading on the lunar surface will be similar to that of on orbit transfer of the cargo from the LTV to the LEV. The forklift -like mechanism mounted on the LEV will be used for transfer. The various positions of the cargo once attached to the LEV are shown in Figure 3.3-1. The cargo is lowered to just below the crew cab for better viewing during landing on the lunar surface. The cargo can then be lowered along the transfer mechanism to heights which allow for unloading to transporters or others means for lunar deployment. Figure 3.3-2 illustrates an option for unloading cargo directly onto a lunar transporter. After the LEV lands on the lunar surface, the transporter will be positioned under the cargo. Guide rails will guide the cargo directly to the transporter using the forklift mechanism on the LEV. Once the cargo is on the transporter, the forklift blades will unlink and retract back to the LEV. The LEV configuration lowers the cargo to within .9 m of the lunar surface if the cargo fits between the landing legs (< 6.1 m).

4.0 MANIFEST DATA

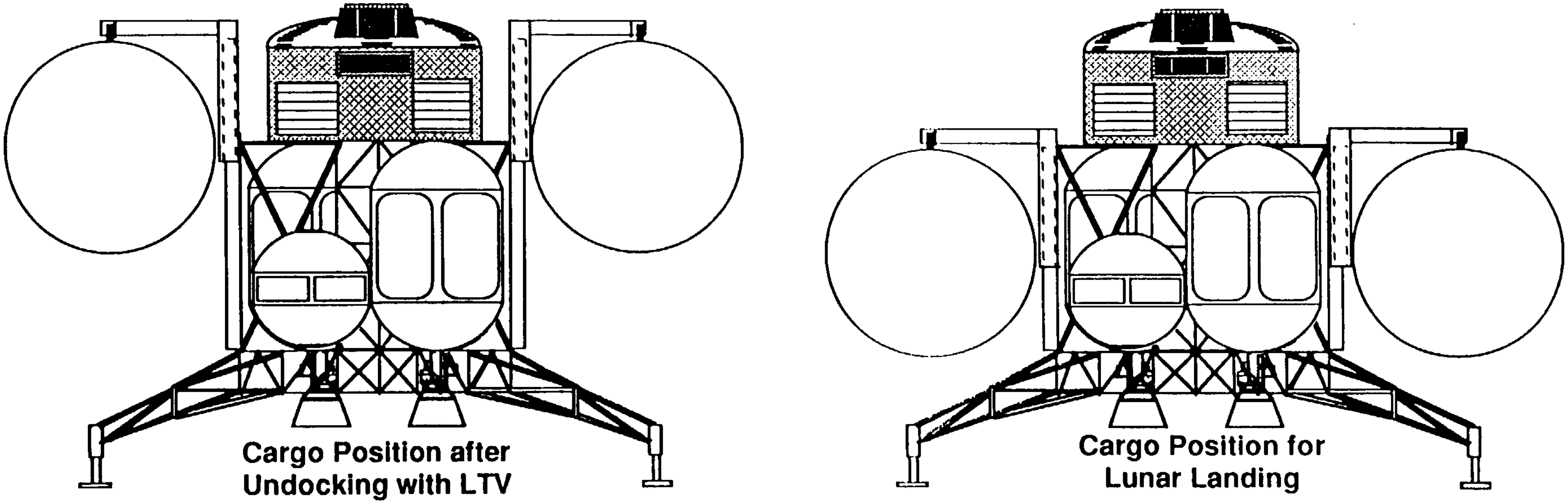
Figure 3.2-1 Propellant Transfer from LTV to LEV



1 - LTV/LEV docked and ready to begin Cargo and Propellant transfer. The Cargo Transfer Mechanism will extend from the LEV, and align with the Cargo Support Rack. This will bring the propellant Interface into contact and allow for the refueling of the LEV before the cargo is transferred.

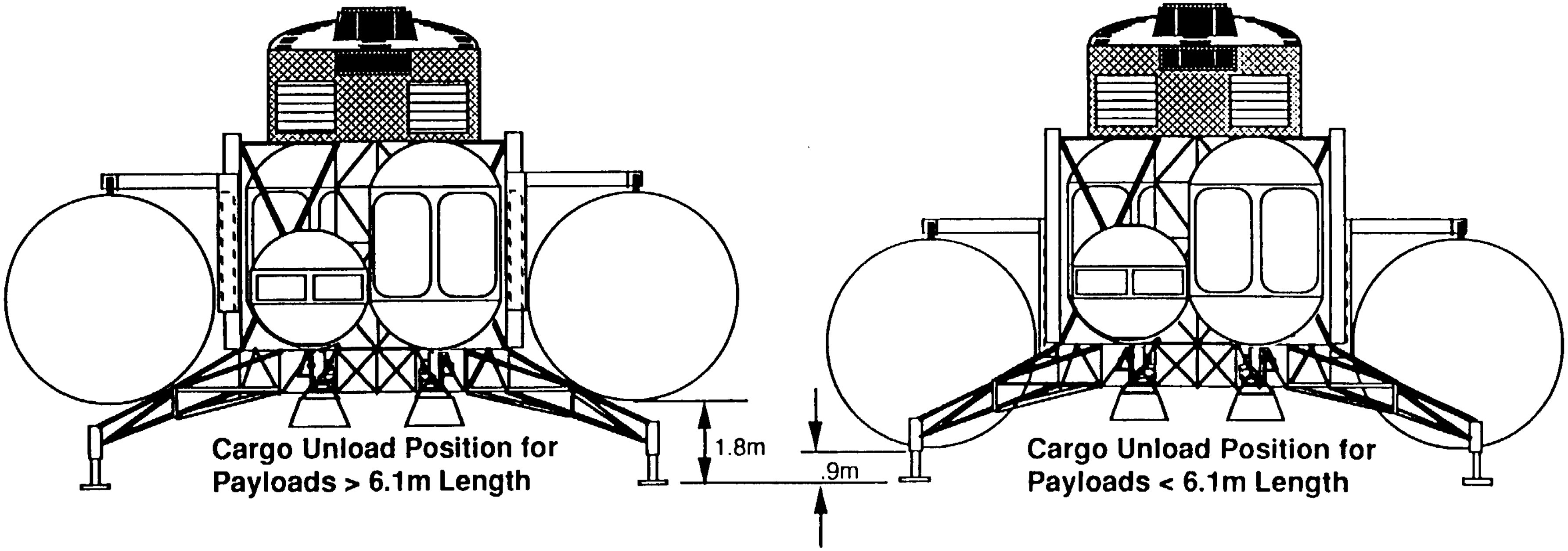
2 - The Cargo Transfer Mechanism has mated with the Cargo Support Rack. When the CTM is extended the LEV Propellant Interfaces (LH2 & LO2) mounted on each side of the CTM are also extended through use of a series of internal bellows. This allows for the linear motion the I/Fs need to complete the hookup and the propellant is then transferred.

Figure 3.3-1 LEV Cargo Scenario



Cargo Position after Undocking with LTV

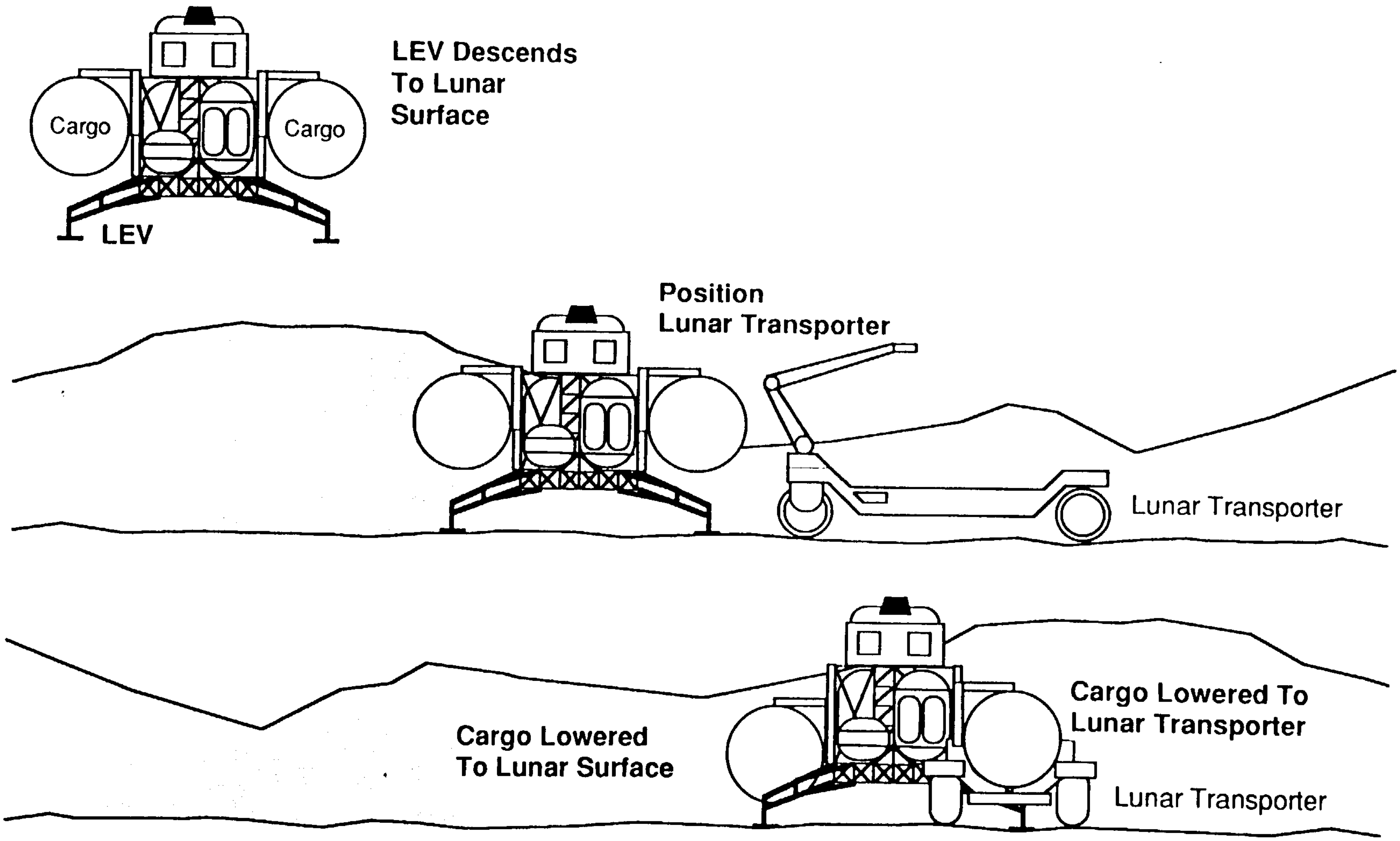
Cargo Position for Lunar Landing



Cargo Unload Position for Payloads > 6.1m Length

Cargo Unload Position for Payloads < 6.1m Length

Figure 3.3-2 Cargo Unloading - Lunar Surface



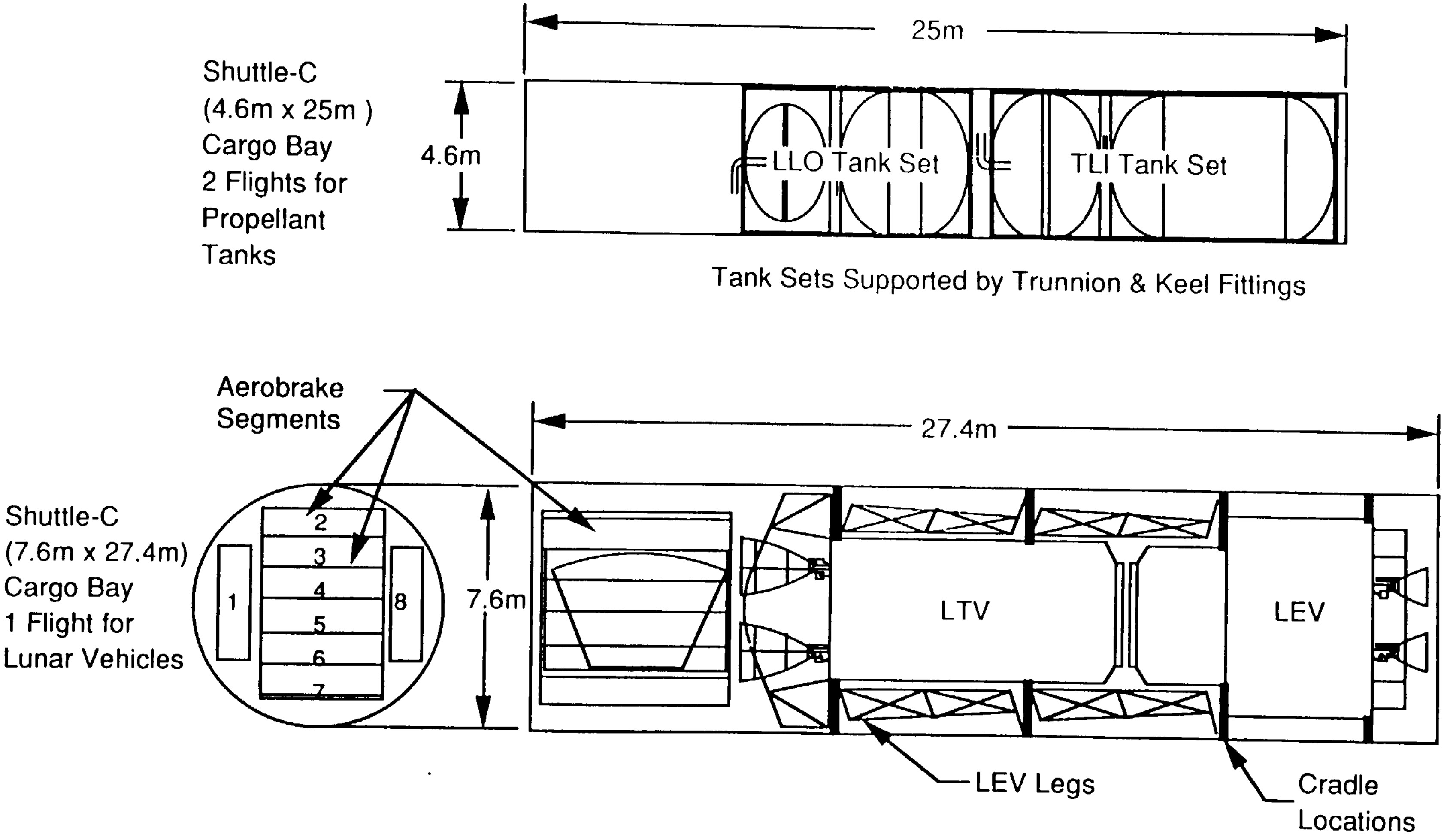
JRH011890-16

The LTV and LEV described in the preceding pages were manifested in the ETO transporation system to determine the number of flights required to Space Station Freedom. The ETO transportation system utilized in the manifest was the Shuttle-C (4.6 m x 25 m cargo bay and 7.6 m by 25 m cargo bay).

The LTV core vehicle and aerobrake outer segments, along with the basic LEV and its detached landing legs require a full Shuttle-C (7.6m x 27.4m) cargo bay for manifesting as shown in Figure 4.0-1. Both the LTV core and LEV will each require two mounting cradles utilizing standard trunnion and keel fittings to secure the payloads in the cargo bay. Special packaging and mounting provisions will be required for the aerobrake outer segments and the LEV landing legs.

The propellant-loaded drop tanksets are packaged in the Shuttle-C (4.6m x 25m) cargo bay. One TLI tankset and one LLO tankset are packaged together in the cargo bay. Two Shuttle-C flights are required to bring all four tanksets to station. Each tankset is supported in the cargo bay using trunnion and keel fittings. Although not volume limited in the Shuttle-C, the weight of the two tanksets pushes the performance limits of the vehicle. Each tankset and the lunar vehicles will also be equipped with handling/grappling fixtures to accommodate transfer from the cargo bay to the station by a cargo transfer or similar vehicle.

Figure 4.0-1 Manifesting Data



STV CONCEPT SELECTION
SS FREEDOM ON-ORBIT OPERATIONS
EVALUATION

PRELIMINARY DATA

DON BRYANT
MDSSC-KSC
6/2/90

METHODOLOGY

1. Defined shopping list of potential on-orbit tasks by phase. (See Methodology Illustration, Ref "A")

2. Defined task "complexity factors" based upon on-orbit crew/telerobot resource usage as follows:

   1 IVA support to control and monitor tests and simple SSRMS operations.

   2 IVA support of propellant loading and SSRMS operations involving high mass elements and/or FTS control

   3 Simple EVA translations, minimal tool usage

   4 Combined IVA/EVA assembly of medium size elements.

   5 Combined IVA/EVA assembly of loaded tanks/stages/large mass elements or use or multiple SSRMSs/FTS.

3. Assigned "complexity factors (C.F.)" to each potential on-orbit task. (See Methodology Illustration, Ref "B")

4. Developed "EXCEL™" spreadsheet to calculate individual task and configuration total serial shifts (8 Hour) and "an arbitrary (but consistent) complexity numerical reference" based upon individual task time estimate inputs multiplied by the C.F.s defined above. (See entire Methodology Illustration)

Note: Spreadsheets are included in backup data file.

CONCEPT # 4E-3A SS **ELEMENTS: IC = TLI Stage, 1E = LOI Stage, 3B = LV, 5A = A/B, 6A = CC, 7 = Cargo, & 8 = Cryo Tanker/Xfer system**

DESCRIPTION: Multistage TV & Separate LV - Single Crew Cab **DATE 5/30/90**

COMPLEXITY FACTORS	RESOURCES - SHIFTS															COMPLEXITY FACTOR	TOTAL COMPLEXITY	COMMENTS
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1C	1E	3B	5A	6A	7.0	7.0	8.0					TOTAL SHIFTS			
Refurbishment Phase																		
Crew Module Refurb			-	-	-	-	45.0	-	-	-					45	1	45	
Electrical Checkout			-	2.0	-	1.5	-	-	-	-					3.5	1	3.5	
Engine Servicing	X		-	8.0	-	-	-	-	-	-					8	3	24	
Aerobrake TPS Repair	X		-	-	-	2.5	-	-	-	-					2.5	3	7.5	
Subsystem Leak And Functionals	X		-	6.0	-	-	-	-	-	-					6	3	18	
TCS Refurbishment	X		-	6.0	-	-	-	-	-	-					6	3	18	
Avionics System Verification			-	6.0	-	-	-	-	-	-					6	1	6	
															77			
Hardware Delivery Phase																		
Delivery Vehicle Offloading		X	1.5	-	-	-	-	0.5	0.5	1.0					3.5	2	7	
Receiving Inspection		X	1.0	-	-	-	-	0.5	0.5	1.0					3	2	6	Returning LOI stage at ASF for refurb then move to ITA during TLI stage arival.
Installation at Temporary Location	X	X	2.0	2.0	-	-	-	-	-	1.5					5.5	5	27.5	
															12			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	-	-	-					0	4	0	
STV Assembly	X	X	-	1.0	-	-	-	1.0	1.0	2.0					5	5	25	Tanker I/F connection
															5			
Verification Phase																		
Interface Verification			-	1.0	-	-	-	-	-	-					1	1	1	
Integrated Vehicle Test			1.0	1.0	-	-	2.0	-	-	-					4	1	4	
Mate & Berthing Test			-	-	-	-	-	-	-	-					0	2	0	
															5			
Propellant Servicing Phase																		
Cryo Servicing			-	2.0	-	-	-	-	-	-					2	2	4	
Cryo Top Off			-	-	-	-	-	-	-	-					0	2	0	
															2			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	4.0	-	-	-					4	1	4	
Vehicle Closeout			-	-	-	-	4.0	-	-	0.5					4.5	1	4.5	Tanker disconnect
Crew Ingress	X		-	-	-	-	0.5	-	-						0.5	1	0.5	
Pre Deployment C/O			-	-	-	-	0.5	-	-						0.5	1	0.5	
															9.5			
Launch Phase																		
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	-	###	-	2.0	2.0	-	-						33	3	99	
Propellant Residual Drain			-	4.0	-	-	-	-	-						4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	9.0	-	-						9	1	9	
															46			
									GRAND TOTALS						159	n/a	327	

REF "A"
CANDIDATE TASK LIST

REF "C"
INDIVIDUAL TASK TIMELINE INPUTS

REF "B"
COMPLEXITY FACTORS

METHODOLOGY

5. Researched past KSC study reports to establish individual element task timelines and input same into spreadsheets (One for each concept initial flight and if appropriate, steady state/reflight). (See Methodology Illustration, Ref "C")
6. Produced timelines for 8 concepts (5 with reflights) based on spreadsheet output data.
7. Produced concept comparison charts utilizing spreadsheet data.
8. All of the above data is to be evaluated to produce summary charts. (TBS)

49

GROUNDRULES AND ASSUMPTIONS

NOTES & OBSERVATIONS:

- Timeline data were derived from the MDSSC-KSC On-Orbit Assembly/Servicing Task Definition Study GFY 1989 Summary Report of November 1989. All processing times are "KSC Ground equivalent" times and do not have EVA and automation enhancements yet incorporated.
- When fully assembled for initial mission , Configurations 3A-3, and 4E-3A&B exceed the presently planned ASF length.
- When fully assembled, Configurations 4E-2A, 4E-2B, 4E-3A, and 4E-3B have widths that are marginal or greater than planned ASF width.
- TLV refurbishment times could be impacted by lunar dust cleanup.

GROUNDRULES AND ASSUMPTIONS

GENERAL

- SSF resources required to support the timeline are: IVA (2); EVA including cabin atmosphere loss associated with Airlock use; MSC; ASF; DMS; TCS; & Power.
  - SSF assembly/refurbishment crew of 4 is baseline.
- The only on-orbit cryo servicing will be for concepts 4E-3A & B steady state missions These missions will be supplied from a tanker that includes an integral propellant transfer system (including displacement gas supply).
  - All other Propellant Tanks are assumed to be delivered full and no top-off capability is required from SSF resources.
- All cargo is passive and is pre-assembled into single or dual containers when received.
- Advanced OMV will be available to support deployment and retrieval operations.
- All LVs require on-orbit erection of the cargo platform and installation of (2) filled cryo Propellant Tanks and (4) Landing Legs

* TLVs require no on-orbit assembly.

GROUNDRULES AND ASSUMPTIONS

SPECIFIC GROUNDRULES (per flight)

3A-2

- LV & TV are mated when delivered to SSF.
- TLV Core/LV will be delivered first, Cargo will be last .

3A-3

- LV & LOI Stages are mated when delivered to SSF.
- TLI Stage will be delivered first, Cargo will be last.

3A-5

- TLI Tanks are pre-plumbed to a dual tank type interface when delivered.
- TLV Core requires no on-orbit assembly and will be delivered first , Cargo will be last.

GROUNDRULES AND ASSUMPTIONS

<u>SPECIFIC GROUNDRULES</u> (per flight) (Cont)

4E-2A,B

- TV Core/Aerobrake/Cargo delivered first - TLI/LOI Tanks Last

4E-3A,B

- TLI Stage will be delivered first, - Re-supply Tanker Last (reflights only)

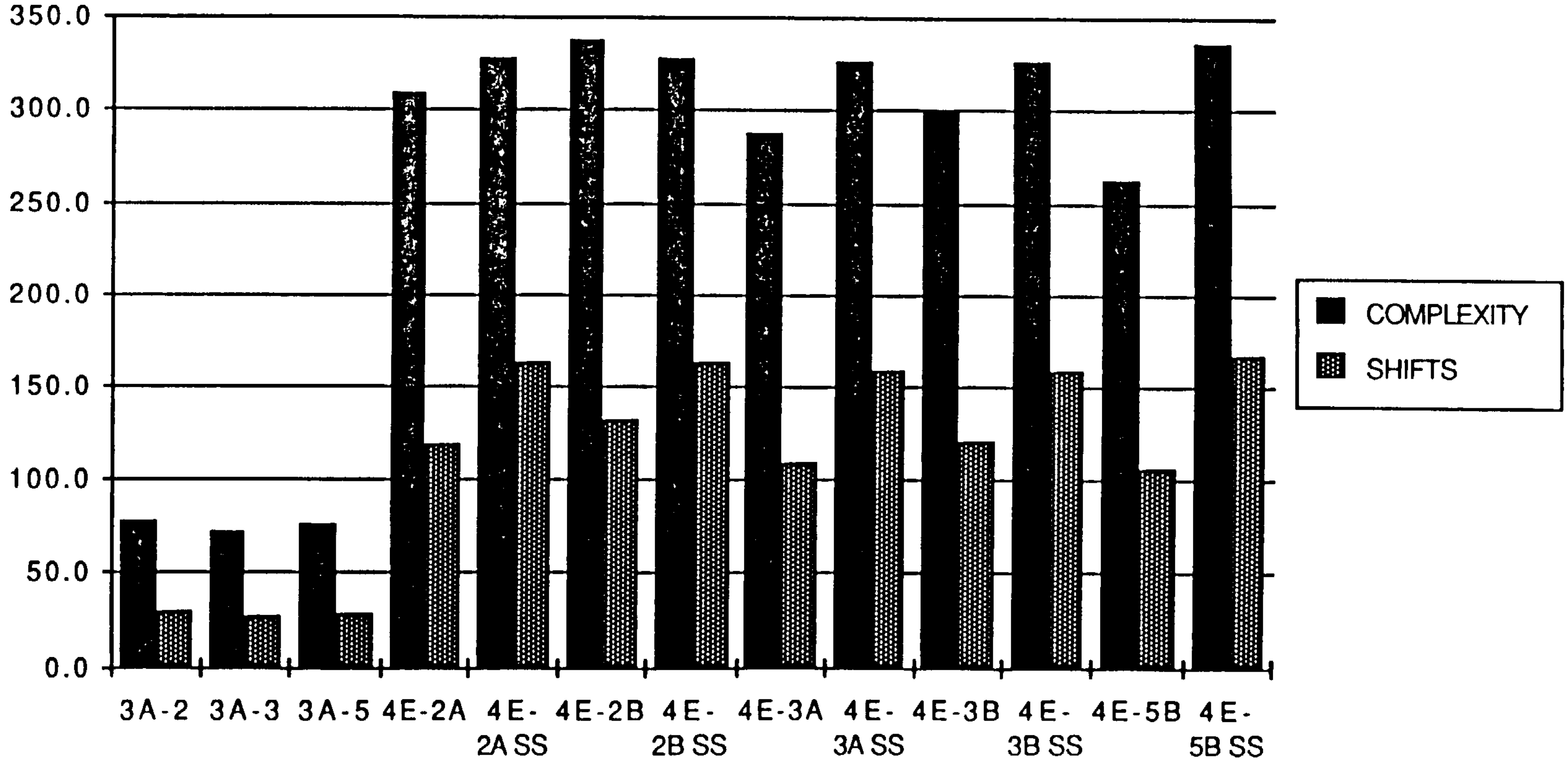
4E-5B

- TLV Stage/Aerobrake will be delivered First.

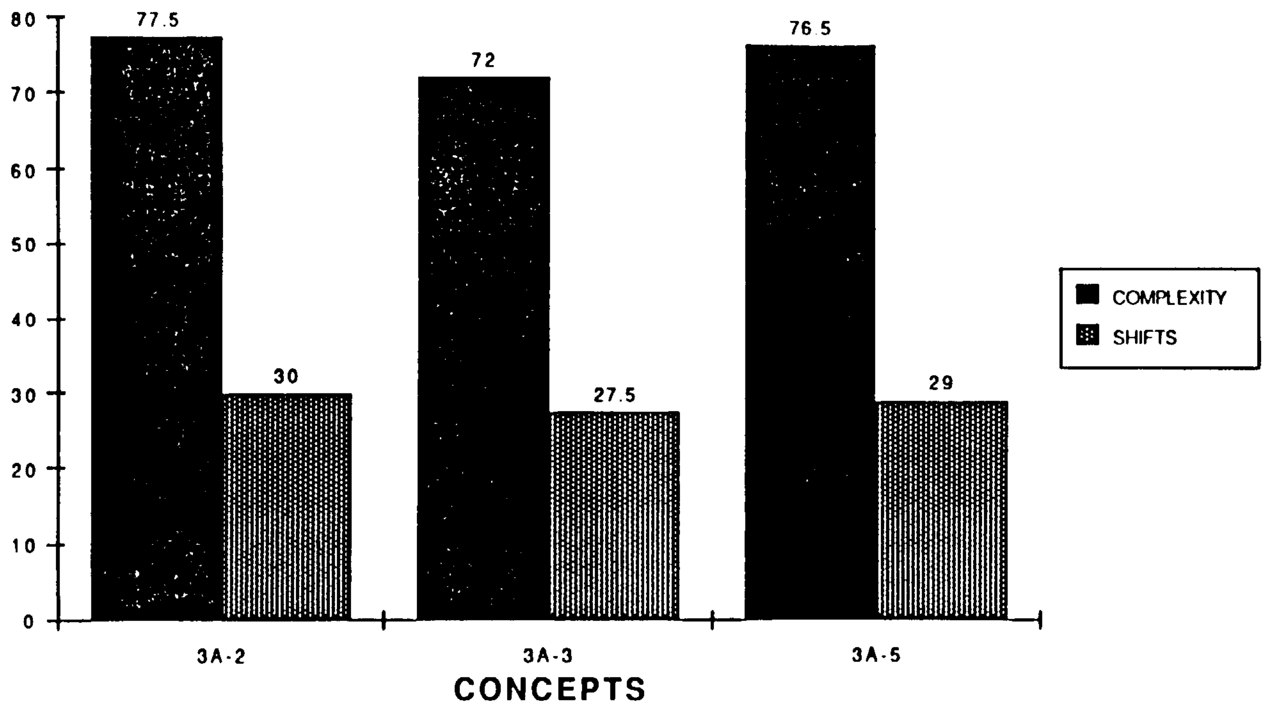
COMPARISON TABLE

CONFIGURATION	COMPLEXITY	SHIFTS
3 A - 2	77.5	30.0
3 A - 3	72.0	27.5
3 A - 5	76.5	29.0
4 E - 2 A	309.5	120.0
4E-2A SS	328.5	163.0
4 E - 2 B	338.5	132.0
4E-2B SS	328.5	163.0
4 E - 3 A	288.0	109.5
4E-3A SS	327.0	159.0
4 E - 3 B	302.0	121.5
4E-3B SS	327.0	159.0
4 E - 5 B	262.5	106.5
4E-5B SS	337.0	167.5

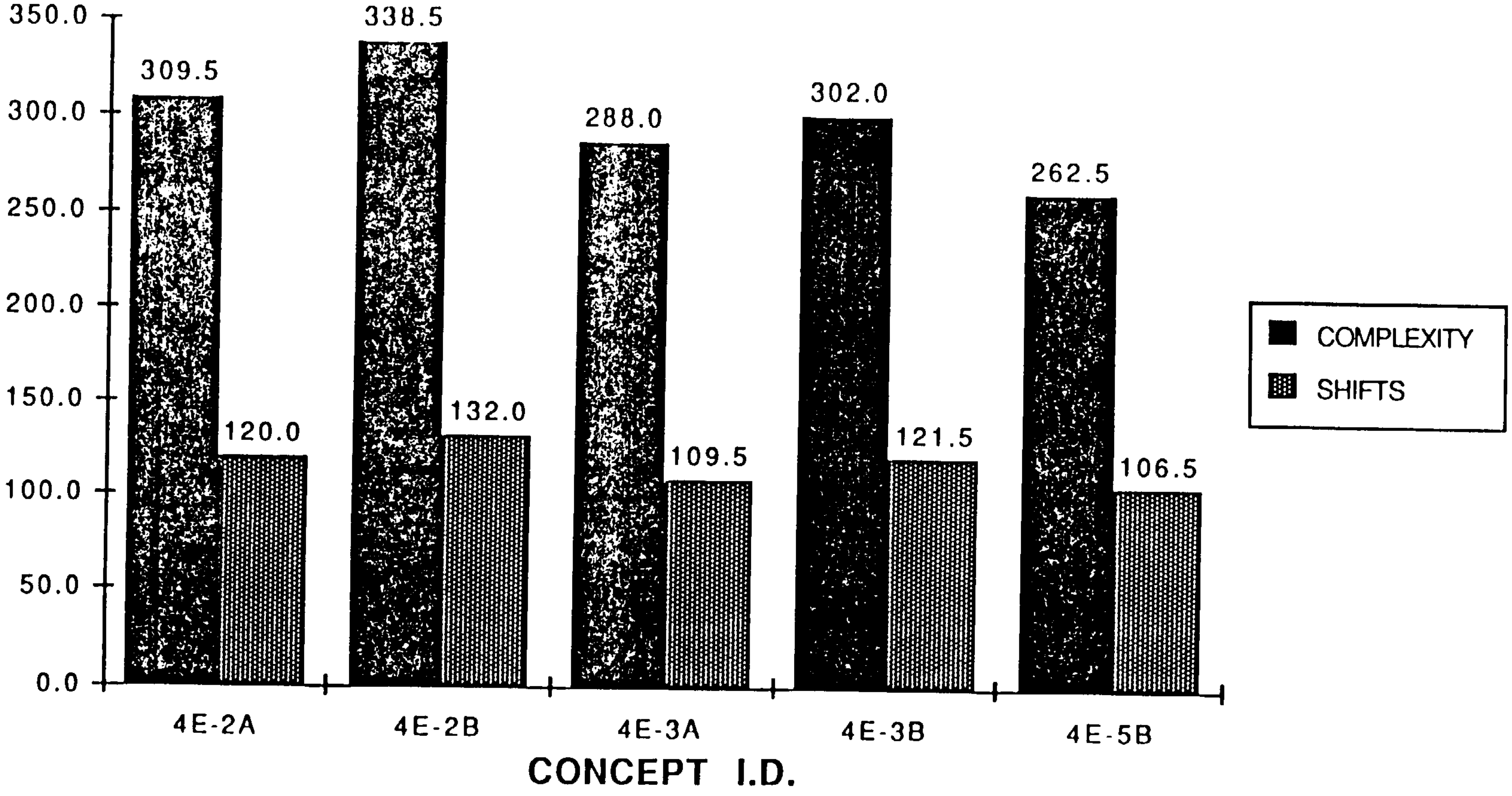
STV CONCEPT ON-ORBIT OPERATIONS AT SS FREEDOM COMPARISON - OVERVIEW



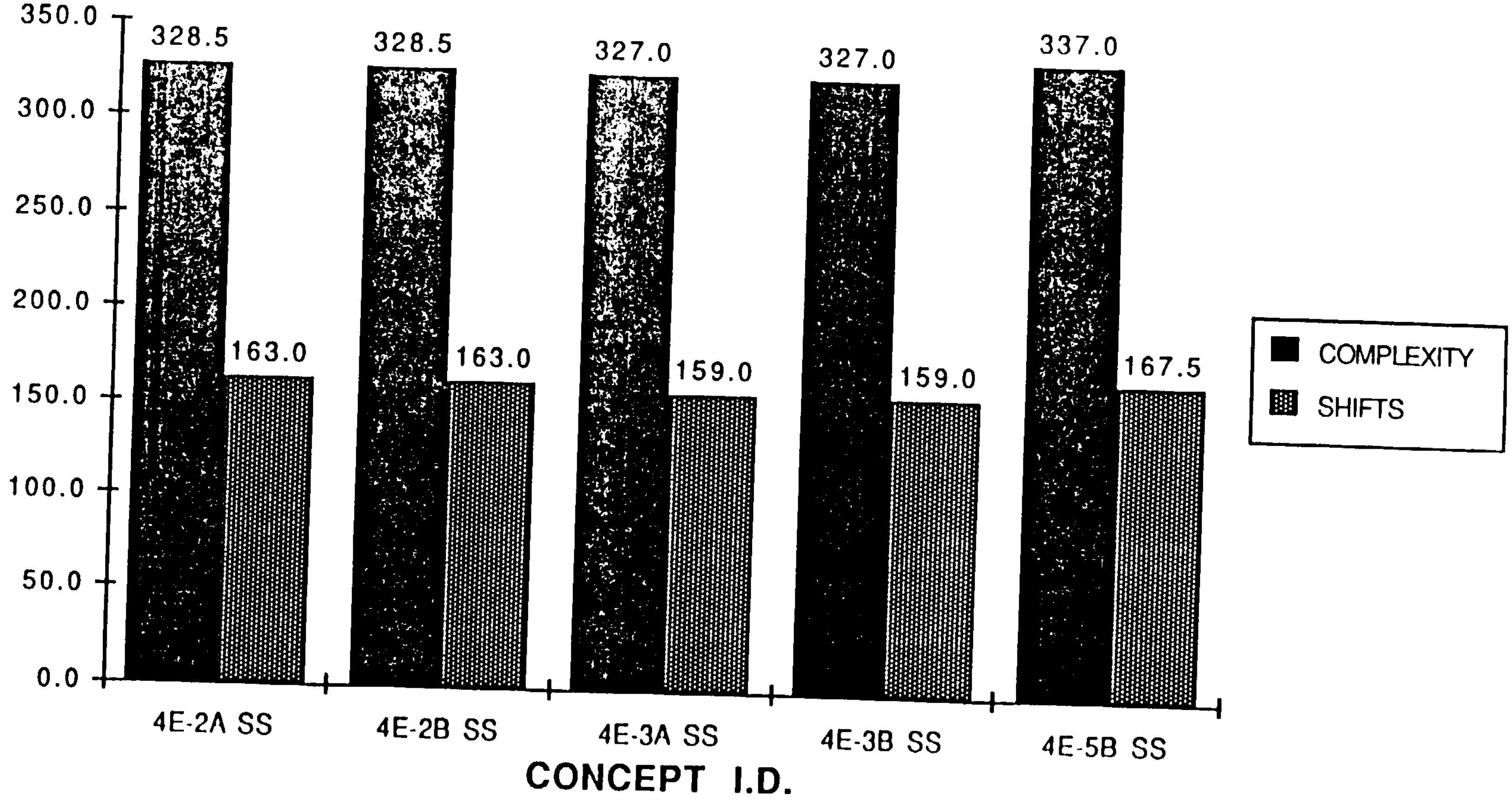
CARGO CONFIGURATIONS - COMPARISON



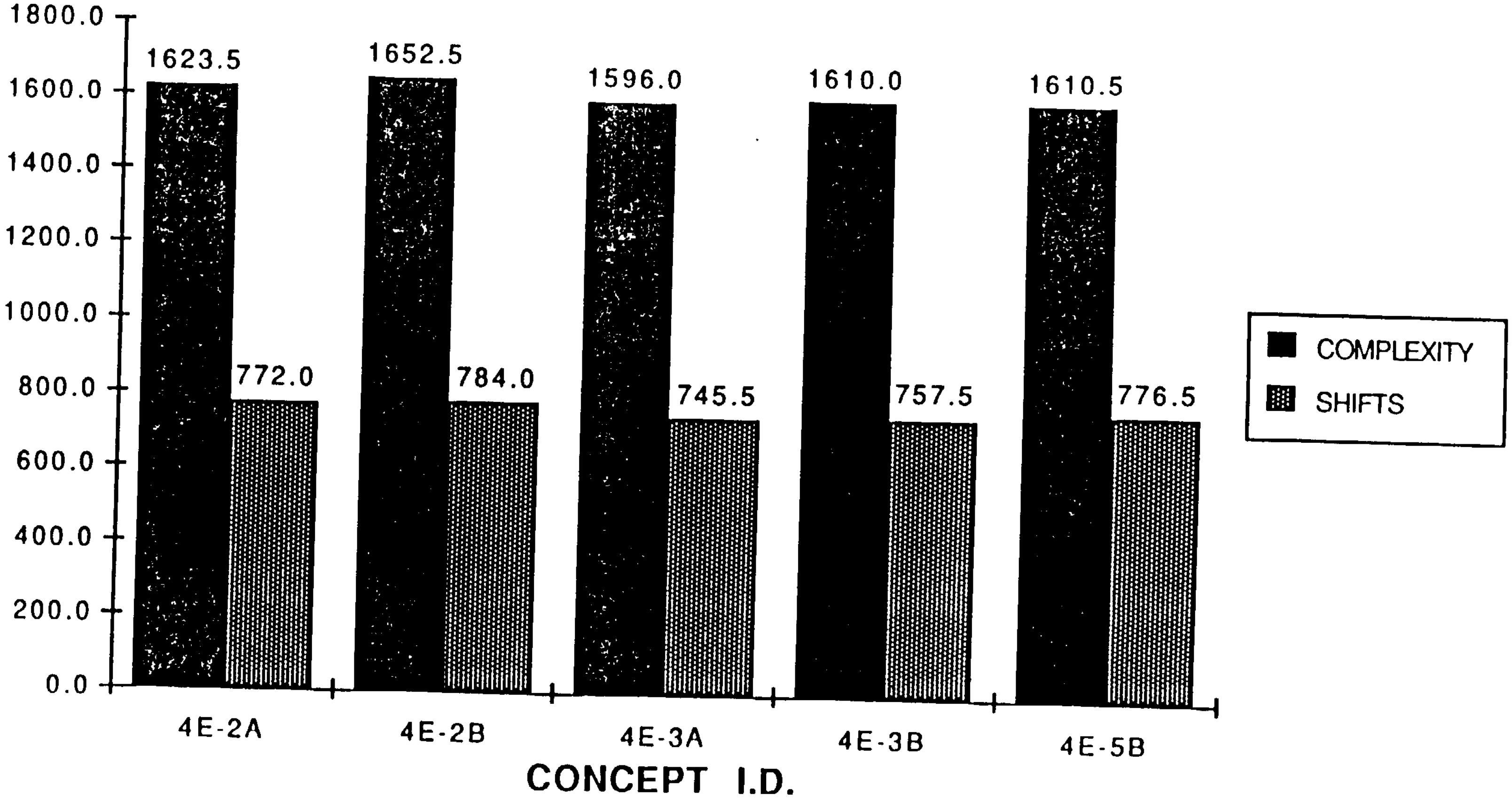
MANNED CONFIGURATIONS - INITIAL LAUNCH COMPARISONS



MANNED CONFIGURATIONS - STEADY STATE COMPARISON



MANNED CONFIGURATIONS - LIFETIME (5 FLIGHT) COMPARISON



BACKUP DATA

3A

CONCEPT #3A-2 ELEMENTS 1A = TV CORE, 2 = TLI TANKS, 3 = LV, 7 = CARGO

DESCRIPTION: 1 STAGE SEPARATE TV & LV W/DROP TANKS - CARGO ONLY (NO RETURN)

DATE 5/31/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1A	2.0	2.0	3A	7.0								TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb															0.0	1	0	
Electrical Checkout															0.0	1	0	
Engine Servicing															0.0	3	0	
Aerobrake TPS Repair															0.0	3	0	
Subsystem Leak And Functionals															0.0	3	0	
TCS Refurbishment															0.0	3	0	
Avionics System Verification															0.0	1	0	
															0.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.0	1.0	1.0	2.0	0.5								5.5	2	11	
Receiving Inspection	-	X	1.0	1.0	1.0	2.0	0.5								5.5	2	11	
Installation at Temporary Location	X	X	1.5	-	-	-	-								1.5	5	7.5	Into ASF assy fixt.
															12.5			
Assembly Phase																		
Element Assembly	X	X				4.0									4.0	4	16	Tanks (2), Platform/ Landing Legs (1)
STV Assembly	X	X	-	1.5	1.5	-	1.0								4.0	5	20	
															8.0			
Verification Phase																		
Interface Verification				1.0	1.0	2.0									4.0	1	4	
Integrated Vehicle Test			1.0	0.5	0.5	1.0									3.0	1	3	
Mate & Berthing Test															0.0	2	0	
															7.0			
Propellant Servicing Phase																	0	
Cryo Servicing															0.0	2	0	
Cryo Top Off															0.0	2	0	
															0.0			
Closeout Phase																		Manned flights only
Fluids Top Off															0.0	1	0	
Vehicle Closeout															0.0	1	0	
Crew Ingress															0.0	1	0	
Pre Deployment C/O															0.0	1	0	
															0.0			
Launch Phase																		Requires OMV
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection															0.0	3	0	
Propellant Residual Drain															0.0	2	0	
Crew Module/Return Cargo Destow															0.0	1	0	
															0.0			
										GRAND TOTALS					30.0	N/A	77.5	

3A-

CONCEPT #3A-3 **ELEMENTS: 1C = TLI Stage, 1D = LOI Stage, 3A = LV. 7 = Cargo**

DESCRIPTION: Multistage TV & separate LV - Cargo only (no return)

DATE 5/31/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1C	1D	3A	7.0									TASK SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb															0	1	0	
Electrical Checkout															0	1	0	
Engine Servicing															0	3	0	
Aerobrake TPS Repair															0	3	0	
Subsystem Leak And Functionals															0	3	0	
TCS Refurbishment															0	3	0	
Avionics System Verification															0	1	0	
															0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.5	1.5	2.0	0.5									5.5	2	11	
Receiving Inspection		x	1.0	1.0	2.0	0.5									4.5	2	9	
Installation at Temporary Location	x	x	2.0												2	5	10	To ASF Assy Fixt
															12			
Assembly Phase																		
Element Assembly	X	X	-	-	4.0	-									4	4	16	Tanks (2), Platform/Landing Legs (1)
STV Assembly	X	X	-	2.0	-	1.0									3	5	15	
															7			
Verification Phase																		
Interface Verification			-	1.0	2.0	-									3	1	3	
Integrated Vehicle Test			1.0	1.0	1.0	-									3	1	3	
Mate & Berthing Test			-	-	-	-									0	2	0	
															6			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-									0	2	0	
Cryo Top Off			-	-	-	-									0	2	0	
															0			
Closeout Phase																		Manned Flights only
Fluids Top Off			-	-	-	-									0	1	0	
Vehicle Closeout			-	-	-	-									0	1	0	
Crew Ingress			-	-	-	-									0	1	0	
Pre Deployment C/O			-	-	-	-									0	1	0	
															0			
Launch Phase																		Requires OMV
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection															0	3	0	
Propellant Residual Drain															0	2	0	
Crew Module/Return Cargo Destow															0	1	0	
															0			
														GRAND TOTALS	27.5	n/a	72	

3A-

CONCEPT #3A-5 **ELEMENTS 2 = TOI & LOI TANKS, 4A = TLV, 7 = CARGO**

DESCRIPTION **SINGLE PROPULSION STAGE COMBINED WITH DROP TANKS**

DATE 5/31/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	2	2	2	2	4A	7							TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb															0.0	1.0	0.0	
Electrical Checkout															0.0	1.0	0.0	
Engine Servicing															0.0	3.0	0.0	
Aerobrake TPS Repair															0.0	3.0	0.0	
Subsystem Leak And Functionals															0.0	3.0	0.0	
TCS Refurbishment															0.0	3.0	0.0	
Avionics System Verification															0.0	1.0	0.0	
															0.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.0	1.0	1.0	1.0	1.0	0.5							5.5	2.0	11.0	
Receiving Inspection	-	X	1.0	1.0	1.0	1.0	1.0	0.5							5.5	2.0	11.0	
Installation at Temporary Location	X	X		-	-	-	1.5	-							1.5	5.0	7.5	To ASF Assembly Fixture
															12.5			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	-							0.0	4.0	0.0	
STV Assembly	X	X	1.5	1.5	1.5	1.5	-	1.0							7.0	5.0	35.0	
															7.0			
Verification Phase																		
Interface Verification	-	-	1.0	1.0	1.0	1.0	-	-							4.0	1.0	4.0	
Integrated Vehicle Test	-	-	0.5	0.5	0.5	0.5	1.0	-							3.0	1.0	3.0	
Mate & Berthing Test	-	-	-	-	-	-	-	-								2.0		
															7.0			
Propellant Servicing Phase																		
Cryo Servicing															0.0	2.0	0.0	
Cryo Top Off															0.0	2.0	0.0	
															0.0			
Closeout Phase																		Manned Flights Only
Fluids Top-Off															0.0	1.0	0.0	
Vehicle Closeout															0.0	1.0	0.0	
Crew Ingress	X														0.0	1.0	0.0	
Pre Deployment C/O															0.0	1.0	0.0	
															0.0			
Launch Phase																		Requires OMV
Countdown Operations															2.5	2.0	5.0	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X													0.0	3.0	0.0	
Propellant Residual Drain															0.0	2.0	0.0	
Crew Module/Return Cargo Destow															0.0	1.0	0.0	
															0.0			
														GRAND TOTALS	29.0	n/a	76.5	

CONCEPT #4E-2A ELEMENTS 1B =TV, 2 =TLI & LOI TANKS, 3B = LV, 5A = A/B, 6A = CC, 7 = CARGO

DESCRITION: SINGLE STAGE SEPARATE TV & LV W/DROP TANKS & SINGLE CREW CABIN

DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1B	2	2	2	2	3B	5A	6A	7	7			TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb															0.0	1.0	0.0	
Electrical Checkout															0.0	1.0	0.0	
Engine Servicing															0.0	3.0	0.0	
Aerobrake TPS Repair															0.0	3.0	0.0	
Subsystem Leak And Functionals															0.0	3.0	0.0	
TCS Refurbishment															0.0	3.0	0.0	
Avionics System Verification															0.0	1.0	0.0	
															0.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.0	1.0	1.0	1.0	1.0	2.0	0.5	-	0.5	0.5			8.5	2.0	17.0	
Receiving Inspection	-	X	1.0	1.0	1.0	1.0	1.0	2.0	0.5	-	0.5	0.5			8.5	2.0	17.0	
Installation at Temporary Location	X	X	1.5	-	-	-	-	-	1.0	-	-	-			2.5	5.0	12.5	To ASF Assy Fixt for 1B, to ITA for 5A
															19.5			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	4.0	11.0	-	-	-			15.0	4.0	60.0	
STV Assembly	X	X	-	1.5	1.5	1.5	1.5	2.0	-	-	1.0	1.0			10.0	5.0	50.0	
															25.0			
Verification Phase																		
Interface Verification			-	1.0	1.0	1.0	1.0	2.0	-	1.0	-	-			7.0	1.0	7.0	
Integrated Vehicle Test			1.0	0.5	0.5	0.5	0.5	1.0	-	2.0	-	-			6.0	1.0	6.0	
Mate & Berthing Test										3.0	1.0	1.0			5.0	2.0	10.0	
															18.0			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-	-	-	-	-	-			0.0	2.0	0.0	
Cryo Top Off			-	-	-	-	-	-	-	-	-	-			0.0	2.0	0.0	
															0.0			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	-	-	-	4.0	-	-			4.0	1.0	4.0	
Vehicle Closeout			-	-	-	-	-	-	-	4.0	-	-			4.0	1.0	4.0	
Crew Ingress	X		-	-	-	-	-	-	-	0.5	-	-			0.5	1.0	0.5	
Pre Deployment C/O			-	-	-	-	-	-	-	0.5	-	-			0.5	1.0	0.5	
															9.0			
Launch Phase																		
Countdown Operations															2.5	2.0	5.0	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	29	-	-	-	-	-	2.0	2.0	-	-			33.0	3.0	99.0	
Propellant Residual Drain			4.0	-	-	-	-	-	-	-	-	-			4.0	2.0	8.0	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	-	9.0	-	-			9.0	1.0	9.0	
															46.0			
								GRAND TOTAL							120.0	N/A	309.5	

CONCEPT #4E-2A SS **ELEMENTS 1B =TV, 2 =TLI & LOI TANKS, 3B = LV, 5A = A/B, 5A = CC, 7 = CARGO**

DESCRIPTION: **SINGLE STAGE SEPARATE TV & LV W/DROP TANKS & SINGLE CREW CABIN**

DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS														COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1B	2	2	2	2	5A	6A	7	7				TOTAL SHIFTS			
Refurbishment Phase																	
Crew Module Refurb	-	-	-	-	-	-	-	-	45.0	-	-				45.0	1.0	45.0	
Electrical Checkout	-	-	2.0	-	-	-	-	1.5	-	-	-				3.5	1.0	3.5	
Engine Servicing	X	-	8.0	-	-	-	-	-	-	-	-				8.0	3.0	24.0	
Aerobrake TPS Repair	X	-	-	-	-	-	-	2.5	-	-	-				2.5	3.0	7.5	
Subsystem Leak And Functionals	X	-	6.0	-	-	-	-	-	-	-	-				6.0	3.0	18.0	
TCS Refurbishment	X	-	6.0	-	-	-	-	-	-	-	-				6.0	3.0	18.0	
Avionics System Verification	-	-	6.0	-	-	-	-	-	-	-	-				6.0	1.0	6.0	
															77.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	x	-	1.0	1.0	1.0	1.0	-	-	0.5	0.5				5.0	2.0	10.0	
Receiving Inspection	-	x	-	1.0	1.0	1.0	1.0	-	-	0.5	0.5				5.0	2.0	10.0	
Installation at Temporary Location	x	x	1.5	-	-	-	-	-	-	-	-				1.5	5.0	7.5	
															11.5			
Assembly Phase																		
Element Assembly	x	x	-	-	-	-	-	-	-	-	-				0.0	5.0	0.0	
STV Assembly	x	x	-	1.5	1.5	1.5	1.5	-	-	1.0	1.0				8.0	5.0	40.0	
															8.0			
Verification Phase																		
Interface Verification			-	1.0	1.0	1.0	1.0	-	-	-	-				4.0	1.0	4.0	
Integrated Vehicle Test			1.0	0.5	0.5	0.5	0.5	-	2.0	-	-				5.0	1.0	5.0	
Mate & Berthing Test			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
															9.0			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
Cryo Top Off			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
															0.0			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	-	-		-	4.0				4.0	1.0	4.0	
Vehicle Closeout			-	-	-	-	-	-		-	4.0				4.0	1.0	4.0	
Crew Ingress	x		-	-	-	-	-	-		-	0.5				0.5	1.0	0.5	
Pre Deployment C/O			-	-	-	-	-	-		-	0.5				0.5	1.0	0.5	
															9.0			
Launch Phase																		
Countdown Operations															2.5	2.0	5.0	
															2.5			
De-Integration Phase																		
Post Flight Inspection	x	x	29	-	-	-	-	2.0	2.0	-	-				33.0	3.0	99.0	
Propellant Residual Drain	-		4.0	-	-	-	-	-	-	-	-				4.0	2.0	8.0	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	9.0	-	-				9.0	1.0	9.0	
															46.0			
														GRAND TOTALS	163.0	n/a	328.5	

CONCEPT #4E-2B **ELEMENTS 1B =TV, 2 =TLI & LOI TANKS, 3B = LV, 5A = A/B, 6B = TVCC, 6C = LVCC, 7 = CARGO**

DESCRIPTION **SINGLE STAGE SEPARATE TV & LV W/DROP TANKS & DUAL CREW CABIN**

DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1B	2	2	2	2	3B	5A	6B	6C	7	7		TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb															0.0	1.0	0.0	
Electrical Checkout															0.0	1.0	0.0	
Engine Servicing															0.0	3.0	0.0	
Aerobrake TPS Repair															0.0	3.0	0.0	
Subsystem Leak And Functionals															0.0	3.0	0.0	
TCS Refurbishment															0.0	3.0	0.0	
Avionics System Verification															0.0	1.0	0.0	
															0.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.0	1.0	1.0	1.0	1.0	2.0	0.5	-	-	0.5	0.5		8.5	2.0	17.0	
Receiving Inspection	-	X	1.0	1.0	1.0	1.0	1.0	2.0	0.5	-	-	0.5	0.5		8.5	2.0	17.0	
Installation at Temporary Location	X	X	1.5	-	-	-	-	-	1.0	-	-	-	-		2.5	5.0	12.5	To ASF Assy Fixt. for 1B & ITA for 5A
															19.5			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	4.0	11.0	-	-	-	-		15.0	5.0	75.0	
STV Assembly	X	X	-	1.5	1.5	1.5	1.5	2.0	-	-	-	1.0	1.0		10.0	5.0	50.0	
															25.0			
Verification Phase																		
Interface Verification			-	1.0	1.0	1.0	1.0	2.0	-	-	-	-	-		6.0	1.0	6.0	
Integrated Vehicle Test			1.0	0.5	0.5	0.5	0.5	1.0	-	2.0	2.0	-	-		8.0	1.0	8.0	
Mate & Berthing Test			-	-	-	-	-	-	-	5.0	-	1.0	1.0		7.0	2.0	14.0	
															21.0			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-	-	-	-	-	-	-		0.0	2.0	0.0	
Cryo Top Off			-	-	-	-	-	-	-	-	-	-	-		0.0	2.0	0.0	
															0.0			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	-	-	-	4.0	4.0	-	-		8.0	1.0	8.0	
Vehicle Closeout			-	-	-	-	-	-	-	4.0	4.0	-	-		8.0	1.0	8.0	
Crew Ingress	X		-	-	-	-	-	-	-	0.5	0.5	-	-		1.0	1.0	1.0	
Pre Deployment C/O			-	-	-	-	-	-	-	0.5	0.5	-	-		1.0	1.0	1.0	
															18.0			
Launch Phase																		Requires OMV
Countdown Operations															2.5	2.0	5.0	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	29	-	-	-	-	-	2.0	2.0	-	-	-		33.0	3.0	99.0	
Propellant Residual Drain			4.0	-	-	-	-	-	-	-	-	-	-		4.0	2.0	8.0	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	-	9.0	-	-	-		9.0	1.0	9.0	
															46.0			
										GRAND TOTALS					132.0	N/A	338.5	

CONCEPT #4E-2B SS **ELEMENTS 1B =TV, 2 =TLI & LOI TANKS, 3B = LV, 5A = A/B, 5A = CC, 6B = TVCC, 6C = LVCC, 7 = CARGO**

DESCRIPTION: SINGLE STAGE SEPARATE TV & LV W/DROP TANKS & DUAL CREW CABIN **DATE 5/31/90**

COMPLEXITY FACTORS	RESOURCES - SHIFTS														COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1B	2	2	2	2	5A	6B	7	7				TOTAL SHIFTS			
Refurbishment Phase																		
Crew Module Refurb	-	-	-	-	-	-	-	-	45	-	-				45.0	1.0	45.0	
Electrical Checkout	-	-	2.0	-	-	-	-	1.5	-	-	-				3.5	1.0	3.5	
Engine Servicing	X	-	8.0	-	-	-	-	-	-	-	-				8.0	3.0	24.0	
Aerobrake TPS Repair	X	-	-	-	-	-	-	2.5	-	-	-				2.5	3.0	7.5	
Subsystem Leak And Functionals	X	-	6.0	-	-	-	-	-	-	-	-				6.0	3.0	18.0	
TCS Refurbishment	X	-	6.0	-	-	-	-	-	-	-	-				6.0	3.0	18.0	
Avionics System Verification	-	-	6.0	-	-	-	-	-	-	-	-				6.0	1.0	6.0	
															77.0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	-	1.0	1.0	1.0	1.0	-	-	0.5	0.5				5.0	2.0	10.0	
Receiving Inspection	-	X	-	1.0	1.0	1.0	1.0	-	-	0.5	0.5				5.0	2.0	10.0	
Installation at Temporary Location	X	X	1.5	-	-	-	-	-	-	-	-				1.5	5.0	7.5	
															11.5			
Assembly Phase																		
Element Assembly			-	-	-	-	-	-	-	-	-				0.0	5.0	0.0	
STV Assembly	X	X	-	1.5	1.5	1.5	1.5	-	-	1.0	1.0				8.0	5.0	40.0	
															8.0			
Verification Phase																		
Interface Verification			-	1.0	1.0	1.0	1.0	-	-	-	-				4.0	1.0	4.0	
Integrated Vehicle Test			1.0	0.5	0.5	0.5	0.5	-	2.0	-	-				5.0	1.0	5.0	
Mate & Berthing Test			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
															9.0			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
Cryo Top Off			-	-	-	-	-	-	-	-	-				0.0	2.0	0.0	
															0.0			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	-	-	4.0	-	-				4.0	1.0	4.0	
Vehicle Closeout			-	-	-	-	-	-	4.0	-	-				4.0	1.0	4.0	
Crew Ingress	X		-	-	-	-	-	-	0.5	-	-				0.5	1.0	0.5	
Pre Deployment C/O			-	-	-	-	-	-	0.5	-	-				0.5	1.0	0.5	
															9.0			
Launch Phase																		
Countdown Operations															2.5	2.0	5.0	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	29	-	-	-	-	2.0	2.0	-	-				33.0	3.0	99.0	
Propellant Residual Drain	-		4.0	-	-	-	-	-	-	-	-				4.0	2.0	8.0	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	9.0	-	-				9.0	1.0	9.0	
															46.0			
								GRAND TOTALS							163.0	N/A	328.5	

CONCEPT #4E-3A **ELEMENTS: 1c = TLI Stage, 1E = LOI Stage, 3B = LV, 5A = A/B, 6A = CC, 7 = Cargo**

DESCRIPTION: Multistage TV & Separate LV - Single Crew Cab

DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1C	1E	3B	5A	6A	7.0	7.0						TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb	-	-	-	-	-	-	-	-	-						0	1	0	
Electrical Checkout	-	-	-	-	-	-	-	-	-						0	1	0	
Engine Servicing	-	-	-	-	-	-	-	-	-						0	3	0	
Aerobrake TPS Repair	-	-	-	-	-	-	-	-	-						0	3	0	
Subsystem Leak And Functionals	-	-	-	-	-	-	-	-	-						0	3	0	
TCS Refurbishment	-	-	-	-	-	-	-	-	-						0	3	0	
Avionics System Verification	-	-	-	-	-	-	-	-	-						0	1	0	
															0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.5	1.5	2.0	0.5	-	0.5	0.5						6.5	2	13	
Receiving Inspection	-	X	1.0	1.0	2.0	0.5	-	0.5	0.5						5.5	2	11	
Installation at Temporary Location	X	X	2.0	2.0	-	1.0	-	-	-						5	5	25	
															17			
Assembly Phase																		
Element Assembly	x	x	-	-	4.0	11.0	-	-	-						15	4	60	
STV Assembly	x	x	-	2.0	2.0	-	-	1.0	1.0						6	5	30	
															21			
Verification Phase																		
Interface Verification			-	1.0	2.0	-	1.0	-	-						4	1	4	
Integrated Vehicle Test			1.0	1.0	1.0	-	2.0	-	-						5	1	5	
Mate & Berthing Test			-	-	-	-	3.0	1.0	1.0						5	2	10	
															14			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-	-	-						0	2	0	
Cryo Top Off			-	-	-	-	-	-	-						0	2	0	
															0			
Closeout Phase																		
Fluids Top Off			-	-	-	-	4.0	-	-						4	1	4	
Vehicle Closeout			-	-	-	-	4.0	-	-						4	1	4	
Crew Ingress	X		-	-	-	-	0.5	-	-						0.5	1	0.5	
Pre Deployment C/O			-	-	-	-	0.5	-	-						0.5	1	0.5	
															9			
Launch Phase																		
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	-	29.0	-	2.0	2.0	-	-						33	3	99	
Propellant Residual Drain			-	4.0	-	-	-	-	-						4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	9.0	-	-						9	1	9	
															46			
									GRAND TOTALS						109.5	n/a	288	

CONCEPT # 4E-3A SS **ELEMENTS: IC = TLI Stage, 1E = LOI Stage, 3B = LV, 5A = A/B, 6A = CC, 7 = Cargo, & 8 = Cryo Tanker/Xfer system**

DESCRIPTION: Multistage TV & Separate LV - Single Crew Cab

DATE 5/30/90

COMPLEXITY FACTORS CANDIDATE TASK (Select Only As Appropriate)	RESOURCES - SHIFTS														TOTAL SHIFTS	COMPLEXITY FACTOR	TOTAL COMPLEXITY	COMMENTS
	EVA	RMS	1C	1E	3B	5A	6A	7.0	7.0	8.0								
Refurbishment Phase																		
Crew Module Refurb			-	-	-	-	45.0	-	-	-					45	1	45	
Electrical Checkout			-	2.0	-	1.5	-	-	-	-					3.5	1	3.5	
Engine Servicing	X		-	8.0	-	-	-	-	-	-					8	3	24	
Aerobrake TPS Repair	X		-	-	-	2.5	-	-	-	-					2.5	3	7.5	
Subsystem Leak And Functionals	X		-	6.0	-	-	-	-	-	-					6	3	18	
TCS Refurbishment	X		-	6.0	-	-	-	-	-	-					6	3	18	
Avionics System Verification			-	6.0	-	-	-	-	-	-					6	1	6	
															77			
Hardware Delivery Phase																		
Delivery Vehicle Offloading		X	1.5	-	-	-	-	0.5	0.5	1.0					3.5	2	7	
Receiving Inspection		X	1.0	-	-	-	-	0.5	0.5	1.0					3	2	6	
Installation at Temporary Location	X	X	2.0	2.0	-	-	-	-	-	1.5					5.5	5	27.5	Returning LOI stage at ASF for refurb then move to ITA during TLI stage arival.
															12			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	-	-	-					0	4	0	
STV Assembly	X	X	-	1.0	-	-	-	1.0	1.0	2.0					5	5	25	Tanker I/F connection
															5			
Verification Phase																		
Interface Verification			-	1.0	-	-	-	-	-	-					1	1	1	
Integrated Vehicle Test			1.0	1.0	-	-	2.0	-	-	-					4	1	4	
Mate & Berthing Test			-	-	-	-	-	-	-	-					0	2	0	
															5			
Propellant Servicing Phase																		
Cryo Servicing			-	2.0	-	-	-	-	-	-					2	2	4	
Cryo Top Off			-	-	-	-	-	-	-	-					0	2	0	
															2			
Closeout Phase																		
Fluids Top-Off			-	-	-	-	4.0	-	-	-					4	1	4	
Vehicle Closeout			-	-	-	-	4.0	-	-	0.5					4.5	1	4.5	Tanker disconnect
Crew Ingress	X		-	-	-	-	0.5	-	-						0.5	1	0.5	
Pre Deployment C/O			-	-	-	-	0.5	-	-						0.5	1	0.5	
															9.5			
Launch Phase																		
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	-	###	-	2.0	2.0	-	-						33	3	99	
Propellant Residual Drain			-	4.0	-	-	-	-	-						4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	9.0	-	-						9	1	9	
															46			
														GRAND TOTALS	159	n/a	327	

CONCEPT #4E-3B ELEMENTS: 1c = TLI Stage, 1E = LOI Stage, 3B = LV, 5A = A/B, 6B = CC, 6C = CC, 7 = Cargo

DESCRIPTION: Multistage TV & Separate LV - Dual Crew Cabs DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS															COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1C	1E	3B	5A	6B	6C	7.0	7.0					TOTAL SHIFTS			
Refurbishment Phase																		
Crew Module Refurb	-	-	-	-	-	-	-	-	-	-					0	1	0	
Electrical Checkout	-	-	-	-	-	-	-	-	-	-					0	1	0	
Engine Servicing	-	-	-	-	-	-	-	-	-	-					0	3	0	
Aerobrake TPS Repair	-	-	-	-	-	-	-	-	-	-					0	3	0	
Subsystem Leak And Functionals	-	-	-	-	-	-	-	-	-	-					0	3	0	
TCS Refurbishment	-	-	-	-	-	-	-	-	-	-					0	3	0	
Avionics System Verification	-	-	-	-	-	-	-	-	-	-					0	1	0	
															0			
Hardware Delivery Phase																		
Delivery Vehicle Offloading	-	X	1.5	1.5	2.0	0.5	-	-	0.5	0.5					6.5	2	13	
Receiving Inspection	-	X	1.0	1.0	2.0	0.5	-	-	0.5	0.5					5.5	2	11	
Installation at Temporary Location	X	X	2.0	2.0	-	1.0	-	-	-	-					5	5	25	
															17			
Assembly Phase																		
Element Assembly	x	x	-	-	4.0	11.0	-	-	-	-					15	4	60	
STV Assembly	x	x	-	2.0	2.0	-	-	-	1.0	1.0					6	5	30	
															21			
Verification Phase																		
Interface Verification			-	1.0	2.0	-	-	-	-	-					3	1	3	
Integrated Vehicle Test			1.0	1.0	1.0	-	2.0	2.0	-	-					7	1	7	
Mate & Berthing Test			-	-	-	-	5.0	-	1.0	1.0					7	2	14	
															17			
Propellant Servicing Phase																		
Cryo Servicing			-	-	-	-	-		-	-					0	2	0	
Cryo Top Off			-	-	-	-	-		-	-					0	2	0	
															0			
Closeout Phase																		
Fluids Top Off			-	-	-	-	4.0	4.0	-	-					8	1	8	
Vehicle Closeout			-	-	-	-	4.0	4.0	-	-					8	1	8	
Crew Ingress	X		-	-	-	-	0.5	0.5	-	-					1	1	1	
Pre Deployment C/O			-	-	-	-	0.5	0.5	-	-					1	1	1	
															18			
Launch Phase																		
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	-	29.0	-	2.0	2.0		-	-					33	3	99	
Propellant Residual Drain			-	4.0	-	-	-		-	-					4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	9.0		-	-					9	1	9	
															46			
														GRAND TOTALS	121.5	n/a	302	

CONCEPT # 4E-3A SS **ELEMENTS: 1C = TLI Stage, 1E = LOI Stage, 5A = A/B, 6B = CC, 7 = Cargo, & 8 = Cryo Tanker/Transfer System**

DESCRIPTION: Multistage TV & Separate LV - Dual Crew Cabs **DATE 5/31/90**

COMPLEXITY FACTORS	RESOURCES - SHIFTS																	
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	1C	1E	5A	6B	7.0	7.0	8.0						TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																		
Crew Module Refurb	-	-	-	-	-	45.0	-	-	-						45	1	45	
Electrical Checkout	-	-	-	2.0	1.5	-	-	-	-						3.5	1	3.5	
Engine Servicing	x	-	-	8.0	-	-	-	-	-						8	3	24	
Aerobrake TPS Repair	x	-	-	-	2.5	-	-	-	-						2.5	3	7.5	
Subsystem Leak And Functionals	x	-	-	6.0	-	-	-	-	-						6	3	18	
TCS Refurbishment	x	-	-	6.0	-	-	-	-	-						6	3	18	
Avionics System Verification	-	-	-	6.0	-	-	-	-	-						6	1	6	
															77			
Hardware Delivery Phase																		
Delivery Vehicle Offloading		X	1.5	-	-	-	0.5	0.5	1.0						3.5	2	7	
Receiving Inspection		X	1.0	-	-	-	0.5	0.5	1.0						3	2	6	
Installation at Temporary Location	X	X	2.0	2.0	-	-	-	-	1.5						5.5	5	27.5	
															12			
Assembly Phase																		
Element Assembly	X	X	-	-	-	-	-	-	-						0	4	0	
STV Assembly	X	X	-	1.0	-	-	1.0	1.0	2.0						5	5	25	Cryo Tanker I/F connect
															5			
Verification Phase																		
Interface Verification			-	1.0	-	-	-	-	-						1	1	1	
Integrated Vehicle Test			1.0	1.0	-	2.0	-	-	-						4	1	4	
Mate & Berthing Test			-	-	-	-	-	-	-						0	2	0	
															5			
Propellant Servicing Phase																		
Cryo Servicing			-	2.0	-	-	-	-	-						2	2	4	
Cryo Top Off			-	-	-	-	-	-	-						0	2	0	
															2			
Closeout Phase																		
Fluids Top Off			-	-	-	4.0	-	-	-						4	1	4	
Vehicle Closeout			-	-	-	4.0	-	-	0.5						4.5	1	4.5	Tanker Disconnect
Crew Ingress	X		-	-	-	0.5	-	-	-						0.5	1	0.5	
Pre Deployment C/O			-	-	-	0.5	-	-	-						0.5	1	0.5	
															9.5			
Launch Phase																		
Countdown Operations															2.5	2	5	
															2.5			
De-Integration Phase																		
Post Flight Inspection	X	X	-	29.0	2.0	2.0	-	-	-						33	3	99	
Propellant Residual Drain			-	4.0	-	-	-	-	-						4	2	8	
Crew Module/Return Cargo Destow			-	-	-	9.0	-	-	-						9	1	9	
															46			
														GRAND TOTALS	159	N/A	327	

CONCEPT # 4E-5B ELEMENTS 2 = TLI/LOI Tanks, 2B = A/B Tanks, 4B = TLV, 5B = A/B, 6D = C.C., 7 = Cargo

DESCRIPTION: Single Propulsion Stage Combined Vehicle w/Drop Tanks

DATE 5/30/90

COMPLEXITY FACTORS	RESOURCES - SHIFTS																			
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	2	2	2	2	2A	2A	4B	5B	6D	7	7				TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
Refurbishment Phase																				
Crew Module Refurb																	0	1	0	
Electrical Checkout																	0	1	0	
Engine Servicing																	0	3	0	
Aerobrake TPS Repair																	0	3	0	
Subsystem Leak And Functionals																	0	3	0	
TCS Refurbishment																	0	3	0	
Avionics System Verification																	0	1	0	
																	0			
Hardware Delivery Phase																				
Delivery Vehicle Offloading		X	1.0	1.0	1.0	1.0	0.5	0.5	1.0	0.5	-	0.5	0.5				7.5	2	15	
Receiving Inspection		X	1.0	1.0	1.0	1.0	0.5	0.5	1.0	0.5	-	0.5	0.5				7.5	2	15	
Installation at Temporary Location	X	X	-	-	-	-	-	-	1.5	-	-	-	-				1.5	5	7.5	
																	16.5			
Assembly Phase																				
Element Assembly	X	X	-	-	-	-	1.0	1.0	-	6.5	-	-	-				8.5	4	34	
STV Assembly	X	X	1.5	1.5	1.5	1.5	-	-	-	1.0	-	1.0	1.0				9	5	45	
																	17.5			
Verification Phase																				
Interface Verification			1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	-				7	1	7	
Integrated Vehicle Test			0.5	0.5	0.5	0.5	-	-	1.0	1.0	2.0	-	-				6	1	6	
Mate & Berthing Test			-	-	-	-	-	-	3.0	-	-	-	-				3	2	6	Demate/mate to A/B
																	16			
Propellant Servicing Phase																				
Cryo Servicing			-	-	-	-	-	-	-	-	-	-	-				0	2	0	
Cryo Top Off			-	-	-	-	-	-	-	-	-	-	-				0	2	0	
																	0			
Closeout Phase																				
Fluids Top-Off			-	-	-	-	-	-	-	-	4.0	-	-				4	1	4	
Vehicle Closeout			-	-	-	-	-	-	-	-	4.0	-	-				4	1	4	
Crew Ingress			-	-	-	-	-	-	-	-	0.5	-	-				0.5	1	0.5	
Pre Deployment C/O			-	-	-	-	-	-	-	-	0.5	-	-				0.5	1	0.5	
																	9			
Launch Phase																				
Countdown Operations																	2.5	2	5	
																	2.5			
De-Integration Phase																				
Post Flight Inspection	X	X	-	-	-	-	-	-	29.0	1.0	2.0	-	-				32	3	96	
Propellant Residual Drain			-	-	-	-	•	•	4.0	-	-	-	-				4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	-	-	9.0	-	-				9	1	9	
																	45			
GRAND TOTALS																	106.5	N/A	262.5	

CONCEPT #4E-5B SS **ELEMENTS: 2 = TLI/LOI Tanks, 2A = A/B Tanks, 4B = TLV, 5B = A/B, 6D = CC, 7 = Cargo**

DATE 5/30/90

DESCRIPTION Single Propulsion Stage Combined Vehicle w/Drop Tanks

COMPLEXITY FACTORS	RESOURCES - SHIFTS																TOTAL SHIFTS	COMPLEXITY FACTOR	TASK COMPLEXITY	COMMENTS
CANDIDATE TASK (Select Only As Appropriate)	EVA	RMS	2.0	2.0	2.0	2.0	2A	2A	4B	5B	6D	7.0	7.0							
Refurbishment Phase																				
Crew Module Refurb	-	-	-	-	-	-	-	-	-	-	45.0	-	-				45	1	45	
Electrical Checkout	-	-	-	-	-	-	-	-	2.0	1.0	-	-	-				3	1	3	Simplified Aerobrake
Engine Servicing	x	-	-	-	-	-	-	-	8.0	-	-	-	-				8	3	24	
Aerobrake TPS Repair	x	-	-	-	-	-	-	-	-	1.5	-	-	-				1.5	3	4.5	Simplified Aerobrake
Subsystem Leak And Functionals	x	-	-	-	-	-	-	-	6.0	-	-	-	-				6	3	18	
TCS Refurbishment	x	-	-		-	-	-	-	6.0	-	-	-	-				6	3	18	
Avionics System Verification	-	-		-	-	-	-	-	6.0		-	-	-				6	1	6	
																	75.5			
Hardware Delivery Phase																				
Delivery Vehicle Offloading	-	X	1.0	1.0	1.0	1.0	0.5	0.5	-	-	-	0.5	0.5				6	2	12	
Receiving Inspection	-	X	1.0	1.0	1.0	1.0	0.5	0.5	-	-	-	0.5	0.5				6	2	12	
Installation at Temporary Location	X	X	-	-	-	-	-	-	1.5	-	-	-	-				1.5	5	7.5	
																	13.5			
Assembly Phase																				
Element Assembly			-	-	-	-	1.0	1.0	-	-	-	-	-				2	4	8	
STV Assembly	X	X	1.5	1.5	1.5	1.5	-	-	-	-	-	1.0	1.0				8	5	40	
																	10			
Verification Phase																				
Interface Verification			1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-				6	1	6	
Integrated Vehicle Test			0.5	0.5	0.5	0.5	-	-	1.0	1.0	2.0	-	-				6	1	6	
Mate & Berthing Test			-	-	-	-	-	-	-	-	-	-	-				0	2	0	
																	12			
Propellant Servicing Phase																				
Cryo Servicing			-	-	-	-	-	-	-	-	-	-	-				0	2	0	
Cryo Top Off			-	-	-	-	-	-	-	-	-	-	-				0	2	0	
																	0			
Closeout Phase																				
Fluids Top-Off			-	-	-	-	-	-	-	-	4.0	-	-				4	1	4	
Vehicle Closeout			-	-	-	-	-	-	-	-	4.0	-	-				4	1	4	
Crew Ingress			-	-	-	-	-	-	-	-	0.5	-	-				0.5	1	0.5	
Pre Deployment C/O			-	-	-	-	-	-	-	-	0.5	-	-				0.5	1	0.5	
																	9			
Launch Phase																				
Countdown Operations																	2.5	2	5	
																	2.5			
De-Integration Phase																				
Post Flight Inspection			-	-	-	-	-	-	29.0	1.0	2.0	-	-				32	3	96	Simplified Aerobrake
Propellant Residual Drain			-	-	-	-	•	•	4.0	-	-	-	-				4	2	8	
Crew Module/Return Cargo Destow			-	-	-	-	-	-	-	-	9.0	-	-				9	1	9	
																	45			
																GRAND TOTAL	167.5	N/A	337	

STV/LTS Phase II On-Orbit Operation Evaluations

Overall Assumptions - All Configurations

Overall Assumptions - All Configurations

Note: Timelines are based on these assumptions
(Any change to assumptions will require timeline adjustment)

- ☐ Timelines assume all undefined design details operate trouble free to produce the intended result
- ☐ All Aerobrake (A/B) configurations have identical subsystems including docking features:
  - ☐ A/B subsystem checkout is not timelined (Not identified and not a discriminator)
  - ☐ No A/B subsystem assembly is required on-orbit (e.g., No electrical or fluid connections across on-orbit field joints except as follows:
    - ☐ Timelines accommodate the connection of two redundant electrical connectors per detachable segment.)
- ☐ Any additional TV monitoring and/or lighting capability required by individual scenarios (not provided by the SSRMS or SPDM) is set up pre-task (not timelined)
- ☐ All configurations require launch restraints and/or FSE/OSE to hold segments together during launch
  - ☐ Release of launch restraints is by remote control
    - ☐ No special steps by SSRMS or SPDM required
    - ☐ Control from SSF is through umbilicals
      - ☐ Umbilical hook-up is timelined

Overall Assumptions - All Configurations (Cont)

- ☐ Control and monitoring of the A/B functions is through a single ASF to A/B umbilical
  - ☐ The umbilical is designed to permit a minimum A/B rotation of 315 degrees while connected
- ✓ ☐ It is highly desirable to maintain ASF Doors and Segments closed during assembly operations to protect the aerobrake from micrometeorite/debris damage and a constantly changing thermal environment.
- ☐ ASF Doors and Segments must remain open during all periods when the SSRMS supports A/B assembly
- ☐ Whenever possible, an SPDM mounted on a dedicated Power Data Grapple Fixture (PDGF) within the ASF is used to perform all assembly and inspection Functions
  - ☐ ASF may be closed during SPDM only assembly
  - ☐ Special end effectors as required to support assembly will be stored on the SPDM body pre-task
- ✓ ☐ Special adapter OSE structures are provided as required to attach A/B elements to the MSC for transportation.
- ✓ ☐ All A/B configurations have a special passive female adapter at their forward (TPS) center to interface with the Assembly and Servicing Facility (ASF) Aerobrake Assembly and attach Fixture (AAAF) active probe
  - ☐ Closeout of this AB/AAAF adapter TPS discontinuity is not timelined

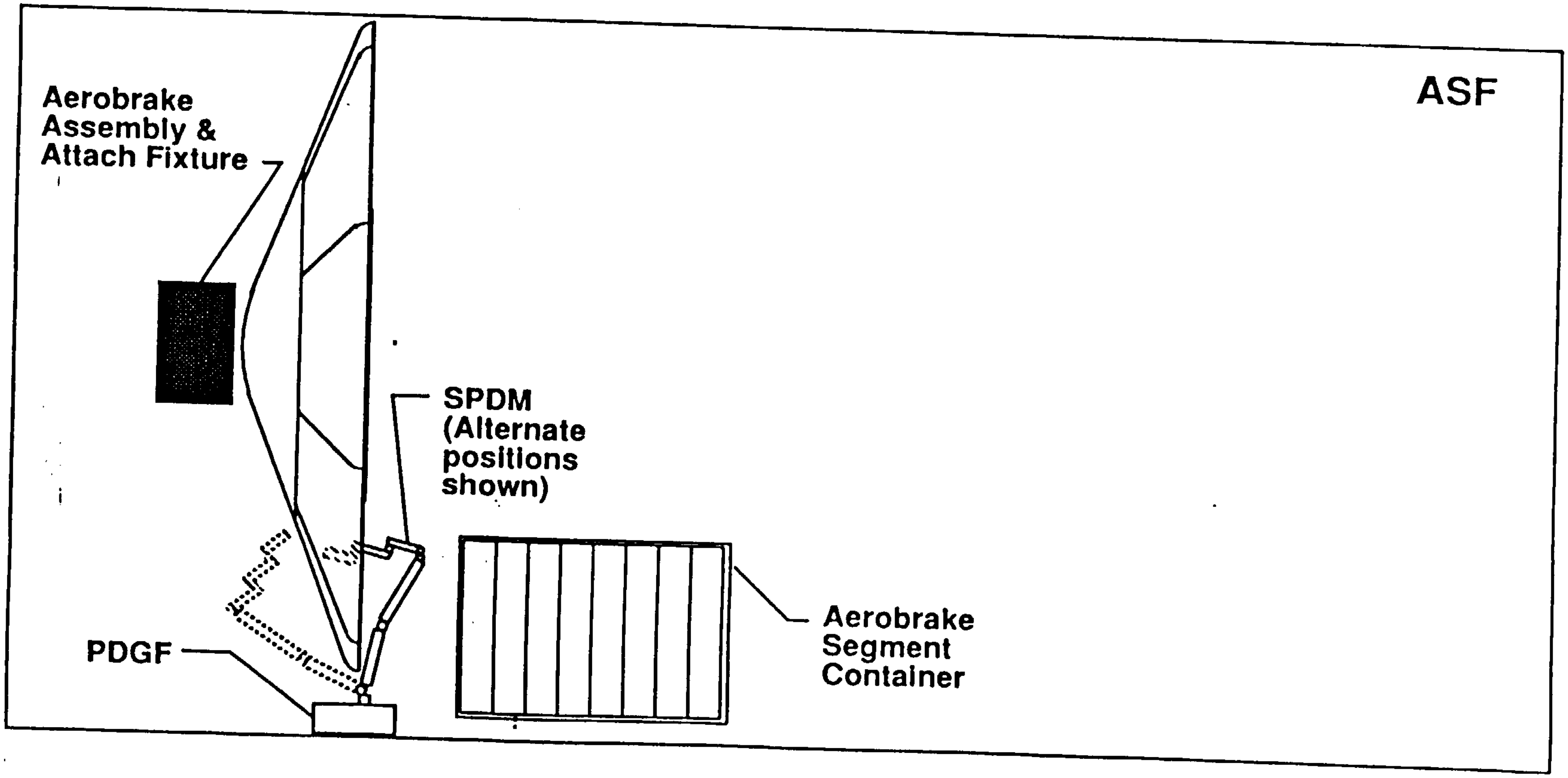
✓ Indicates that this assumption is also a recomendation

Overall Assumptions - All Configurations (Cont)

✓ ☐ A grapple fixture is located on the aft (structure) side of every aerobrake segment

  - ☐ The launch carrier vehicle is docked at the SSF ITA with cargo doors open prior to timeline start

Assumed ASF Facility Accomodations Configuration



* This generic configuration is not applicable to F-1 & F-1A Aerobrakes

Overall Assumptions - All Configurations (Cont)

- ☐ In order to make direct one to one comparisons between all configuration scenarios, the following MSFC Rigid A/B Groundrules and Assumptions have been adopted for all scenarios
  - ☐ Turntable will hold the aerobrake to facilitate robotic assembly with only one RMS. Assembly operations are limited to available SSF robotic capabilities. RMS maneuvers not limited by hanger.

    Note: "Hanger" is assumed to be the Assembly and Servicing Facility (ASF) without Mobile Manipulators. The "Turntable" is assumed to be the ASF Aerobrake Assembly And Attach Fixture without any robotic capabilities.
  - ☐ Crew. robotic arm , lights, cameras, etc. are in place on SSF and ready for assembly operations.
  - ☐ Aerobrake segments are stored where the robotic arm can grapple each one and assemble it without translation.
  - ☐ EVA required for backup of all robotic tasks, but will be used for contingency only
  - ☐ Segment design should consider tolerance buildup and loading for space environment

Recommendations - All Configurations

Recommendations - All Configurations

- ☐ Incorporate all checked (✓) general assumptions
- ☐ Design AAAF as a specialized robot to assemble the selected A/B design
  - ☐ Provide AAAF with ground controlled and monitored inspection capability including multiple TV cameras to allow inspection/documentation of the entire A/B TPS surface in a single rotation/pass (1 Hr. max)
  - ☐ Provide at least one Remote Manipulator within the ASF to allow ASF closure during assembly and to free up the MSC for SSF oriented tasks
- ☐ Design A/B specifically for telerobotic assembly
- ☐ Develop AAAF to A/B interface to minimize TPS closeout after disconnect

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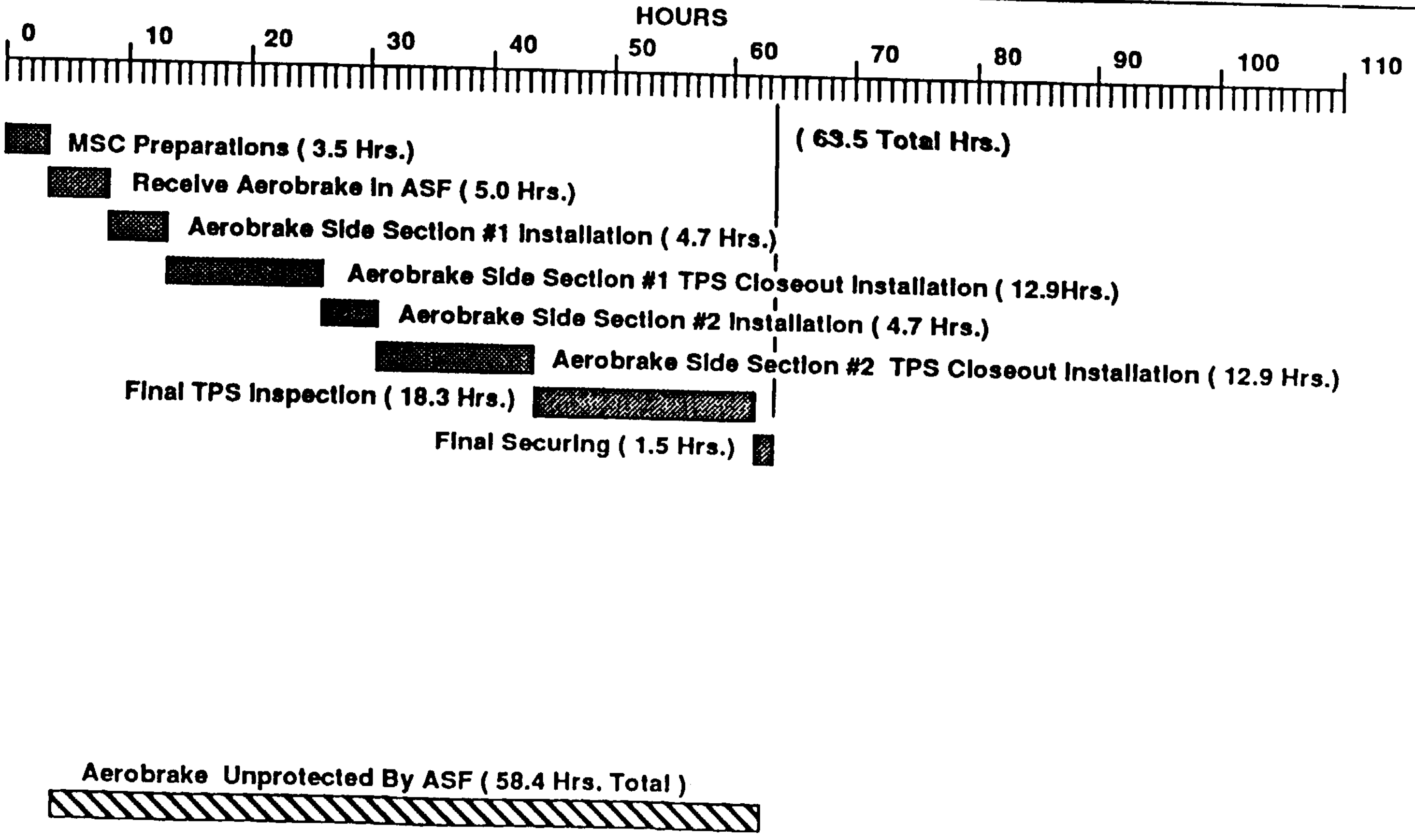
MMC R-2 Aerobrake Assembly Timeline



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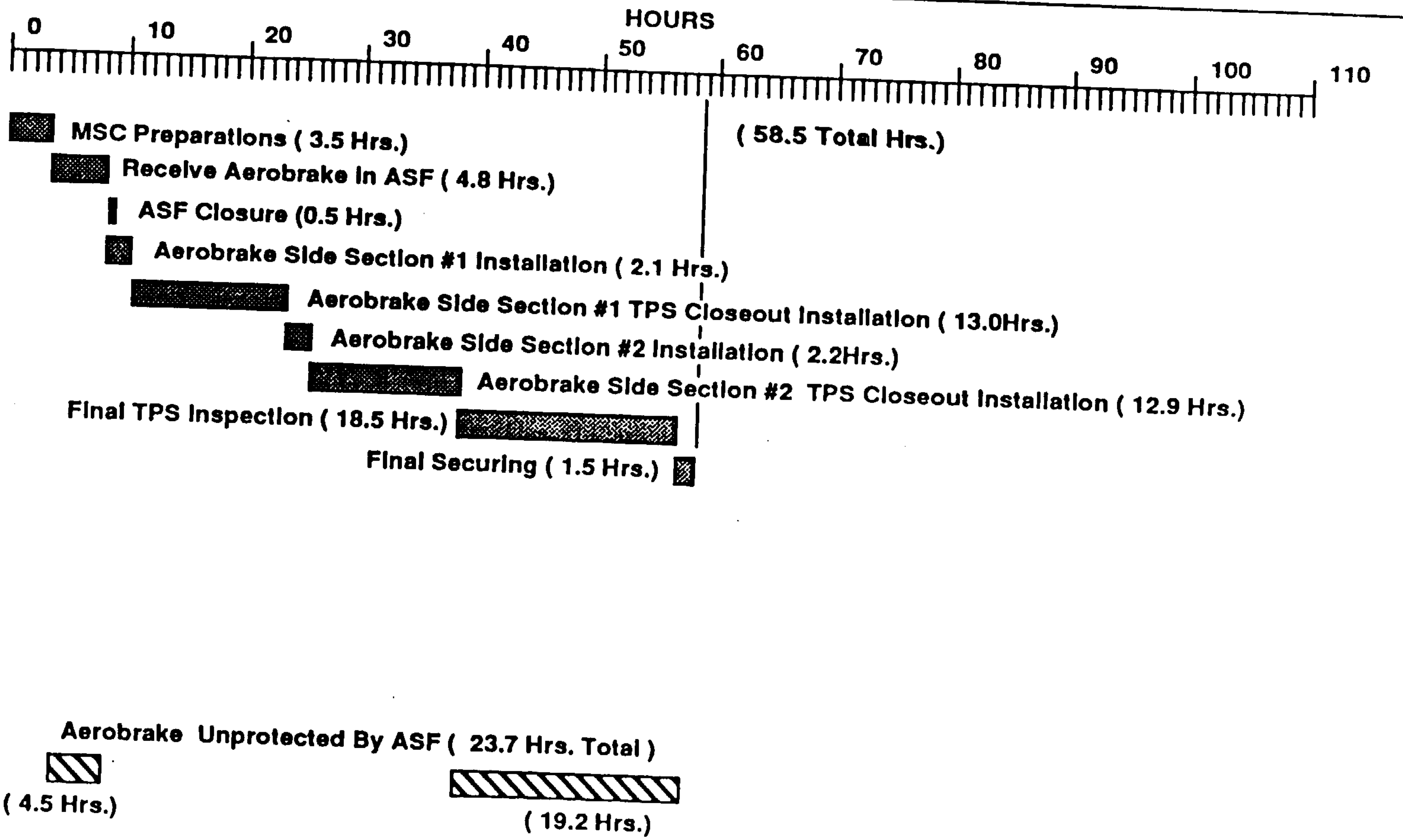
MMC R-3 Aerobrake Assembly Timeline



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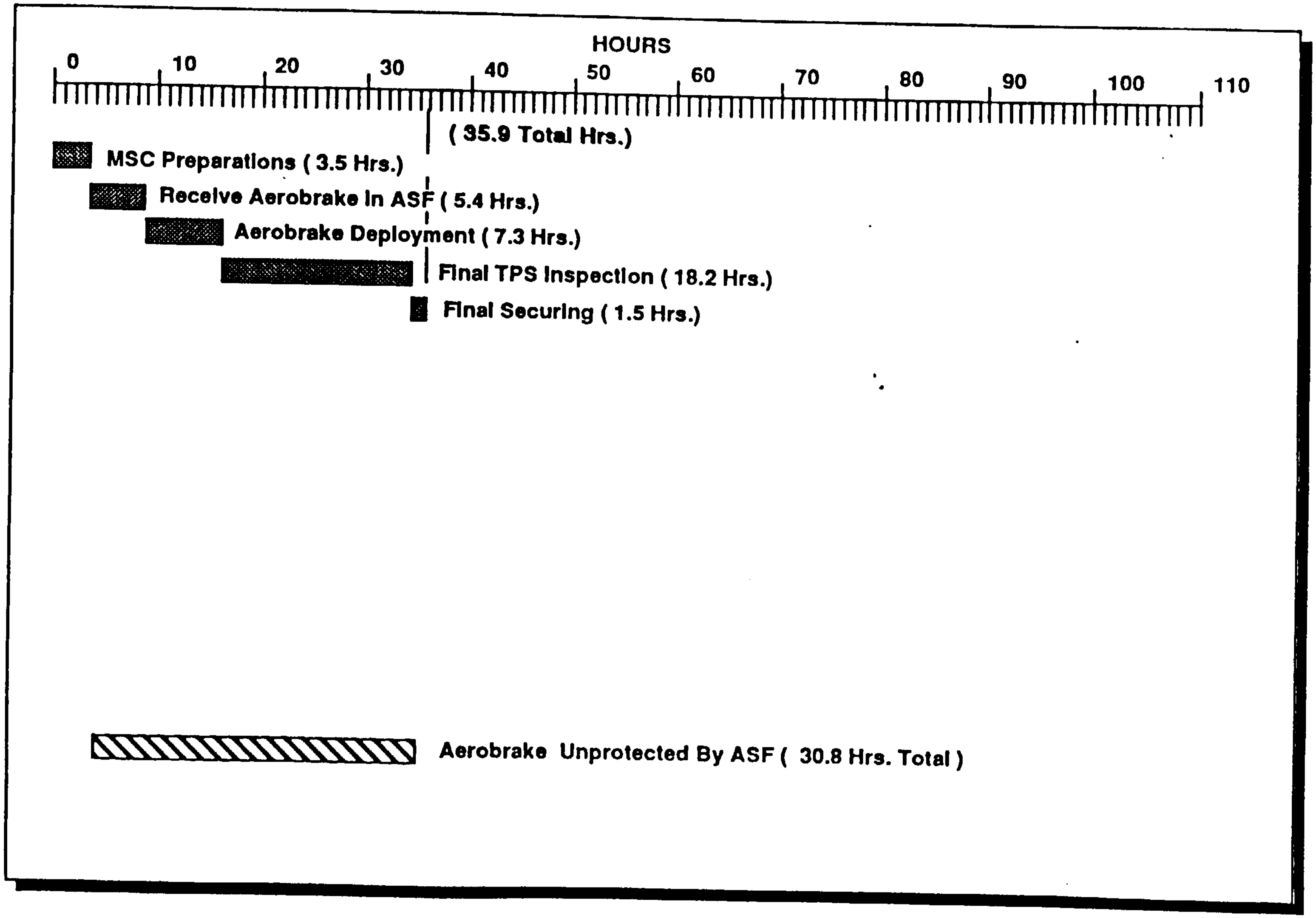
MMC F-1 Aerobrake Assembly Timeline



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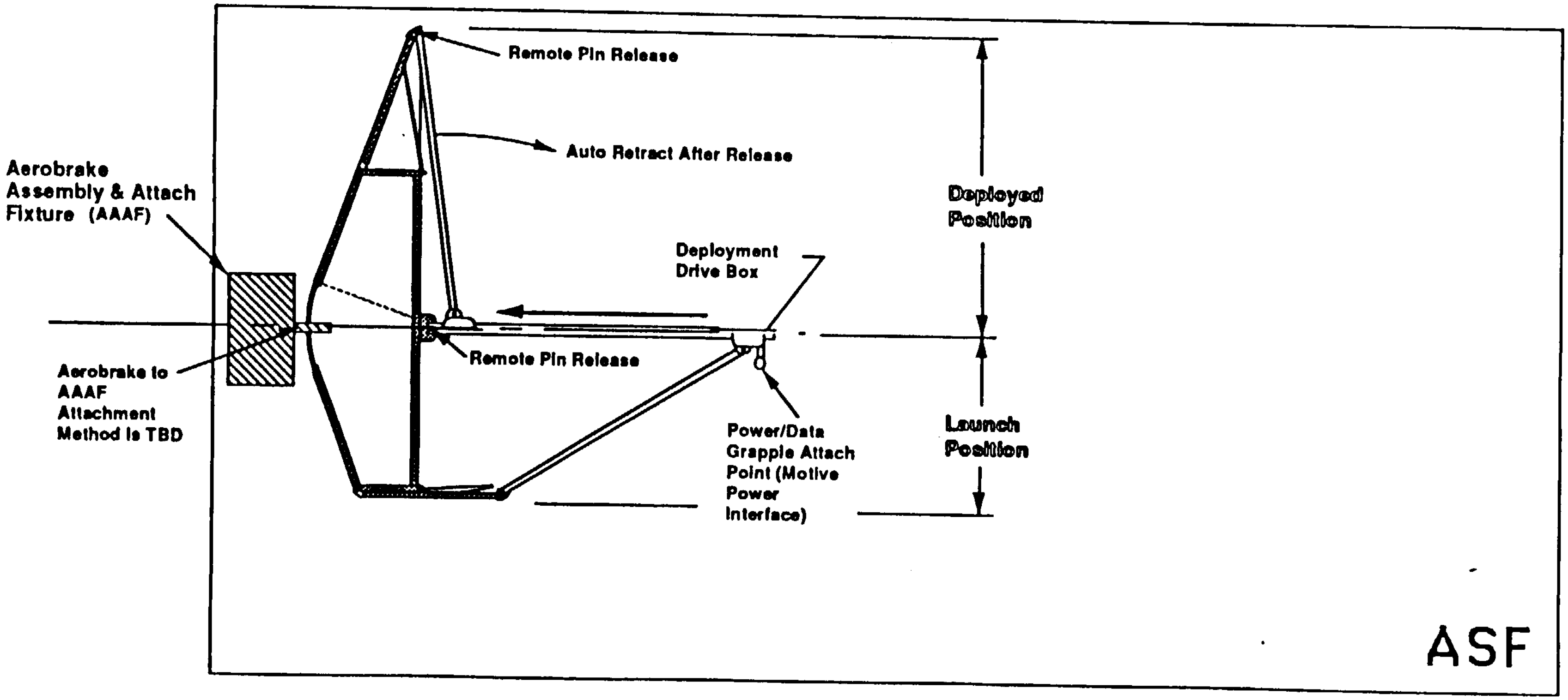
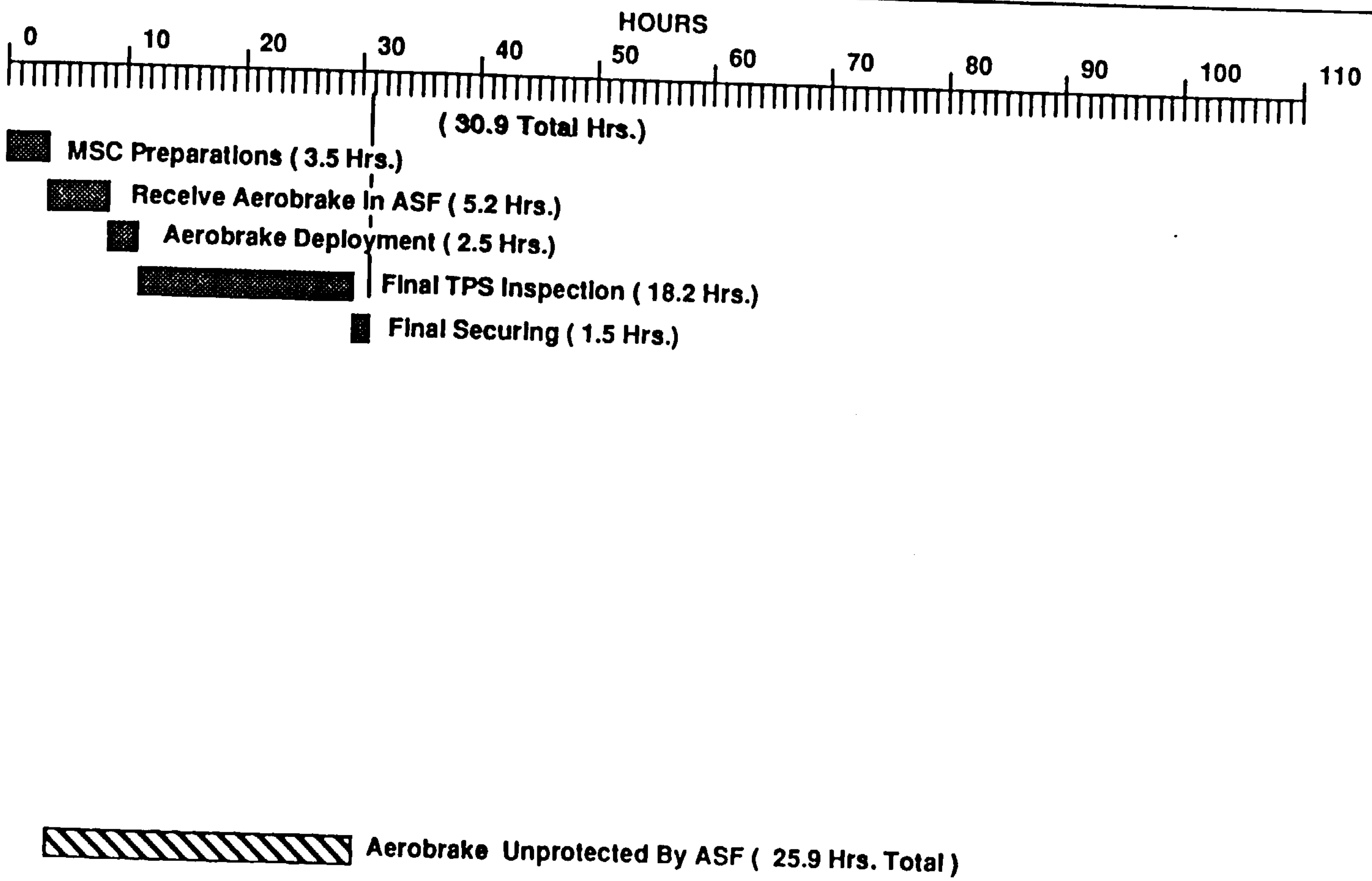
Configuration F-1A OSE

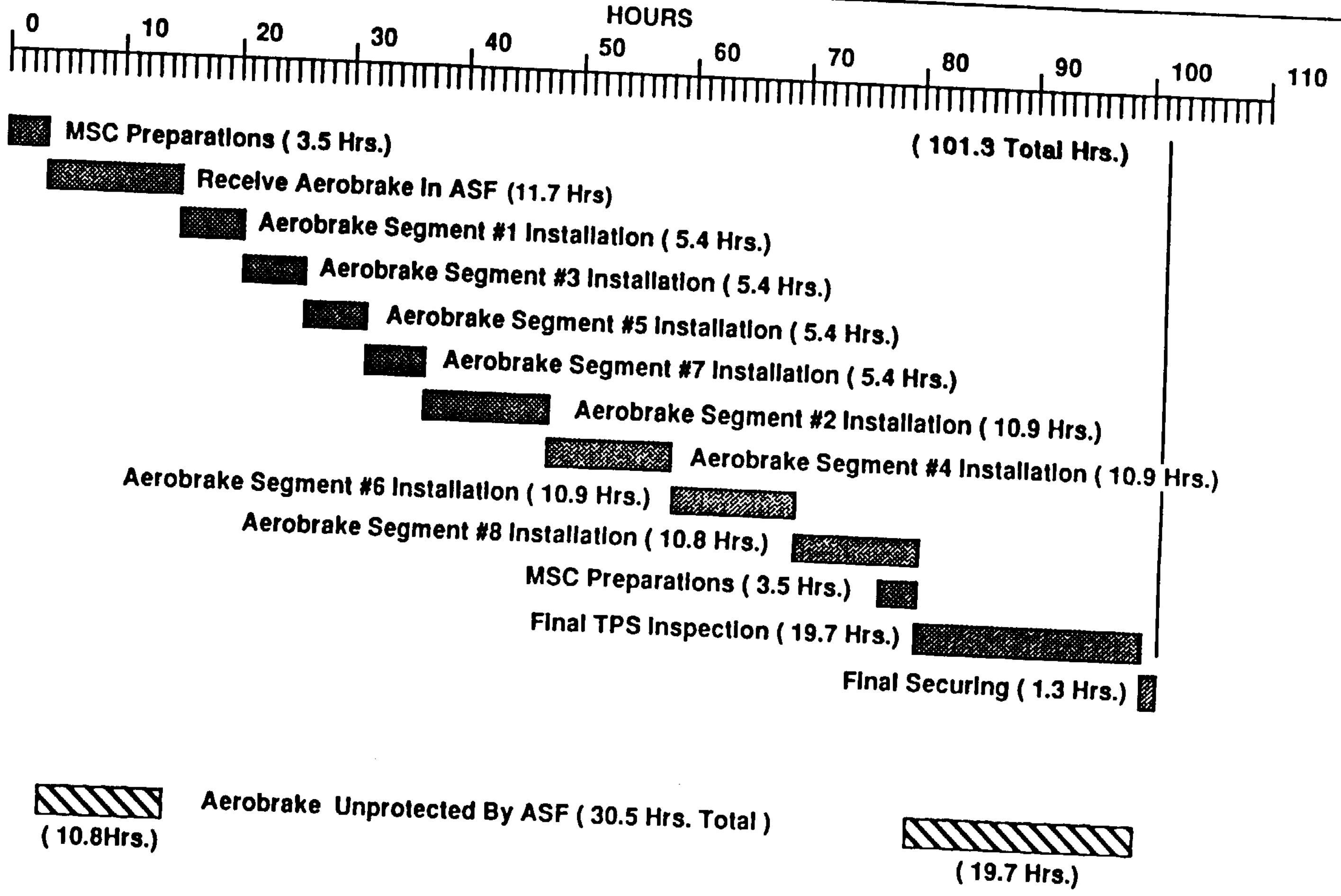


Note: Two positions shown on same sketch for brevity
All Non-Shaded Items are OSE (Aerobrake Deployment fixture (ADF))
ADF Is launched From KSC Attached to The Aerobrake

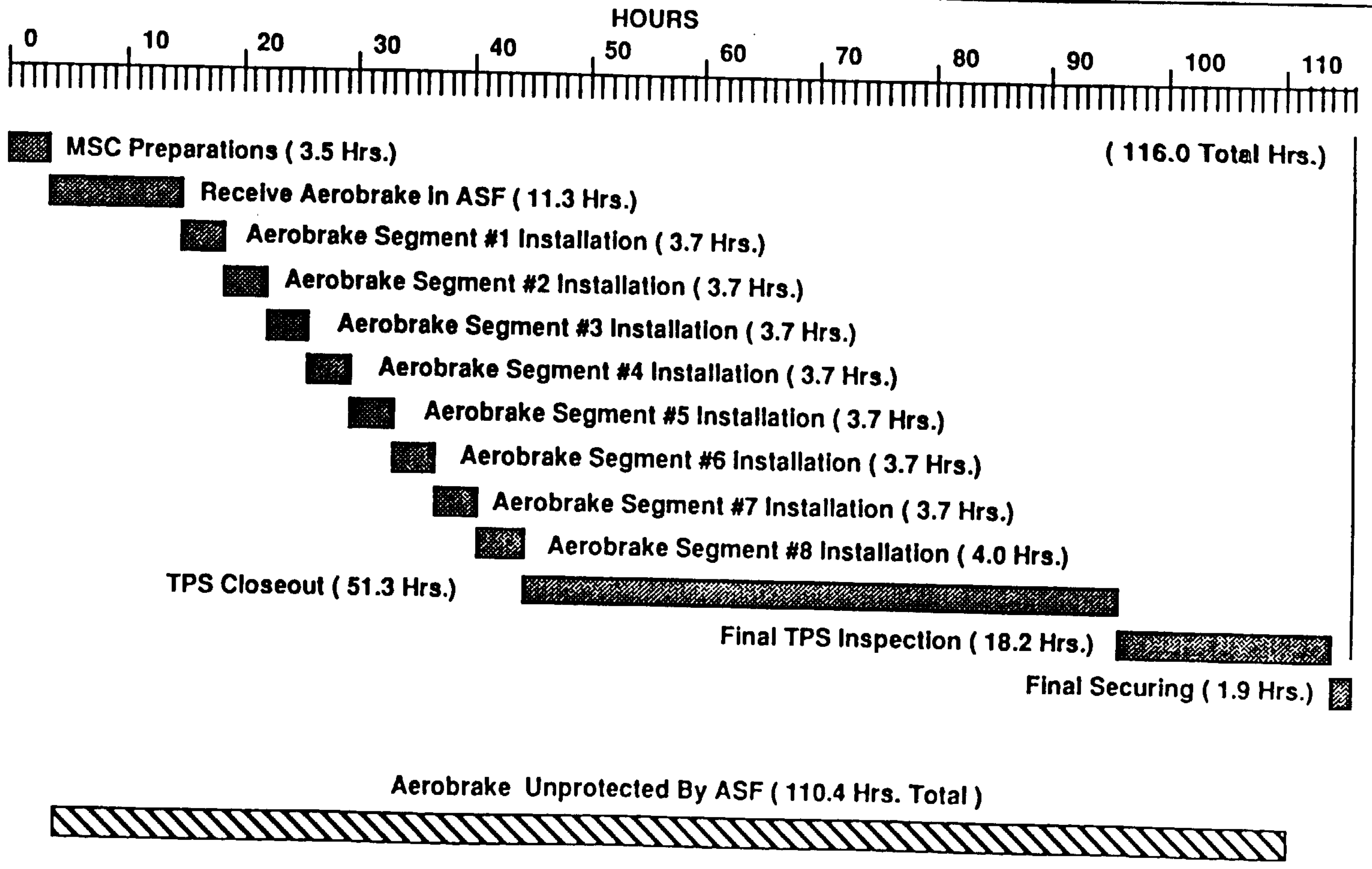
MMC F-1A Aerobrake Assembly Timeline



MSFC Rigid Aerobrake Assembly Timeline



MMC R-1 Aerobrake Assembly Timeline



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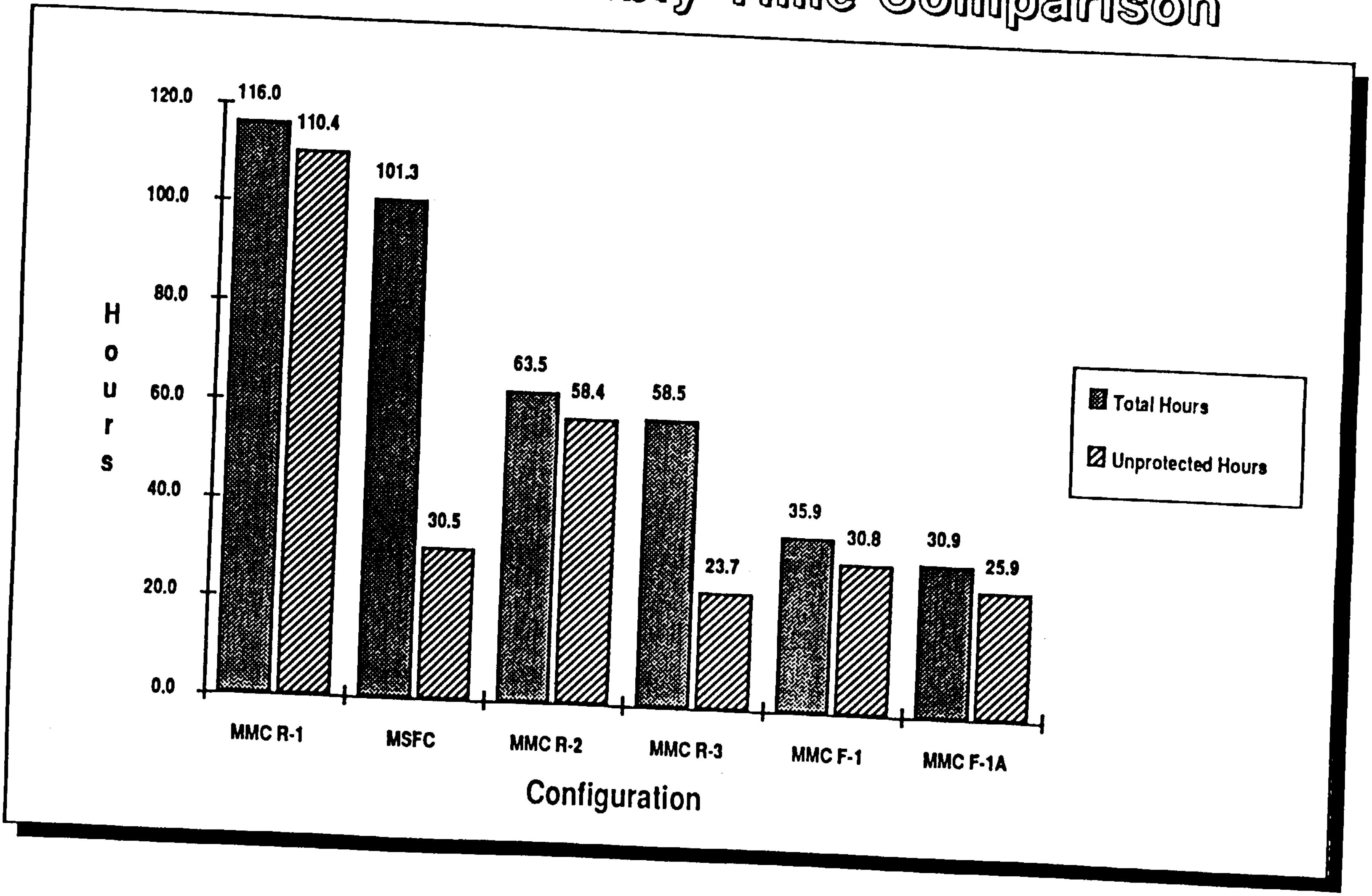
Aerobrake Assembly Time Comparison



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Conclusions

- ☐ The preceding Assembly Timeline Comparison chart reiterates:
  - ☐ The MMC R-1 configuration requires the most on-orbit assembly time
  - ☐ The MSFC Rigid option takes nearly the greatest amount of on-orbit assembly time, but:
    - ☐ The long duration tasks are good automation candidates
    - ☐ This is possibly the lowest risk option
    - ☐ Addition of robotics capabilities to the ASF could reduce already low A/B exposure time
  - ☐ The MMC R-2 configuration represents a considerable improvement from an assembly timeline standpoint but exposure time is still high due to the need to support sections with the SSRMS while making actual attachment connections with the SPDM
  - ☐ The MMC R-3 configuration assembly time is only reduced by 8 percent compared to R-2 but the exposure time is reduced by 96 percent.
    - ☐ This option appears to have the greatest potential for minimizing operations complexity and risk due to its overall simplicity and minimum number of parts to be manipulated on-orbit

Conclusions (Cont)

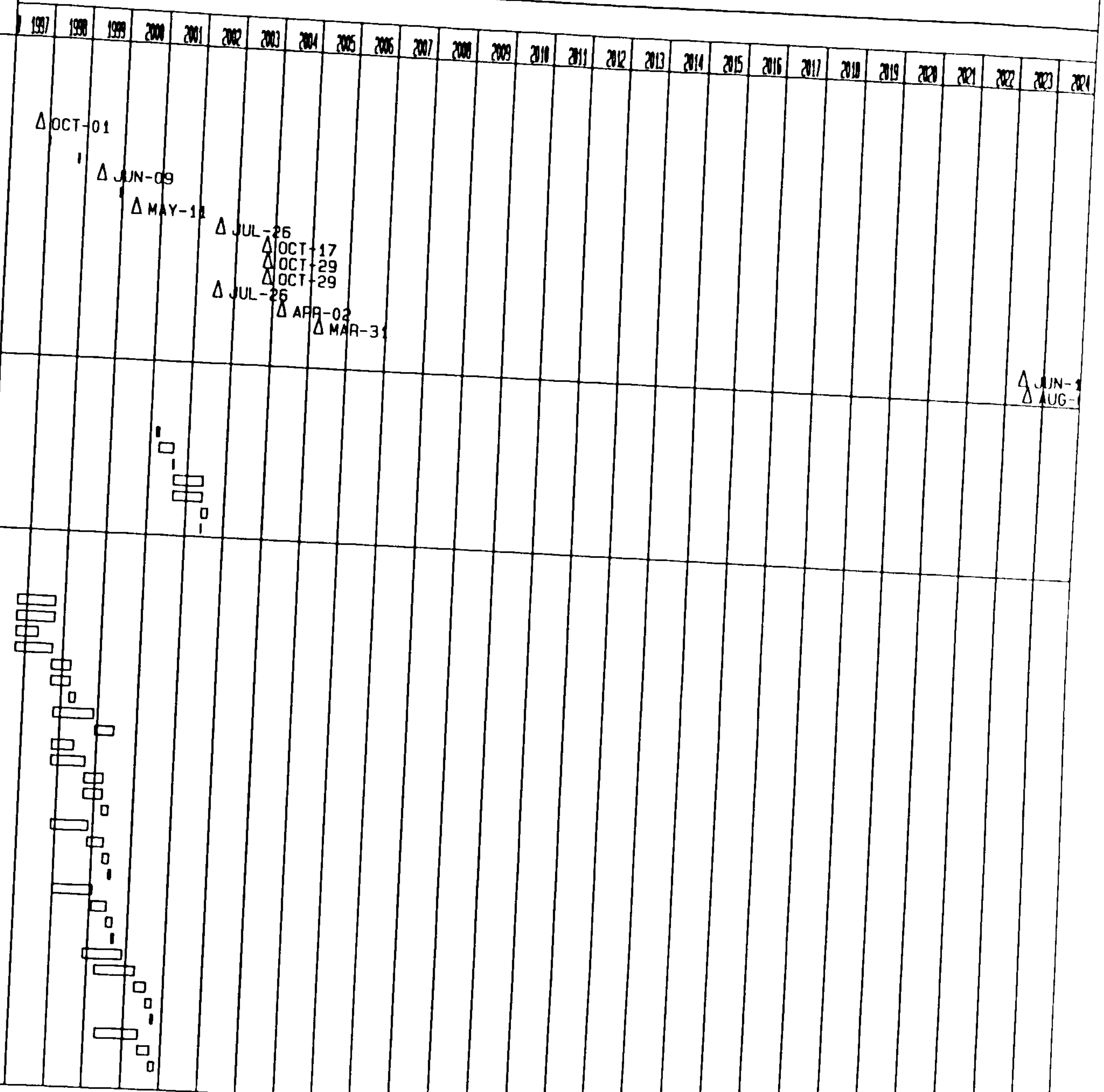
- ☐ On-orbit assembly time for the MMC F-1 option is next to the lowest of all options but:
  - ☐ This option presents the greatest risk due to:
    - ☐ Deployment mechanism complexity
    - ☐ Supporting OSE complexity
    - ☐ Operational complexity associated with OSE to flight hardware interface mate on-orbit
  - ☐ Suggested Improvements would not appreciably reduce the risk associated with flight mechanism complexity

- ☐ On-orbit assembly time for the MMC F-1A option is the lowest of all options but:
  - ☐ Risk is less than for the MMC F-1 due primarily to simpler OSE and OSE to flight hardware interfaces.

STV/LTS Network Logic Derived Schedules

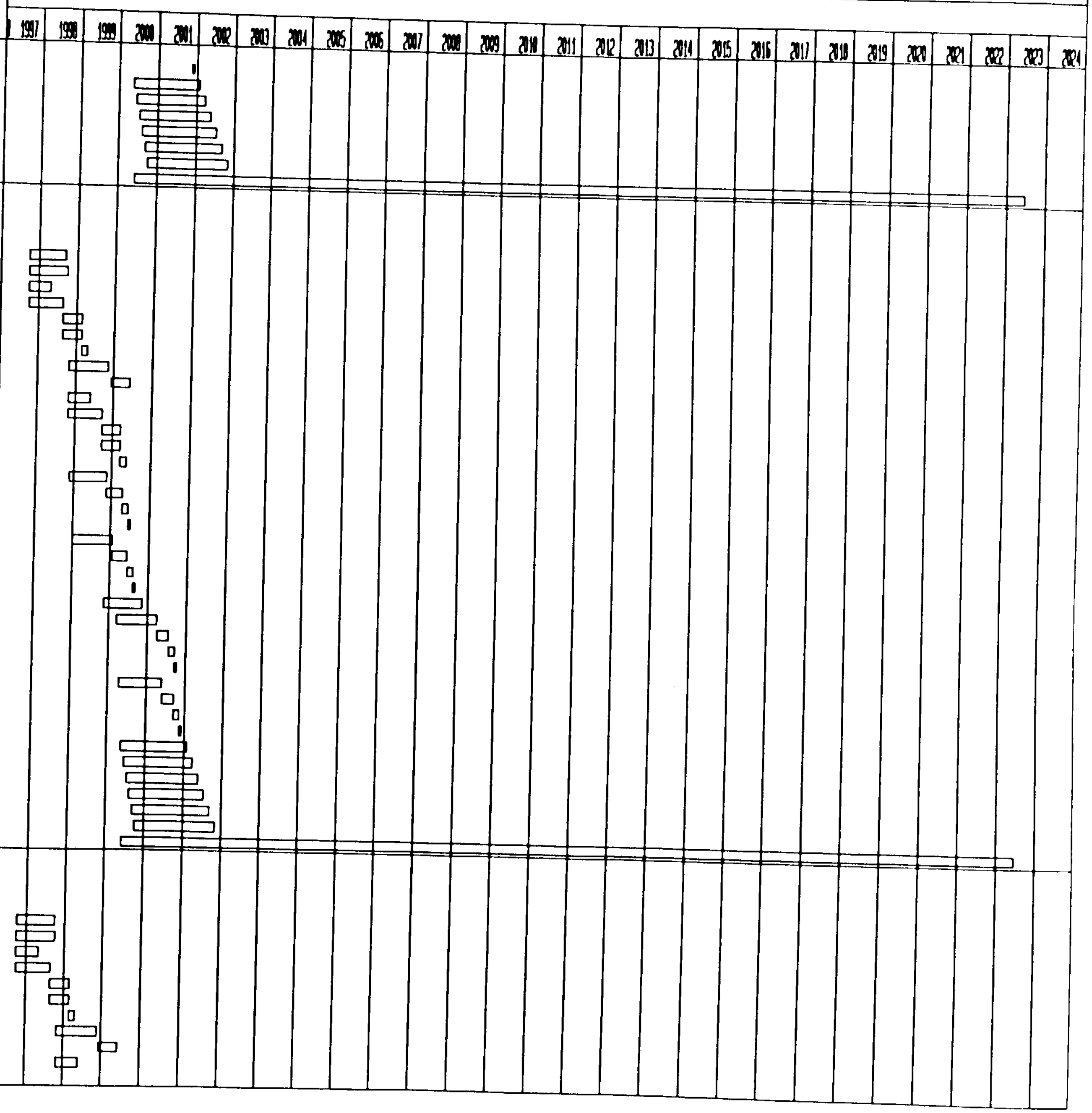
Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
PROGRAM MILESTONES		
PHASE C/D ATP	10/02/1997	10/01/1997
SYSTEM PROG RQMTS REVIEW (PRR)	01/08/1998	01/14/1998
SYSTEM PDR	10/21/1998	10/27/1998
COMPLETE DEVELOPMENT TESTING	06/10/1999	06/09/1999
SYSTEM CDR	12/01/1999	12/07/1999
COMPLETE COMPONENT QUAL TESTS	05/12/2000	05/11/2000
COMPLETE VEHICLE QUAL TESTING	07/29/2002	07/26/2002
LTS INITIAL FLIGHT CAPABILITY	10/20/2003	10/17/2003
1ST OPRNTL TEST FLT COMPLETE	10/30/2003	10/29/2003
PHASE C/D COMPLETE	10/30/2003	10/29/2003
PHASE E/F ATP	07/29/2002	07/26/2002
1ST LUNAR CARGO MISSION	03/29/2004	04/02/2004
1ST LUNAR PILOTED MISSION	02/23/2005	03/31/2005
COMPLETE FLT UNIT PRODUCTION	06/19/2023	06/16/2023
PHASE E COMPLETE	08/07/2023	08/04/2023
PROPULSION SYSTEM QUALIFICATION		
PTA RECEIVE & INSPECT HARDWARE	02/26/2001	03/23/2001
PTA ASSEMBLY	03/26/2001	08/10/2001
PTA QC INSPECT/ACCEPTANCE	08/13/2001	08/24/2001
PTA SYS QUAL TESTING/HOTFIRES	08/27/2001	05/31/2002
PTA SYS QUAL ANAYSIS & EVAL	08/27/2001	05/31/2002
PTA SYS QUAL TEST REPORT	06/03/2002	07/26/2002
PTA REFURB OR STORE	06/03/2002	06/03/2002
ENGINE		
PRELIMINARY DESIGN	10/02/1997	10/06/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNITS	10/02/1997	09/22/1998
DEVELOPMENT TESTING	09/23/1998	03/22/1999
DEV TEST ANALYSIS & EVAL	09/23/1998	03/22/1999
DEV TEST REPORT	03/23/1999	05/18/1999
CRITICAL DESIGN	10/28/1998	11/17/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB PTA UNITS	11/25/1998	11/12/1999
ATP PTA UNITS	11/15/1999	04/12/2000
ATP REPORT PTA UNITS	04/13/2000	06/09/2000
QC ACCEPTANCE/TO PTA	06/12/2000	06/30/2000
FAB GTU UNITS	01/05/1999	01/19/2000
ATP GTU UNITS	01/20/2000	06/09/2000
ATP REPORT GTU UNITS	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/18/1999	11/20/2000
FAB LTS-TST UNITS	03/16/2000	03/30/2001
ATP LTS-TST UNITS	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNITS	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNITS	04/13/2000	05/25/2001
ATP LTS-1 UNITS	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNITS	09/17/2001	11/09/2001



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

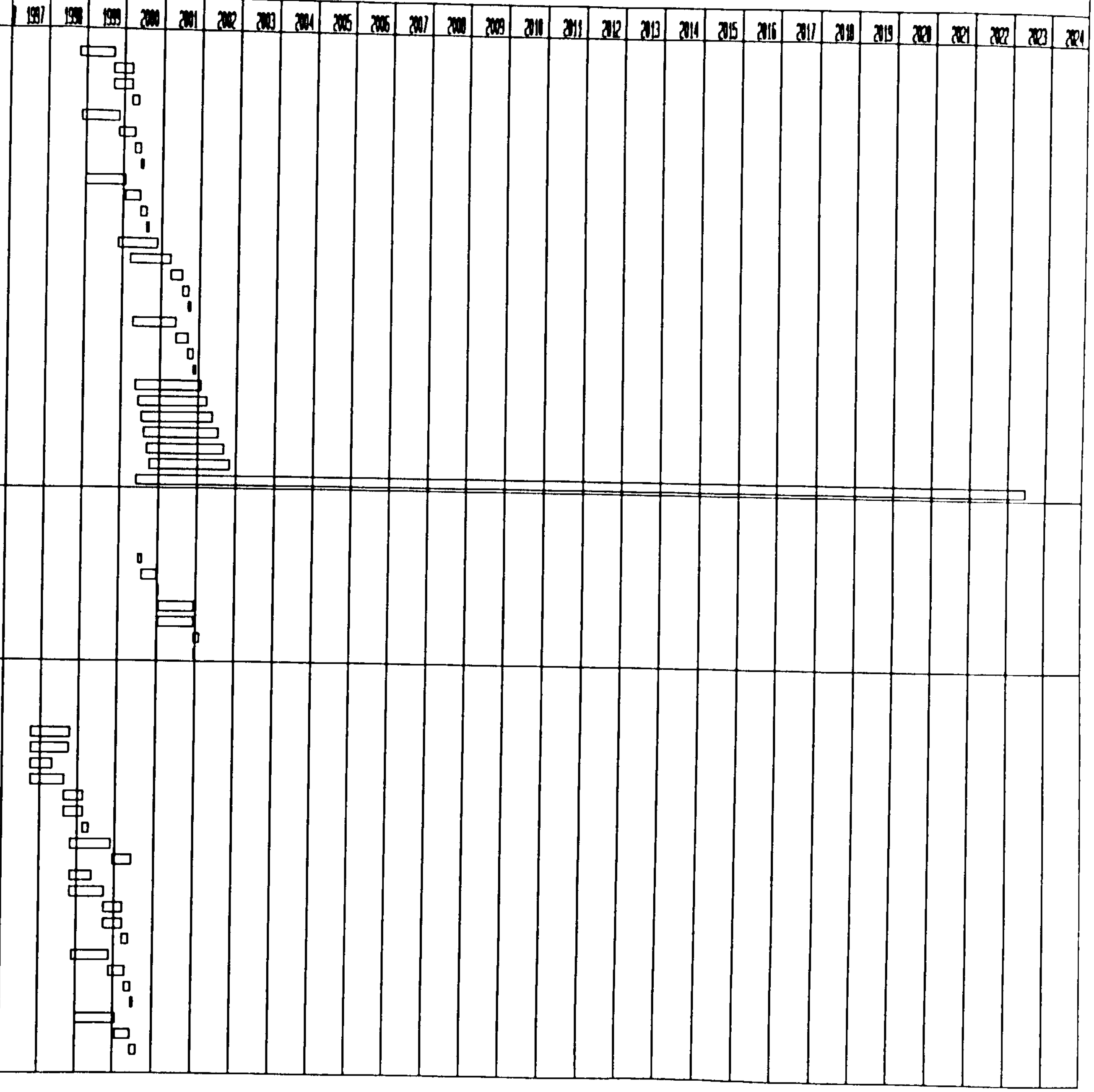
Activity Description	Start	Complete
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
MAIN PROPULSION SYSTEM		
PRELIMINARY DESIGN	10/02/1997	09/15/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	11/05/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNIT	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB PTA UNIT	11/25/1998	11/12/1999
ATP PTA UNIT	11/15/1999	04/12/2000
ATP REPORT PTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO PTA	06/12/2000	06/30/2000
FAB GTU UNITS	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/08/1999	11/08/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
REACTION CONTROL SYSTEM		
PRELIMINARY DESIGN	10/02/1997	09/28/1998
LONG LEAD PROCUREMENT	10/01/1997	10/05/1998
DEV HDWE PROCUREMENT	10/01/1997	04/29/1998
FAB DEV TEST UNIT	10/01/1997	08/21/1998
DEVELOPMENT TESTING	08/24/1998	02/19/1999
DEV TEST ANALYSIS & EVAL	08/24/1998	02/19/1999
DEV TEST REPORT	02/22/1999	04/19/1999
CRITICAL DESIGN	10/28/1998	11/18/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999



Space Transfer Vehicle/Lunar Transportation System

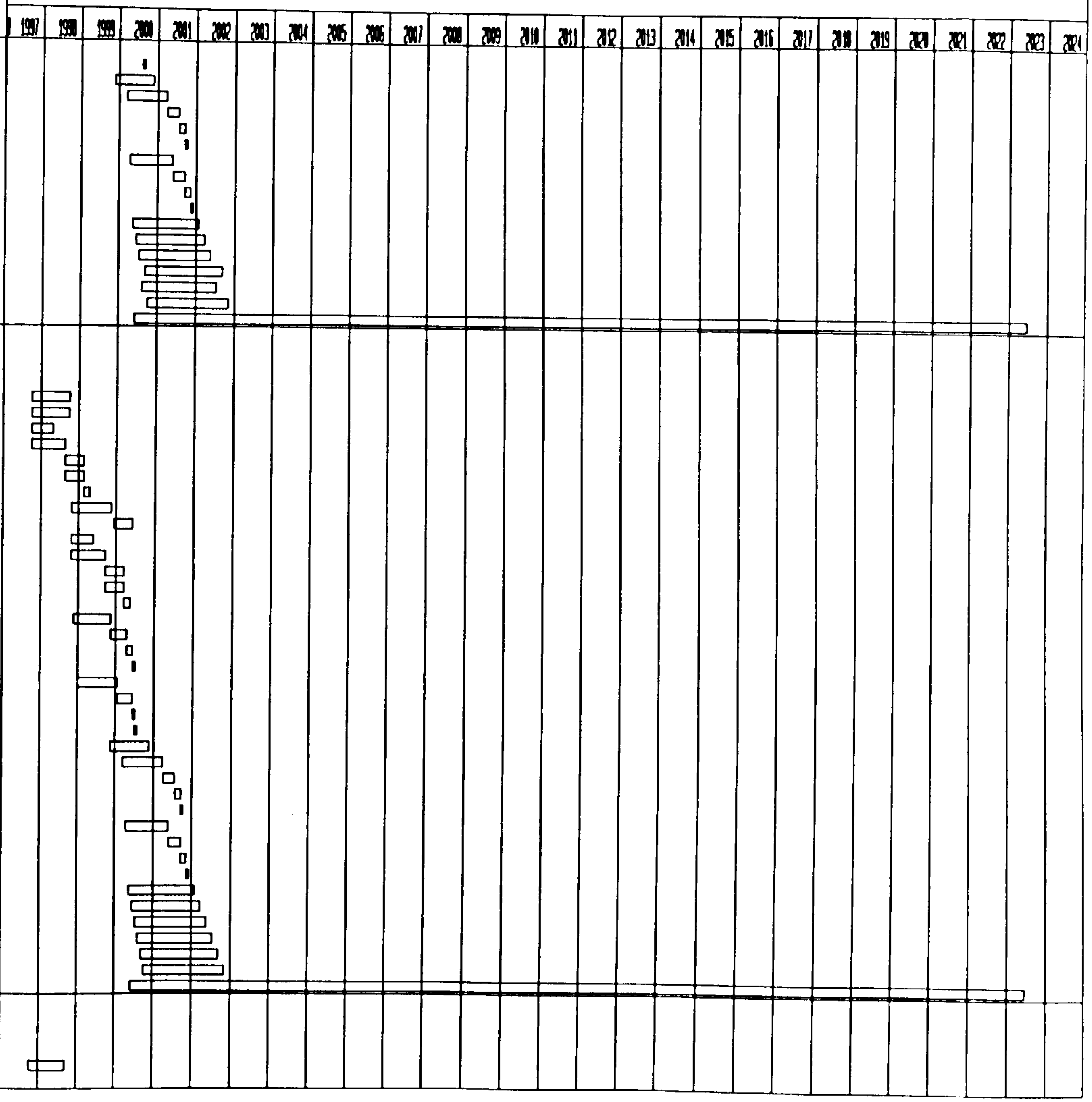
Master Schedule

Activity Description	Start	Complete
FAB CMPNT QUAL TEST UNIT	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB PTA UNIT	11/25/1998	11/12/1999
ATP PTA UNIT	11/15/1999	04/12/2000
ATP REPORT PTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO PTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/19/1999	11/21/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
INTEGRATED AVIONICS SYSTEM QUALIFICATION		
FTA RECEIVE & INSPECT HARDWARE	07/05/2000	08/01/2000
FTA ASSEMBLY	08/02/2000	12/22/2000
FTA QC INSPECT/ACCEPTANCE	01/01/2001	01/12/2001
FTA SYS QUAL TESTING	01/15/2001	12/14/2001
FTA SYS QUAL ANALYSIS & EVAL	01/15/2001	12/14/2001
FTA SYS QUAL TEST REPORT	12/17/2001	02/08/2002
FTA REFURB OR STORE	12/17/2001	12/17/2001
GUIDANCE & NAVIGATION CONTROL		
PRELIMINARY DESIGN	10/02/1997	10/13/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	11/19/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	04/12/2000
ATP REPORT FTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO FTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/22/1999	11/22/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
DATA MANAGEMENT/SEQUENCING		
PRELIMINARY DESIGN	10/02/1997	10/09/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	11/15/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	04/12/2000
ATP REPORT FTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO FTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	06/30/2000
QC ACCEPTANCE/TO GTU	07/05/2000	07/25/2000
PROD HDWE PROCUREMENT	11/16/1999	11/16/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
TELEMETRY, TRACKING & COMMAND		
PRELIMINARY DESIGN	10/02/1997	09/17/1998



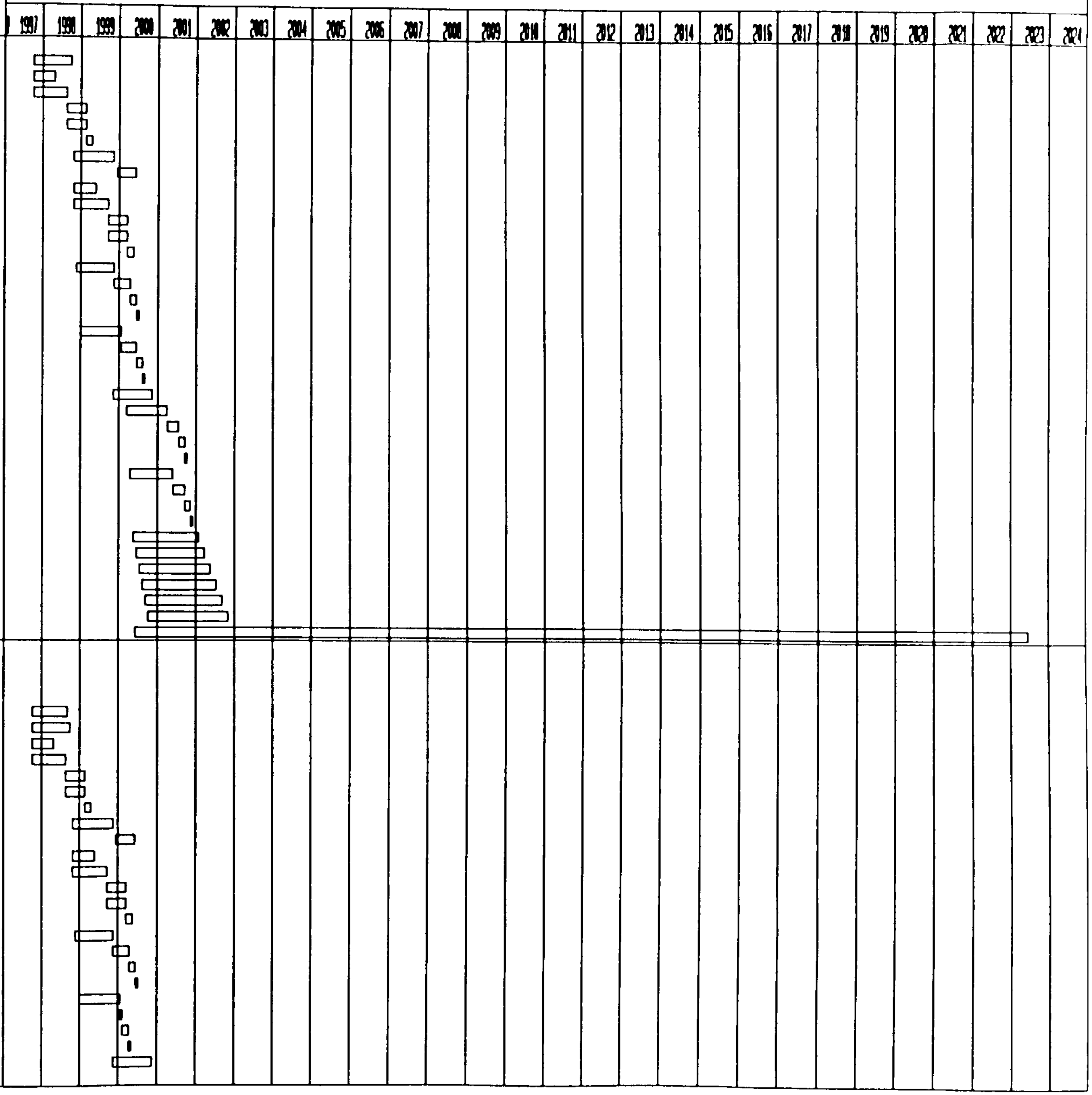
Space Transfer Vehicle/Lunar Transportation System

Master Schedule

Activity Description	Start	Complete
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	11/05/1999
ENGRG UPDATE & BASELINE	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	04/12/2000
ATP REPORT FTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO FTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/08/1999	11/08/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023

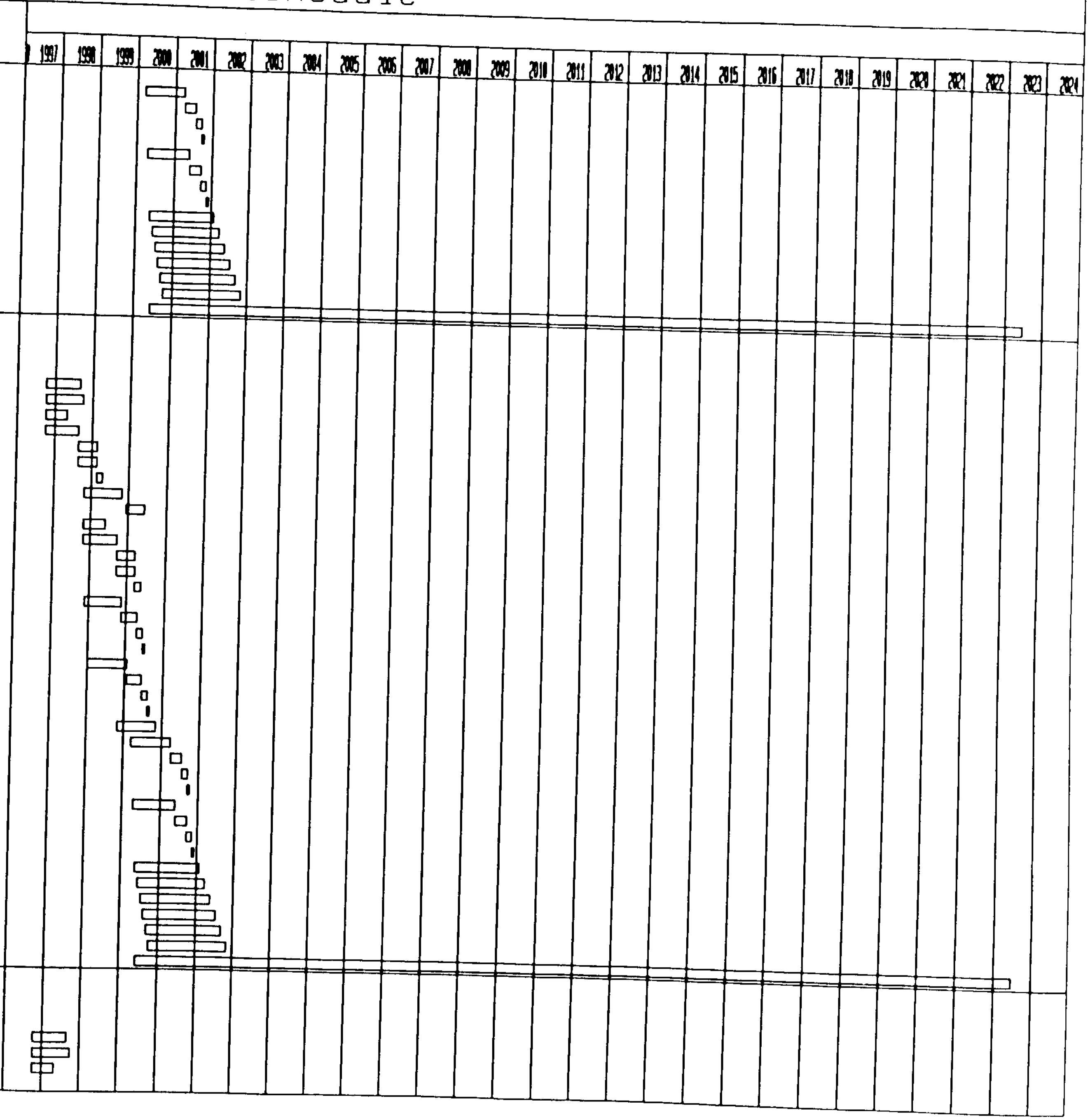
POWER GENERATION & STORAGE

Activity Description	Start	Complete
PRELIMINARY DESIGN	10/02/1997	09/08/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	11/10/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	04/12/2000
ATP REPORT FTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO FTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	02/09/2000
ATP REPORT GTU UNIT	02/10/2000	04/05/2000
QC ACCEPTANCE/TO GTU	04/06/2000	04/27/2000
PROD HDWE PROCUREMENT	11/11/1999	11/13/2000



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

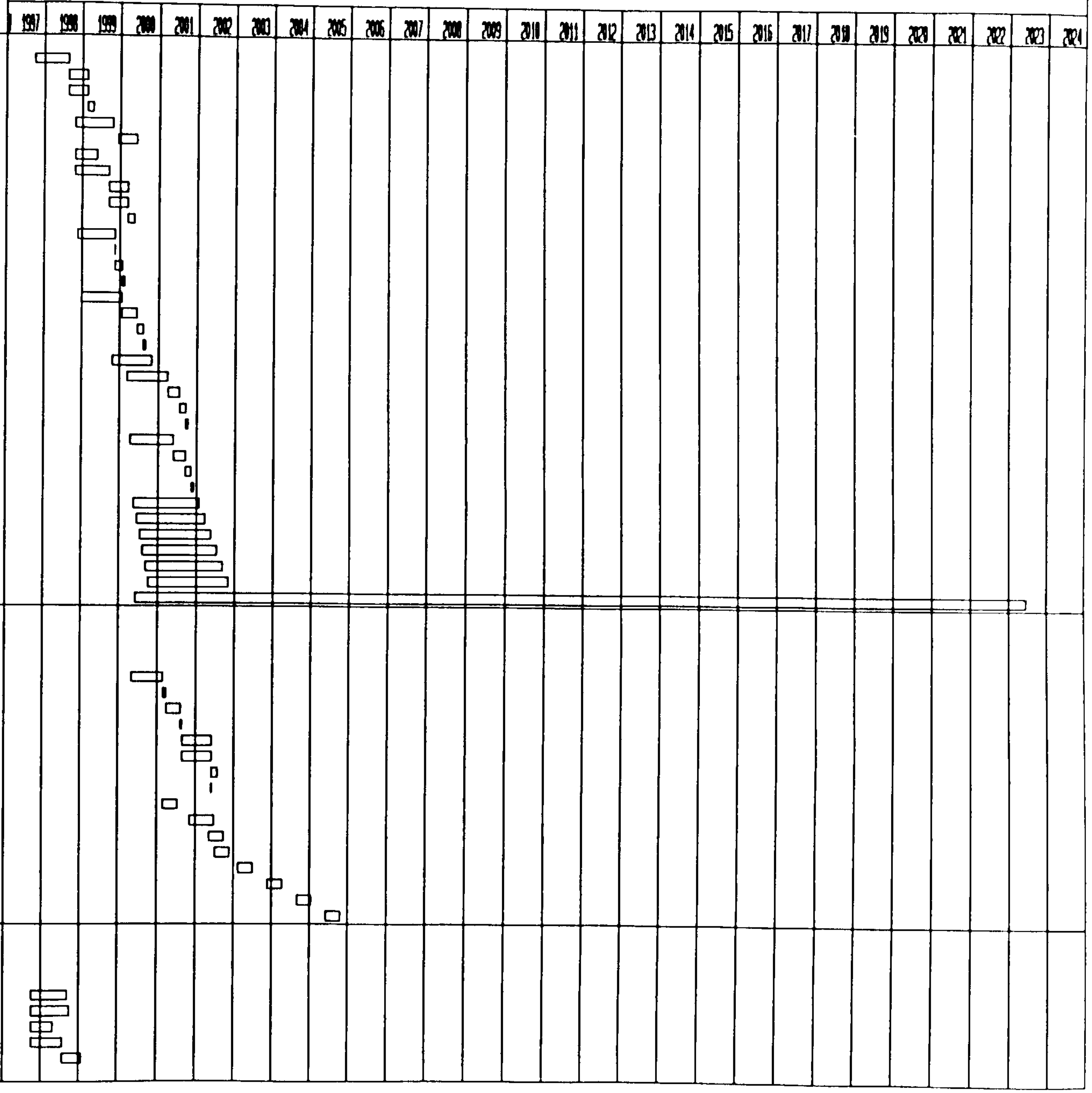
Activity Description	Start	Complete
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
DISTRIBUTION/HARNESS		
PRELIMINARY DESIGN	10/02/1997	09/02/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	10/29/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	09/17/1999
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	04/12/2000
ATP REPORT FTA UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO FTA	06/12/2000	06/30/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/01/1999	11/01/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
OTHER AVIONICS COMPONENTS		
PRELIMINARY DESIGN	10/02/1997	08/31/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998



Space Transfer Vehicle/Lunar Transportation System

Master Schedule

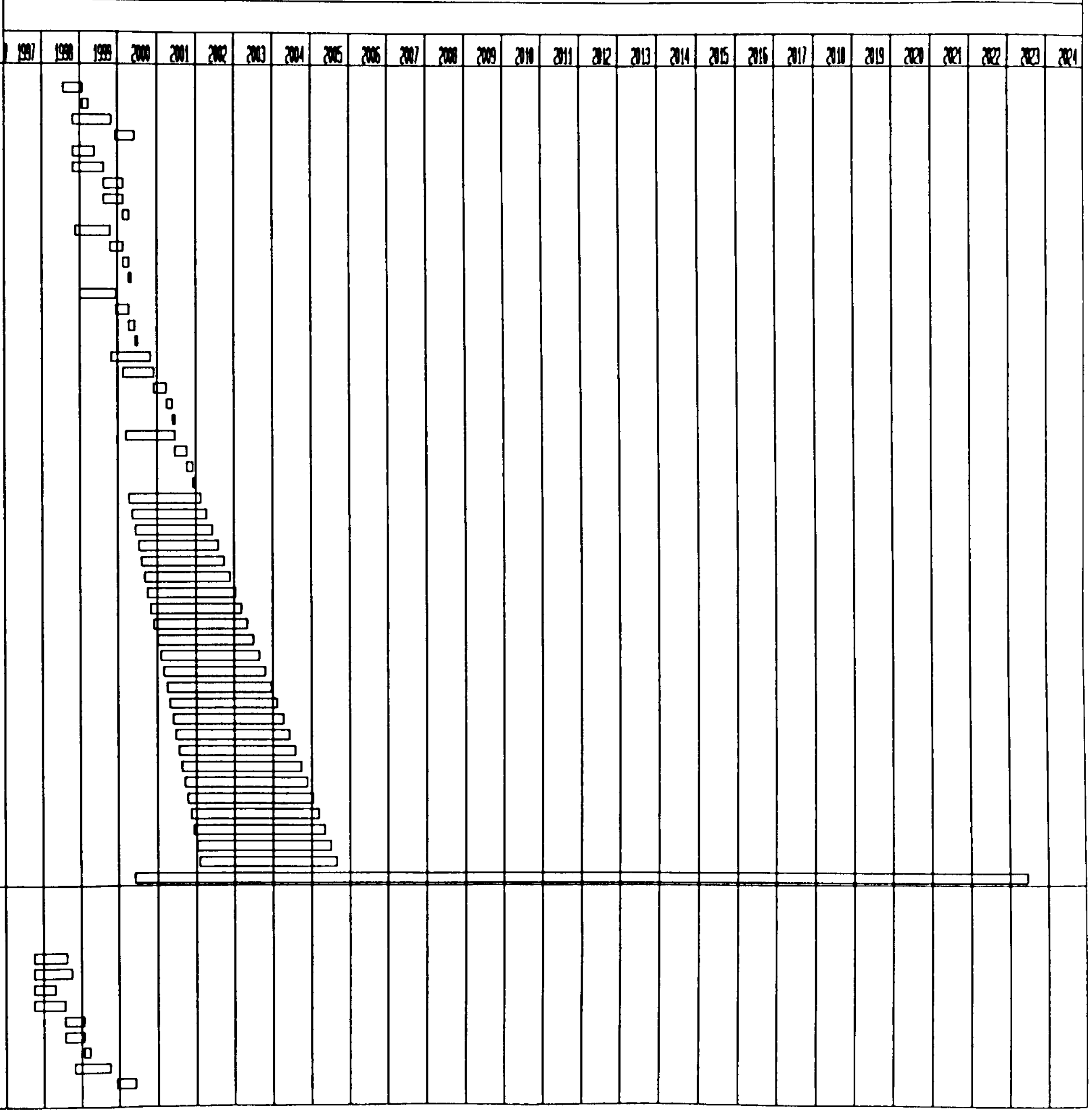
Activity Description	Start	Complete
FAB DEV TEST UNIT	10/02/1997	08/24/1998
DEVELOPMENT TESTING	08/25/1998	02/22/1999
DEV TEST ANALYSIS & EVAL	08/25/1998	02/22/1999
DEV TEST REPORT	02/23/1999	04/20/1999
CRITICAL DESIGN	10/28/1998	10/22/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL TEST ANAL & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB FTA UNIT	11/25/1998	11/12/1999
ATP FTA UNIT	11/15/1999	11/15/1999
ATP REPORT FTA UNIT	11/16/1999	01/20/2000
QC ACCEPTANCE/TO FTA	01/21/2000	02/10/2000
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	10/25/1999	10/25/2000
FAB LTS-TST UNIT	03/16/2000	03/30/2001
ATP LTS-TST UNIT	04/02/2001	07/20/2001
ATP REPORT LTS-TST UNIT	07/23/2001	09/14/2001
QC ACCEPTANCE/TO LTS-TST	09/17/2001	10/05/2001
FAB LTS-1 UNIT	04/13/2000	05/25/2001
ATP LTS-1 UNIT	05/28/2001	09/14/2001
ATP REPORT LTS-1 UNIT	09/17/2001	11/09/2001
QC ACCEPTANCE/TO LTS-1	11/12/2001	11/30/2001
FAB/ATP/QC/TO LTS-2	05/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-3	06/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-4	07/12/2000	05/17/2002
FAB/ATP/QC/TO LTS-5	08/09/2000	07/12/2002
FAB/ATP/QC/TO LTS-6	09/07/2000	09/06/2002
FAB/ATP/QC/SPARES	10/05/2000	11/01/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
STRUCT & MECH INTEGRATION/ASSY/QUAL		
PTA/STA STRUCTURES INTEGRATION	05/05/2000	02/23/2001
STA REC & INSPECT SUBSYSTEMS	02/26/2001	03/23/2001
STA ASSEMBLY	03/26/2001	08/10/2001
STA QC ACCEPTANCE	08/13/2001	08/24/2001
STA SYS QUAL TEST/MODAL SURVEY	08/27/2001	05/31/2002
STA SYS QUAL ANALYSIS & EVAL	08/27/2001	05/31/2002
STA SYS QUAL TEST REPORT	06/03/2002	07/26/2002
STA REFURB OR STORE	06/03/2002	06/03/2002
GTU P/A MOD INTEGRATION	02/26/2001	07/13/2001
LTS-TST P/A MOD INTEGRATION	11/05/2001	06/28/2002
LTS-1 P/A MOD INTEGRATION	05/13/2002	09/27/2002
LTS-2 P/A MOD INTEGRATION	07/08/2002	11/22/2002
LTS-3 P/A MOD INTEGRATION	02/17/2003	07/04/2003
LTS-4 P/A MOD INTEGRATION	11/24/2003	04/09/2004
LTS-5 P/A MOD INTEGRATION	08/30/2004	01/14/2005
LTS-6 P/A MOD INTEGRATION	06/06/2005	10/21/2005
BASIC STRUCTURE		
PRELIMINARY DESIGN	10/02/1997	09/15/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNIT	10/02/1997	07/27/1998
DEVELOPMENT TESTING	07/28/1998	01/25/1999



Space Transfer Vehicle/Lunar Transportation System

Master Schedule

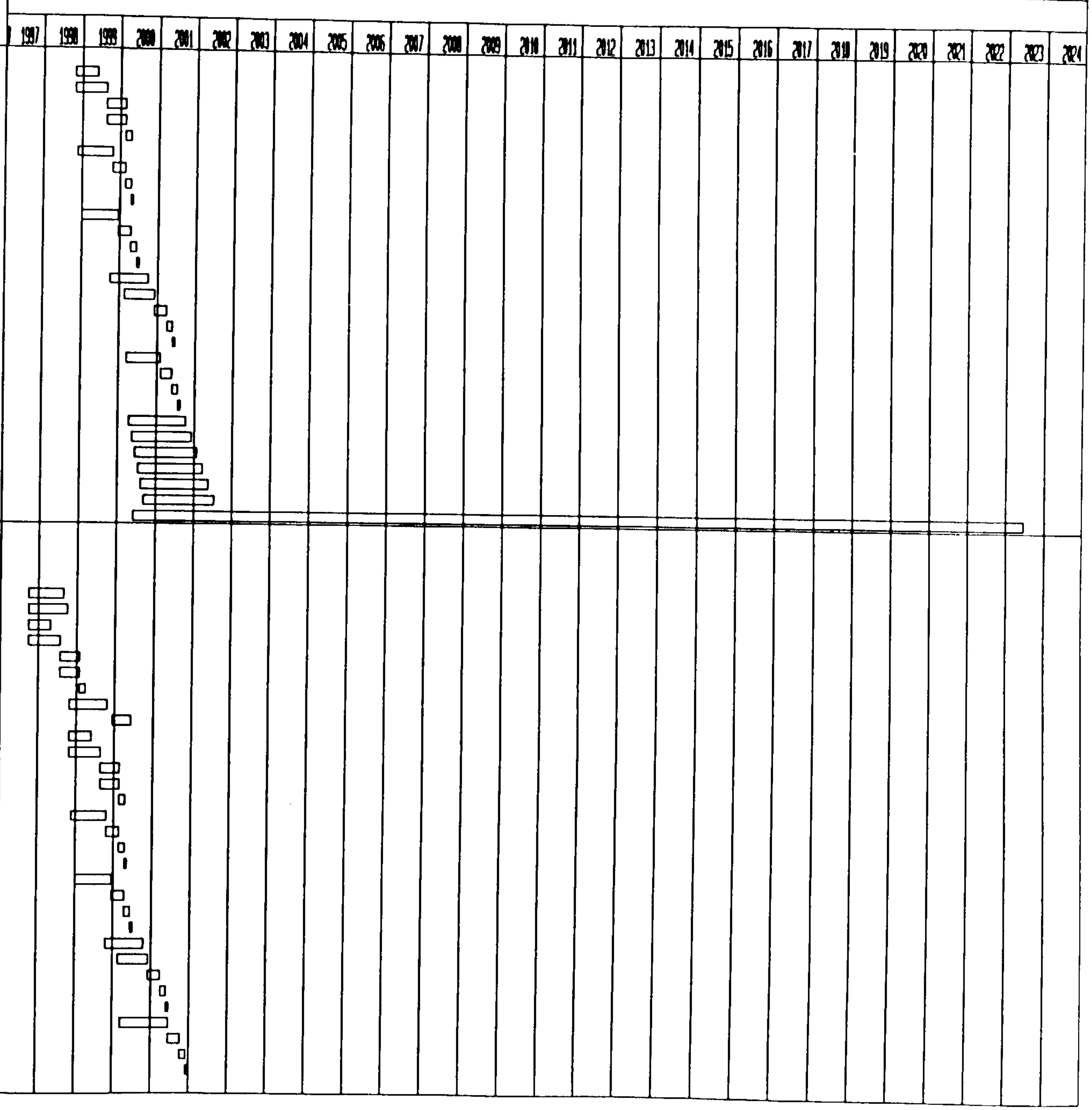
Activity Description	Start	Complete
DEV TEST ANALYSIS & EVAL	07/28/1998	01/25/1999
DEV TEST REPORT	01/26/1999	03/22/1999
CRITICAL DESIGN	10/28/1998	10/29/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNIT	10/28/1998	08/19/1999
CMPNT QUAL TESTING	08/20/1999	02/16/2000
CMPNT QUAL TEST ANAL & EVAL	08/20/1999	02/16/2000
CMPNT QUAL TEST REPORT	02/17/2000	04/12/2000
FAB PTA/STA UNITS	11/25/1998	10/15/1999
ATP PTA/STA UNITS	10/18/1999	02/16/2000
ATP REPORT PTA/STA UNITS	02/17/2000	04/12/2000
QC ACCEPTANCE/TO PTA/STA	04/13/2000	05/04/2000
FAB GTU UNIT	01/05/1999	12/14/1999
ATP GTU UNIT	12/15/1999	04/12/2000
ATP REPORT GTU UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO GTU	06/12/2000	06/30/2000
PROD HDWE PROCUREMENT	11/01/1999	11/01/2000
FAB LTS-TST UNIT	02/17/2000	12/01/2000
ATP LTS-TST UNIT	12/04/2000	03/30/2001
ATP REPORT LTS-TST UNIT	04/02/2001	05/25/2001
QC ACCEPTANCE/TO LTS-TST	05/28/2001	06/15/2001
FAB LTS-1 UNIT	03/16/2000	06/15/2001
ATP LTS-1 UNIT	06/18/2001	10/05/2001
ATP REPORT LTS-1 UNIT	10/08/2001	11/30/2001
QC ACCEPTANCE/TO LTS-1	12/03/2001	12/21/2001
FAB/ATP/QC/TO LTS-2A	04/13/2000	02/15/2002
FAB/ATP/QC/TO LTS-2B	05/12/2000	04/12/2002
FAB/ATP/QC/TO LTS-2C	06/12/2000	06/07/2002
FAB/ATP/QC/TO LTS-2D	07/12/2000	08/02/2002
FAB/ATP/QC/TO LTS-3A	08/09/2000	09/27/2002
FAB/ATP/QC/TO LTS-3B	09/07/2000	11/22/2002
FAB/ATP/QC/TO LTS-3C	10/05/2000	01/17/2003
FAB/ATP/QC/TO LTS-3D	11/02/2000	03/14/2003
FAB/ATP/QC/TO LTS-3E	12/04/2000	05/09/2003
FAB/ATP/QC/TO LTS-4A	01/08/2001	07/04/2003
FAB/ATP/QC/TO LTS-4B	02/05/2001	08/29/2003
FAB/ATP/QC/TO LTS-4C	03/05/2001	10/24/2003
FAB/ATP/QC/TO LTS-4D	04/02/2001	12/19/2003
FAB/ATP/QC/TO LTS-4E	04/30/2001	02/13/2004
FAB/ATP/QC/TO LTS-5A	05/28/2001	04/09/2004
FAB/ATP/QC/TO LTS-5B	06/25/2001	06/04/2004
FAB/ATP/QC/TO LTS-5C	07/23/2001	07/30/2004
FAB/ATP/QC/TO LTS-5D	08/20/2001	09/24/2004
FAB/ATP/QC/TO LTS-5E	09/17/2001	11/19/2004
FAB/ATP/QC/TO LTS-6A	10/15/2001	01/14/2005
FAB/ATP/QC/TO LTS-6B	11/12/2001	03/11/2005
FAB/ATP/QC/TO LTS-6C	12/10/2001	05/06/2005
FAB/ATP/QC/TO LTS-6D	01/07/2002	07/01/2005
FAB/ATP/QC/TO LTS-6E	02/04/2002	08/26/2005
ENGRG MAINTENANCE	06/05/2000	06/16/2023
SKIRTS/ADAPTERS/MECHANISMS		
PRELIMINARY DESIGN	10/02/1997	08/17/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNITS	10/02/1997	07/27/1998
DEVELOPMENT TESTING	07/28/1998	01/25/1999
DEV TEST ANALYSIS & EVAL	07/28/1998	01/25/1999
DEV TEST REPORT	01/26/1999	03/22/1999
CRITICAL DESIGN	10/28/1998	10/01/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000



Space Transfer Vehicle/Lunar Transportation System

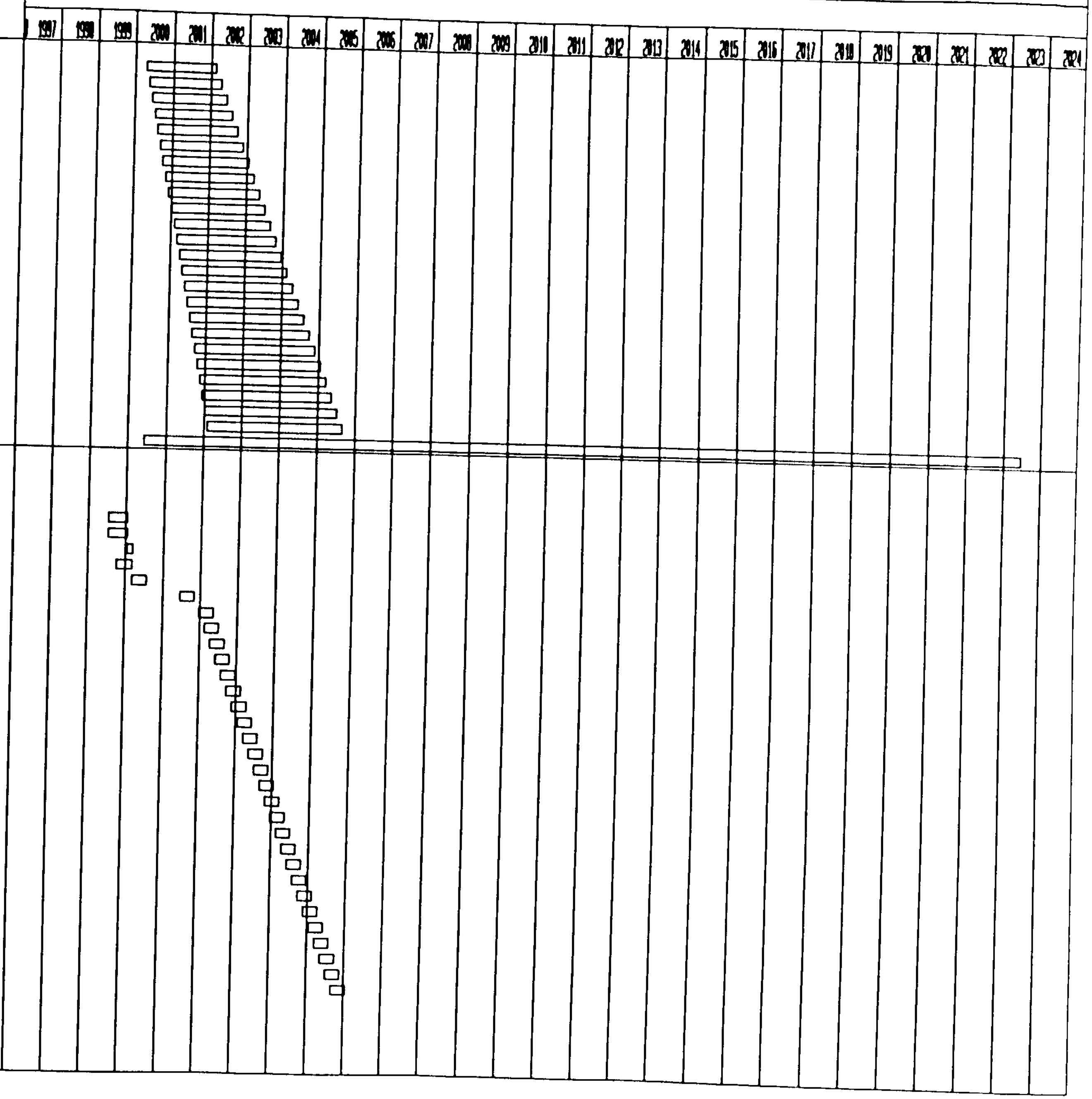
Master Schedule

Activity Description	Start	Complete
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	08/19/1999
CMPNT QUAL TESTING	08/20/1999	02/16/2000
CMPNT QUAL TEST ANAL & EVAL	08/20/1999	02/16/2000
CMPNT QUAL TEST REPORT	02/17/2000	04/12/2000
FAB PTA/STA UNITS	11/25/1998	10/15/1999
ATP PTA/STA UNITS	10/18/1999	02/16/2000
ATP REPORT PTA/STA UNITS	02/17/2000	04/12/2000
QC ACCEPTANCE/TO PTA/STA	04/13/2000	05/04/2000
FAB GTU UNIT	01/05/1999	12/14/1999
ATP GTU UNIT	12/15/1999	04/12/2000
ATP REPORT GTU UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO GTU	06/12/2000	06/30/2000
PROD HDWE PROCUREMENT	10/04/1999	10/04/2000
FAB LTS-TST UNIT	02/17/2000	12/01/2000
ATP LTS-TST UNIT	12/04/2000	03/30/2001
ATP REPORT LTS-TST UNIT	04/02/2001	05/25/2001
QC ACCEPTANCE/TO LTS-TST	05/28/2001	06/15/2001
FAB LTS-1 UNIT	03/16/2000	02/02/2001
ATP LTS-1 UNIT	02/05/2001	05/25/2001
ATP REPORT LTS-1 UNIT	05/28/2001	07/20/2001
QC ACCEPTANCE/TO LTS-1	07/23/2001	08/10/2001
FAB/ATP/QC/TO LTS-2	04/13/2000	10/05/2001
FAB/ATP/QC/TO LTS-3	05/12/2000	11/30/2001
FAB/ATP/QC/TO LTS-4	06/12/2000	01/25/2002
FAB/ATP/QC/TO LTS-5	07/12/2000	03/22/2002
FAB/ATP/QC/TO LTS-6	08/09/2000	05/17/2002
FAB/ATP/QC/SPARES	09/07/2000	07/12/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
TANKS		
PRELIMINARY DESIGN	10/02/1997	08/31/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNITS	10/02/1997	07/27/1998
DEVELOPMENT TESTING	07/28/1998	01/25/1999
DEV TEST ANALYSIS & EVAL	07/28/1998	01/25/1999
DEV TEST REPORT	01/26/1999	03/22/1999
CRITICAL DESIGN	10/28/1998	10/15/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	08/19/1999
CMPNT ATP & QUAL TESTING	08/20/1999	02/16/2000
CMPNT QUAL TEST ANAL & EVAL	08/20/1999	02/16/2000
QUAL TEST REPORT	02/17/2000	04/12/2000
FAB PTA/STA UNITS	11/25/1998	10/15/1999
TANKS ATP PTA/STA UNITS	10/18/1999	02/16/2000
ATP REPORT PTA/STA UNITS	02/17/2000	04/12/2000
QC ACCEPTANCE/TO PTA/STA	04/13/2000	05/04/2000
FAB GTU UNITS	01/05/1999	12/14/1999
ATP GTU UNITS	12/15/1999	04/12/2000
ATP REPORT GTU UNITS	04/13/2000	06/09/2000
QC ACCEPTANCE/TO GTU	06/12/2000	06/30/2000
PROD HDWE PROCUREMENT	10/18/1999	10/18/2000
FAB LTS-TST UNITS	02/17/2000	12/01/2000
ATP LTS-TST UNITS	12/04/2000	03/30/2001
ATP REPORT LTS-TST UNITS	04/02/2001	05/25/2001
QC ACCEPTANCE/TO LTS-TST	05/28/2001	06/15/2001
FAB LTS-1 UNITS	03/16/2000	06/15/2001
ATP LTS-1 UNITS	06/18/2001	10/05/2001
ATP REPORT LTS-1	10/08/2001	11/30/2001
QC ACCEPTANCE/TO LTS-1	12/03/2001	12/21/2001



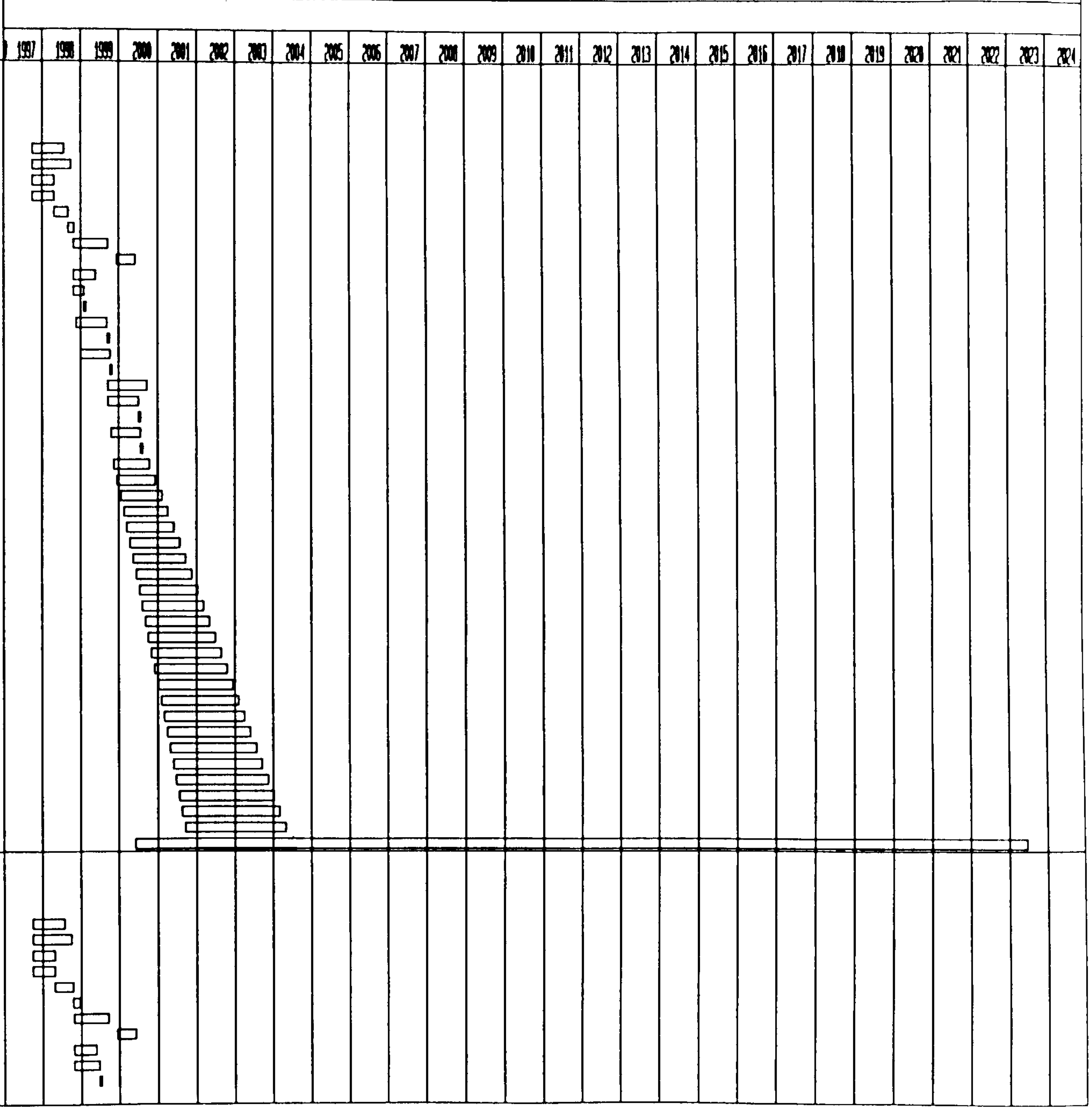
Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
FAB/ATP/QC/TO LTS-2A	04/13/2000	02/15/2002
FAB/ATP/QC/TO LTS-2B	05/12/2000	04/12/2002
FAB/ATP/QC/TO LTS-2C	06/12/2000	06/07/2002
FAB/ATP/QC/TO LTS-2D	07/12/2000	08/02/2002
FAB/ATP/QC/TO LTS-3A	08/09/2000	09/27/2002
FAB/ATP/QC/TO LTS-3B	09/07/2000	11/22/2002
FAB/ATP/QC/TO LTS-3C	10/05/2000	01/17/2003
FAB/ATP/QC/TO LTS-3D	11/02/2000	03/14/2003
FAB/ATP/QC/TO LTS-3E	12/04/2000	05/09/2003
FAB/ATP/QC/TO LTS-4A	01/08/2001	07/04/2003
FAB/ATP/QC/TO LTS-4B	02/05/2001	08/29/2003
FAB/ATP/QC/TO LTS-4C	03/05/2001	10/24/2003
FAB/ATP/QC/TO LTS-4D	04/02/2001	12/19/2003
FAB/ATP/QC/TO LTS-4E	04/30/2001	02/13/2004
FAB/ATP/QC/TO LTS-5A	05/28/2001	04/09/2004
FAB/ATP/QC/TO LTS-5B	06/25/2001	06/04/2004
FAB/ATP/QC/TO LTS-5C	07/23/2001	07/30/2004
FAB/ATP/QC/TO LTS-5D	08/20/2001	09/24/2004
FAB/ATP/QC/TO LTS-5E	09/17/2001	11/19/2004
FAB/ATP/QC/TO LTS-6A	10/15/2001	01/14/2005
FAB/ATP/QC/TO LTS-6B	11/12/2001	03/11/2005
FAB/ATP/QC/TO LTS-6C	12/10/2001	05/06/2005
FAB/ATP/QC/TO LTS-6D	01/07/2002	07/01/2005
FAB/ATP/QC/TO LTS-6E	02/04/2002	08/26/2005
ENGRG MAINTENANCE	06/05/2000	06/16/2023
INTEGRATION & ASSEMBLY - THERM CNTL		
THERM CTRL SYS CMPNT QUAL TSTS	07/16/1999	01/12/2000
THERM CTRL SYS CQUAL ANL & EVL	07/16/1999	01/12/2000
THERM CTRL SYS CQUAL REPORT	01/13/2000	03/08/2000
PTA UNIT TCS INTEGRATION	10/04/1999	03/01/2000
GTU UNIT TCS INTEGRATION	03/02/2000	07/25/2000
LTS-TST UNIT INTEGRATION	06/18/2001	11/02/2001
LTS-1 UNIT INTEGRATION	12/24/2001	05/10/2002
LTS-2A UNIT INTEGRATION	02/18/2002	07/05/2002
LTS-2B UNIT INTEGRATION	04/15/2002	08/30/2002
LTS-2C UNIT INTEGRATION	06/10/2002	10/25/2002
LTS-2D UNIT INTEGRATION	08/05/2002	12/20/2002
LTS-3A UNIT INTEGRATION	09/30/2002	02/14/2003
LTS-3B UNIT INTEGRATION	11/25/2002	04/11/2003
LTS-3C UNIT INTEGRATION	01/20/2003	06/06/2003
LTS-3D UNIT INTEGRATION	03/17/2003	08/01/2003
LTS-3E UNIT INTEGRATION	05/12/2003	09/26/2003
LTS-4A UNIT INTEGRATION	07/07/2003	11/21/2003
LTS-4B UNIT INTEGRATION	09/01/2003	01/16/2004
LTS-4C UNIT INTEGRATION	10/27/2003	03/12/2004
LTS-4D UNIT INTEGRATION	12/22/2003	05/07/2004
LTS-4E UNIT INTEGRATION	02/16/2004	07/02/2004
LTS-5A UNIT INTEGRATION	04/12/2004	08/27/2004
LTS-5B UNIT INTEGRATION	06/07/2004	10/22/2004
LTS-5C UNIT INTEGRATION	08/02/2004	12/17/2004
LTS-5D UNIT INTEGRATION	09/27/2004	02/11/2005
LTS-5E UNIT INTEGRATION	11/22/2004	04/08/2005
LTS-6A UNIT INTEGRATION	01/17/2005	06/03/2005
LTS-6B UNIT INTEGRATION	03/14/2005	07/29/2005
LTS-6C UNIT INTEGRATION	05/09/2005	09/23/2005
LTS-6D UNIT INTEGRATION	07/04/2005	11/18/2005
LTS-6E UNIT INTEGRATION	08/29/2005	01/13/2006



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

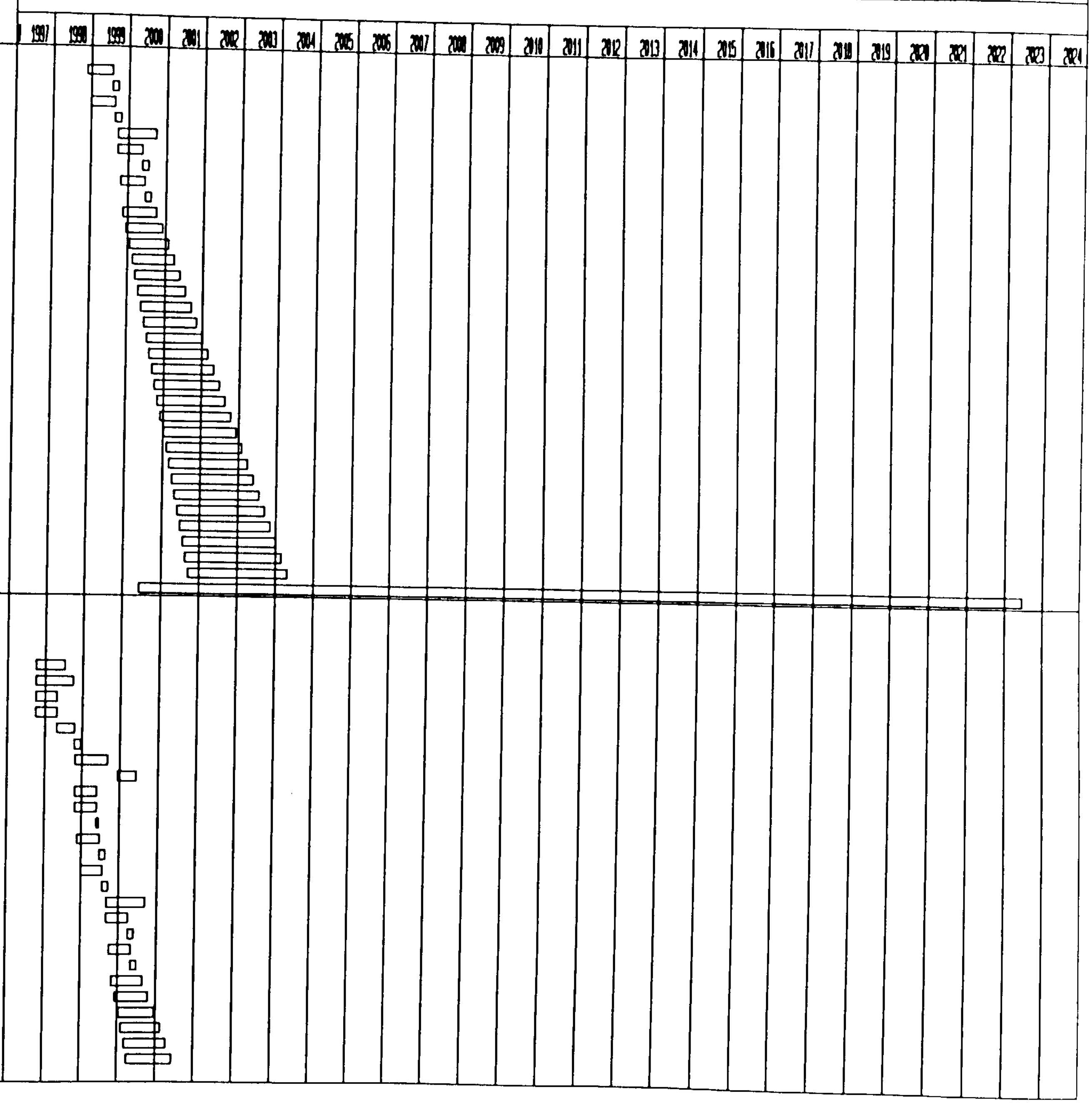
Activity Description	Start	Complete
INSULATION		
PRELIMINARY DESIGN	10/02/1997	07/27/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
DEV TEST PREP	10/02/1997	04/30/1998
DEVELOPMENT TESTING	05/01/1998	09/08/1998
DEV TEST REPORT	09/09/1998	11/03/1998
CRITICAL DESIGN	10/28/1998	09/17/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST INSUL	10/28/1998	02/01/1999
CMPNT QUAL PACK & SHIP	02/02/1999	02/22/1999
FAB PTA INSUL	11/25/1998	09/10/1999
ATP/QC ACCEPTANCE/TO PTA	09/13/1999	10/01/1999
FAB GTU INSUL	01/05/1999	10/08/1999
ATP/QC ACCEPTANCE/TO GTU	10/11/1999	10/29/1999
PROD HDWE PROCUREMENT	09/20/1999	09/20/2000
FAB LTS-TST INSUL	09/20/1999	06/30/2000
ATP/QC ACCEPTANCE/TO LTS-TST	07/05/2000	07/25/2000
FAB LTS-1 INSUL	10/18/1999	07/25/2000
ATP/QC ACCEPTANCE/TO LTS-1	07/26/2000	08/15/2000
PREP/ATP/QC/TO LTS-2A	11/15/1999	10/11/2000
PREP/ATP/QC/TO LTS-2B	12/15/1999	12/08/2000
PREP/ATP/QC/TO LTS-2C	01/20/2000	02/09/2001
PREP/ATP/QC/TO LTS-2D	02/17/2000	04/06/2001
PREP/ATP/QC/TO LTS-3A	03/16/2000	06/01/2001
PREP/ATP/QC/TO LTS-3B	04/13/2000	07/27/2001
PREP/ATP/QC/TO LTS-3C	05/12/2000	09/21/2001
PREP/ATP/QC/TO LTS-3D	06/12/2000	11/16/2001
PREP/ATP/QC/TO LTS-3E	07/12/2000	01/11/2002
PREP/ATP/QC/TO LTS-4A	08/09/2000	03/08/2002
PREP/ATP/QC/TO LTS-4B	09/07/2000	05/03/2002
PREP/ATP/QC/TO LTS-4C	10/05/2000	06/28/2002
PREP/ATP/QC/TO LTS-4D	11/02/2000	08/23/2002
PREP/ATP/QC/TO LTS-4E	12/04/2000	10/18/2002
PREP/ATP/QC/TO LTS-5A	01/08/2001	12/13/2002
PREP/ATP/QC/TO LTS-5B	02/05/2001	02/07/2003
PREP/ATP/QC/TO LTS-5C	03/05/2001	04/04/2003
PREP/ATP/QC/TO LTS-5D	04/02/2001	05/30/2003
PREP/ATP/QC/TO LTS-5E	04/30/2001	07/25/2003
PREP/ATP/QC/TO LTS-6A	05/28/2001	09/19/2003
PREP/ATP/QC/TO LTS-6B	06/25/2001	11/14/2003
PREP/ATP/QC/TO LTS-6C	07/23/2001	01/09/2004
PREP/ATP/QC/TO LTS-6D	08/20/2001	03/05/2004
PREP/ATP/QC/TO LTS-6E	09/17/2001	04/30/2004
ENGRG MAINTENANCE	06/05/2000	06/16/2023
HEATERS		
PRELIMINARY DESIGN	10/02/1997	07/27/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNITS	10/02/1997	04/30/1998
DEVELOPMENT TESTING	05/01/1998	10/20/1998
DEV TEST REPORT	10/21/1998	12/17/1998
CRITICAL DESIGN	10/28/1998	09/17/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	06/23/1999
CMPNT QUAL UNITS PACK & SHIP	06/24/1999	07/15/1999



Space Transfer Vehicle/Lunar Transportation System

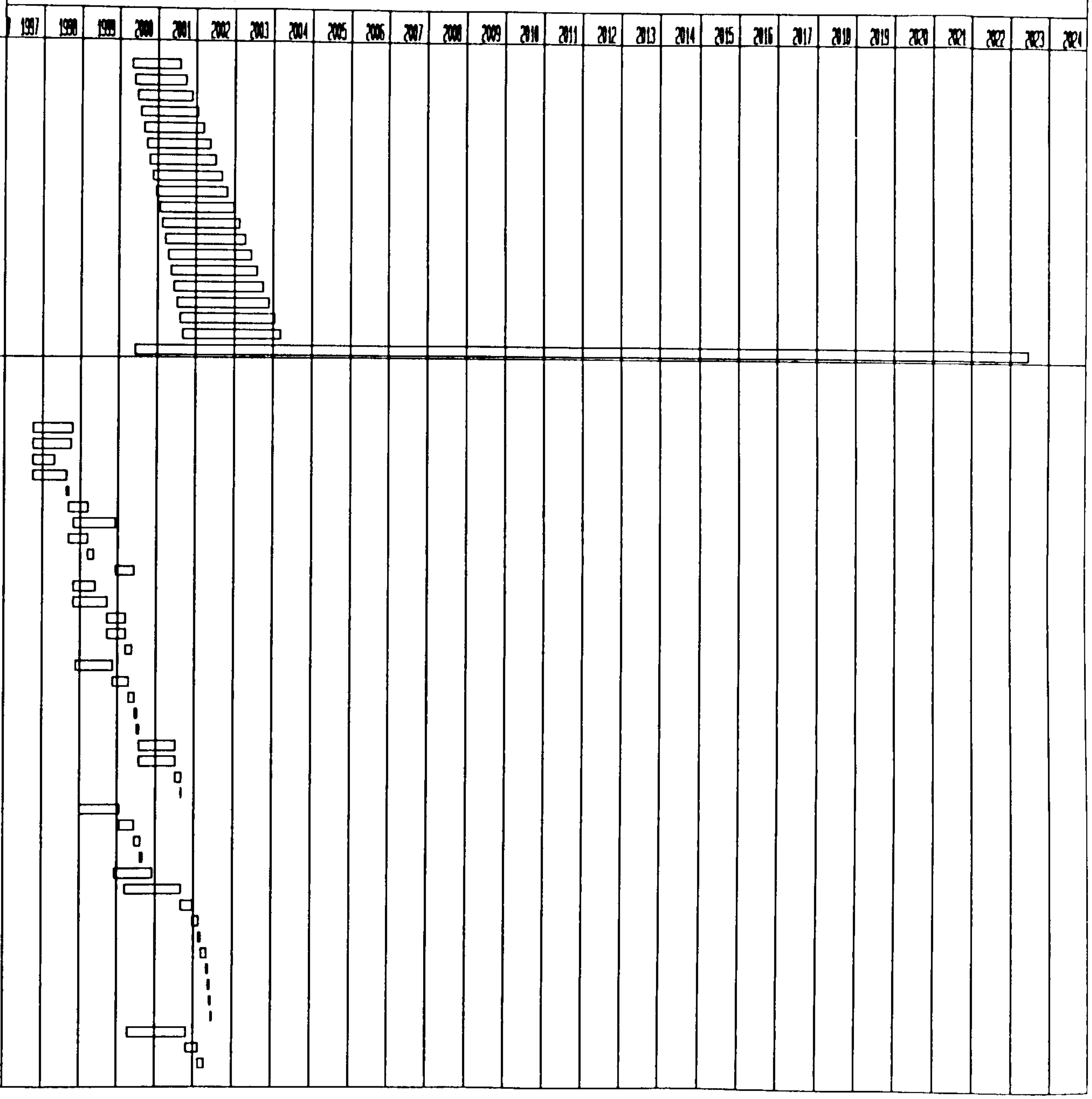
Master Schedule

Activity Description	Start	Complete
FAB PTA UNITS	11/25/1998	07/22/1999
ATP/QC/TO PTA	07/23/1999	09/17/1999
FAB GTU UNITS	01/05/1999	08/19/1999
ATP/QC/TO GTU	08/20/1999	10/15/1999
PROD HDWE PROCUREMENT	09/20/1999	09/20/2000
FAB LTS-TST UNITS	09/20/1999	05/11/2000
ATP/QC/TO LTS-TST	05/12/2000	07/11/2000
FAB LTS-1 UNITS	10/18/1999	06/09/2000
ATP/QC/TO LTS-1	06/12/2000	08/08/2000
FAB/ATP/QC/TO LTS-2A	11/15/1999	10/04/2000
FAB/ATP/QC/TO LTS-2B	12/15/1999	12/01/2000
FAB/ATP/QC/TO LTS-2C	01/20/2000	02/02/2001
FAB/ATP/QC/TO LTS-2D	02/17/2000	03/30/2001
FAB/ATP/QC/TO LTS-3A	03/16/2000	05/25/2001
FAB/ATP/QC/TO LTS-3B	04/13/2000	07/20/2001
FAB/ATP/QC/TO LTS-3C	05/12/2000	09/14/2001
FAB/ATP/QC/TO LTS-3D	06/12/2000	11/09/2001
FAB/ATP/QC/TO LTS-3E	07/12/2000	01/04/2002
FAB/ATP/QC/TO LTS-4A	08/09/2000	03/01/2002
FAB/ATP/QC/TO LTS-4B	09/07/2000	04/26/2002
FAB/ATP/QC/TO LTS-4C	10/05/2000	06/21/2002
FAB/ATP/QC/TO LTS-4D	11/02/2000	08/16/2002
FAB/ATP/QC/TO LTS-4E	12/04/2000	10/11/2002
FAB/ATP/QC/TO LTS-5A	01/08/2001	12/06/2002
FAB/ATP/QC/TO LTS-5B	02/05/2001	01/31/2003
FAB/ATP/QC/TO LTS-5C	03/05/2001	03/28/2003
FAB/ATP/QC/TO LTS-5D	04/02/2001	05/23/2003
FAB/ATP/QC/TO LTS-5E	04/30/2001	07/18/2003
FAB/ATP/QC/TO LTS-6A	05/28/2001	09/12/2003
FAB/ATP/QC/TO LTS-6B	06/25/2001	11/07/2003
FAB/ATP/QC/TO LTS-6C	07/23/2001	01/02/2004
FAB/ATP/QC/TO LTS-6D	08/20/2001	02/27/2004
FAB/ATP/QC/TO LTS-6E	09/17/2001	04/23/2004
ENGRG MAINTENANCE	06/05/2000	06/16/2023
OTHER THERMAL CONTROL		
PRELIMINARY DESIGN	10/02/1997	07/13/1998
LONG LEAD REQUIREMENTS	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
FAB DEV TEST UNITS	10/02/1997	04/30/1998
DEVELOPMENT TESTING	05/01/1998	10/20/1998
DEV TEST REPORT	10/21/1998	12/17/1998
CRITICAL DESIGN	10/28/1998	09/02/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	05/25/1999
CMPNT QUAL UNITS PACK & SHIP	05/26/1999	06/16/1999
FAB PTA UNITS	11/25/1998	06/23/1999
ATP/QC ACCEPTANCE/TO PTA	06/24/1999	08/19/1999
FAB GTU UNITS	01/05/1999	07/22/1999
ATP/QC ACCEPTANCE/TO GTU	07/23/1999	09/17/1999
PROD HDWE PROCUREMENT	09/03/1999	09/06/2000
FAB LTS-TST UNITS	09/03/1999	03/29/2000
ATP/QC ACCEPTANCE/TO LTS-TST	03/30/2000	05/25/2000
FAB LTS-1 UNITS	10/04/1999	04/27/2000
ATP/QC ACCEPTANCE/TO LTS-1	04/28/2000	06/23/2000
FAB/ATP/QC/SHIP LTS-2A	11/01/1999	08/22/2000
FAB/ATP/QC/SHIP LTS-2B	12/01/1999	10/18/2000
FAB/ATP/QC/SHIP LTS-2C	01/06/2000	12/15/2000
FAB/ATP/QC/SHIP LTS-2D	02/03/2000	02/16/2001
FAB/ATP/QC/SHIP LTS-3A	03/02/2000	04/13/2001
FAB/ATP/QC/SHIP LTS-3B	03/30/2000	06/08/2001



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

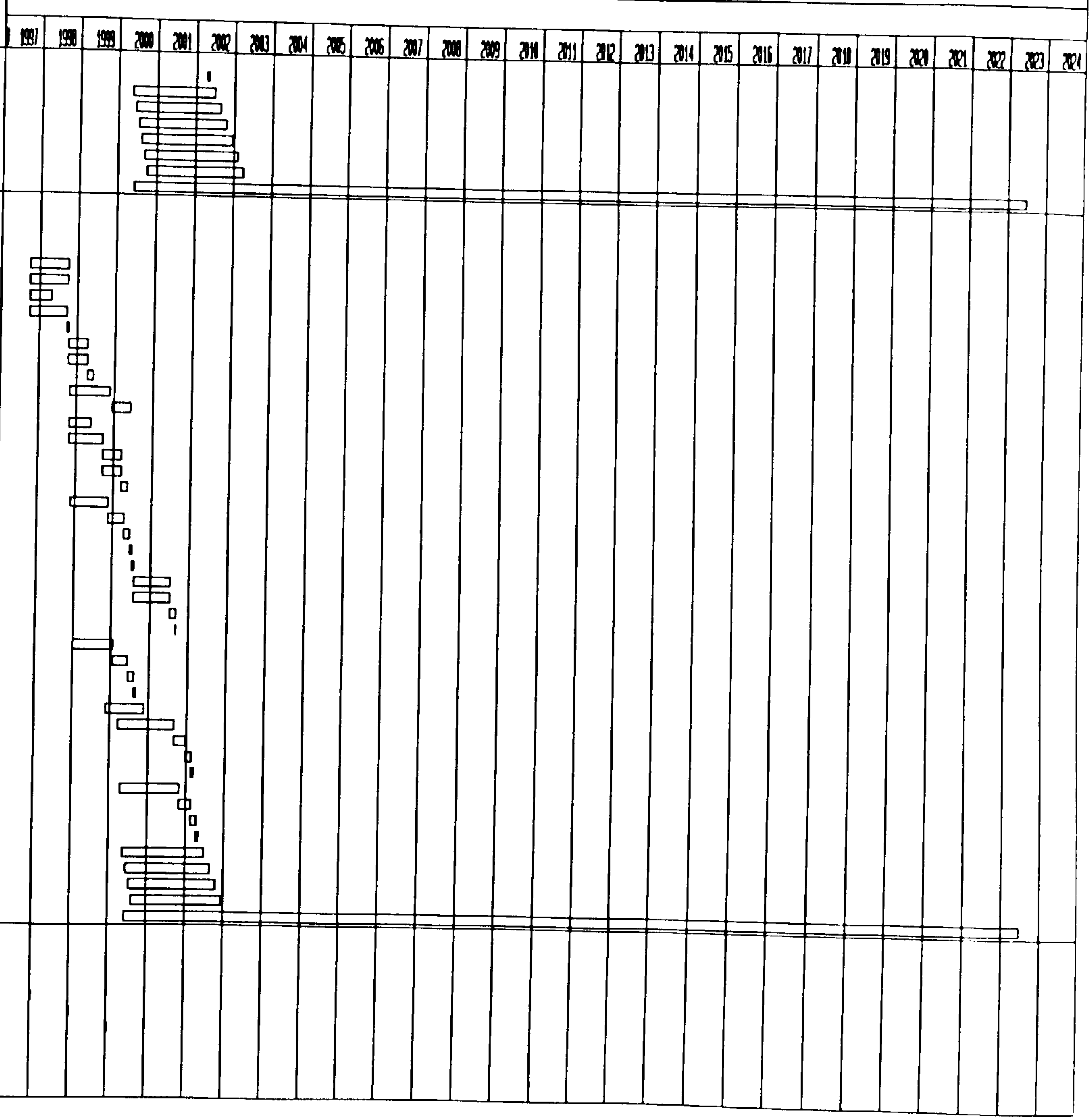
Activity Description	Start	Complete
FAB/ATP/QC/SHIP LTS-3C	04/28/2000	08/03/2001
FAB/ATP/QC/SHIP LTS-3D	05/26/2000	09/28/2001
FAB/ATP/QC/TO LTS-3E	06/26/2000	11/23/2001
FAB/ATP/QC/TO LTS-4A	07/26/2000	01/18/2002
FAB/ATP/QC/TO LTS-4B	08/23/2000	03/15/2002
FAB/ATP/QC/TO LTS-4C	09/21/2000	05/10/2002
FAB/ATP/QC/TO LTS-4D	10/19/2000	07/05/2002
FAB/ATP/QC/TO LTS-4E	11/16/2000	08/30/2002
FAB/ATP/QC/TO LTS-5A	12/18/2000	10/25/2002
FAB/ATP/QC/TO LTS-5B	01/22/2001	12/20/2002
FAB/ATP/QC/TO LTS-5C	02/19/2001	02/14/2003
FAB/ATP/QC/TO LTS-5D	03/19/2001	04/11/2003
FAB/ATP/QC/TO LTS-5E	04/16/2001	06/06/2003
FAB/ATP/QC/TO LTS-6A	05/14/2001	08/01/2003
FAB/ATP/QC/TO LTS-6B	06/11/2001	09/26/2003
FAB/ATP/QC/TO LTS-6C	07/09/2001	11/21/2003
FAB/ATP/QC/TO LTS-6D	08/06/2001	01/16/2004
FAB/ATP/QC/TO LTS-6E	09/03/2001	03/12/2004
ENGRG MAINTENANCE	06/05/2000	06/16/2023
AEROBRAKE		
PRELIMINARY DESIGN	10/02/1997	10/20/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
ENG MODEL HDWE PROCUREMENT	10/02/1997	04/30/1998
ENG MODEL FAB	10/02/1997	08/24/1998
PREP FOR ENG MODEL TESTING	08/25/1998	09/15/1998
ENG MODEL TESTING	09/16/1998	03/15/1999
CRITICAL DESIGN	10/28/1998	11/30/1999
ENG MODEL TEST DATA EVAL	09/16/1998	03/15/1999
ENG MODEL TEST REPORT	03/16/1999	05/11/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL TEST UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL ANALYSIS & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORTS	03/16/2000	05/11/2000
FAB SYSTEM QUAL UNIT	11/25/1998	11/12/1999
ATP SYSTEM QUAL UNIT	11/15/1999	04/12/2000
ATP REPORT SYSTEM QUAL UNIT	04/13/2000	06/09/2000
SYSTEM QUAL UNIT PACK & SHIP	06/12/2000	06/30/2000
SYSTEM QUAL R&I/PREP FOR TEST	07/05/2000	07/25/2000
SYSTEM QUAL TESTING	07/26/2000	07/06/2001
SYSTEM QUAL TEST ANAL & EVAL	07/26/2000	07/06/2001
SYSTEM QUAL TEST REPORT	07/09/2001	08/31/2001
SYSTEM QUAL REFURB OR STORE	09/03/2001	09/03/2001
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	12/01/1999	12/01/2000
FAB PROD UNIT #1	03/16/2000	08/31/2001
ATP PROD UNIT #1	09/03/2001	12/21/2001
ATP REPORT PROD UNIT #1	12/24/2001	02/15/2002
QC ACCEPTANCE/SHIP UNIT #1	02/18/2002	03/08/2002
MANAGEMENT RESERVE	03/11/2002	05/03/2002
PROD UNIT #1 DEL TO KSC	05/06/2002	05/17/2002
PROD UNIT #1 REC & INSPECT	05/20/2002	05/31/2002
PROD UNIT #1 QC ACCEPTANCE	06/03/2002	06/14/2002
PROD UNIT #1 DD250	06/17/2002	06/21/2002
FAB PROD UNIT #2	04/13/2000	10/26/2001
ATP PROD UNIT #2	10/29/2001	02/15/2002
ATP REPORT PROD UNIT #2	02/18/2002	04/12/2002



Space Transfer Vehicle/Lunar Transportation System

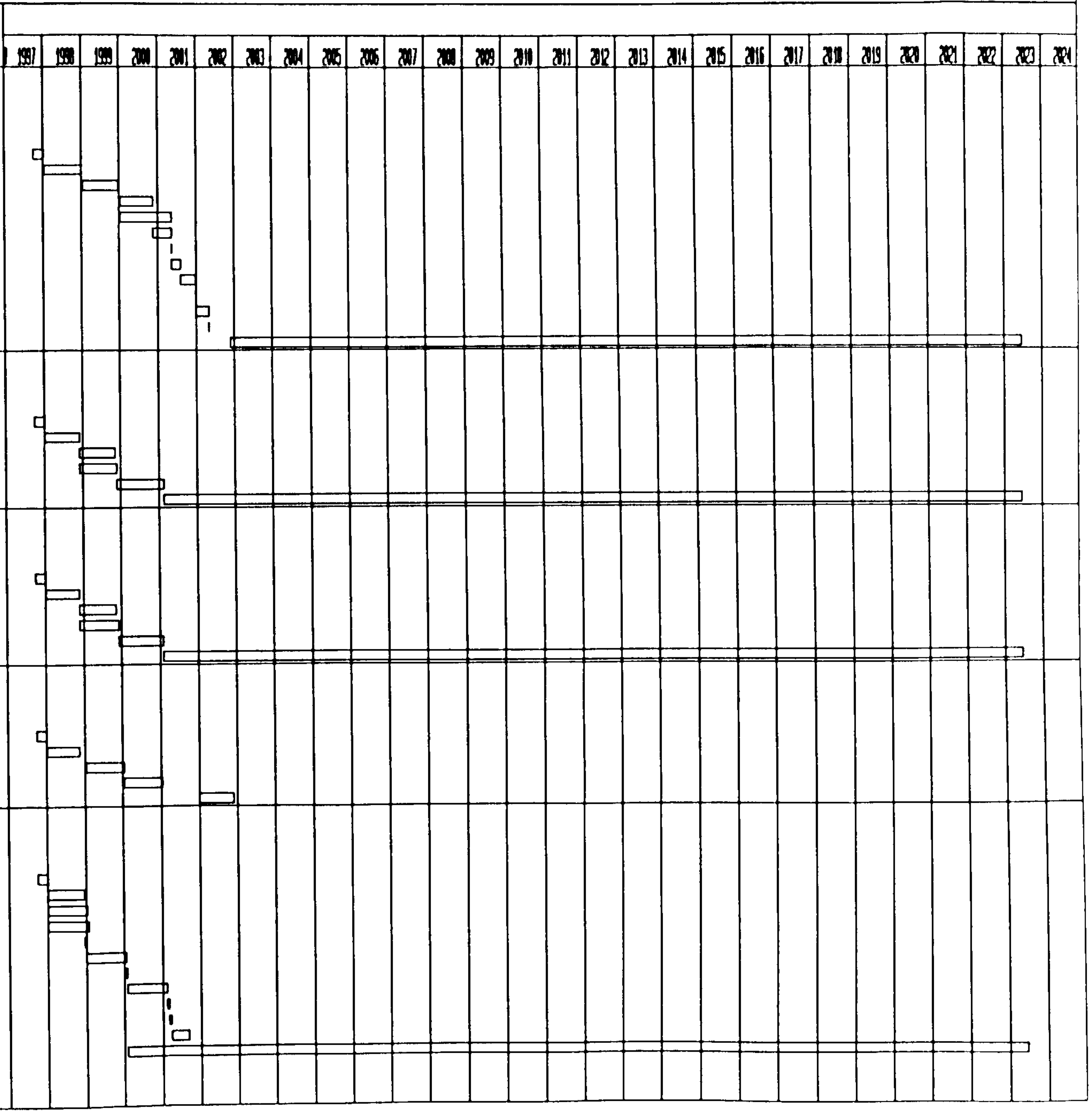
Master Schedule

Activity Description	Start	Complete
QC ACCEPTANCE/SHIP UNIT #2	04/15/2002	05/03/2002
FAB/ATP/QC/SHIP PROD UNIT #3	05/12/2000	06/28/2002
FAB/ATP/QC/SHIP PROD UNIT #4	06/12/2000	08/23/2002
FAB/ATP/QC/SHIP PROD UNIT #5	07/12/2000	10/18/2002
FAB/ATP/QC/SHIP PROD UNIT #6	08/09/2000	12/13/2002
FAB/ATP/QC/SHIP PROD UNIT #7	09/07/2000	02/07/2003
FAB/ATP/QC/SPARES	10/05/2000	04/04/2003
ENGRG MAINTENANCE	06/05/2000	06/16/2023
CREW MODULE		
PRELIMINARY DESIGN	10/02/1997	10/09/1998
LONG LEAD PROCUREMENT	10/02/1997	10/06/1998
DEV HDWE PROCUREMENT	10/02/1997	04/30/1998
ENG MODEL FAB	10/02/1997	09/22/1998
PREP FOR ENG MODEL TESTING	09/23/1998	10/13/1998
ENG MODEL TESTING	10/14/1998	04/13/1999
ENG MODEL TEST ANALYSIS & EVAL	10/14/1998	04/13/1999
ENG MODEL TEST REPORT	04/14/1999	06/09/1999
CRITICAL DESIGN	10/28/1998	11/16/1999
UPDATE & BASELINE ENGRG	12/08/1999	06/02/2000
QUAL/GTU HDWE PROCUREMENT	10/28/1998	05/25/1999
FAB CMPNT QUAL UNITS	10/28/1998	09/17/1999
CMPNT QUAL TESTING	09/20/1999	03/15/2000
CMPNT QUAL ANALYSIS & EVAL	09/20/1999	03/15/2000
CMPNT QUAL TEST REPORT	03/16/2000	05/11/2000
FAB SYSTEM QUAL UNIT	11/25/1998	11/12/1999
ATP SYSTEM QUAL UNIT	11/15/1999	04/12/2000
ATP REPORT SYS QUAL UNIT	04/13/2000	06/09/2000
QC ACCEPTANCE/TO SYS QUAL TEST	06/12/2000	06/30/2000
SYS QUAL UNIT R&I/TEST PREP	07/05/2000	07/25/2000
SYSTEM QUAL TESTING	07/26/2000	07/06/2001
SYSTEM QUAL TEST ANAL & EVAL	07/26/2000	07/06/2001
SYSTEM QUAL TEST REPORT	07/09/2001	08/31/2001
SYSTEM QUAL REFURB OR STORE	09/03/2001	09/03/2001
FAB GTU UNIT	01/05/1999	01/19/2000
ATP GTU UNIT	01/20/2000	06/09/2000
ATP REPORT GTU UNIT	06/12/2000	08/08/2000
QC ACCEPTANCE/TO GTU	08/09/2000	08/29/2000
PROD HDWE PROCUREMENT	11/17/1999	11/17/2000
FAB PROD UNIT #1	03/16/2000	08/31/2001
ATP PROD UNIT #1	09/03/2001	12/21/2001
ATP REPORT PROD UNIT #1	12/24/2001	02/15/2002
QC ACCEPTANCE/SHIP UNIT #1	02/18/2002	03/08/2002
FAB PROD UNIT #2	04/13/2000	10/26/2001
ATP PROD UNIT #2	10/29/2001	02/15/2002
ATP REPORT PROD UNIT #2	02/18/2002	04/12/2002
QC ACCEPTANCE/SHIP UNIT #2	04/15/2002	05/03/2002
FAB/ATP/QC/SHIP PROD UNIT #3	05/12/2000	06/28/2002
FAB/ATP/QC/SHIP PROD UNIT #4	06/12/2000	08/23/2002
FAB/ATP/QC/SHIP PROD UNIT #5	07/12/2000	10/18/2002
FAB/ATP/QC/SHIP PROD UNIT #6	08/09/2000	12/13/2002
ENGRG MAINTENANCE	06/05/2000	06/16/2023
SOFTWARE		
S/W PROGRAM RQMTS REVIEW	01/08/1998	01/14/1998
S/W PDR	01/05/1999	01/11/1999
S/W CDR	12/22/1999	01/05/2000



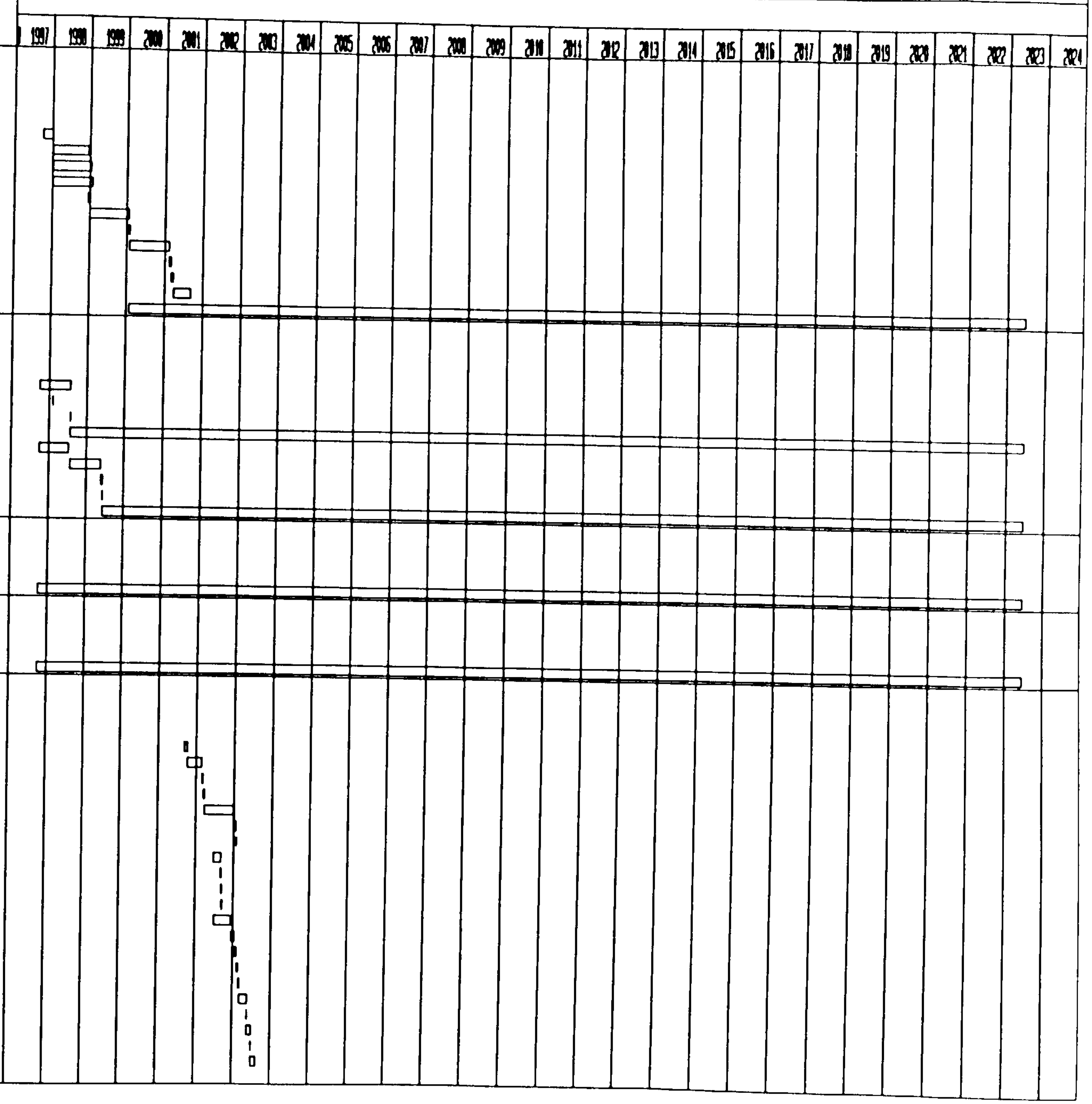
Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
FLIGHT SOFTWARE		
FLT SW RQMTS DEFINITION	10/02/1997	01/07/1998
FLT SW PRELIMINARY DESIGN	01/15/1998	01/04/1999
FLT SW CRITICAL DESIGN	01/12/1999	12/21/1999
FLT SW CODE/DEBUG	01/06/2000	11/15/2000
FLT SW DEV - TEST BED/LAB	01/06/2000	05/11/2001
FLT SW PRELIMINARY VALIDATION	11/16/2000	05/11/2001
FLT SW PRELIM FTA VAL COMPLETE	05/14/2001	05/14/2001
FLT SW MANAGEMENT RESERVE	05/15/2001	08/06/2001
FLT SW UPDATES & BASELINE	08/07/2001	12/24/2001
DEL TO LTS-TST	12/25/2001	12/25/2001
LTS-TST RESULTS UPDATES	12/26/2001	04/30/2002
DEL TO LTS-1	05/01/2002	05/01/2002
UPDATES & MAINTENANCE	11/26/2002	06/16/2023
SUPPORT & CHECKOUT SOFTWARE		
REQUIREMENTS ANALYSIS	10/02/1997	01/07/1998
PRELIMINARY DESIGN	01/08/1998	12/03/1998
PRELIMINARY DEVELOPMENT	12/04/1998	11/05/1999
PROCUREMENT	12/04/1998	11/23/1999
FINAL DEVELOPMENT	11/24/1999	02/13/2001
UPDATES & MAINTENANCE	02/14/2001	06/16/2023
MISSION PLANNING/CONTROL SOFTWARE		
REQUIREMENTS ANALYSIS	10/02/1997	01/07/1998
PRELIMINARY DESIGN	01/08/1998	11/24/1998
PRELIMINARY DEVELOPMENT	11/25/1998	11/05/1999
PROCURE EQUIPMENT	11/25/1998	11/30/1999
FINAL DEVELOPMENT/INTEGRATION	12/01/1999	01/31/2001
UPDATES & MAINTENANCE	02/01/2001	06/16/2023
SOFTWARE VERIFICATION & VALIDATION		
REQUIREMENTS DEFINITION	10/02/1997	01/07/1998
TEST BED DEFINITION	01/08/1998	11/10/1998
TEST BED HDWE PROCUREMENT	01/12/1999	01/12/2000
TEST BED FAB/CHECKOUT/CERTIFY	01/13/2000	01/12/2001
SW INDEPENDENT VERIF & VALID	12/25/2001	11/25/2002
ELECTRICAL SUPPORT EQUIPMENT		
REQUIREMENTS DEFINITION	10/02/1997	01/07/1998
PRELIMINARY DESIGN	01/08/1998	12/17/1998
PROCUREMENT	01/08/1998	01/11/1999
PROTO HDWE BUILD/TEST	01/08/1998	01/25/1999
PDR	12/18/1998	01/04/1999
CRITICAL DESIGN	01/05/1999	01/19/2000
CDR	01/20/2000	01/26/2000
FAB/CHECKOUT PROD HDWE	01/27/2000	02/09/2001
PROD HDWE SHIP	02/12/2001	03/02/2001
RECEIVE & INSPECT	03/05/2001	03/23/2001
INSTALL & CHECKOUT	03/26/2001	09/07/2001
ENGRG MAINTENANCE	01/27/2000	06/16/2023



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
MECHANICAL SUPPORT EQUIPMENT		
REQUIREMENTS DEFINITION	10/02/1997	01/07/1998
PRELIMINARY DESIGN	01/08/1998	12/17/1998
PROCUREMENT	01/08/1998	01/11/1999
DEV UNITS BUILD & TEST	01/08/1998	01/25/1999
PDR	12/18/1998	01/04/1999
CRITICAL DESIGN	01/05/1999	01/19/2000
CDR	01/20/2000	01/26/2000
FAB & CHECKOUT PROD HDWE	01/27/2000	02/09/2001
PROD HDWE SHIP	02/12/2001	03/02/2001
PROD HDWE RECEIVE & INSPECT	03/05/2001	03/23/2001
PROD HDWE CHECKOUT	03/26/2001	09/07/2001
ENGRG MAINTENANCE	01/27/2000	06/16/2023
TOOLING		
DESIGN	10/02/1997	07/27/1998
DESIGN REVIEW 1	02/05/1998	02/09/1998
DESIGN REVIEW 2	07/28/1998	07/30/1998
ENGRG MAINTENANCE	07/31/1998	06/16/2023
PROCUREMENT	10/02/1997	07/13/1998
FABRICATION	07/31/1998	05/21/1999
QC ACCEPTANCE	05/24/1999	06/07/1999
AVAILABLE	06/08/1999	06/08/1999
HDWE MAINTENANCE	06/09/1999	06/16/2023
DATA		
TECHNICAL DATA SERVICES	10/02/1997	06/16/2023
TRAINING		
TRAINING SERVICES	10/02/1997	06/16/2023
FIRST TIME INTEGRATION		
GTU REC & INSPECT SUBSYTEMS	09/10/2001	10/05/2001
GTA ASSEMBLY	10/08/2001	02/22/2002
GTA FINAL ASSY INSPECTION	02/25/2002	03/08/2002
GTA QC ACCEPTANCE	03/11/2002	03/22/2002
GTA PROCESSING	03/25/2002	12/27/2002
GTA POST PROCESSING CHECKOUT	12/30/2002	01/24/2003
GTA REFURB OR STORE	01/27/2003	01/27/2003
AEROBRAKE #1 PREP PAYLOAD	06/22/2002	09/04/2002
AEROBRAKE #1 PAYLOAD LAUNCH	09/05/2002	09/05/2002
AEROBRAKE #1 ON-ORBIT ASSEMBLY	09/06/2002	09/13/2002
POLAR MISSION OPS (A/B TEST)	09/14/2002	09/14/2002
LTS-TST MANAGEMENT RESERVE	07/01/2002	12/13/2002
LTS-TST DELIVER TO KSC	12/16/2002	01/17/2003
LTS-TST RECEIVE & INSPECT	01/20/2003	02/07/2003
LTS-TST QC ACCEPTANCE	02/10/2003	02/21/2003
LTS-TST DD250	02/24/2003	03/07/2003
LTS-TST PAYLOAD #1 PROCESSING	03/08/2003	05/21/2003
LTS-TST PAYLOAD #1 LAUNCH	05/22/2003	05/22/2003
LTS-TST PAYLOAD #2 PROCESSING	05/22/2003	07/03/2003
LTS-TST PAYLOAD #2 LAUNCH	07/04/2003	07/04/2003
LTS-TST PAYLOAD #3 PROCESSING	07/04/2003	08/15/2003



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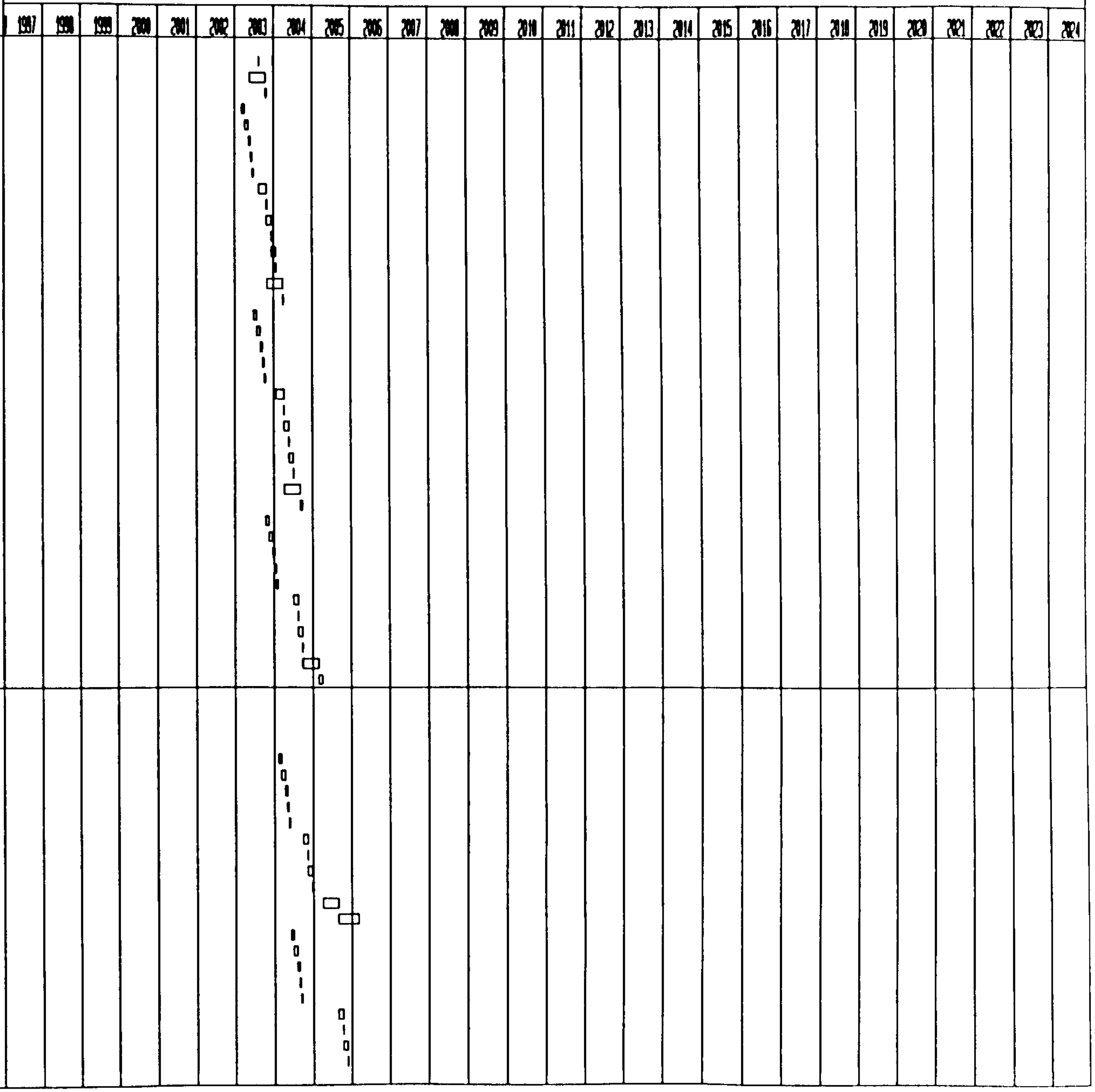
Space Transfer Vehicle/Lunar Transportation System

Master Schedule

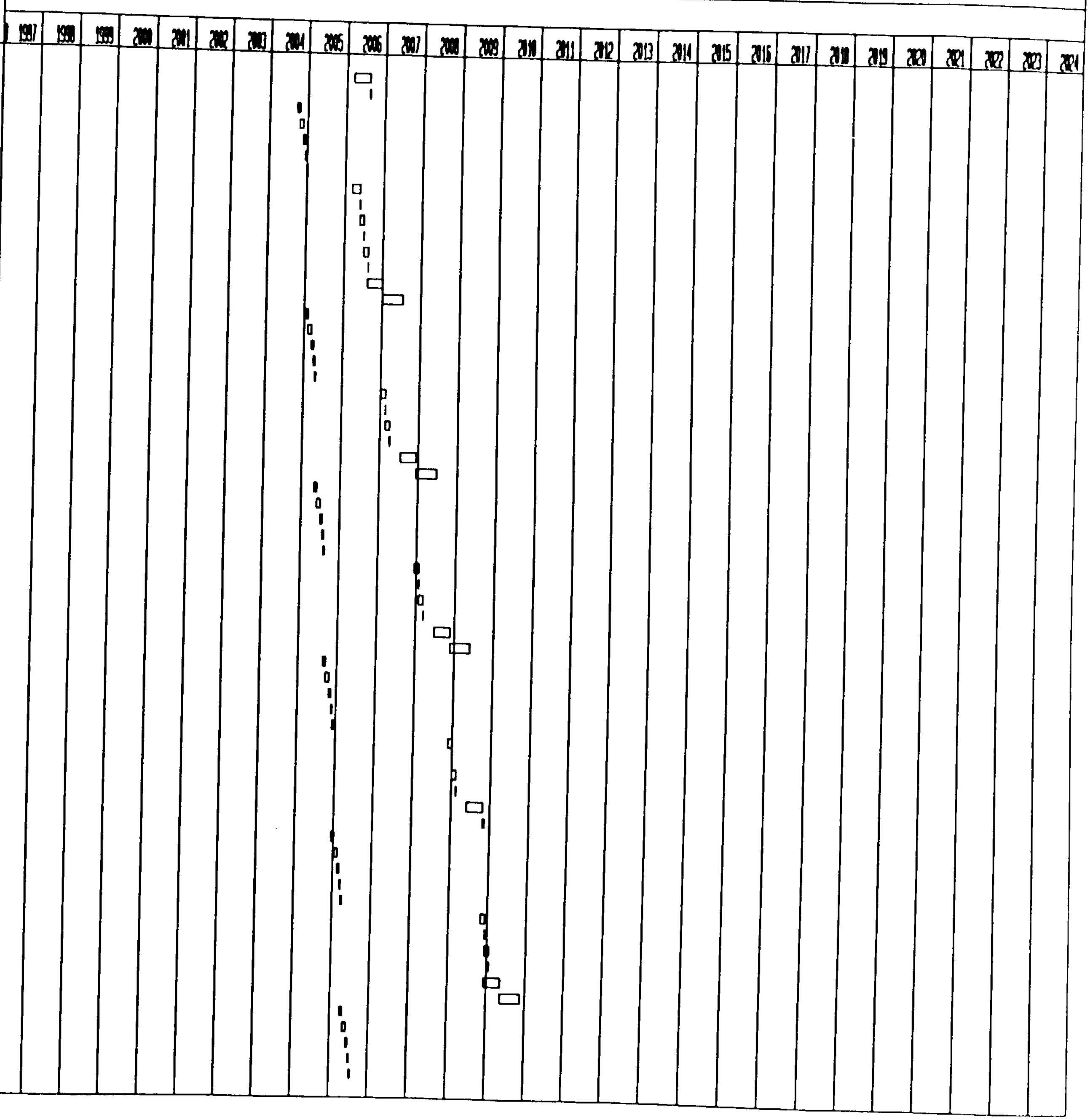
Activity Description	Start	Complete
LTS-TST PAYLOAD #3 LAUNCH	08/18/2003	08/18/2003
LTS-TST ON-ORBIT ASSEMBLY	05/23/2003	10/19/2003
LTS-TST MISSION OPS	10/20/2003	10/29/2003
LTS-1 MANAGEMENT RESERVE	03/10/2003	04/04/2003
LTS-1 DELIVER TO KSC	04/07/2003	05/09/2003
LTS-1 RECEIVE & INSPECT	05/12/2003	05/30/2003
LTS-1 QC ACCEPTANCE	06/02/2003	06/13/2003
LTS-1 DD250	06/16/2003	06/27/2003
LTS-1 PAYLOAD #1 PROCESSING	08/16/2003	10/29/2003
LTS-1 PAYLOAD #1 LAUNCH	10/30/2003	10/30/2003
LTS-1 PAYLOAD #2 PROCESSING	10/30/2003	12/11/2003
LTS-1 PAYLOAD #2 LAUNCH	12/12/2003	12/12/2003
LTS-1 PAYLOAD #3 PROCESSING	12/12/2003	01/23/2004
LTS-1 PAYLOAD #3 LAUNCH	01/26/2004	01/26/2004
LTS-1 ON-ORBIT ASSY	10/31/2003	03/28/2004
LTS-1 MISSION OPS (EXPEND)	03/29/2004	04/04/2004
LTS-2A MANAGEMENT RESERVE	06/30/2003	07/25/2003
LTS-2A DELIVER TO KSC	07/28/2003	08/29/2003
LTS-2A RECEIVE & INSPECT	09/01/2003	09/19/2003
LTS-2A QC ACCEPTANCE	09/22/2003	10/03/2003
LTS-2A DD250	10/06/2003	10/17/2003
LTS-2A PAYLOAD #1 PROCESSING	01/24/2004	04/07/2004
LTS-2A PAYLOAD #1 LAUNCH	04/08/2004	04/08/2004
LTS-2A PAYLOAD #2 PROCESSING	04/08/2004	05/20/2004
LTS-2A PAYLOAD #2 LAUNCH	05/21/2004	05/21/2004
LTS-2A PAYLOAD #3 PROCESSING	05/21/2004	07/02/2004
LTS-2A PAYLOAD #3 LAUNCH	07/05/2004	07/05/2004
LTS-2A ON-ORBIT ASSEMBLY	04/09/2004	09/05/2004
LTS-2A MISSION OPS	09/06/2004	09/25/2004
LTS-2B MANAGEMENT RESERVE	10/20/2003	11/14/2003
LTS-2B TANK SETS DEL TO KSC	11/17/2003	12/19/2003
LTS-2B TANK SETS REC & INSPECT	12/22/2003	01/09/2004
LTS-2B TANK SETS QC ACCEPTANCE	01/12/2004	01/23/2004
LTS-2B TANK SETS DD250	01/26/2004	02/06/2004
LTS-2B PAYLOAD #1 PROCESSING	07/03/2004	08/14/2004
LTS-2B PAYLOAD #1 LAUNCH	08/16/2004	08/16/2004
LTS-2B PAYLOAD #2 PROCESSING	08/15/2004	09/26/2004
LTS-2B PAYLOAD #2 LAUNCH	09/27/2004	09/27/2004
LTS-2B ON-ORBIT ASSEMBLY	09/26/2004	02/22/2005
LTS-2B MISSION OPS	02/23/2005	03/31/2005
REPEAT MISSIONS		
LTS-2C MANAGEMENT RESERVE	02/09/2004	03/05/2004
LTS-2C TANK SETS DEL TO KSC	03/08/2004	04/09/2004
LTS-2C TANK SETS REC & INSPECT	04/12/2004	04/30/2004
LTS-2C TANK SETS QC ACCEPTANCE	05/03/2004	05/14/2004
LTS-2C TANK SETS DD250	05/17/2004	05/28/2004
LTS-2C PAYLOAD #1 PROCESSING	09/27/2004	11/08/2004
LTS-2C PAYLOAD #1 LAUNCH	11/09/2004	11/09/2004
LTS-2C PAYLOAD #2 PROCESSING	11/09/2004	12/21/2004
LTS-2C PAYLOAD #2 LAUNCH	12/22/2004	12/22/2004
LTS-2C ON-ORBIT ASSEMBLY	04/01/2005	08/28/2005
LTS-2C MISSION OPS	08/29/2005	03/06/2006
LTS-2D MANAGEMENT RESERVE	05/31/2004	06/25/2004
LTS-2D TANK SETS DEL TO KSC	06/28/2004	07/30/2004
LTS-2D TANK SETS REC & INSPECT	08/02/2004	08/20/2004
LTS-2D TANK SETS QC ACCEPTANCE	08/23/2004	09/03/2004
LTS-2D TANK SETS DD250	09/06/2004	09/17/2004
LTS-2D PAYLOAD #1 PROCESSING	08/29/2005	10/10/2005
LTS-2D PAYLOAD #1 LAUNCH	10/11/2005	10/11/2005
LTS-2D PAYLOAD #2 PROCESSING	10/11/2005	11/22/2005
LTS-2D PAYLOAD #2 LAUNCH	11/23/2005	11/23/2005



Space Transfer Vehicle/Lunar Transportation System

Master Schedule

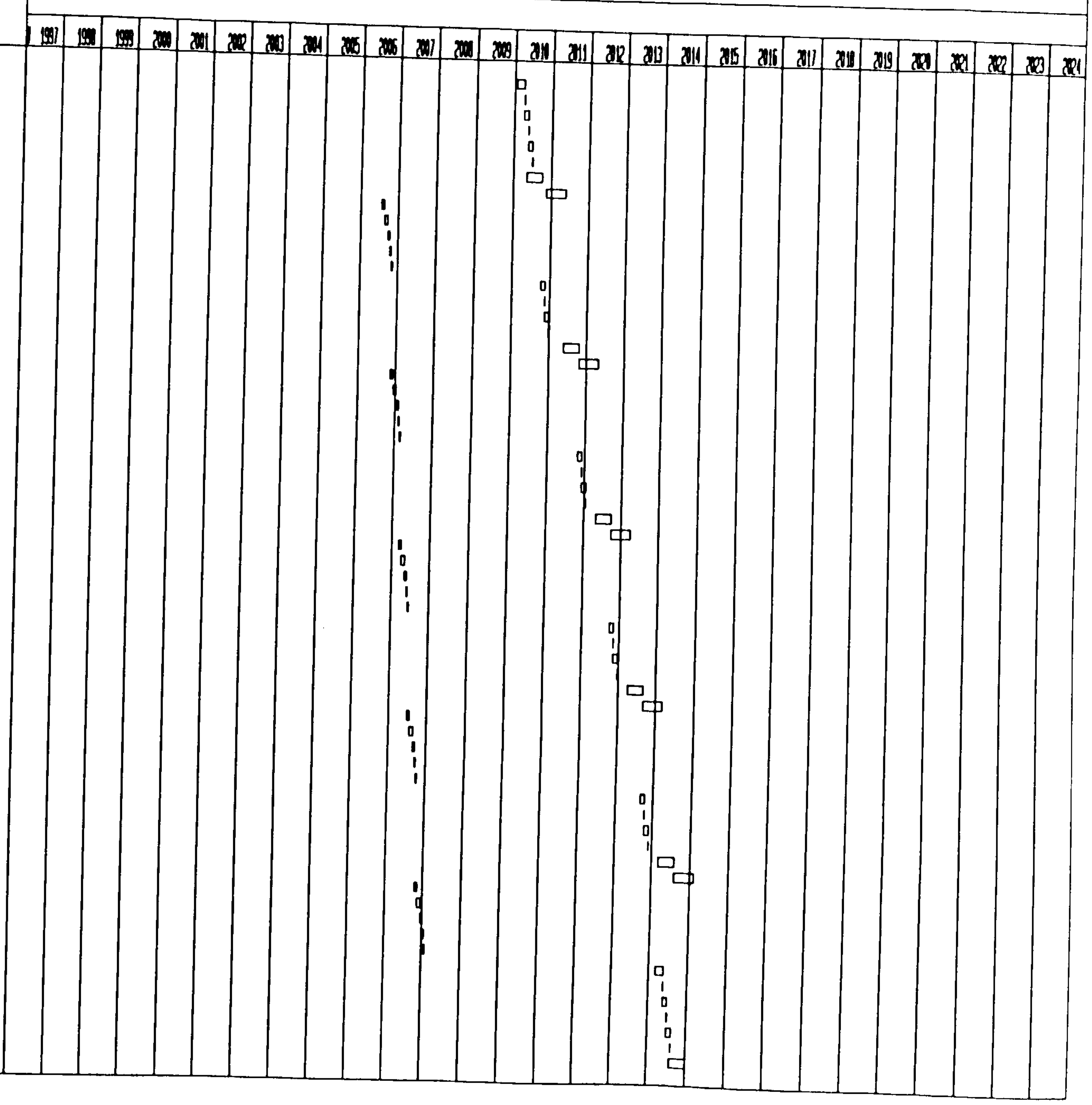
Activity Description	Start	Complete
LTS-2D ON-ORBIT ASSEMBLY	03/07/2006	08/03/2006
LTS-2D MISSION OPS (EXPEND)	08/04/2006	08/10/2006
LTS-3A MANAGEMENT RESERVE	09/20/2004	10/15/2004
LTS-3A DELIVER TO KSC	10/18/2004	11/19/2004
LTS-3A REC & INSPECT	11/22/2004	12/10/2004
LTS-3A QC ACCEPTANCE	12/13/2004	12/24/2004
LTS-3A DD250	12/27/2004	01/07/2005
LTS-3A PAYLOAD #1 PROCESSING	03/07/2006	05/20/2006
LTS-3A PAYLOAD #1 LAUNCH	05/22/2006	05/22/2006
LTS-3A PAYLOAD #2 PROCESSING	05/21/2006	07/02/2006
LTS-3A PAYLOAD #2 LAUNCH	07/03/2006	07/03/2006
LTS-3A PAYLOAD #3 PROCESSING	07/03/2006	08/14/2006
LTS-3A PAYLOAD #3 LAUNCH	08/15/2006	08/15/2006
LTS-3A ON-ORBIT ASSEMBLY	08/11/2006	01/07/2007
LTS-3A MISSION OPS	01/08/2007	07/16/2007
LTS-3B MANAGEMENT RESERVE	01/10/2005	02/04/2005
LTS-3B TANK SETS DEL TO KSC	02/07/2005	03/11/2005
LTS-3B TANK SETS REC & INSPECT	03/14/2005	04/01/2005
LTS-3B TANK SETS QC ACCEPTANCE	04/04/2005	04/15/2005
LTS-3B TANK SETS DD250	04/18/2005	04/29/2005
LTS-3B PAYLOAD #1 PROCESSING	01/08/2007	02/19/2007
LTS-3B PAYLOAD #1 LAUNCH	02/20/2007	02/20/2007
LTS-3B PAYLOAD #2 PROCESSING	02/20/2007	04/03/2007
LTS-3B PAYLOAD #2 LAUNCH	04/04/2007	04/04/2007
LTS-3B ON-ORBIT ASSEMBLY	07/17/2007	12/13/2007
LTS-3B MISSION OPS	12/14/2007	06/20/2008
LTS-3C MANAGEMENT RESERVE	05/02/2005	05/27/2005
LTS-3C TANK SETS DEL TO KSC	05/30/2005	07/01/2005
LTS-3C TANK SETS REC & INSPECT	07/04/2005	07/22/2005
LTS-3C TANK SETS QC ACCEPTANCE	07/25/2005	08/05/2005
LTS-3C TANK SETS DD250	08/08/2005	08/19/2005
LTS-3C PAYLOAD #1 PROCESSING	12/14/2007	01/25/2008
LTS-3C PAYLOAD #1 LAUNCH	01/28/2008	01/28/2008
LTS-3C PAYLOAD #2 PROCESSING	01/26/2008	03/08/2008
LTS-3C PAYLOAD #2 LAUNCH	03/10/2008	03/10/2008
LTS-3C ON-ORBIT ASSEMBLY	06/21/2008	11/17/2008
LTS-3C MISSION OPS	11/18/2008	05/26/2009
LTS-3D MANAGEMENT RESERVE	08/22/2005	09/16/2005
LTS-3D TANK SETS DEL TO KSC	09/19/2005	10/21/2005
LTS-3D TANK SETS REC & INSPECT	10/24/2005	11/11/2005
LTS-3D TANK SETS QC ACCEPTANCE	11/14/2005	11/25/2005
LTS-3D TANK SETS DD250	11/28/2005	12/09/2005
LTS-3D PAYLOAD #1 PROCESSING	11/18/2008	12/30/2008
LTS-3D PAYLOAD #1 LAUNCH	12/31/2008	12/31/2008
LTS-3D PAYLOAD #2 PROCESSING	12/31/2008	02/11/2009
LTS-3D PAYLOAD #2 LAUNCH	02/12/2009	02/12/2009
LTS-3D ON-ORBIT ASSEMBLY	05/27/2009	10/23/2009
LTS-3D MISSION OPS	10/24/2009	11/12/2009
LTS-3E MANAGEMENT RESERVE	12/12/2005	01/06/2006
LTS-3E TANK SETS DEL TO KSC	01/09/2006	02/10/2006
LTS-3E TANK SETS REC & INSPECT	02/13/2006	03/03/2006
LTS-3E TANK SETS QC ACCEPTANCE	03/06/2006	03/17/2006
LTS-3E TANK SETS DD250	03/20/2006	03/31/2006
LTS-3E PAYLOAD #1 PROCESSING	10/24/2009	12/05/2009
LTS-3E PAYLOAD #1 LAUNCH	12/07/2009	12/07/2009
LTS-3E PAYLOAD #2 PROCESSING	12/06/2009	01/17/2010
LTS-3E PAYLOAD #2 LAUNCH	01/18/2010	01/18/2010
LTS-3E ON-ORBIT ASSEMBLY	12/08/2009	05/06/2010
LTS-3E MISSION OPS	05/07/2010	11/12/2010
LTS-4A MANAGEMENT RESERVE	04/03/2006	04/28/2006
LTS-4A DELIVERY TO KSC	05/01/2006	06/02/2006
LTS-4A REC & INSPECTION	06/05/2006	06/23/2006
LTS-4A QC ACCEPTANCE	06/26/2006	07/07/2006
LTS-4A DD250	07/10/2006	07/21/2006



Space Transfer Vehicle/Lunar Transportation System

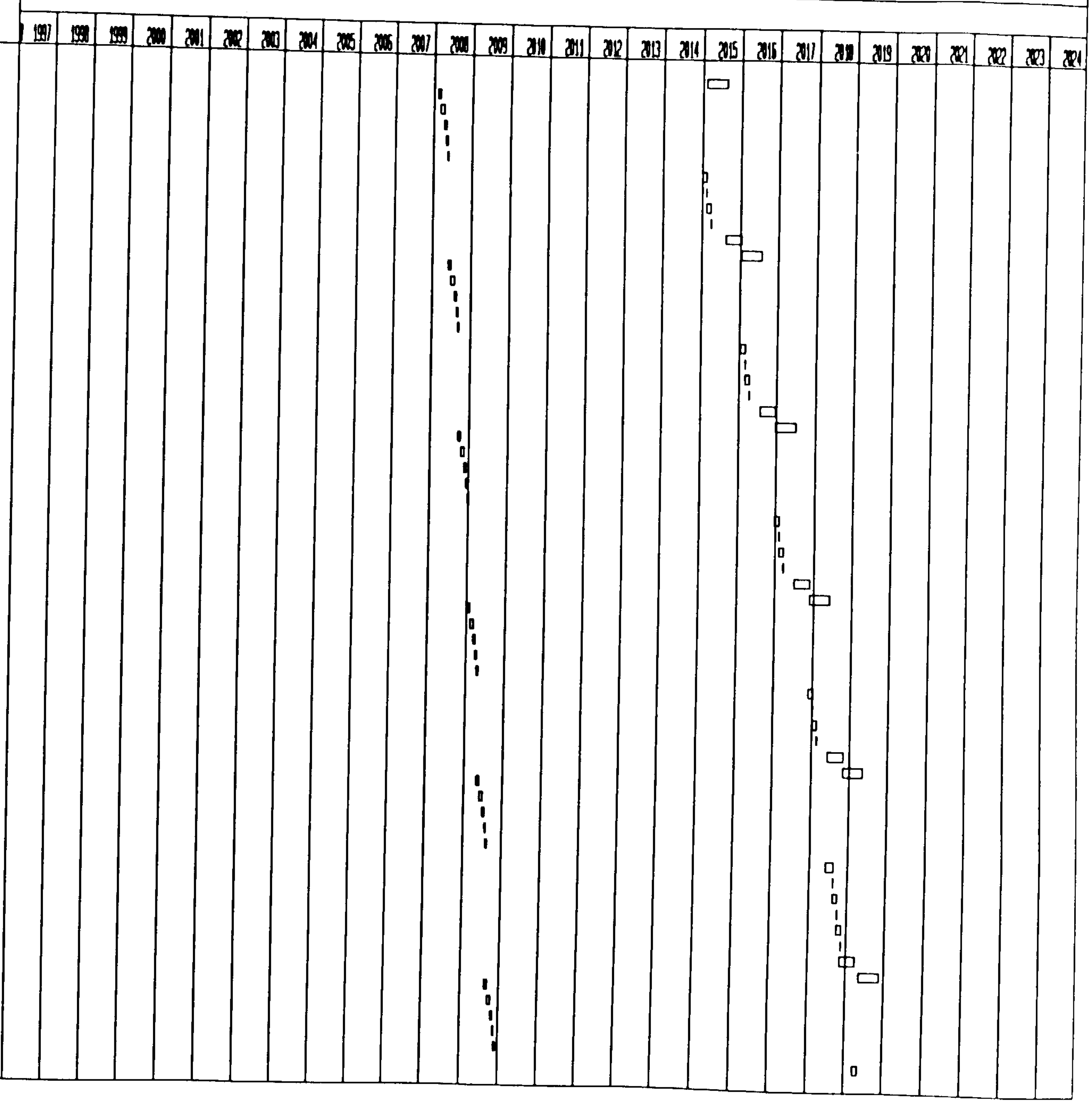
Master Schedule

Activity Description	Start	Complete
LTS-4A PAYLOAD #1 PROCESSING	01/18/2010	04/02/2010
LTS-4A PAYLOAD #1 LAUNCH	04/05/2010	04/05/2010
LTS-4A PAYLOAD #2 PROCESSING	04/03/2010	05/15/2010
LTS-4A PAYLOAD #2 LAUNCH	05/17/2010	05/17/2010
LTS-4A PAYLOAD #3 PROCESSING	05/16/2010	06/27/2010
LTS-4A PAYLOAD #3 LAUNCH	06/28/2010	06/28/2010
LTS-4A ON-ORBIT ASSEMBLY	05/07/2010	10/03/2010
LTS-4A MISSION OPS	11/13/2010	05/21/2011
LTS-4B MANAGEMENT RESERVE	07/24/2006	08/18/2006
LTS-4B TANK SETS DEL TO KSC	08/21/2006	09/22/2006
LTS-4B TANK SETS REC & INSPECT	09/25/2006	10/13/2006
LTS-4B TANK SETS QC ACCEPTANCE	10/16/2006	10/27/2006
LTS-4B TANK SETS DD250	10/30/2006	11/10/2006
LTS-4B PAYLOAD #1 PROCESSING	10/04/2010	11/15/2010
LTS-4B PAYLOAD #1 LAUNCH	11/16/2010	11/16/2010
LTS-4B PAYLOAD #2 PROCESSING	11/16/2010	12/28/2010
LTS-4B PAYLOAD #2 LAUNCH	12/29/2010	12/29/2010
LTS-4B ON-ORBIT ASSEMBLY	05/22/2011	10/18/2011
LTS-4B MISSION OPS	10/19/2011	04/25/2012
LTS-4C MANAGEMENT RESERVE	11/13/2006	12/08/2006
LTS-4C TANK SETS DEL TO KSC	12/11/2006	01/12/2007
LTS-4C TANK SETS REC & INSPECT	01/15/2007	02/02/2007
LTS-4C TANK SETS QC ACCEPTANCE	02/05/2007	02/16/2007
LTS-4C TANK SETS DD250	02/19/2007	03/02/2007
LTS-4C PAYLOAD #1 PROCESSING	10/19/2011	11/30/2011
LTS-4C PAYLOAD #1 LAUNCH	12/01/2011	12/01/2011
LTS-4C PAYLOAD #2 PROCESSING	12/01/2011	01/12/2012
LTS-4C PAYLOAD #2 LAUNCH	01/13/2012	01/13/2012
LTS-4C ON-ORBIT ASSEMBLY	04/26/2012	09/22/2012
LTS-4C MISSION OPS	09/23/2012	03/31/2013
LTS-4D MANAGEMENT RESERVE	03/05/2007	03/30/2007
LTS-4D TANK SETS DEL TO KSC	04/02/2007	05/04/2007
LTS-4D TANK SETS REC & INSPECT	05/07/2007	05/25/2007
LTS-4D TANK SETS QC ACCEPTANCE	05/28/2007	06/08/2007
LTS-4D TANK SETS DD250	06/11/2007	06/22/2007
LTS-4D PAYLOAD #1 PROCESSING	09/23/2012	11/04/2012
LTS-4D PAYLOAD #1 LAUNCH	11/05/2012	11/05/2012
LTS-4D PAYLOAD #2 PROCESSING	11/05/2012	12/17/2012
LTS-4D PAYLOAD #2 LAUNCH	12/18/2012	12/18/2012
LTS-4D ON-ORBIT ASSEMBLY	04/01/2013	08/28/2013
LTS-4D MISSION OPS	08/29/2013	03/06/2014
LTS-4E MANAGEMENT RESERVE	06/25/2007	07/20/2007
LTS-4E TANK SETS DEL TO KSC	07/23/2007	08/24/2007
LTS-4E TANK SETS REC & INSPECT	08/27/2007	09/14/2007
LTS-4E TANK SETS QC ACCEPTANCE	09/17/2007	09/28/2007
LTS-4E TANK SETS DD250	10/01/2007	10/12/2007
LTS-4E PAYLOAD #1 PROCESSING	08/29/2013	10/10/2013
LTS-4E PAYLOAD #1 LAUNCH	10/11/2013	10/11/2013
LTS-4E PAYLOAD #2 PROCESSING	10/11/2013	11/22/2013
LTS-4E PAYLOAD #2 LAUNCH	11/25/2013	11/25/2013
LTS-4E ON-ORBIT ASSEMBLY	03/07/2014	08/03/2014
LTS-4E MISSION OPS (EXPEND)	08/04/2014	02/09/2015
LTS-5A MANAGEMENT RESERVE	10/15/2007	11/09/2007
LTS-5A DELIVERIES TO KSC	11/12/2007	12/14/2007
LTS-5A REC & INSPECTION	12/17/2007	01/04/2008
LTS-5A QC ACCEPTANCE	01/07/2008	01/18/2008
LTS-5A DD250	01/21/2008	02/01/2008
LTS-5A PAYLOAD #1 PROCESSING	03/07/2014	05/20/2014
LTS-5A PAYLOAD #1 LAUNCH	05/21/2014	05/21/2014
LTS-5A PAYLOAD #2 PROCESSING	05/21/2014	07/02/2014
LTS-5A PAYLOAD #2 LAUNCH	07/03/2014	07/03/2014
LTS-5A PAYLOAD #3 PROCESSING	07/03/2014	08/14/2014
LTS-5A PAYLOAD #3 LAUNCH	08/15/2014	08/15/2014
LTS-5A ON-ORBIT ASSEMBLY	08/04/2014	12/31/2014



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

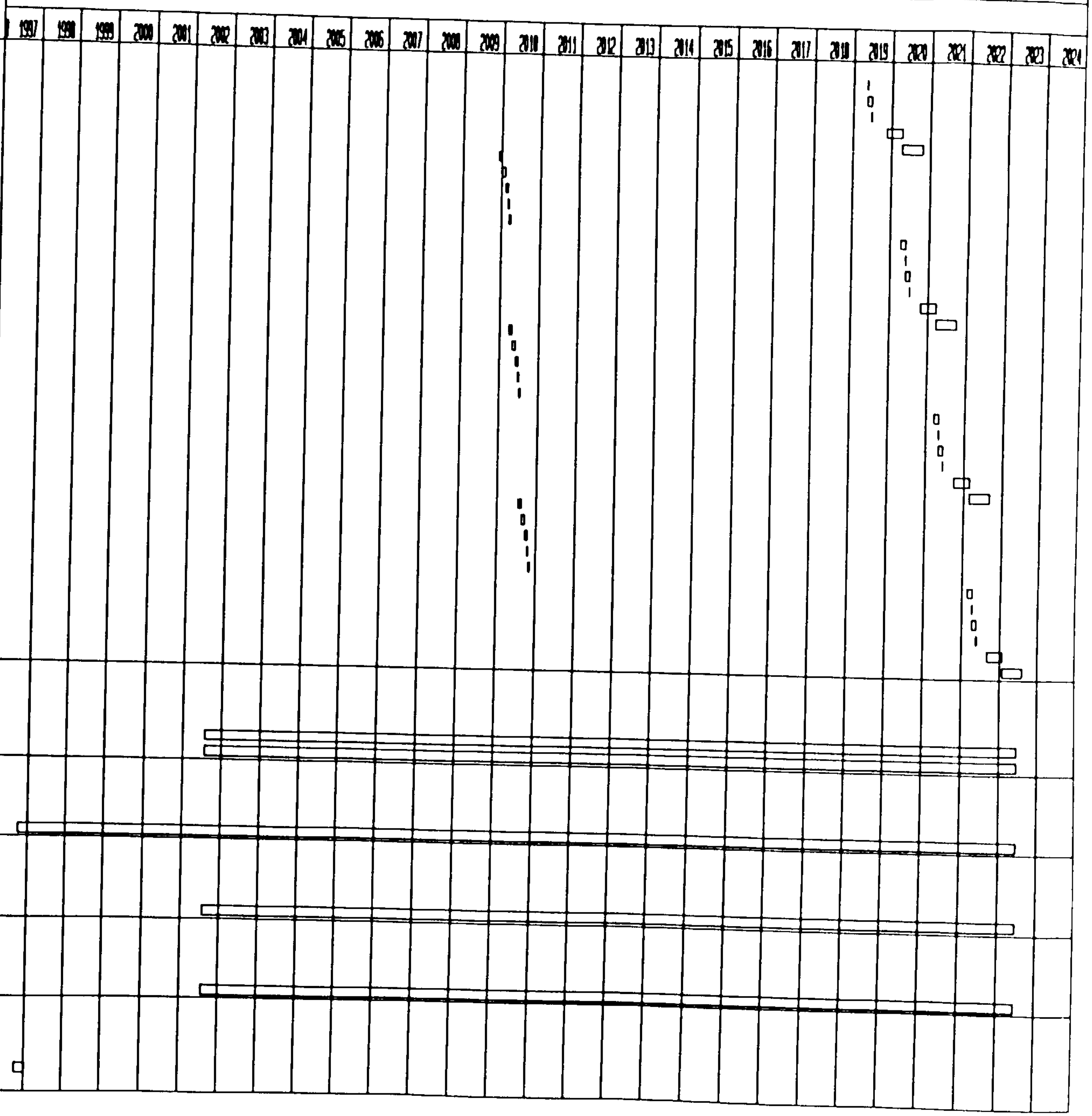
Activity Description	Start	Complete
LTS-5A MISSION OPS	02/10/2015	08/18/2015
LTS-5B MANAGEMENT RESERVE	02/04/2008	02/29/2008
LTS-5B TANK SETS DEL TO KSC	03/03/2008	04/04/2008
LTS-5B TANK SETS REC & INSPECT	04/07/2008	04/25/2008
LTS-5B TANK SETS QC ACCEPTANCE	04/28/2008	05/09/2008
LTS-5B TANK SETS DD250	05/12/2008	05/23/2008
LTS-5B PAYLOAD #1 PROCESSING	01/01/2015	02/12/2015
LTS-5B PAYLOAD #1 LAUNCH	02/13/2015	02/13/2015
LTS-5B PAYLOAD #2 PROCESSING	02/13/2015	03/27/2015
LTS-5B PAYLOAD #2 LAUNCH	03/30/2015	03/30/2015
LTS-5B ON-ORBIT ASSEMBLY	08/19/2015	01/15/2016
LTS-5B MISSION OPS	01/16/2016	07/23/2016
LTS-5C MANAGEMENT RESERVE	05/26/2008	06/20/2008
LTS-5C TANK SETS DEL TO KSC	06/23/2008	07/25/2008
LTS-5C TANK SETS REC & INSPECT	07/28/2008	08/15/2008
LTS-5C TANK SETS QC ACCEPTANCE	08/18/2008	08/29/2008
LTS-5C TANK SETS DD250	09/01/2008	09/12/2008
LTS-5C PAYLOAD #1 PROCESSING	01/16/2016	02/27/2016
LTS-5C PAYLOAD # LAUNCH	02/29/2016	02/29/2016
LTS-5C PAYLOAD #2 PROCESSING	02/28/2016	04/10/2016
LTS-5C PAYLOAD #2 LAUNCH	04/11/2016	04/11/2016
LTS-5C ON-ORBIT ASSEMBLY	07/24/2016	12/20/2016
LTS-5C MISSION OPS	12/21/2016	06/28/2017
LTS-5D MANAGEMENT RESERVE	09/15/2008	10/10/2008
LTS-5D TANK SETS DEL TO KSC	10/13/2008	11/14/2008
LTS-5D TANK SETS REC & INSPECT	11/17/2008	12/05/2008
LTS-5D TANK SETS QC ACCEPTANCE	12/08/2008	12/19/2008
LTS-5D TANK SETS DD250	12/22/2008	01/02/2009
LTS-5D PAYLOAD #1 PROCESSING	12/21/2016	02/01/2017
LTS-5D PAYLOAD #1 LAUNCH	02/02/2017	02/02/2017
LTS-5D PAYLOAD #2 PROCESSING	02/02/2017	03/16/2017
LTS-5D PAYLOAD #2 LAUNCH	03/17/2017	03/17/2017
LTS-5D ON-ORBIT ASSEMBLY	06/29/2017	11/25/2017
LTS-5D MISSION OPS	11/26/2017	06/03/2018
LTS-5E MANAGEMENT RESERVE	01/05/2009	01/30/2009
LTS-5E TANK SETS DEL TO KSC	02/02/2009	03/06/2009
LTS-5E TANK SETS REC & INSPECT	03/09/2009	03/27/2009
LTS-5E TANK SETS QC ACCEPTANCE	03/30/2009	04/10/2009
LTS-5E TANK SETS DD250	04/13/2009	04/24/2009
LTS-5E PAYLOAD #1 PROCESSING	11/26/2017	01/07/2018
LTS-5E PAYLOAD #1 LAUNCH	01/08/2018	01/08/2018
LTS-5E PAYLOAD #2 PROCESSING	01/08/2018	02/19/2018
LTS-5E PAYLOAD #2 LAUNCH	02/20/2018	02/20/2018
LTS-5E ON-ORBIT ASSEMBLY	06/04/2018	10/31/2018
LTS-5E MISSION OPS (EXPEND)	11/01/2018	05/09/2019
LTS-6A MANAGEMENT RESERVE	04/27/2009	05/22/2009
LTS-6A DELIVERIES TO KSC	05/25/2009	06/26/2009
LTS-6A REC & INSPECTION	06/29/2009	07/17/2009
LTS-6A QC ACCEPTANCE	07/20/2009	07/31/2009
LTS-6A DD250	08/03/2009	08/14/2009
LTS-6A PAYLOAD #1 PROCESSING	06/04/2018	08/17/2018
LTS-6A PAYLOAD #1 LAUNCH	08/20/2018	08/20/2018
LTS-6A PAYLOAD #2 PROCESSING	08/18/2018	09/29/2018
LTS-6A PAYLOAD #2 LAUNCH	10/01/2018	10/01/2018
LTS-6A PAYLOAD #3 PROCESSING	09/30/2018	11/11/2018
LTS-6A PAYLOAD #3 LAUNCH	11/12/2018	11/12/2018
LTS-6A ON-ORBIT ASSEMBLY	11/01/2018	03/30/2019
LTS-6A MISSION OPS	05/10/2019	11/15/2019
LTS-6B MANAGEMENT RESERVE	08/17/2009	09/11/2009
LTS-6B TANK SETS DEL TO KSC	09/14/2009	10/16/2009
LTS-6B TANK SETS REC & INSPECT	10/19/2009	11/06/2009
LTS-6B TANK SETS QC ACCEPTANCE	11/09/2009	11/20/2009
LTS-6B TANK SETS DD250	11/23/2009	12/04/2009
LTS-6B PAYLOAD #1 PROCESSING	03/31/2019	05/12/2019



Space Transfer Vehicle/Lunar Transportation System

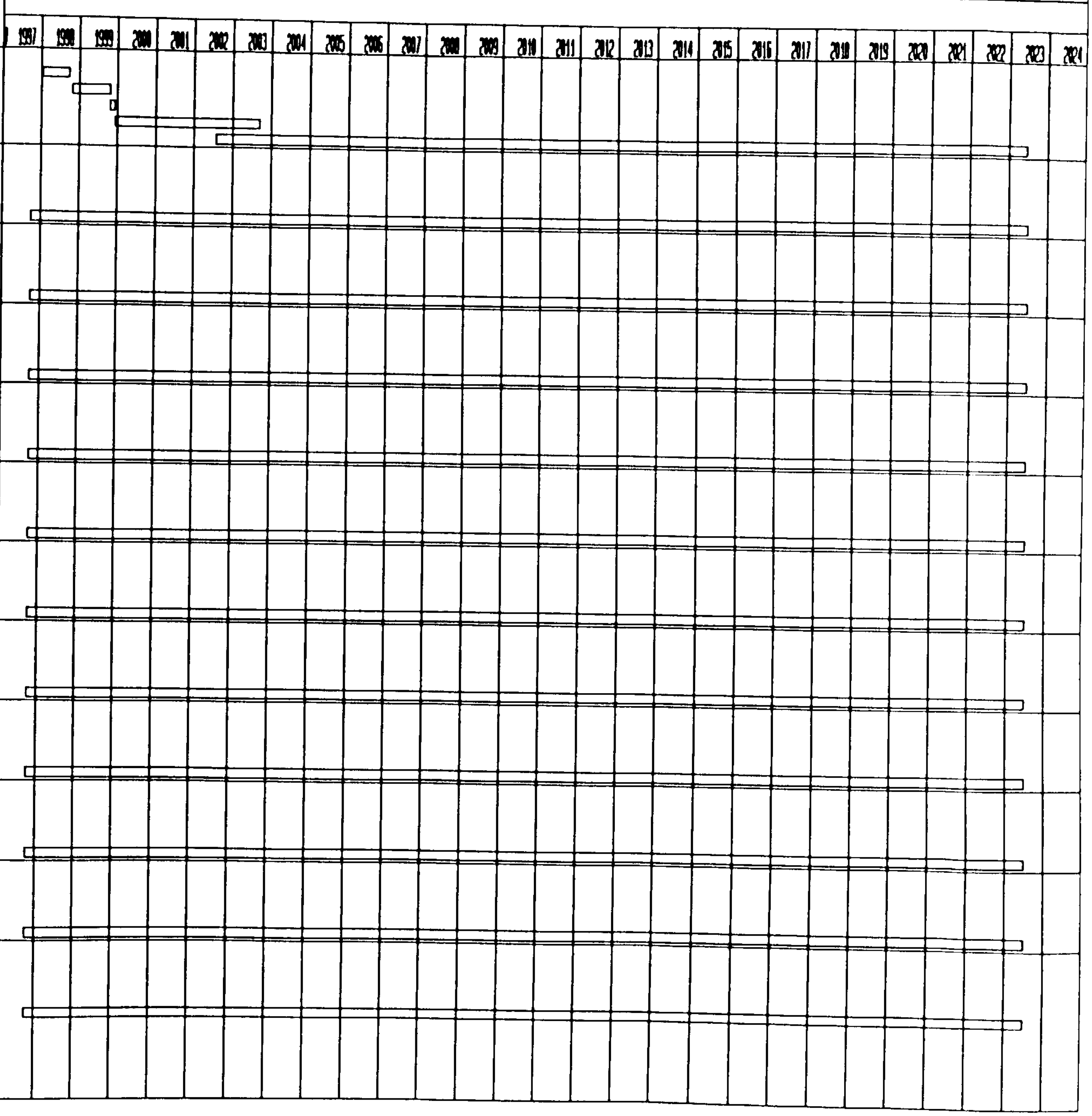
Master Schedule

Activity Description	Start	Complete
LTS-6B PAYLOAD #1 LAUNCH	05/13/2019	05/13/2019
LTS-6B PAYLOAD #2 PROCESSING	05/13/2019	06/24/2019
LTS-6B PAYLOAD #2 LAUNCH	06/25/2019	06/25/2019
LTS-6B ON-ORBIT ASSEMBLY	11/16/2019	04/13/2020
LTS-6B MISSION OPS	04/14/2020	10/20/2020
LTS-6C MANAGEMENT RESERVE	12/07/2009	01/01/2010
LTS-6C TANK SETS DEL TO KSC	01/04/2010	02/05/2010
LTS-6C TANK SETS REC & INSPECT	02/08/2010	02/26/2010
LTS-6C TANK SETS QC ACCEPTANCE	03/01/2010	03/12/2010
LTS-6C TANK SETS DD250	03/15/2010	03/26/2010
LTS-6C PAYLOAD #1 PROCESSING	04/14/2020	05/26/2020
LTS-6C PAYLOAD #1 LAUNCH	05/27/2020	05/27/2020
LTS-6C PAYLOAD #2 PROCESSING	05/27/2020	07/08/2020
LTS-6C PAYLOAD #2 LAUNCH	07/09/2020	07/09/2020
LTS-6C ON-ORBIT ASSEMBLY	10/21/2020	03/19/2021
LTS-6C MISSION OPS	03/20/2021	09/25/2021
LTS-6D MANAGEMENT RESERVE	03/29/2010	04/23/2010
LTS-6D TANK SETS DEL TO KSC	04/26/2010	05/28/2010
LTS-6D TANK SETS REC & INSPECT	05/31/2010	06/18/2010
LTS-6D TANK SETS QC ACCEPTANCE	06/21/2010	07/02/2010
LTS-6D TANK SETS DD250	07/05/2010	07/16/2010
LTS-6D PAYLOAD #1 PROCESSING	03/20/2021	05/01/2021
LTS-6D PAYLOAD #1 LAUNCH	05/03/2021	05/03/2021
LTS-6D PAYLOAD #2 PROCESSING	05/02/2021	06/13/2021
LTS-6D PAYLOAD #2 LAUNCH	06/14/2021	06/14/2021
LTS-6D ON-ORBIT ASSEMBLY	09/26/2021	02/22/2022
LTS-6D MISSION OPS	02/23/2022	08/31/2022
LTS-6E MANAGEMENT RESERVE	07/19/2010	08/13/2010
LTS-6E TANK SETS DEL TO KSC	08/16/2010	09/17/2010
LTS-6E TANK SETS REC & INSPECT	09/20/2010	10/08/2010
LTS-6E TANK SETS QC ACCEPTANCE	10/11/2010	10/22/2010
LTS-6E TANK SETS DD250	10/25/2010	11/05/2010
LTS-6E PAYLOAD #1 PROCESSING	02/23/2022	04/06/2022
LTS-6E PAYLOAD #1 LAUNCH	04/07/2022	04/07/2022
LTS-6E PAYLOAD #2 PROCESSING	04/07/2022	05/19/2022
LTS-6E PAYLOAD #2 LAUNCH	05/20/2022	05/20/2022
LTS-6E ON-ORBIT ASSEMBLY	09/01/2022	01/28/2023
LTS-6E MISSION OPS (EXPEND)	01/29/2023	08/06/2023
LAUNCH SERVICES		
FLIGHT OPERATIONS	07/29/2002	06/16/2023
GROUND OPERATIONS	07/29/2002	06/16/2023
LOGISTICS		
LOGISTICS MAINT SUPPORT	10/02/1997	06/16/2023
SOFTWARE OPERATION		
SW OPERATIONS (SERVICES)	07/29/2002	06/16/2023
SOFTWARE MAINTENANCE		
SW MAINTENANCE (SERVICES)	07/29/2002	06/16/2023
SYSTEMS ENGINEERING		
SYSTEMS RQMTS/SRA	10/02/1997	01/07/1998



Space Transfer Vehicle/Lunar Transportation System
Master Schedule

Activity Description	Start	Complete
SYSTEMS SPEC DEVELOPMENT	01/15/1998	09/29/1998
SYSTEMS CRIT SPEC DEVELOPMENT	10/28/1998	10/15/1999
SYSTEMS MANAGEMENT RESERVE	10/18/1999	11/30/1999
SYSTEMS SUSTAINING ENGINEERING	12/08/1999	09/10/2003
SYSTEMS PROD ENG SUPPORT	07/29/2002	06/16/2023
HUMAN FACTORS		
HUMAN FACTORS PROGRAM	10/02/1997	06/30/2023
VALUE ENGINEERING		
VALUE ENGINEERING PROGRAM	10/02/1997	06/30/2023
ENGINEERING ECONOMIC ANALYSIS		
ENGINEERING ECONOMIC ANALYSIS	10/02/1997	06/30/2023
SAFETY		
SAFETY PROGRAM	10/02/1997	06/30/2023
RELIABILITY		
RELIABILITY PROGRAM	10/02/1997	06/30/2023
MAINTAINABILITY		
MAINTAINABILITY PROGRAM	10/02/1997	06/30/2023
QUALITY ASSURANCE		
QUALITY ASSURANCE PROGRAM	10/02/1997	06/30/2023
PROGRAM ADMINISTRATION		
PROGRAM ADMINISTRATION	10/02/1997	06/30/2023
PROGRAM PLANNING & CONTROL		
PROGRAM PLANNING & CONTROL	10/02/1997	06/30/2023
CONTRACTS ADMINISTRATION		
CONTRACTS ADMINISTRATION	10/02/1997	06/30/2023
ENGINEERING MANAGEMENT		
ENGINEERING MANAGEMENT	10/02/1997	06/30/2023



Space Transfer Vehicle/Lunar Transportation System

Master Schedule

Activity Description	Start	Complete
MANUFACTURING ENGINEERING		
MANUFACTURING ENGINEERING	10/02/1997	06/30/2023
SUPPORT MANAGEMENT		
SUPPORT MANAGEMENT	10/02/1997	06/30/2023
QUALITY ASSURANCE MANAGEMENT		
QUALITY ASSURANCE MANAGEMENT	10/02/1997	06/30/2023
CONFIGURATION MANAGEMENT		
DATA MANAGEMENT	10/02/1997	06/30/2023
CONFIGURATION MANAGEMENT	10/02/1997	06/30/2023
DATA MANAGEMENT		
FINANCE MANAGEMENT	10/02/1997	06/30/2023
SUBCONTRACT MANAGEMENT		
SUBCONTRACT MANAGEMENT	10/02/1997	06/30/2023