Space Transportation System Stack Assembly

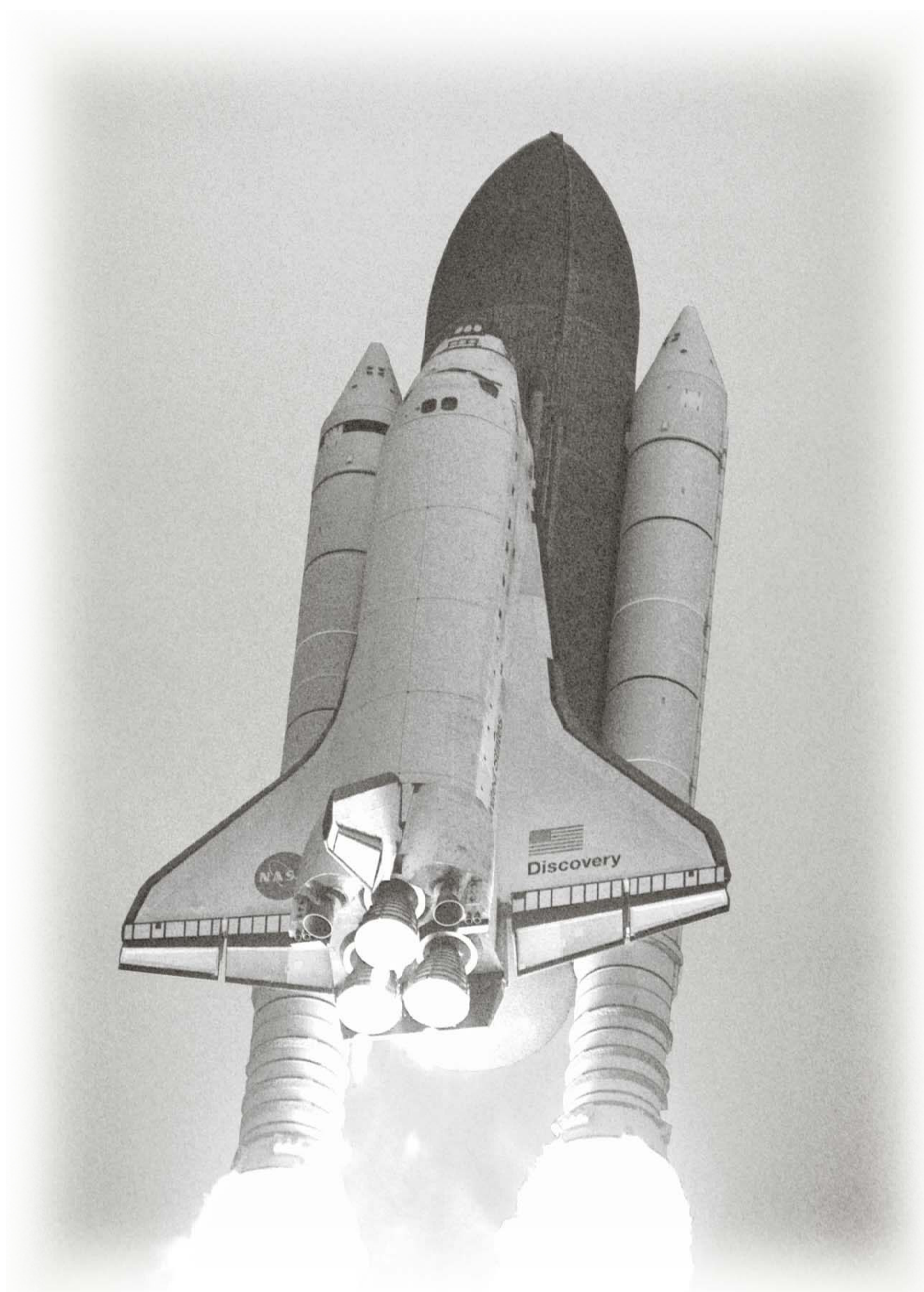

Image Caption and Credit

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Development of the Space Shuttle commenced in 1969 and a contract for the construction of the Space Shuttle was awarded in July 1972. The vehicle consisted basically of the orbiter vehicle, built by North American Rockwell (later Boeing), two solid fuelled booster rockets built by Thiokol (later ATK Launch Systems) and an external tank built by Martin Marietta (later Lockheed Martin). Of these only the external tank was not re-usable.

The orbiter was propelled by three Rocketdyne liquid fuelled motors which gave a thrust of 2,100,000 N during the launch. The fuel was stored in the external tank, which was jettisoned after launch. The orbiter had a length of 37.25 m and a span of 23.79 m, whilst the external tank had a length of 47.00 m and a diameter of 8.38 m. The early Standard Weight Tanks (SWT) had a mass of 35,000 km and they were superseded by the Light Weight Tank (LWT) of 30,000 kg and the Super Light Weight Tanks (SLWT) of 26,500 kg. The payload bay had a length of 18.29 m and a width of 4.57 m and allowed, typically, three satellites to be stored. Payload capability was 24,000 kg. The two solid fuelled boosters had been developed by Thiokol, used polybutadiene and developed a thrust 23,572,400 N. They had a length of 45.47 m and a diameter of 3.78 m. After separation from the orbiter, immediately after launch, these boosters returned to Earth suspended from parachutes and were recovered from the ocean surface.

The orbiter provided accommodation to up to seven astronauts, four of which were seated on the flight deck during the launch whilst another three were seated in the mid-deck area below the flight deck. This mid-deck area also housed bunks for the astronauts, the galley and the washroom. This area was also used for the storage of certain experiments.

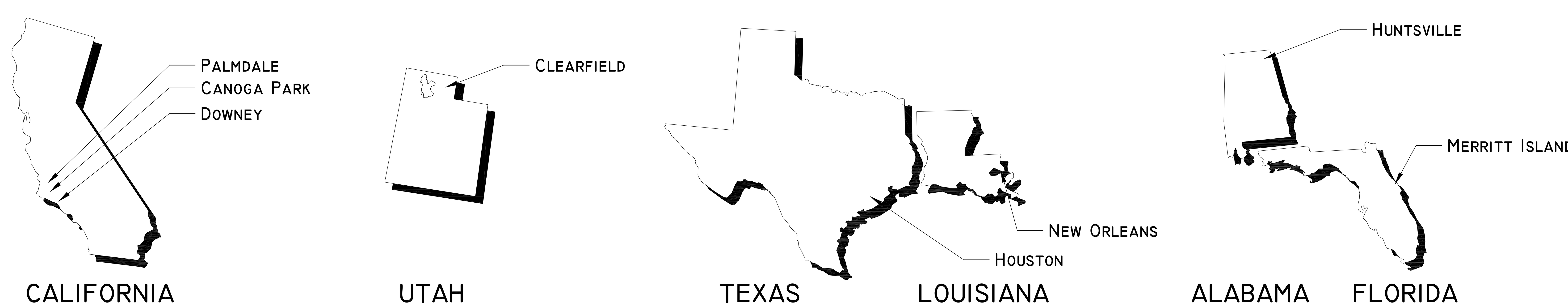
The payload bay was fitted with the Canadian built remote manipulator system, consisting of two 'arms' of 6.7 m length each, joined by means of a flexible joint and with a grappling hook and television camera at the end. The system was controlled from the mid-deck control station. Once in orbit, the payload bay doors were opened as they contained the radiators of the orbiters cooling system. Although the orbiter had three main engines these could not be used after separation from the external tank. In orbit maneuvers were performed with two orbital maneuvering engines which used monomethylhydrazine and nitrogen peroxide. In addition there was an attitude control system consisting of 16 thrusters in the nose and 28 thrusters in the rear of the orbiter.
Thermal protection for the orbiter during re-entry was provided by a range of hard silica tiles which cover the flat bottom of the orbiter, whilst the nose and wing edges were covered with reinforced carbon.

After re-entry the orbiter glided back to the landing strip, either at Edwards Air Force Base or at the Kennedy Space Centre. The orbiter did not have a propulsion system that permitted maneuvering beyond the use of flaps, during this glide. A landing facility was also built at Vandenberg which was, however, never used, whilst an emergency landing facility at White Sands existed and was used once.

The program initially covered the construction of three test vehicles of the orbiter - MPTA-098, STA-099 and OV-101 - and three space rated orbiters: Columbia (OV-102), Discovery (OV-103) and Atlantis (OV-104). OV-101 became the Space Shuttle Enterprise, which was used in sub-orbital tests and which did not have an orbiting capability but was used in the development of the numerous techniques required for the Space Shuttle, in particular the landing techniques. It had been the intention to convert OV-101 as a space rated orbiter but instead it was found to be more convenient to convert STA-099, which became orbiter Challenger (OV-099) in January 1979. Following the loss of the Challenger a replacement orbiter, known as Endeavour (OV-105), was built.

In the 1990s the remaining orbiters were converted severeal times to allow longer duration flights as well as integration with the proposed International Space Station.

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering, industrial, and maritime works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Space Transportation System recording project was cosponsored during 2011 by the Space Shuttle Program Transition and Retirement Office of the Johnson Space Center (JSC), with the guidance and assistance of Barbara Severance, Integration Manager, JSC, Jennifer Groman, Federal Preservation Officer, NASA Headquarters and Ralph Allen, Historic Preservation Officer , Marshall Space Flight Center. The field work and measured drawings were prepared under the general direction of Richard O'Connor, Chief, Heritage Documentation Programs, National Park Service. The project was managed by Thomas Behrens, HAER Architect and Project Leader. The Space Transportation System Recording Project consisted architectural delineators, John Wachtel, Iowa State and Joseph Klimek, Illinois Institute of Technology. This documentation is based high-definition laser scans provided by Smart GeoMetrics, Houston, Texas and documentation provided by NASA's Headquarters, Johnson Space Center and Marshall Space Flight Center. Written historical and descriptive data was provided by Archaeological Consultants Inc., Sarasota, Florida. Large-format photographs were produced by NASA's Imaging Lab at Johnson Space Flight Center with supplimental images provided by Jet Lowe, HAER photographer.



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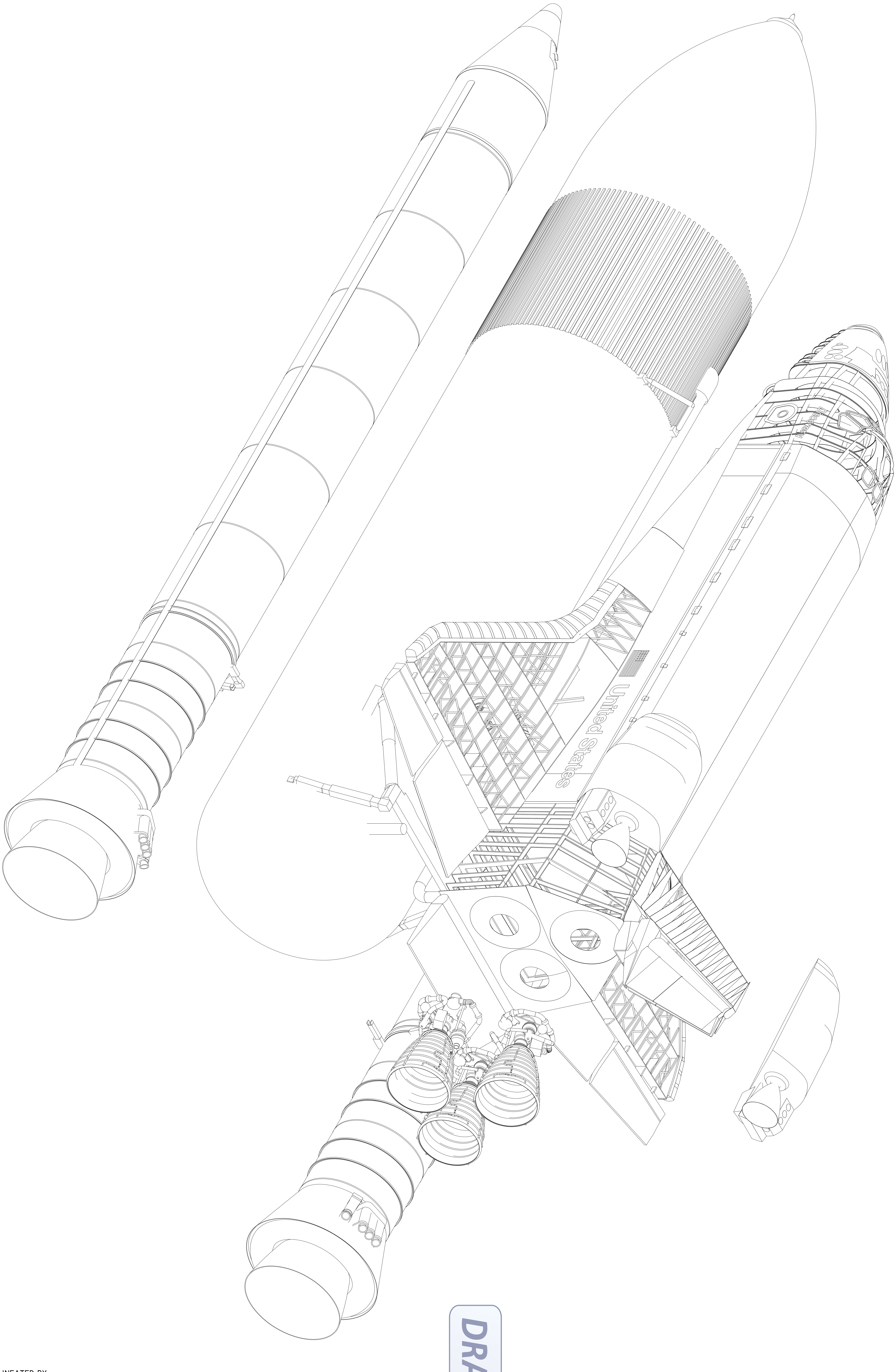

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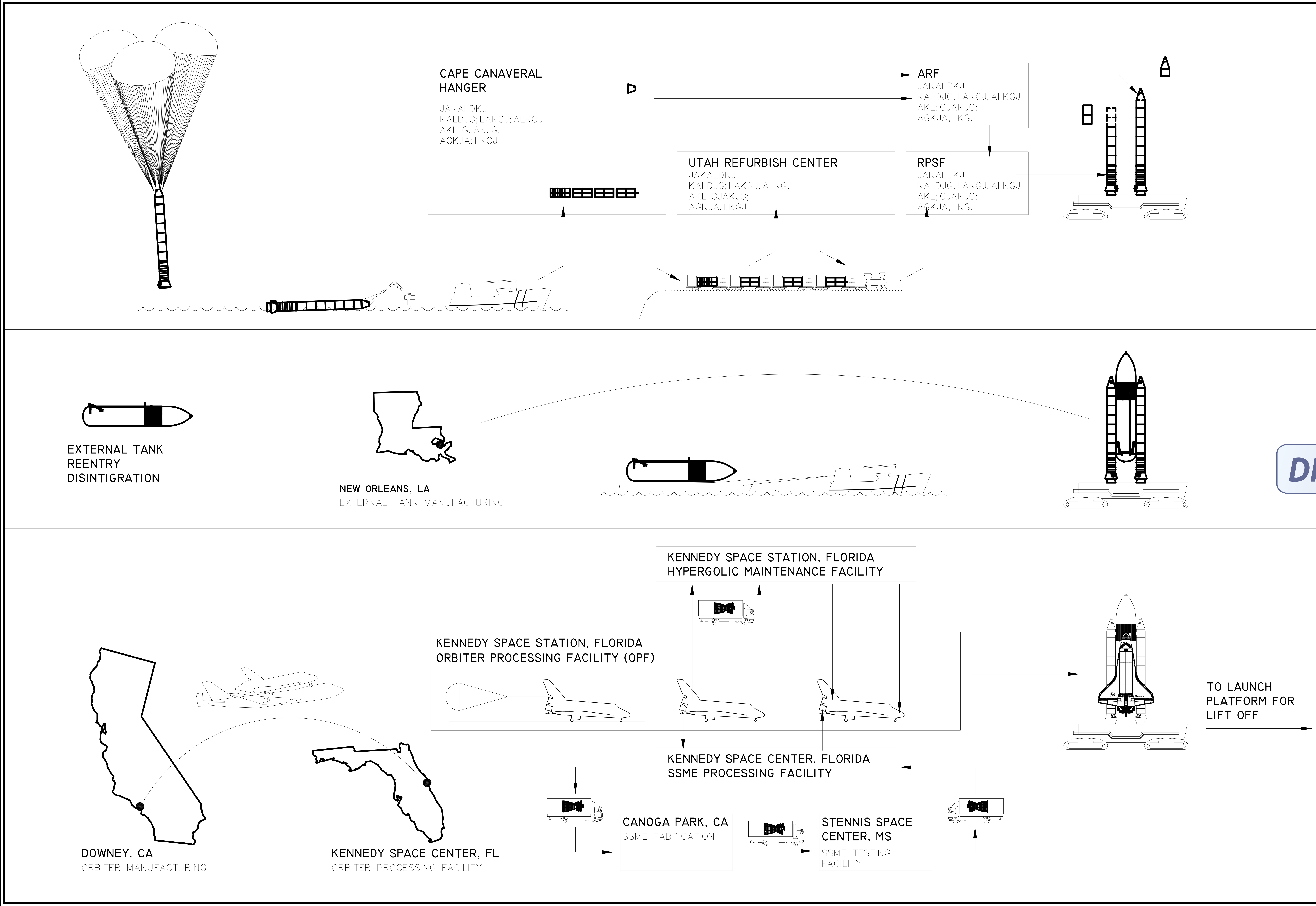

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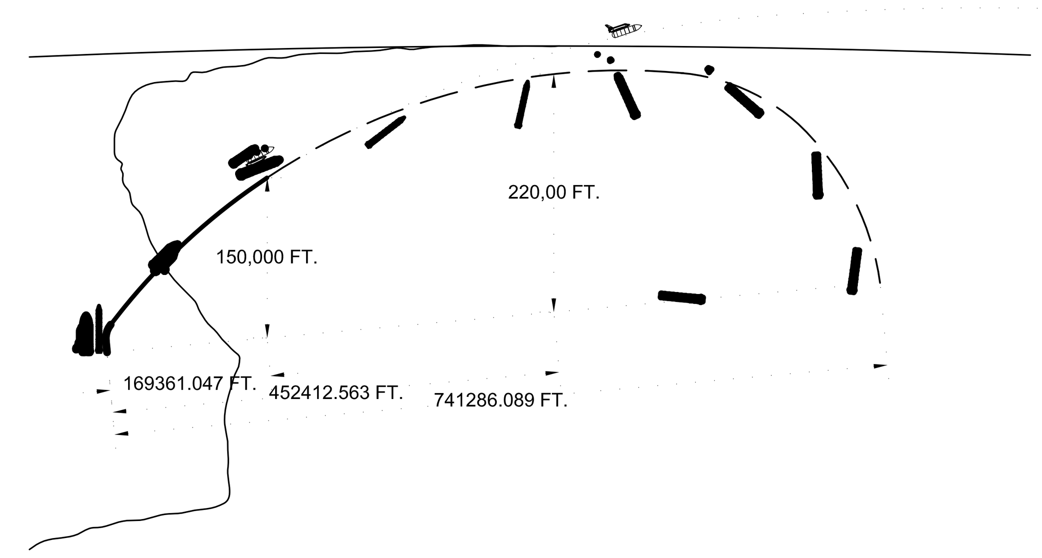
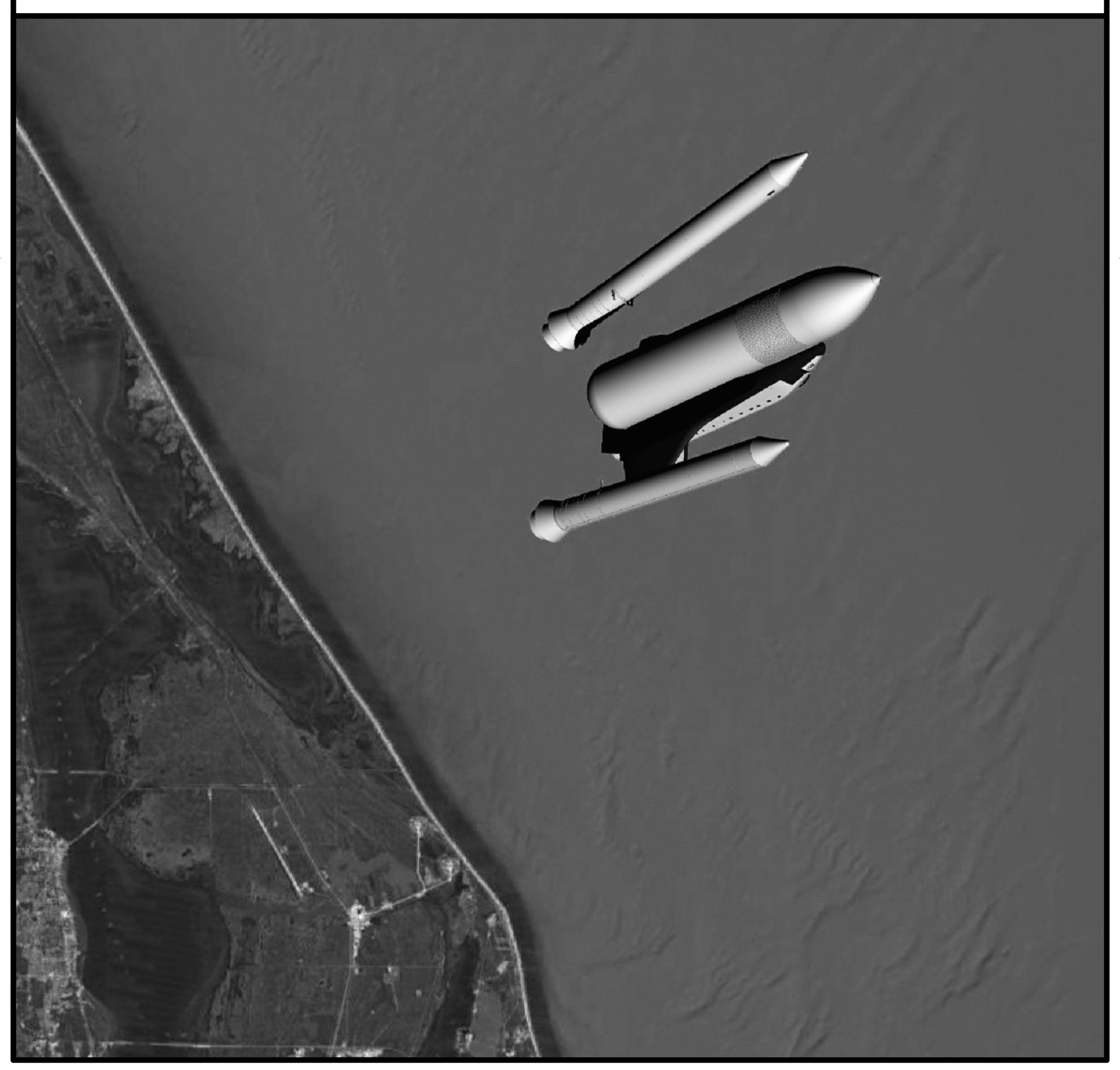
Lift Off
At lift of... Flight Launch Mission Profile TextFlight Launch Mission Profile Text Flight Launch Mission Profile Text

Pitch and Roll
This operation happens immediately after clearing away from the launch platform in order to postion the STS towards it's flight path and orbit entrance angle.

SRB Staging
The SRB's jettison so that they can be retreived upon falling back onto the earth and reused after analyzed and refurbished.





Payload Bay Door Opening
This is for heat relief, kle;lakjg;lkang;lkn lka sng;lakng ;la nkglka ng;la ng;lakn gb;lnka b;la

(A) Launch
T+: 00:00:00

(B) Pitch + Roll
T+: 00:00:11-18

(C) SRB Staging
T+: 00:02:03

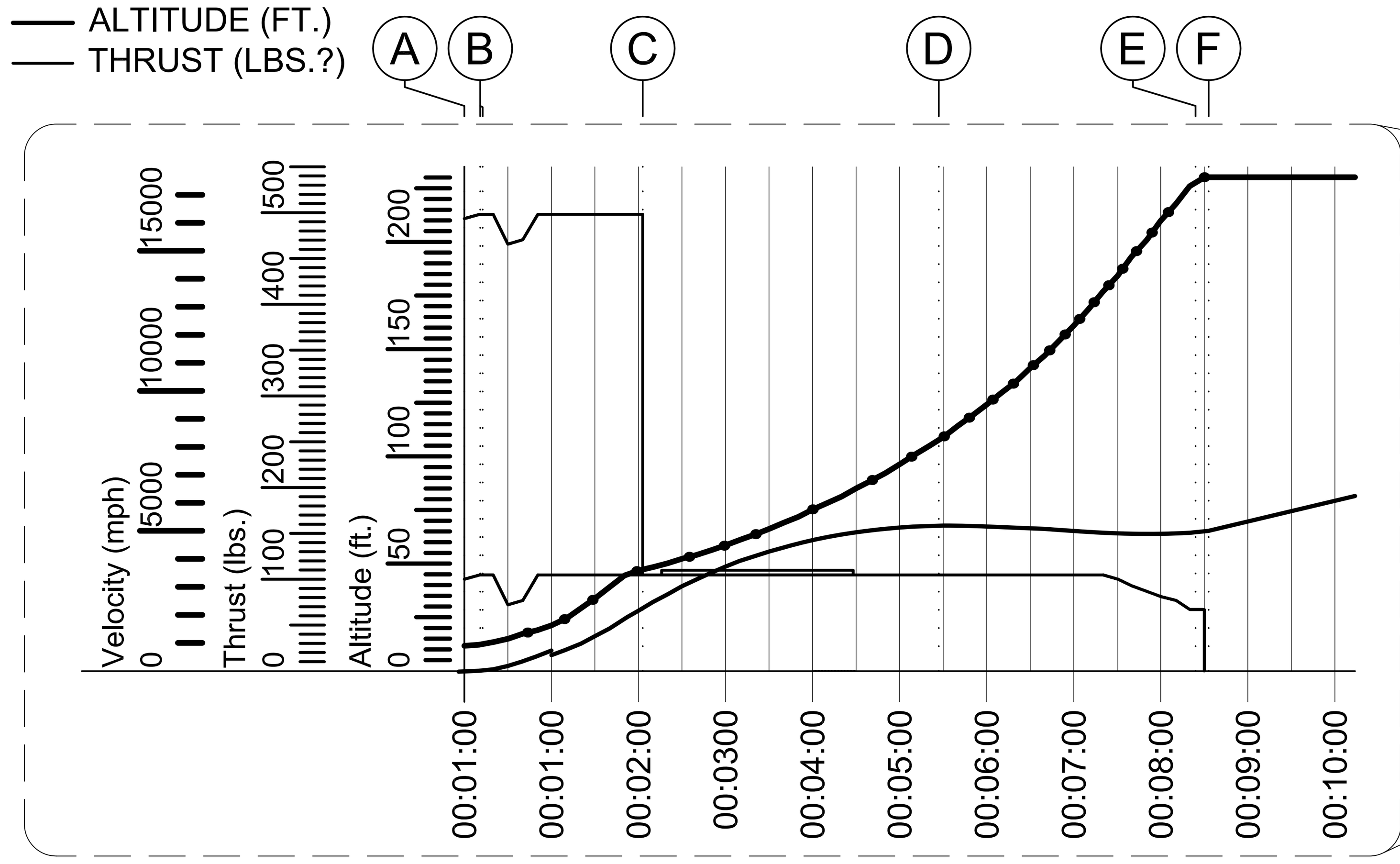
D Roll to Heads Up
T+: 00:05:28

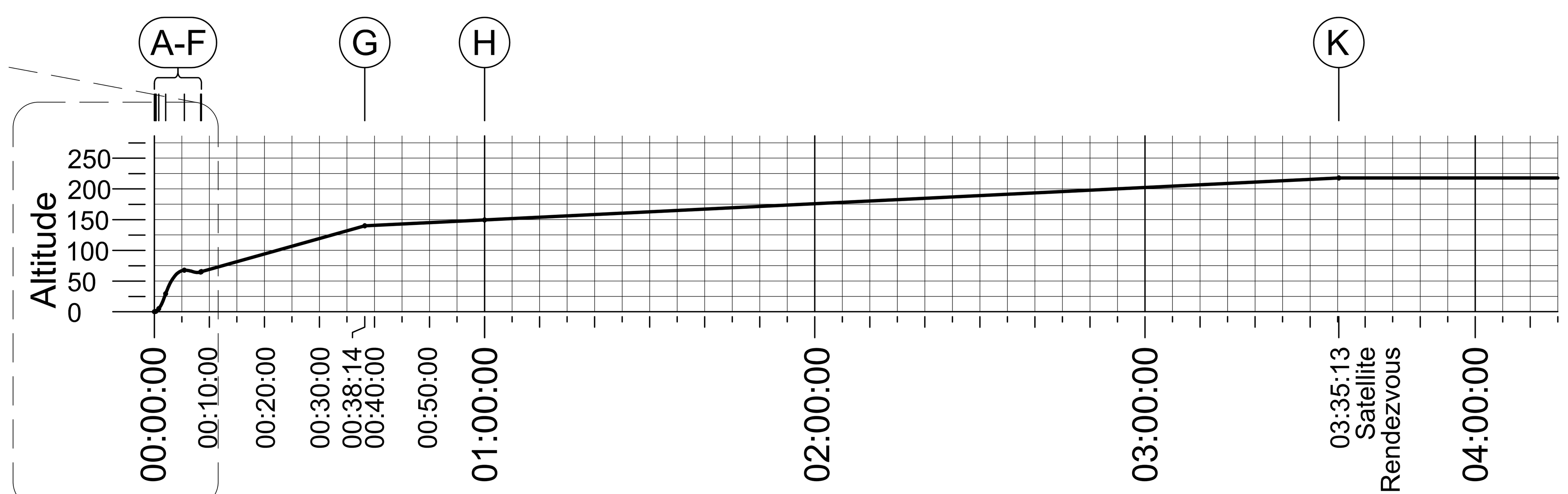
(E)+(F) MECO + ET Seperation
T+: 00:08:24 + T+: 00:08:33

(G) Apogee (OMS Burn #2)
T+: 00:38:14

(H) Payload Bay Door Opening
T+: 01:00:00 (?)

MACH SPEEDS
VELOCITY (MPH)
ALTITUDE (FT.)
THRUST (LBS.?)





Timeline of Typical Mission Profile from Launch to Space Station Rendezvous
T+: 00:00:00 - 03:35:13

Flight Launch Mission Profile

Flight Launch Mission Profile Text Flight Launch Mission Profile Text
Flight Launch Mission Profile TextFlight Launch Mission Profile Text
Flight Launch Mission Profile Text
Flight Launch Mission Profile TextFlight Launch Mission Profile Text
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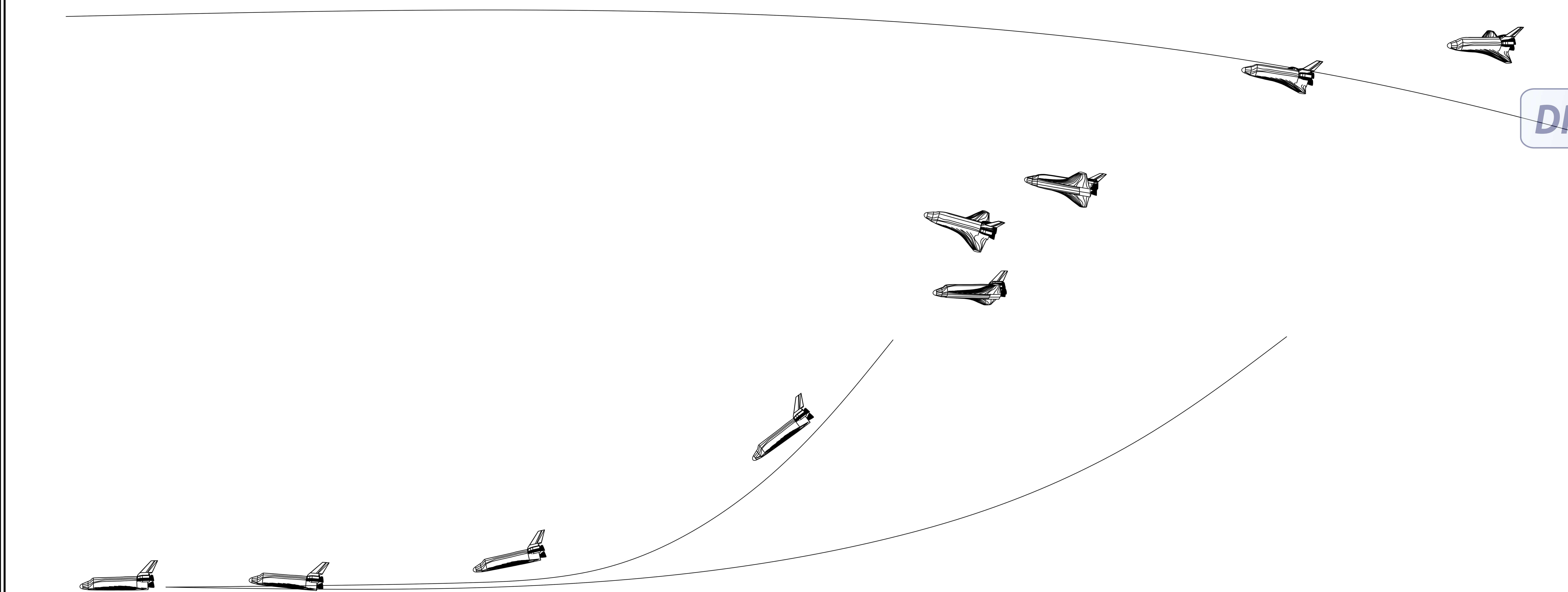

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Space Transportation System Orbiter Discovery (OV-103)

- 1981 — STS-1 [First Flight, Columbia]
- 1982
- 1983
- 1984 — STS-14 (41-D), STS-19 (51-A), STS-20 (51-C)
- 1985 — STS-23 (51-D), STS-25 (51-G), STS-27 (51-I)
- 1986 — STS-26 (51-L) [Challenger Tragedy]
- 1987
- 1988 — Return To Flight-1
- 1989 — STS-28R, STS-29R
- 1990 — STS-33R, STS-31R
- 1991 — STS-41, STS-39
- 1992 — STS-48, STS-42, J-1 (Uprgrade Downtime)
- 1993 — STS-53, STS-56
- 1994 — STS-51, STS-80
- 1995 — STS-84, STS-83, STS-70
- 1996 — J-2 (Uprgrade Downtime)
- 1997 — STS-82, STS-85
- 1998 — STS-91
- 1999 — STS-95, STS-96
- 2000 — STS-103
- 2001 — STS-92, STS-102, STS-105
- 2002
- 2003 — STS-107 [Columbia Tragedy]
- 2004 — J-3 (Uprgrade Downtime)
- 2005 — Return To Flight-2
- 2006 — STS-114
- 2007 — STS-121, STS-116
- 2008 — STS-120, STS-124
- 2009 — STS-119, STS-128
- 2010 — STS-131
- 2011 — STS-133, STS-135 [Final Flight, Atlantis]
- 2012

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Discovery (OV-103) was NASA's third pace shuttle orbiter to join the fleet, arriving for the first time at the Kennedy Space Center in Florida in November 1983.

After checkout and processing, it was launched on Aug. 30, 1984, for its first mission, 41-D, to deploy three communications satellites.

Since that inaugural flight, Discovery has completed more than 30 successful missions, surpassing the number of flights made by any other orbiter in NASA's fleet. Just like all of the orbiters, it has undergone some major modifications over the years. The most recent began in 2002 and was the first carried out at Kennedy. It provided 99 upgrades and 88 special tests, including new changes to make it safer for flight. gines.

Discovery has the distinction of being chosen as the Return to Flight orbiter twice. The first was for STS-26 in 1988, and the second when it carried the STS-114 crew on NASA's Return to Flight mission to the International Space Station in July 2005.

The choice of the name "Discovery" carried on a tradition drawn from some historic, Earth-bound exploring ships of the past. One of these sailing forerunners was the vessel used in the early 1600s by Henry Hudson to explore Hudson Bay and search for a northwest passage from the Atlantic to the Pacific.

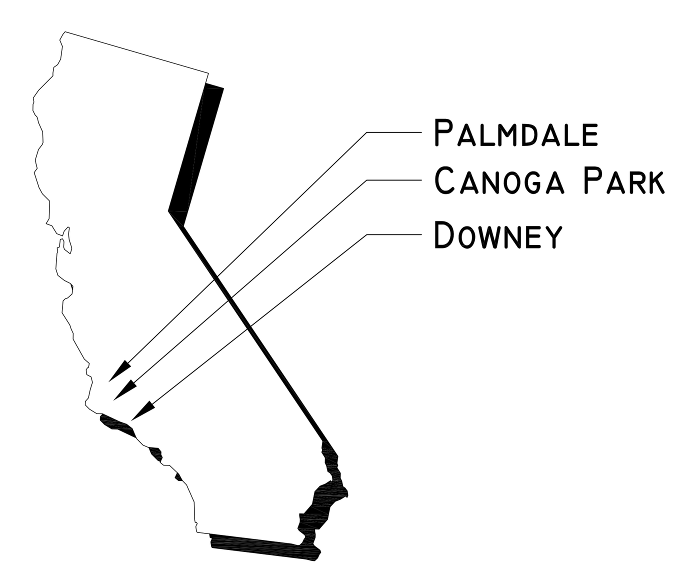
Another such ship was used by British explorer James Cook in the 1770s during his voyages in the South Pacific, leading to the discovery of the Hawaiian Islands. In addition, two British Royal Geographical Society ships have carried the name "Discovery" as they sailed on expeditions to the North Pole and the Antarctic.

Destined for exploring the heavens instead of the seas, it was only fitting that NASA's Discovery carried the Hubble Space Telescope into space during mission STS-31 in April 1990, and provided both the second and third Hubble servicing missions (STS-82 in February 1997 and STS-103 in December 1999).

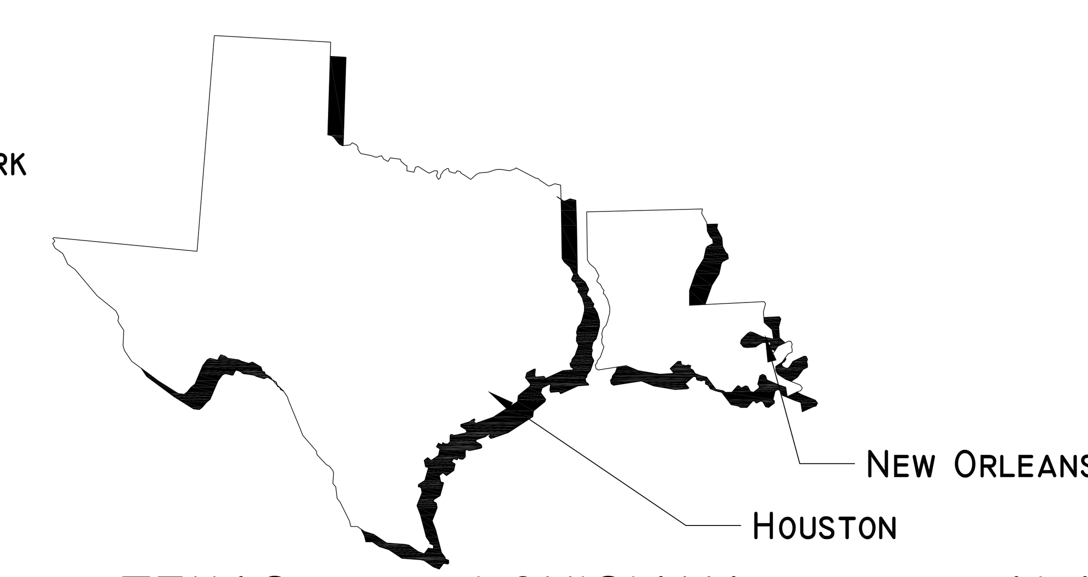
Beginning in the fall of 1995, the orbiter underwent a nine-month Orbiter Maintenance Down Period (OMDP) in Palmdale California. The vehicle was outfitted with a 5th set of cryogenic tanks and an external airlock to support missions to the International Space Station. It returned to the Kennedy Space Center, riding piggy-back on a modified Boeing 747, in June 1996.

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering, industrial, and maritime works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Space Transportation System recording project was cosponsored during 2011 by the Space Shuttle Program Transition and Retirement Office of the Johnson Space Center (JSC), with the guidance and assistance of Barbara Severance, Integration Manager, JSC, Jennifer Groman, Federal Preservation Officer, NASA Headquarters and Ralph Allen, Historic Preservation Officer , Marshall Space Flight Center. The field work and measured drawings were prepared under the general direction of Richard O'Connor, Chief, Heritage Documentation Programs, National Park Service. The project was managed by Thomas Behrens, HAER Architect and Project Leader. The Space Transportation System Recording Project consisted architectural delineators, John Wachtel, Iowa State and Joseph Klimek, Illinois Institute of Technology. This documentation is based high-definition laser scans provided by Smart GeoMetrics, Houston, Texas and documentation provided by NASA's Headquarters, Johnson Space Center and Marshall Space Flight Center. Written historical and descriptive data was provided by Archaeological Consultants Inc., Sarasota, Florida. Large-format photographs were produced by NASA's Imaging Lab at Johnson Space Flight Center with supplimental images provided by Jet Lowe, HAER photographer.

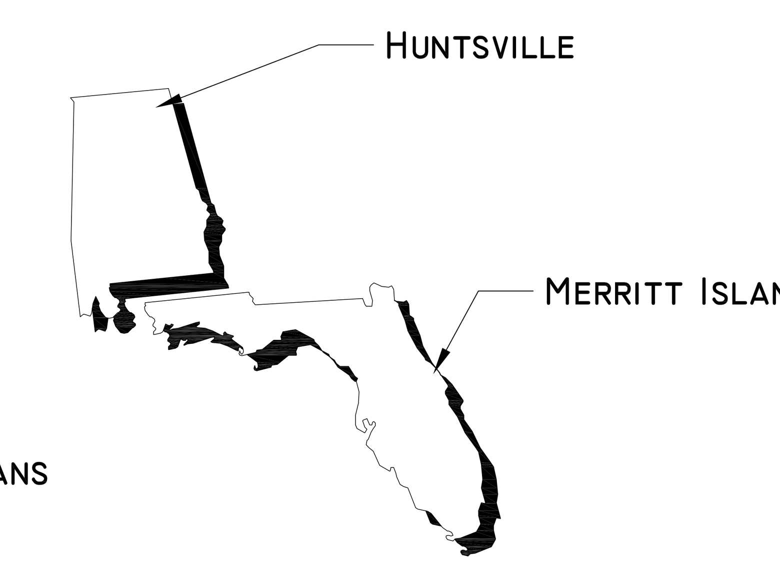
VICINITY MAP PALMDALE, CA



CALIFORNIA



TEXAS LOUISIANA



ALABAMA FLORIDA

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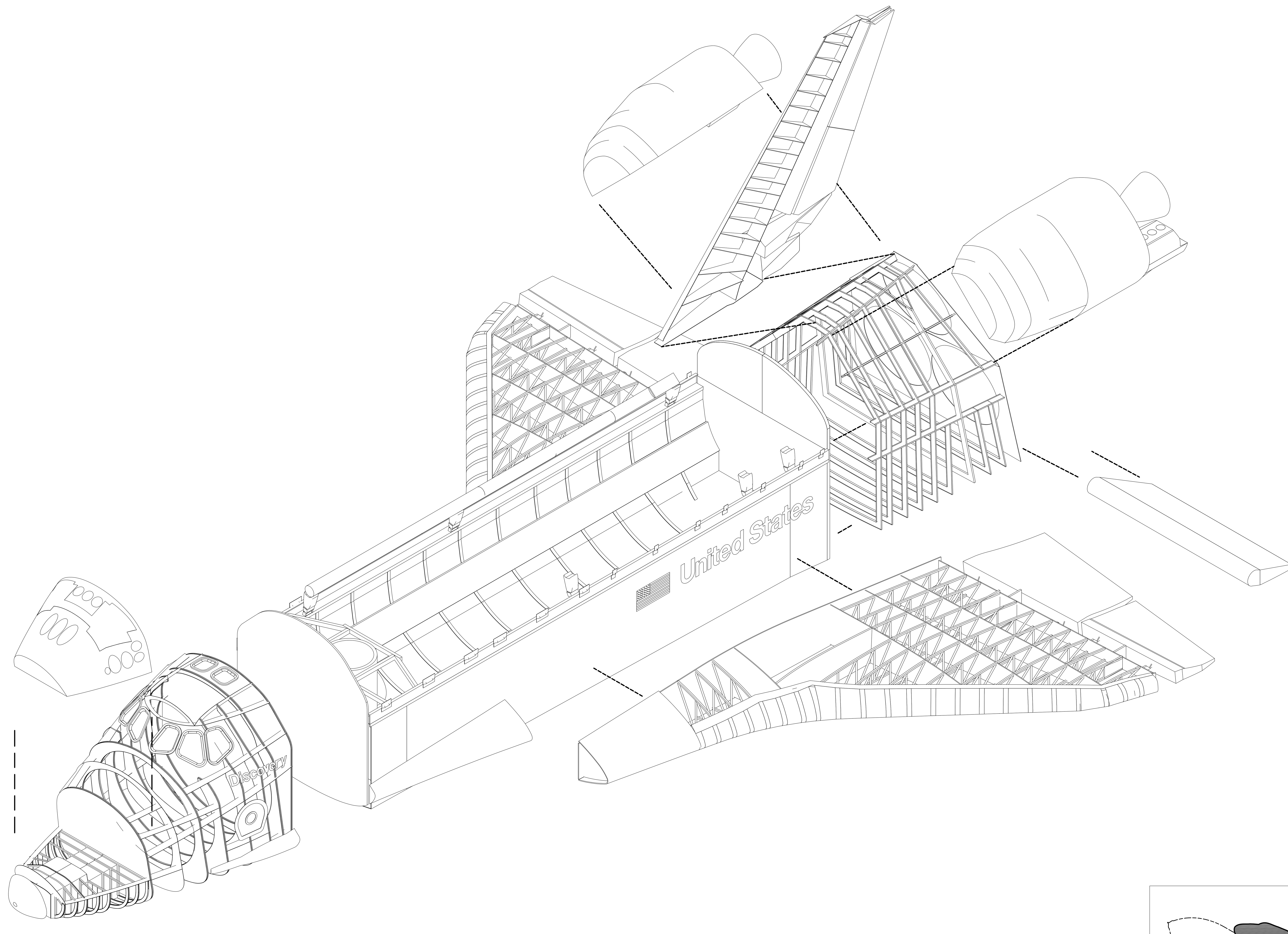
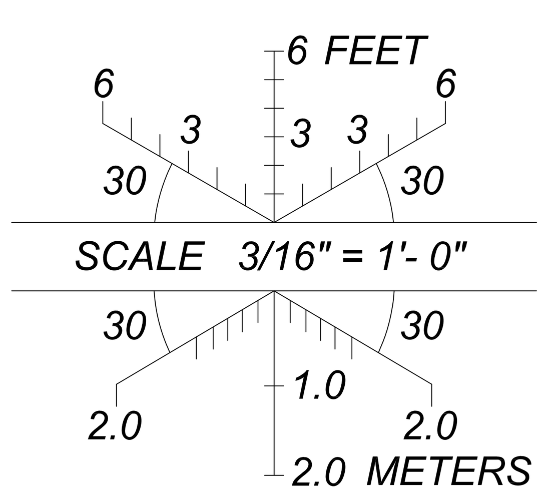
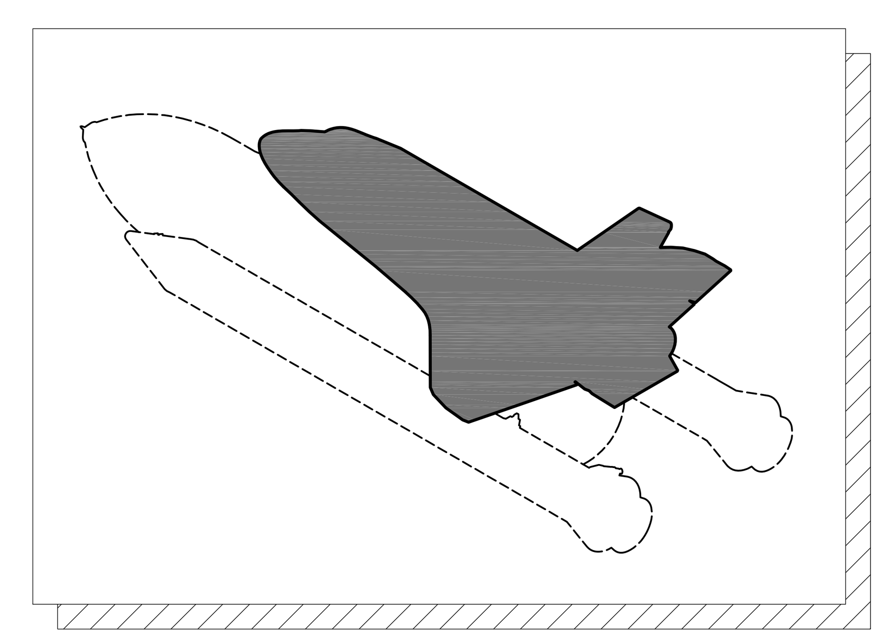




ORBITER VEHICLE 103 DISCOVERY



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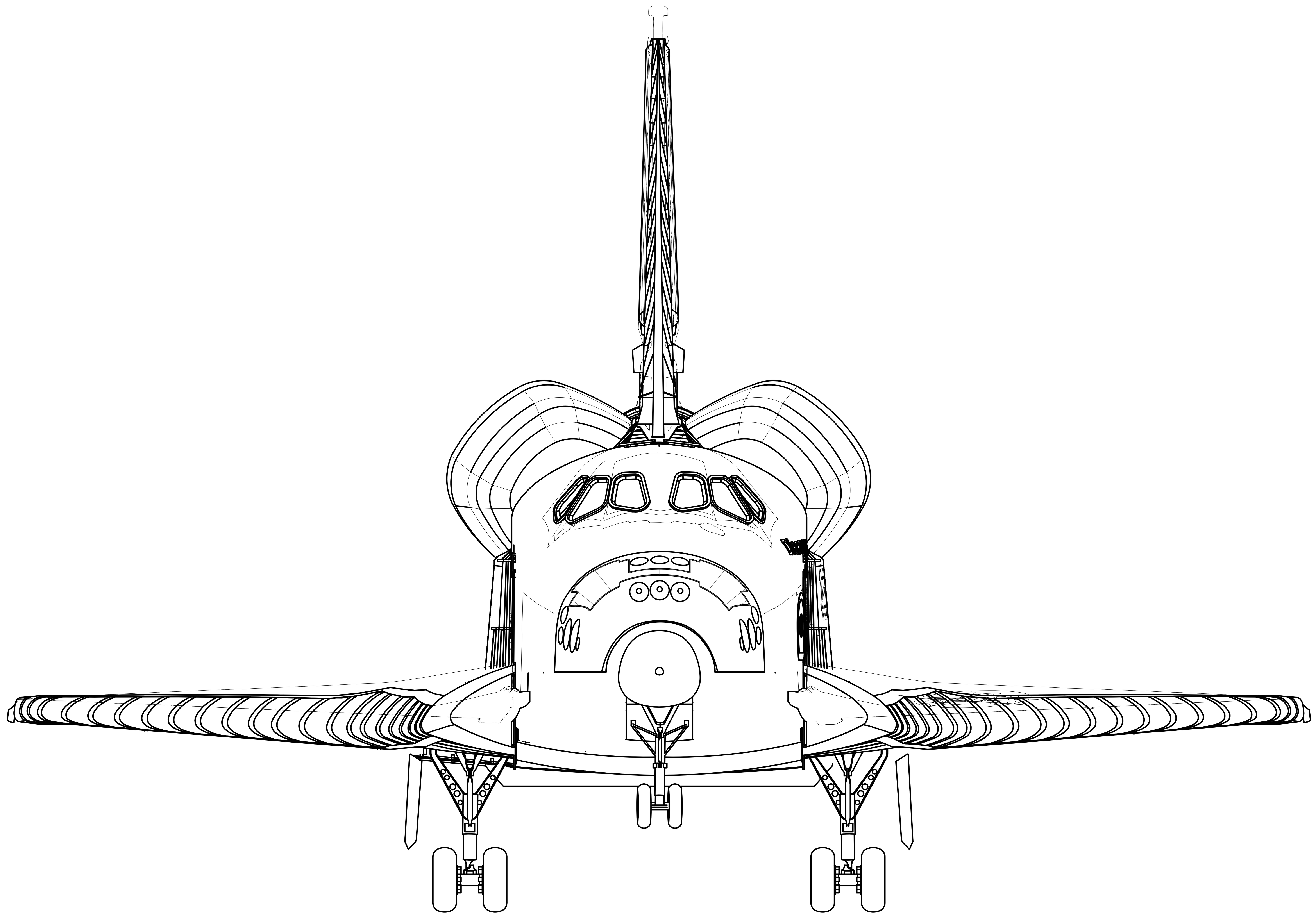

FORWARD ELEVATION

SCALE: 1/4" = 1'-0"

0 5 10 FEET
0 1 2 3 METERS

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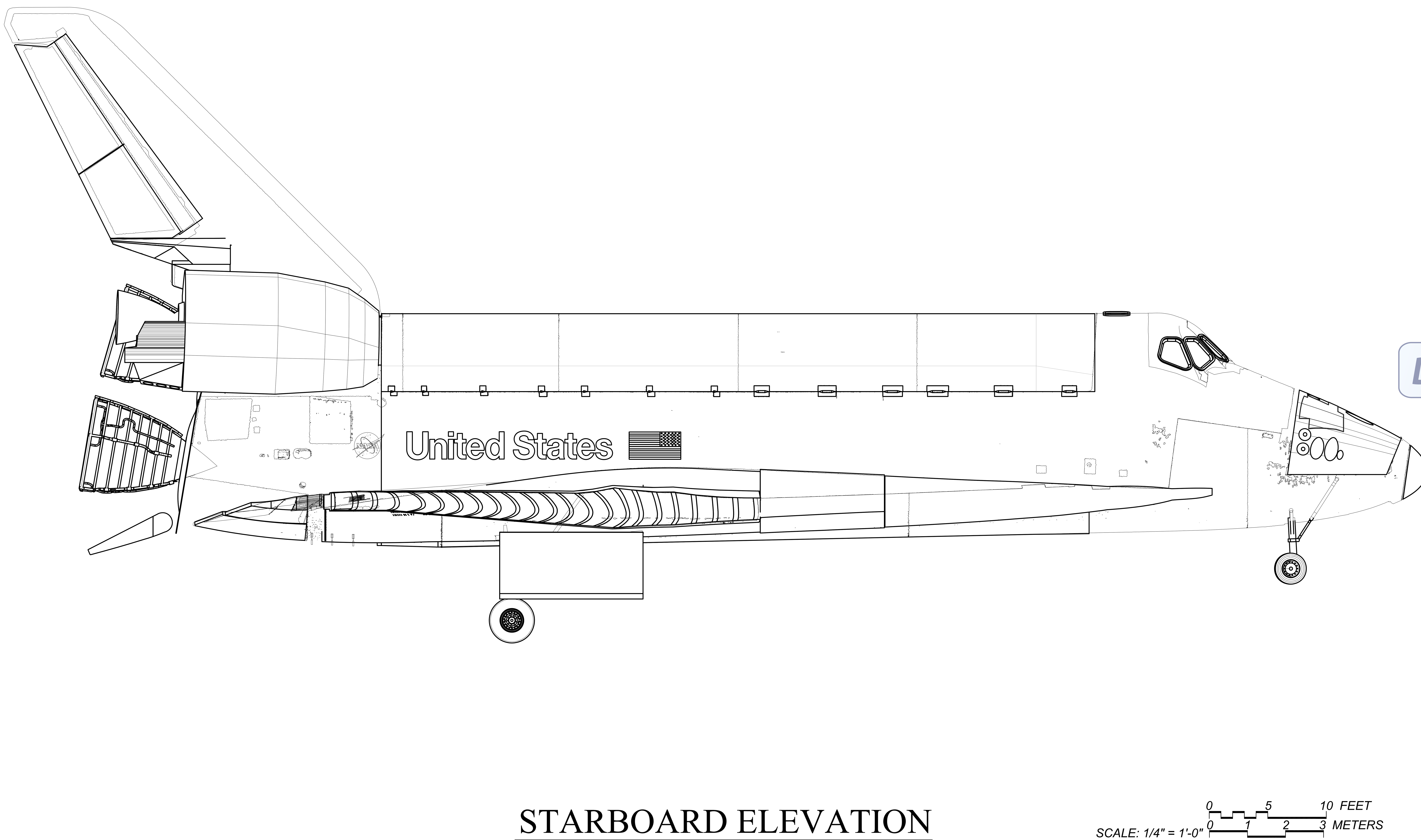

STARBOARD ELEVATION

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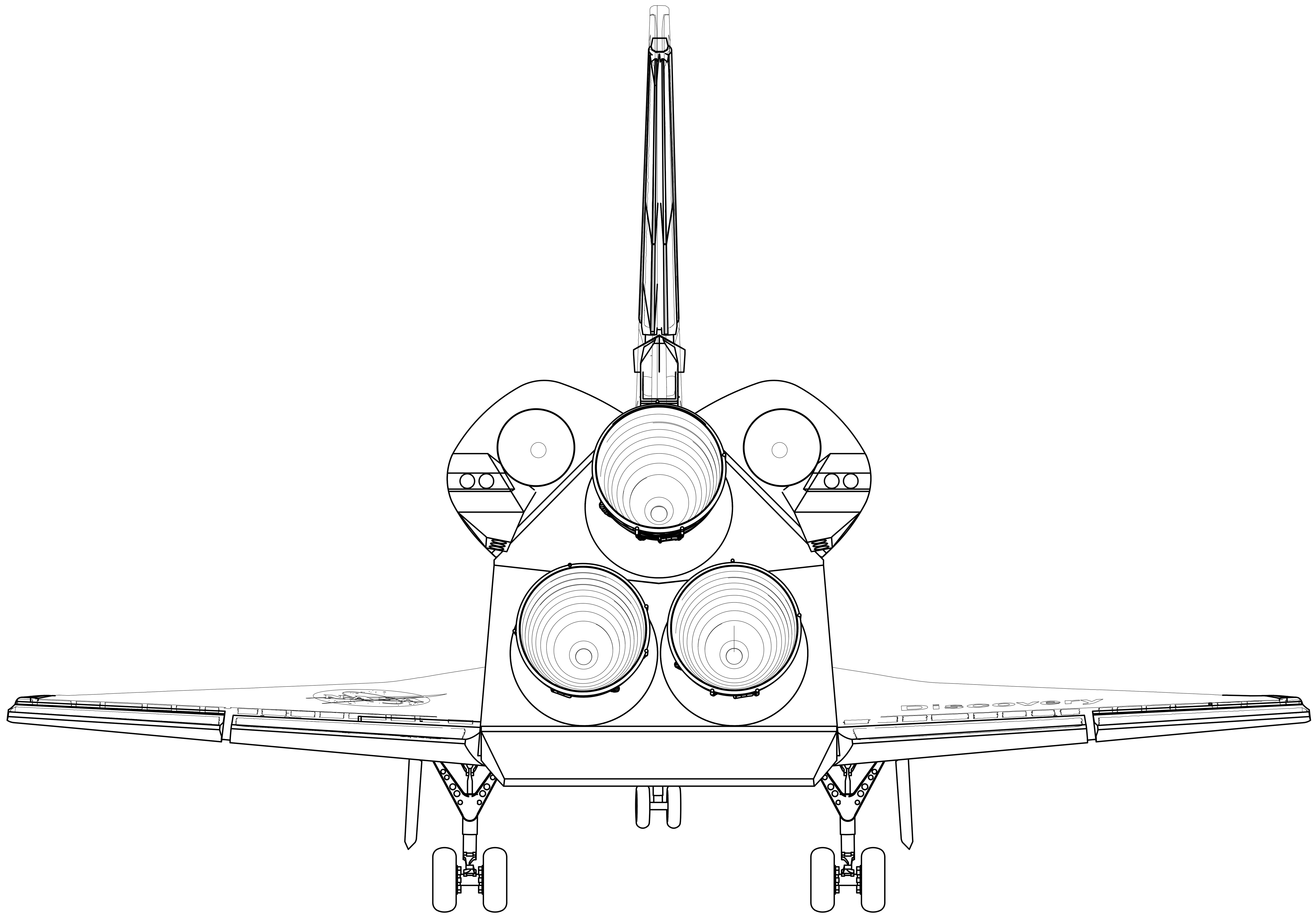

AFT ELEVATION

SCALE: 1/4" = 1'-0"

0 5 10 FEET
0 1 2 3 METERS

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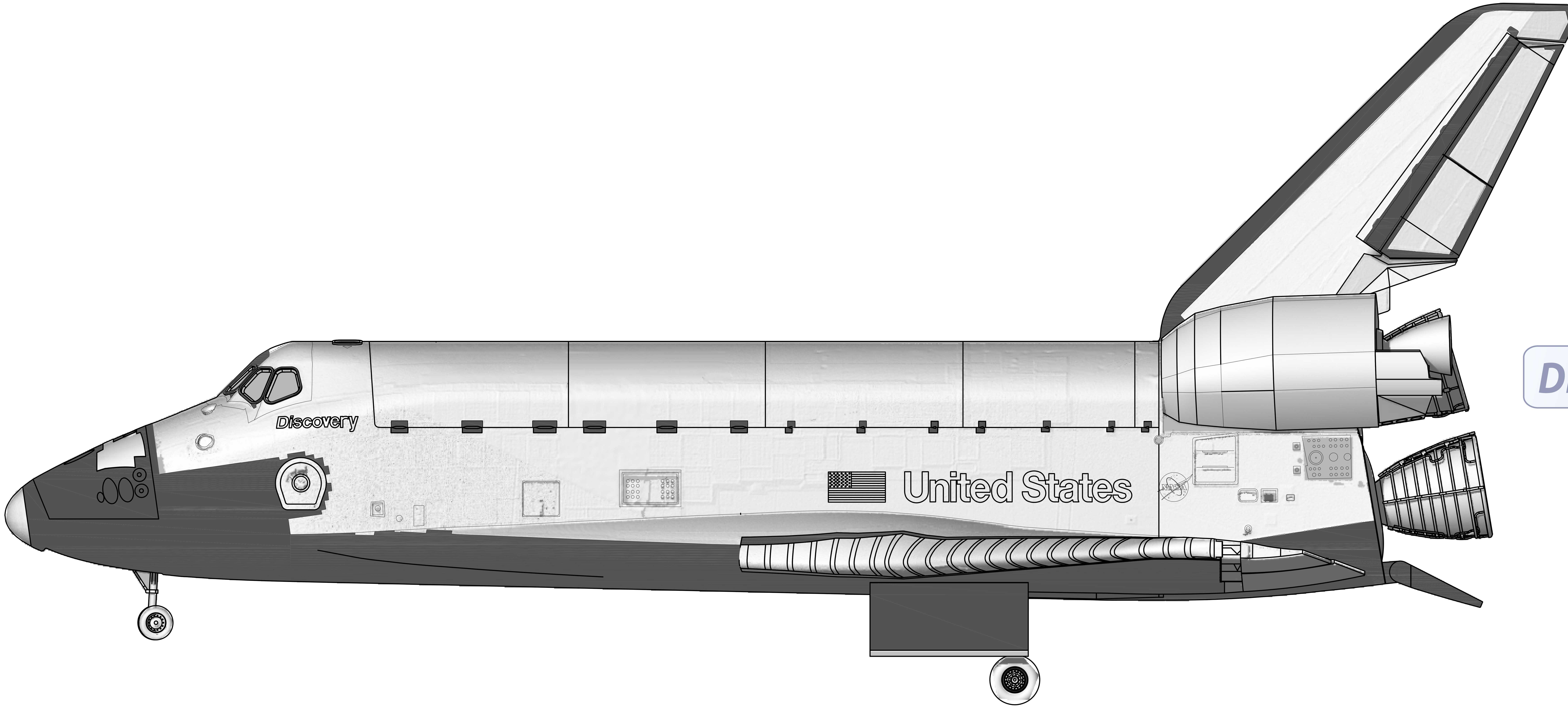

PORT ELEVATION

SCALE: 1/4" = 1'-0"
0 5 10 FEET
0 1 2 3 METERS

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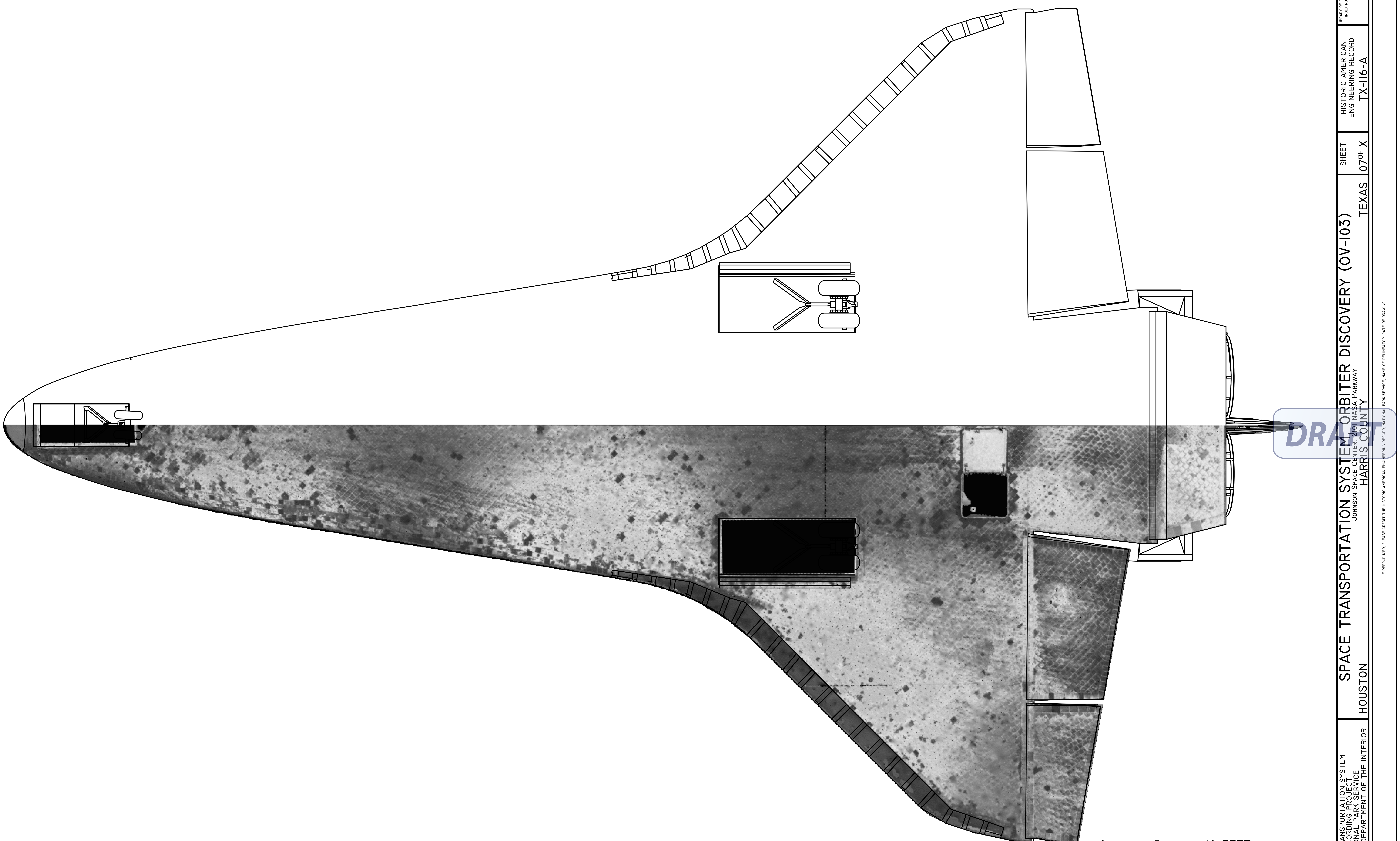

BOTTOM PLAN

SCALE: 1/4" = 1'-0"

0 5 10 FEET

0 1 2 3 METERS

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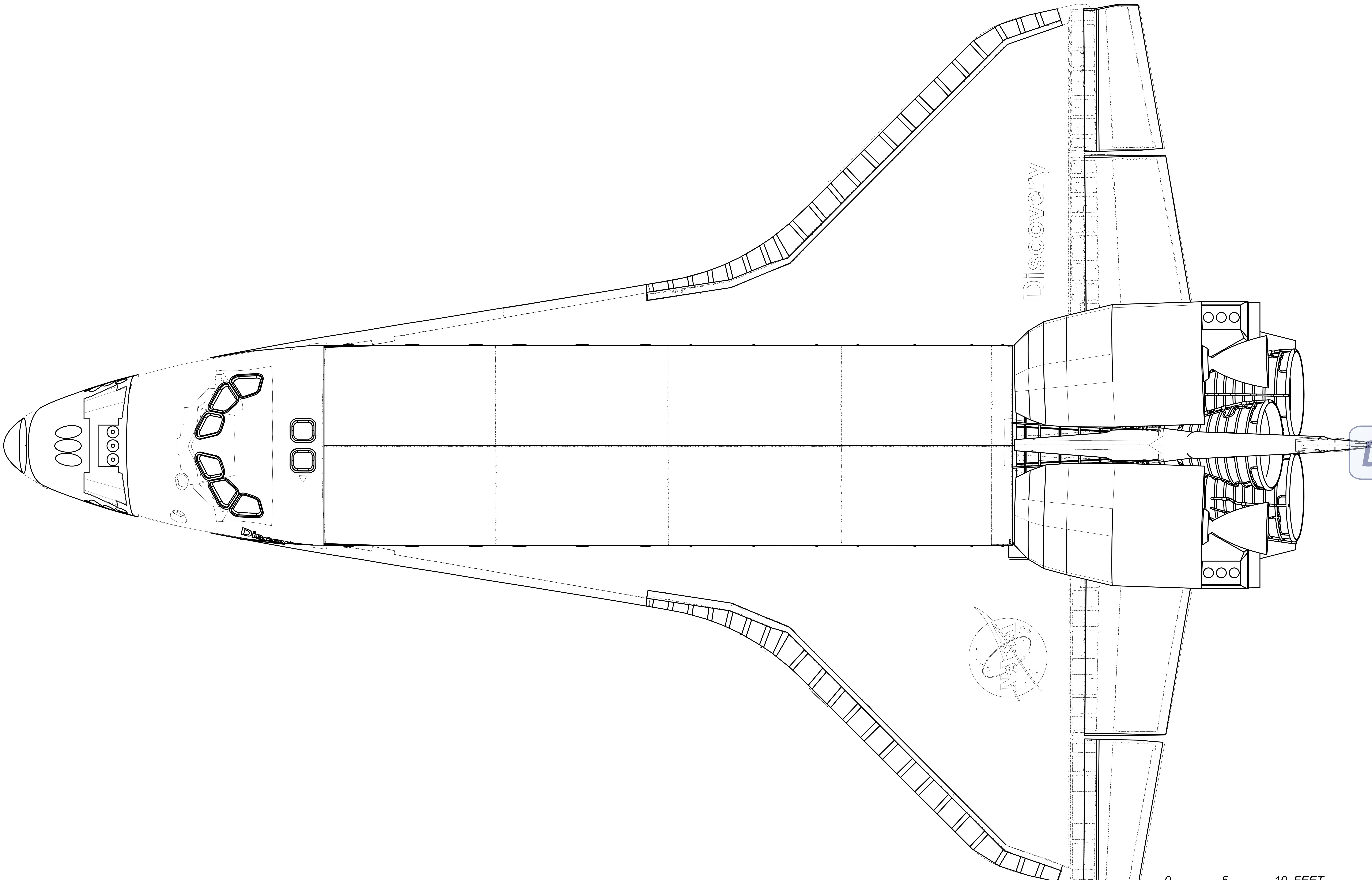

TOP PLAN

SCALE: 1/4" = 1'-0"

0 5 10 FEET
0 1 2 3 METERS

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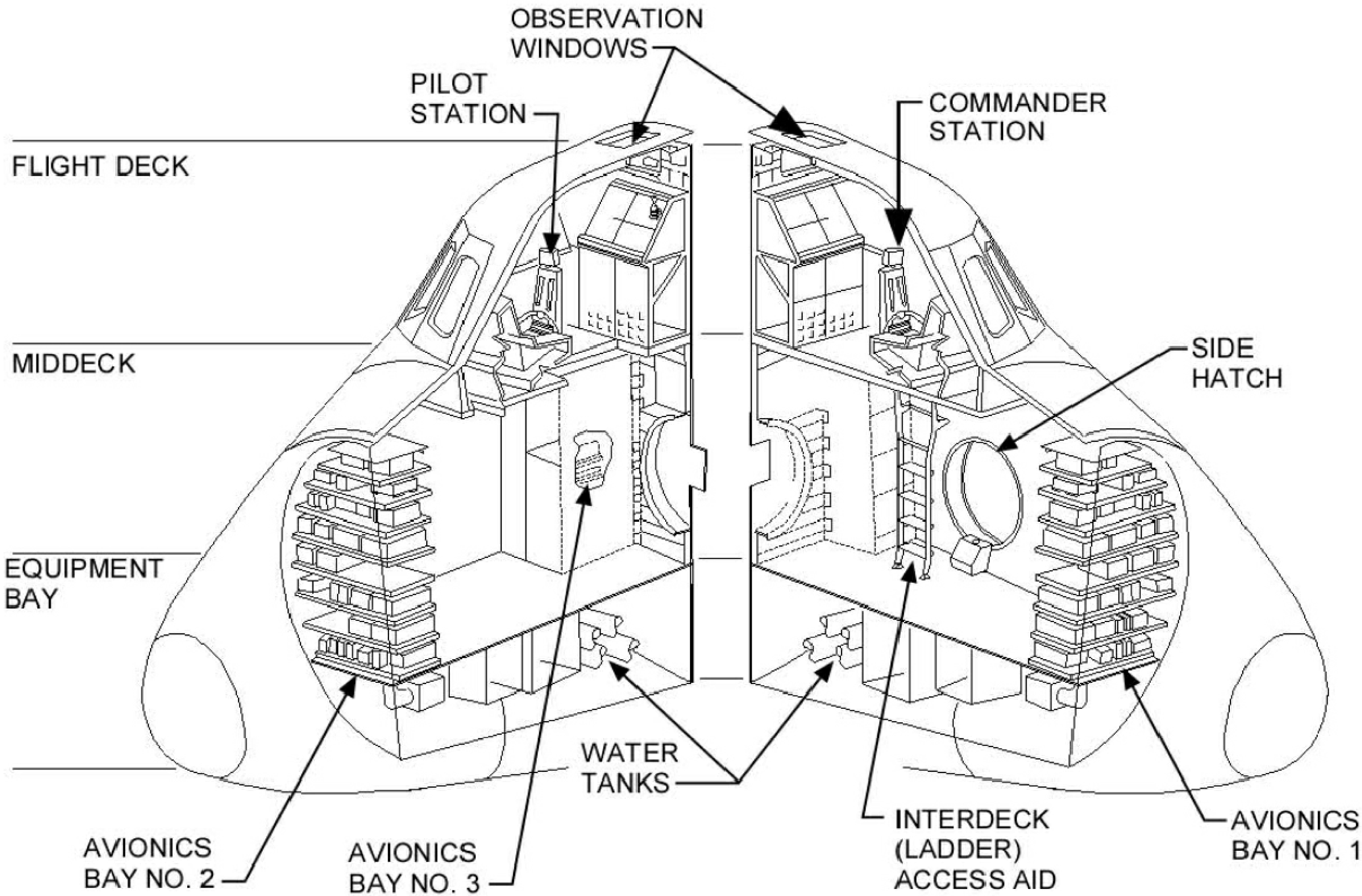

CREW CABIN ISOMETRIC

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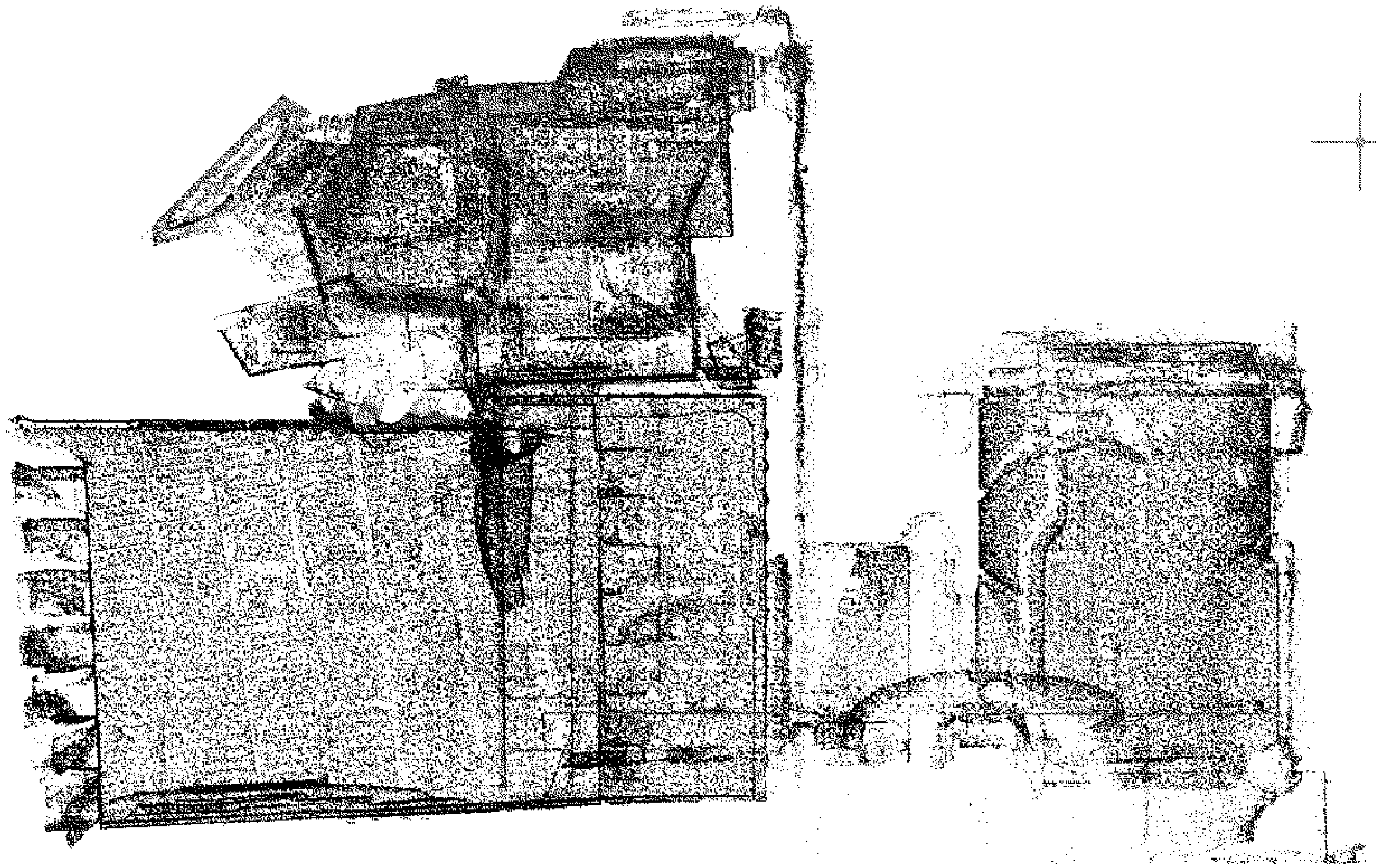
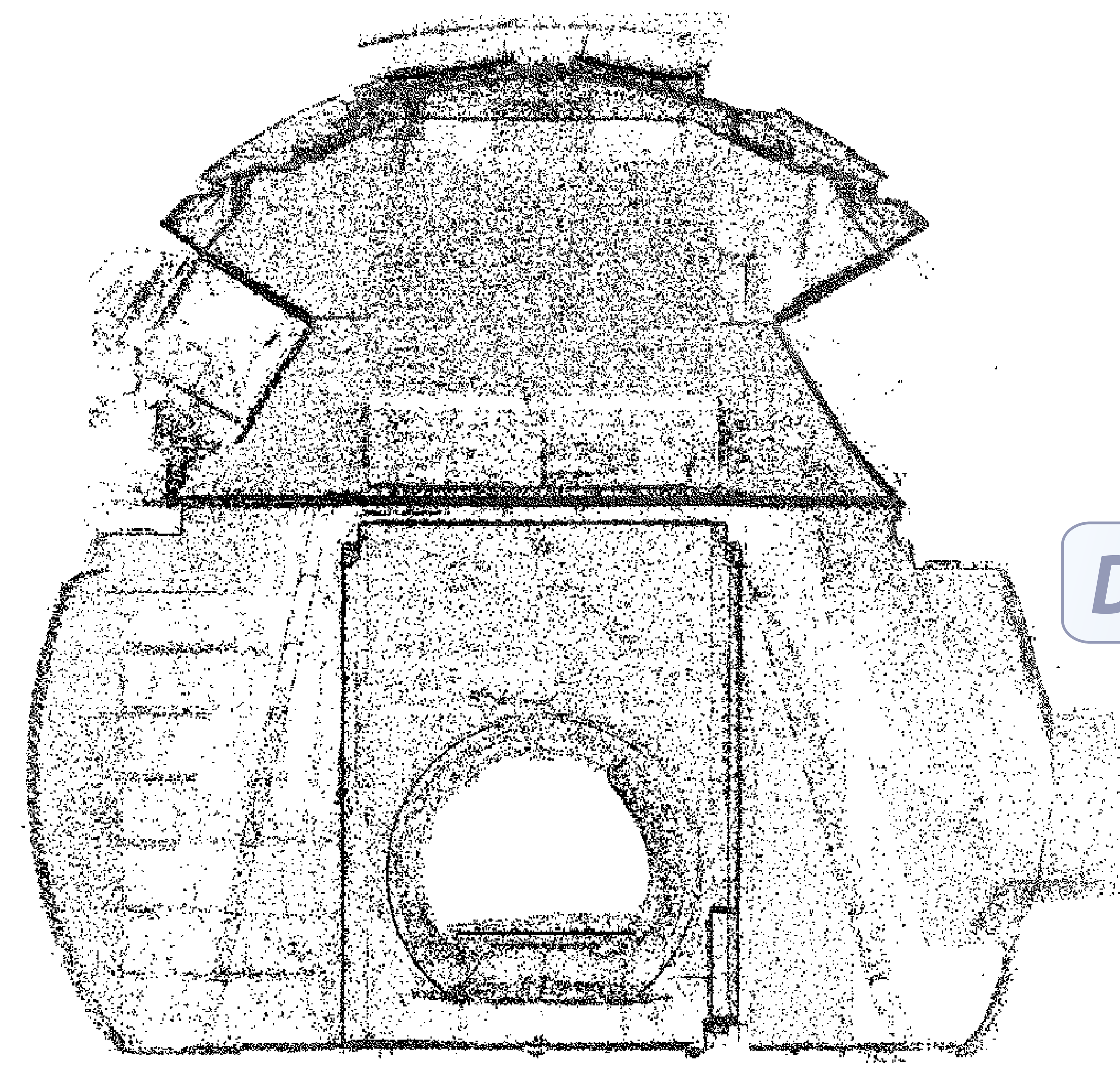


LONGITUDINAL SECTION



TRANSVERSE SECTION

CREW CABIN SECTIONS

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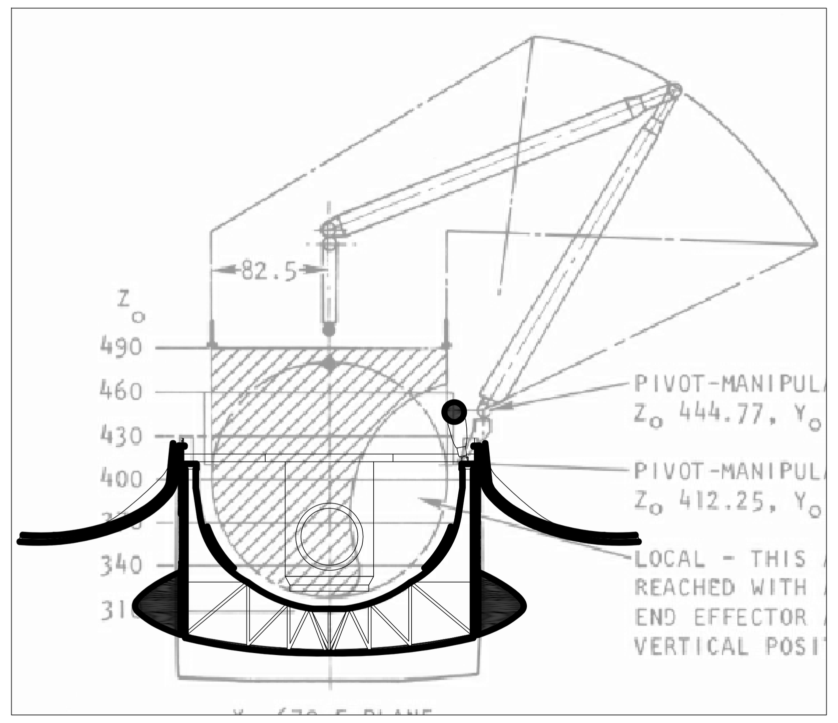
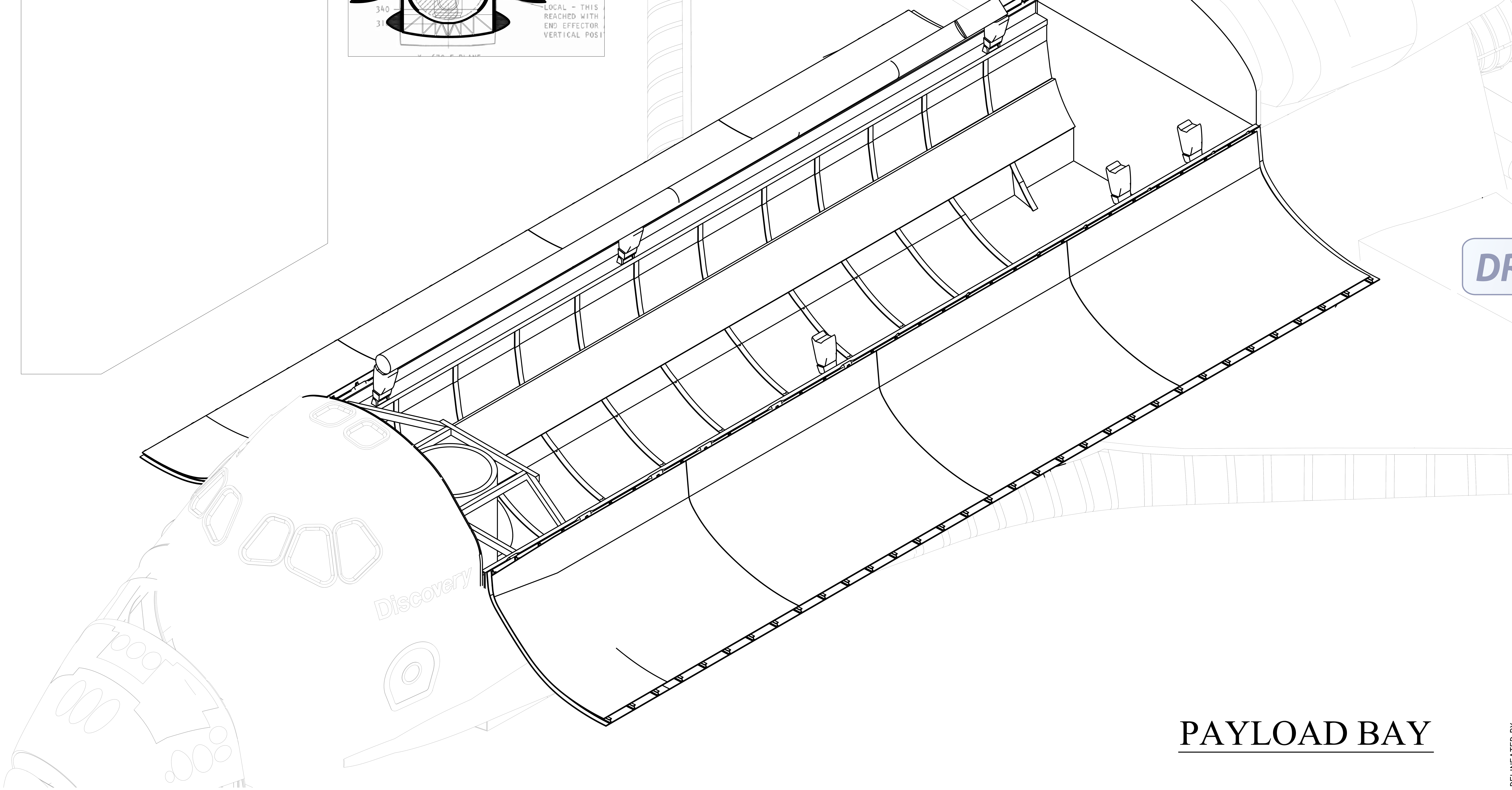
PLACEHOLDER TEXT BOX





PAYLOAD BAY

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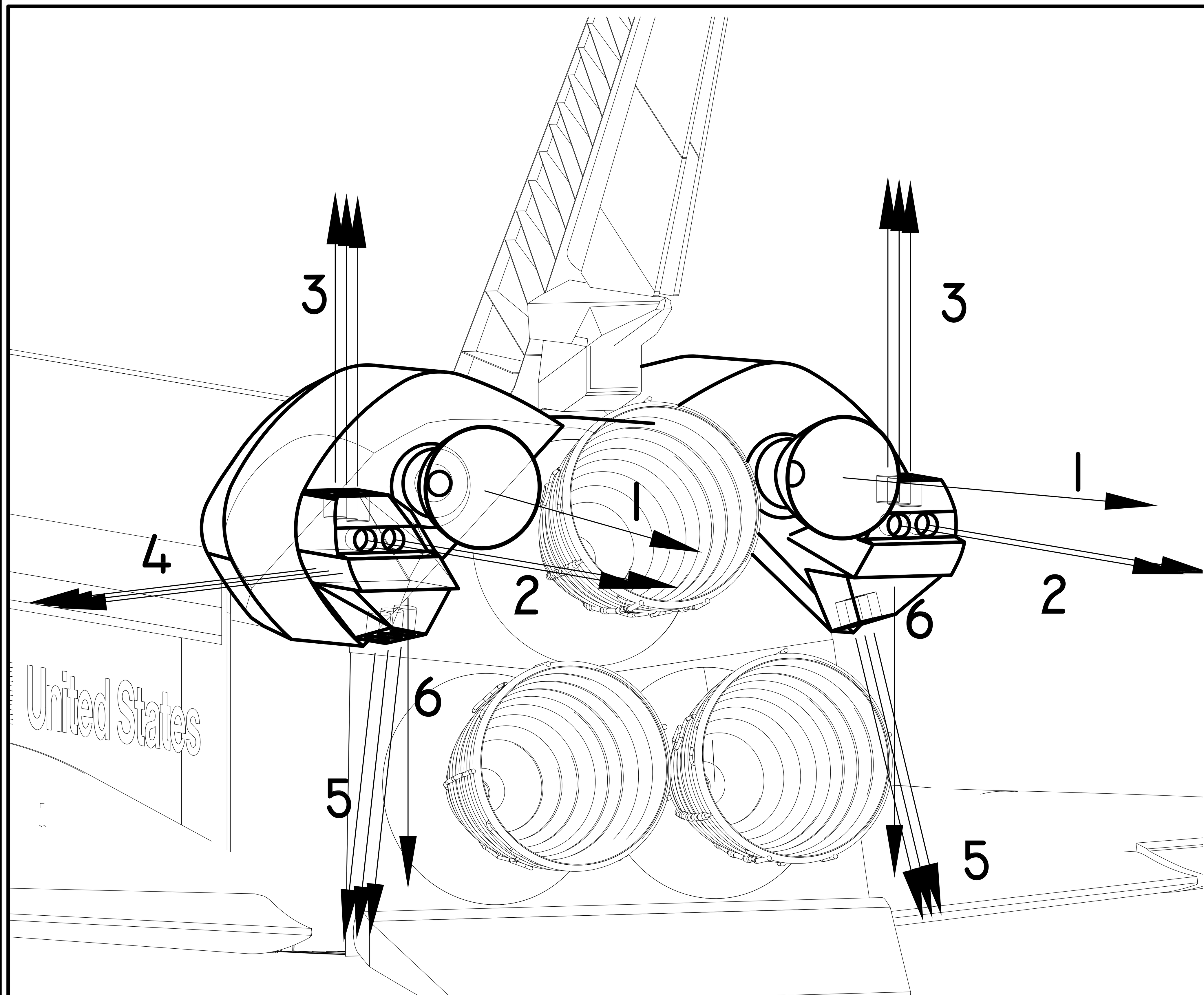
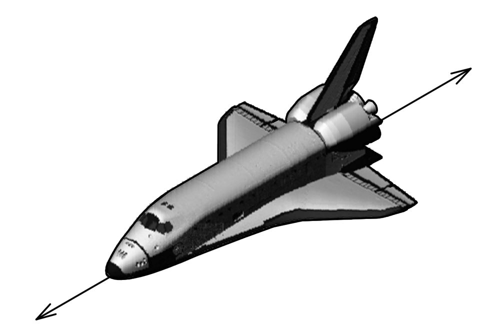
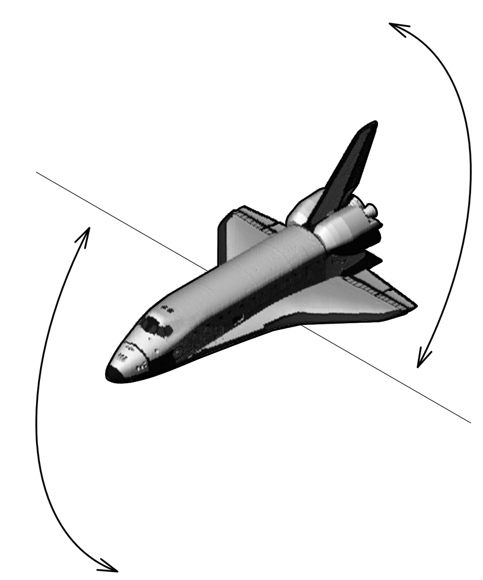


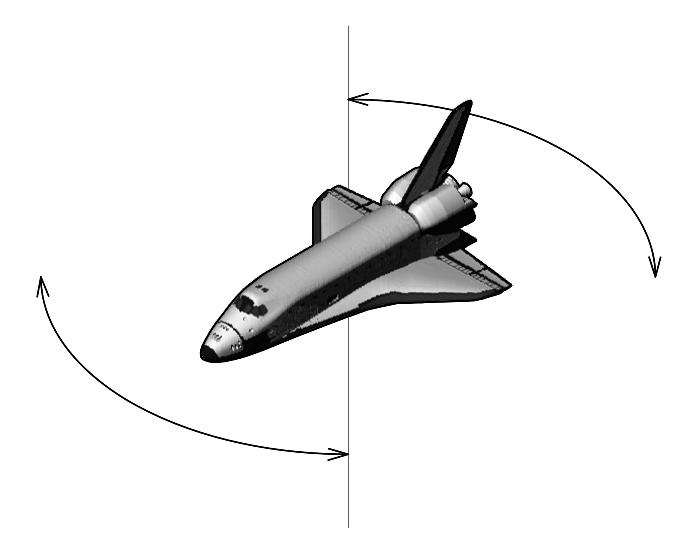
OMS (Orbiter Manuvering System) + Aft RCS
Propulsion Jets and Direction Diagrams
Scale: NTS



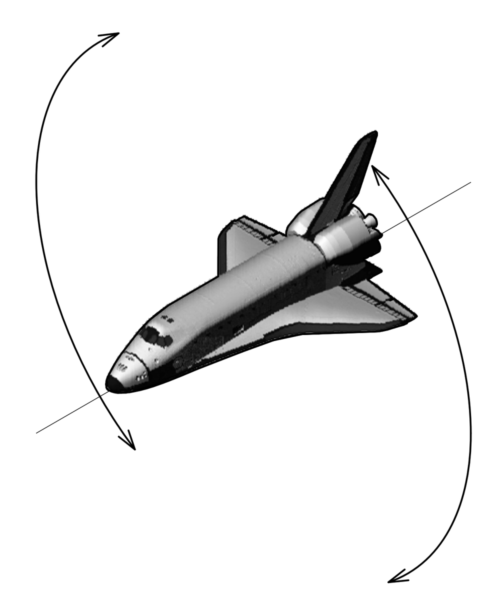
Foreward/ Reverse Manuever
Jets: 1, 2, 10
Scale: NTS



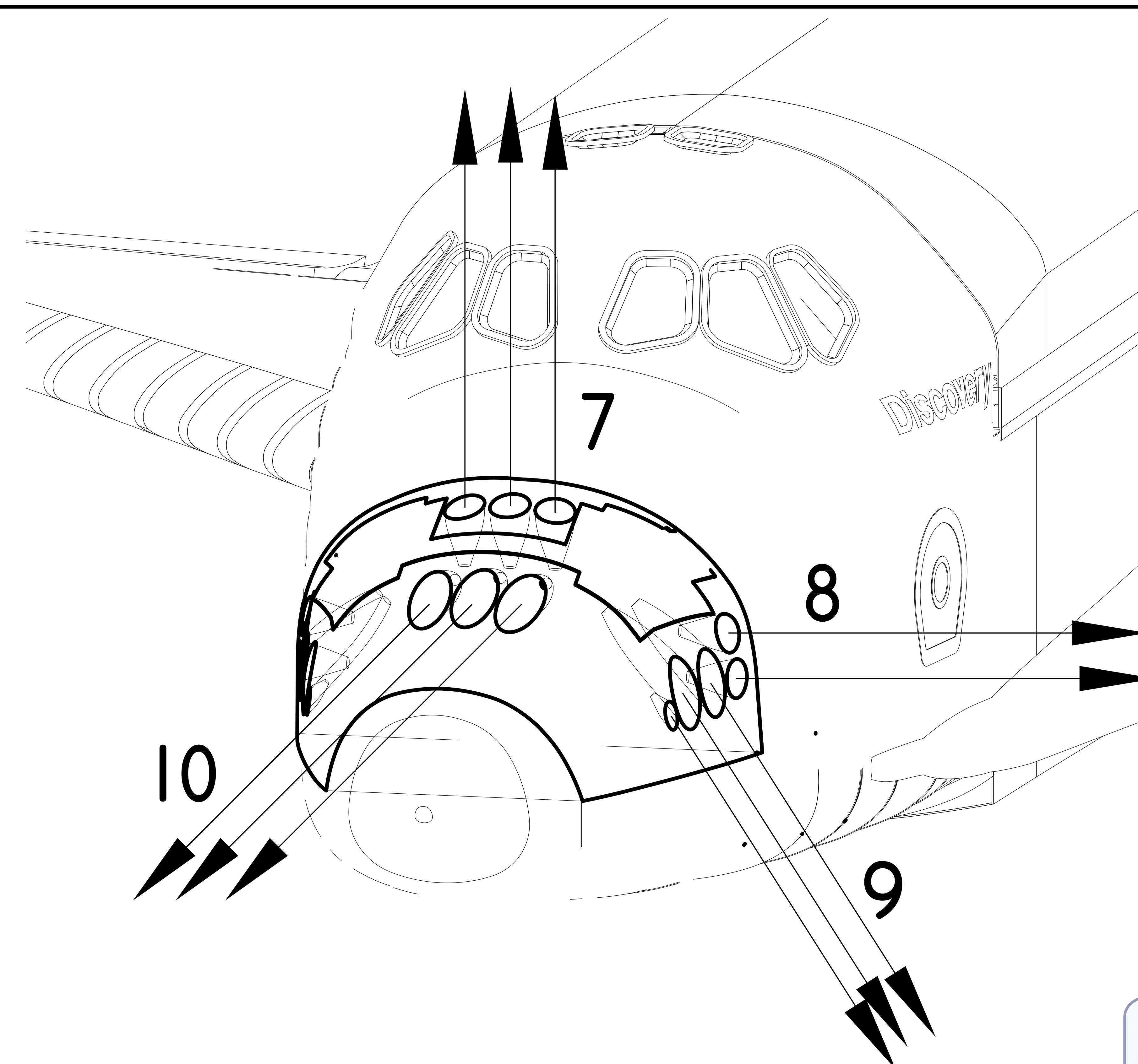
Pitch Maneuver
Jets: 6, 9
Scale: NTS



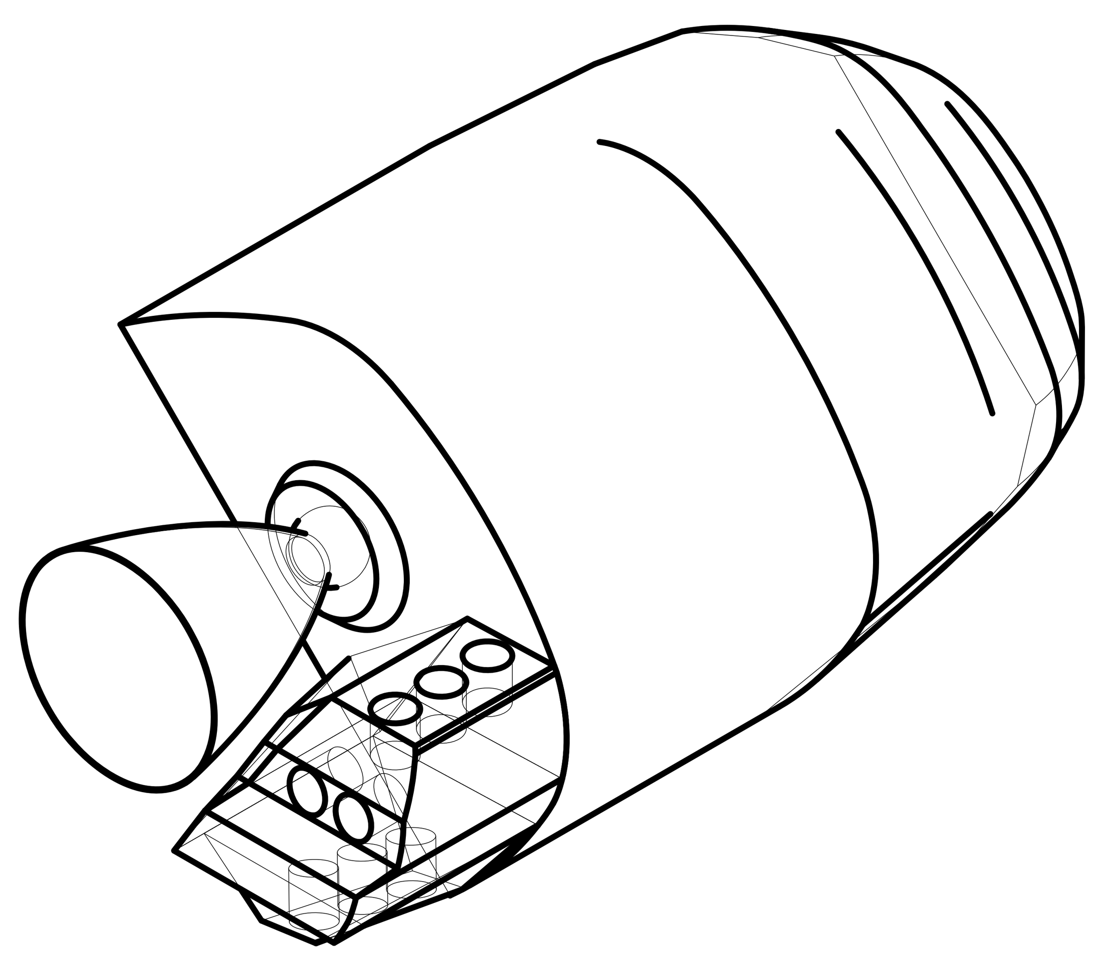
Yaw Maneuver
Jets: 4, 8
Scale: NTS



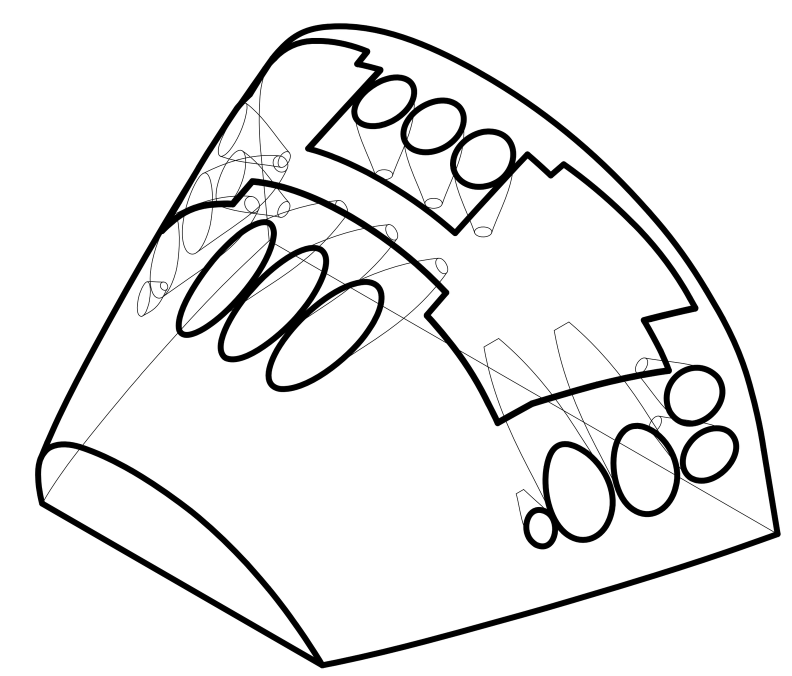
Roll Maneuver
Jets: 3, 5, 9
Scale: NTS



Forward RCS (Reaction Control System)
Propulsion Jets and Direction Diagrams
Scale: NTS



OMS Pod + Aft RCS Content and System Diagram
Scale: NTS



Foreward RCS Content and Systems Diagram
Scale: NTS

Delineated by:
Space Transportation System Recording Project
National Park Service
United States Department of the Interior

Space Transportation System, Orbiter Discovery (OV-103)
Johnson Space Center, 2101 NASA Parkway
Houston
Harris County
Texas

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Oribter TCS - Thermal Control System:

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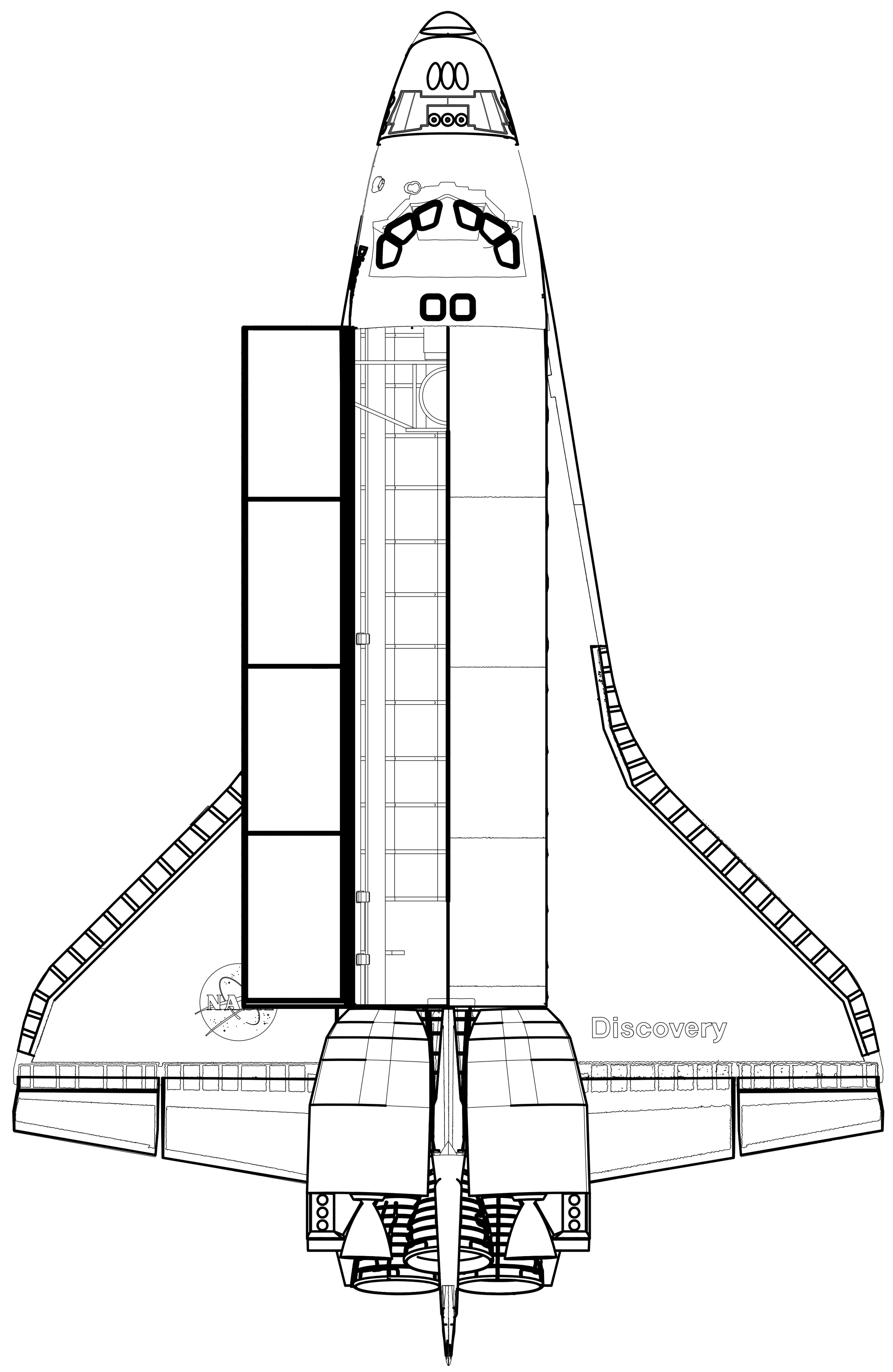
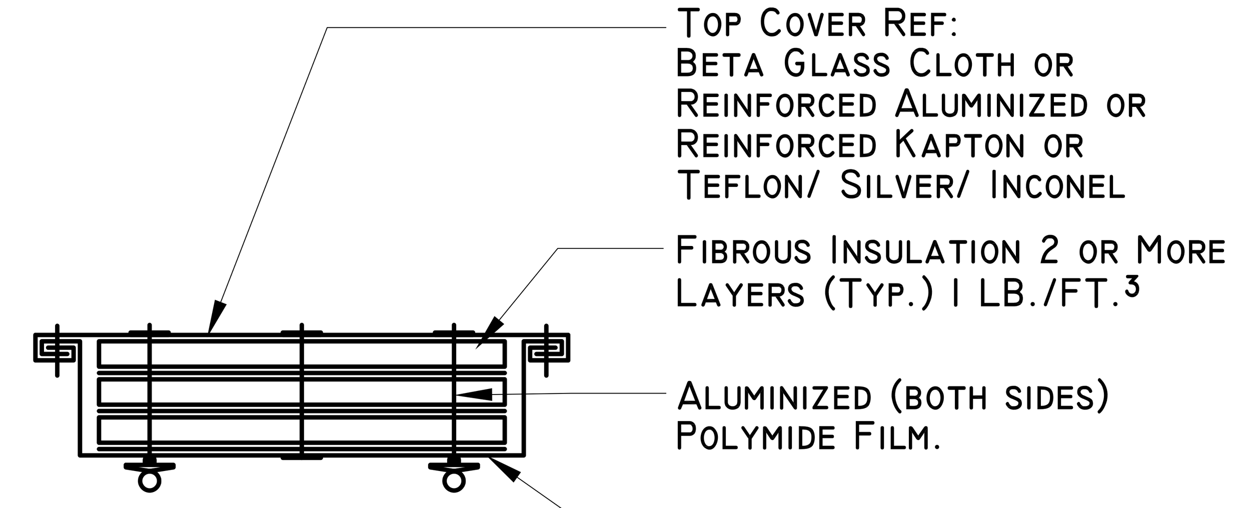
Material Legend

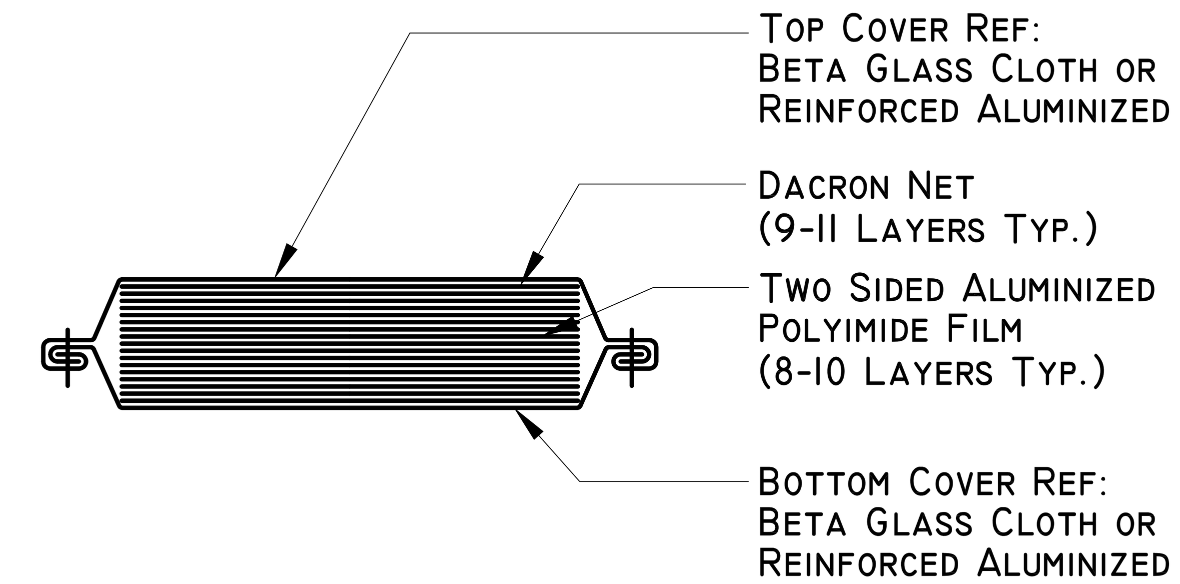
- AFRSI - Advanced Flexible Reusable Surface Insulation
- FRSI - Felt Reusable Surface Insulation
- LRSI - Low Temperature Reusable Surface Insulation
- HRSI - High Temperature Reusable Surface Insulation
- RCC - Reinforced Carbon Carbon



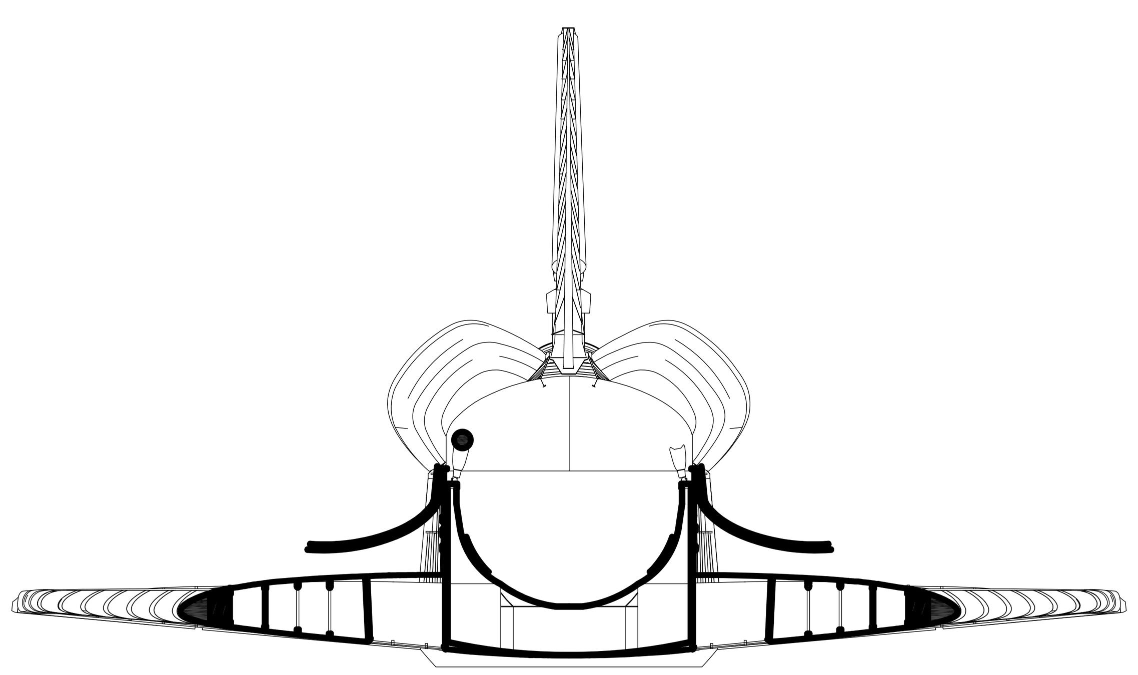
Top + Bottom TPS Cover
3/32" = 1'-0"



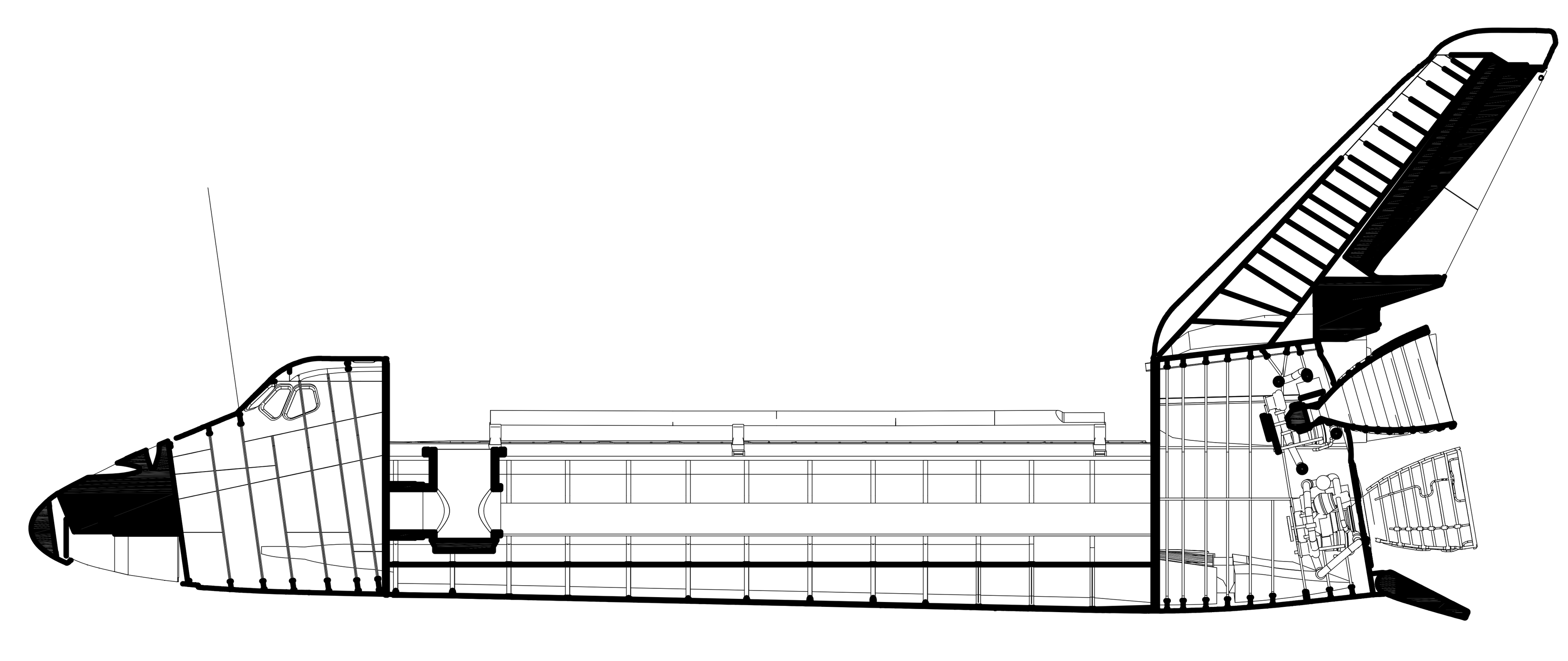
Typical Fibrous Blanket Detail
1-1/2" = 1'-0"



MLI - Multilayer TCS Blanket Detail
1-1/2" = 1'-0"



PAYLOAD BAY SECTION LOOKING TOWARDS AFT
3/32" = 1'-0"



LONGITUDINAL PAYLOAD BAY SECTION LOOKING TOWARDS STARBOARD
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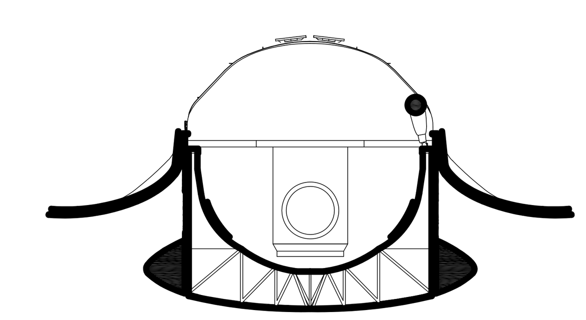

PAYLOAD BAY SECTION LOOKING TOWARDS FRONT
3/32" = 1'-0"

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SPACE TRANSPORTATION SYSTEM, ORBITER DISCOVERY (OV-103)
Johnson Space Center, 2101 NASA Parkway
HOUSTON HARRIS COUNTY TEXAS
DELINEATED BY: SPACE TRANSPORTATION SYSTEM RECORDING PROJECT
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UNITED STATES DEPARTMENT OF THE INTERIOR

Oribter TPS - Thermal Protection System:

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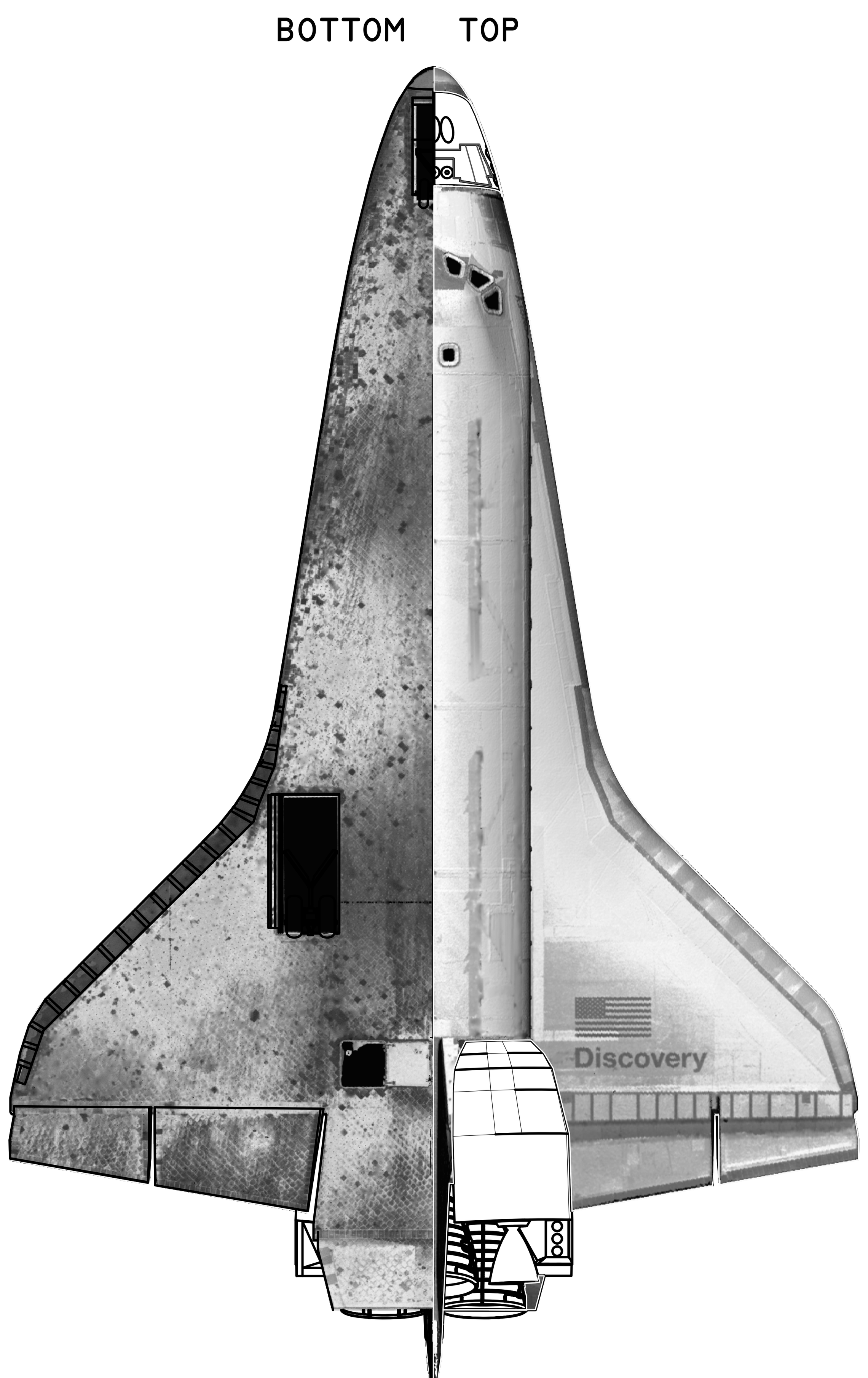

Top + Bottom TPS Cover
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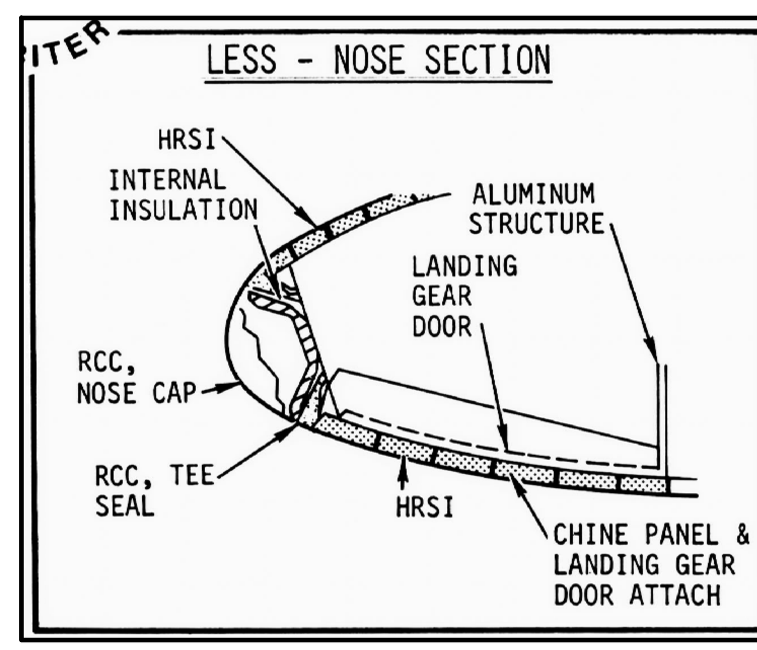
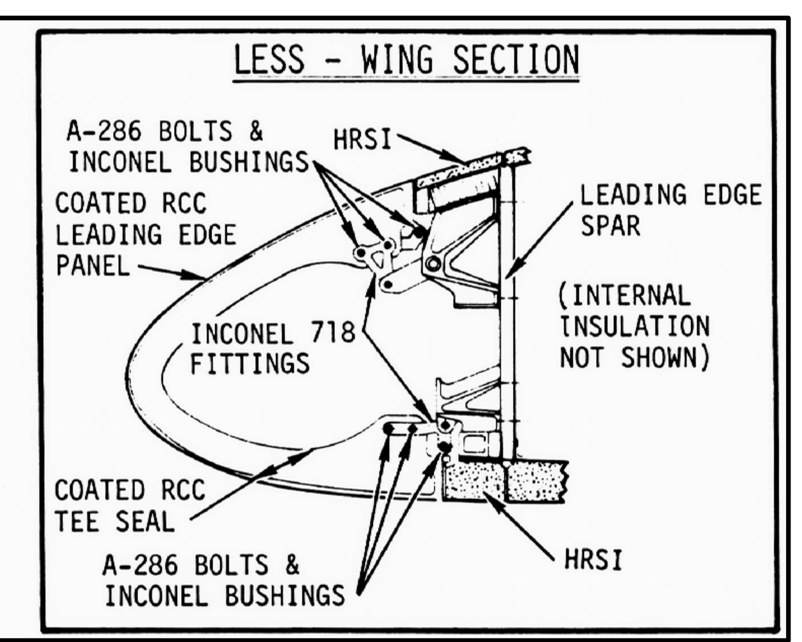
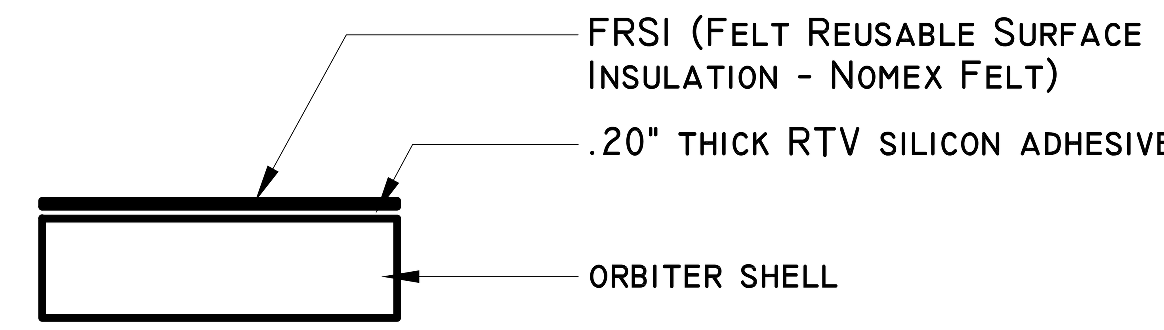


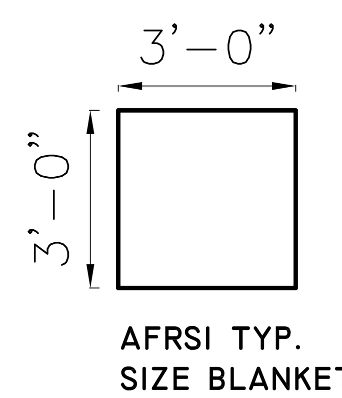
Nose Section @ RCC Cap
3/4" = 1'-0"

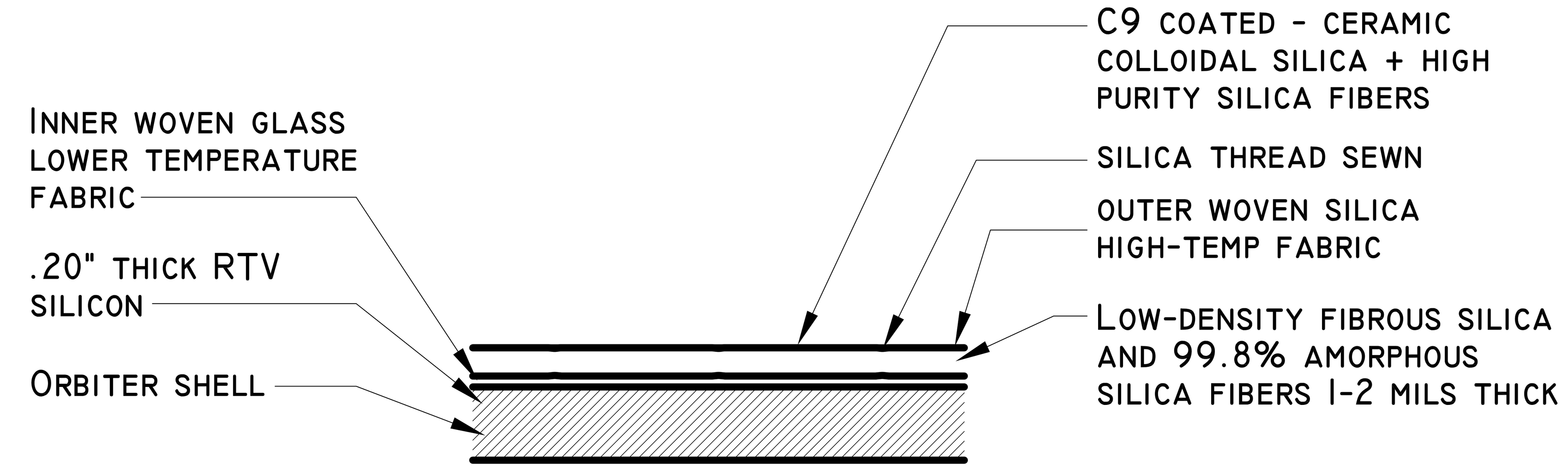


Wing Front Section @ RCC Cover
3/4" = 1'-0"

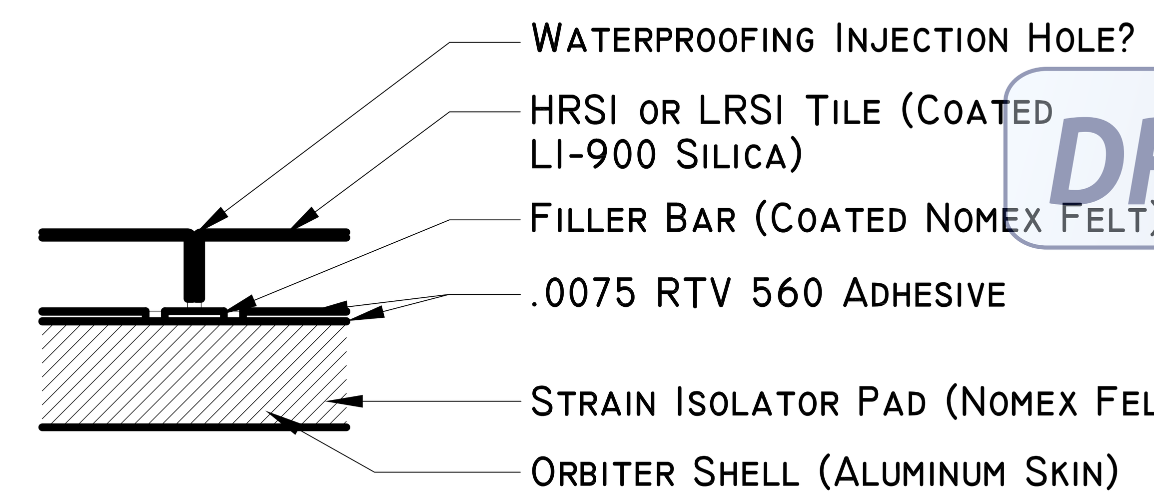


FRSI - Flexible Reusable Surface Insultation Detail
1-1/2" = 1'-0"





AFRSI - Advanced Flexible Reusable Surface Insulation Detail
1-1/2" = 1'-0"



AFRSI - Advanced Flexible Reusable Surface Insulation Detail
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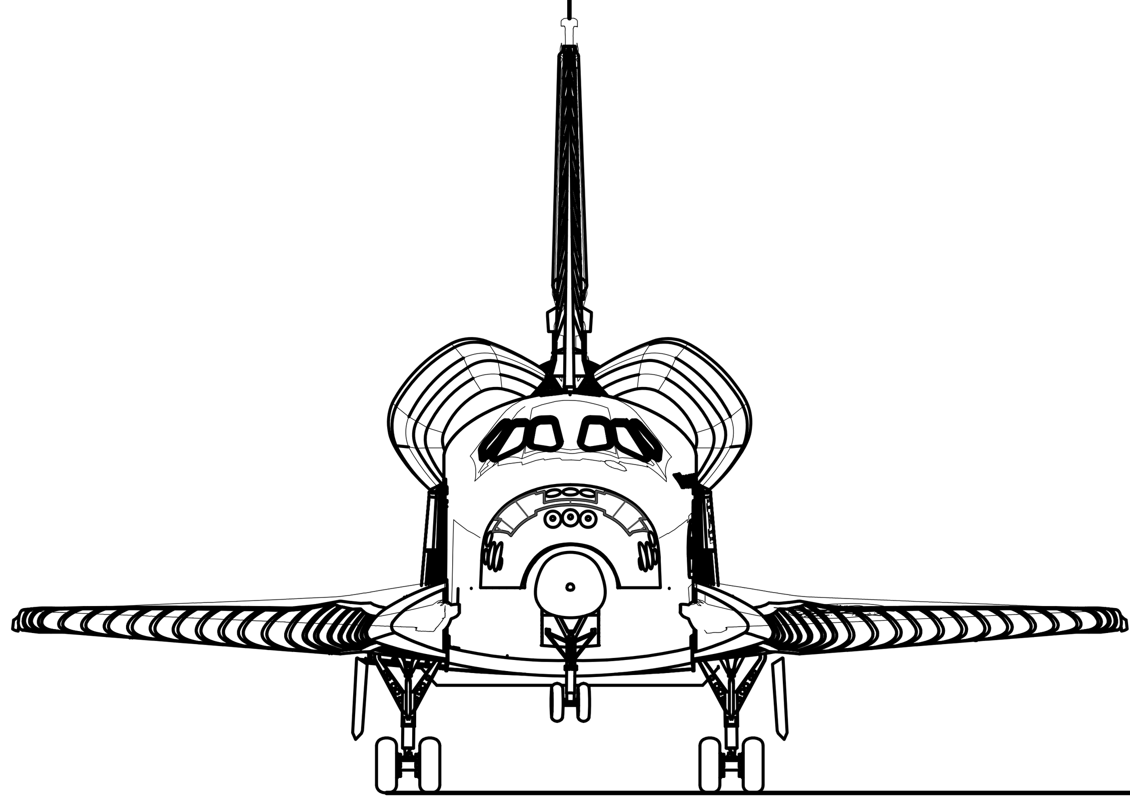
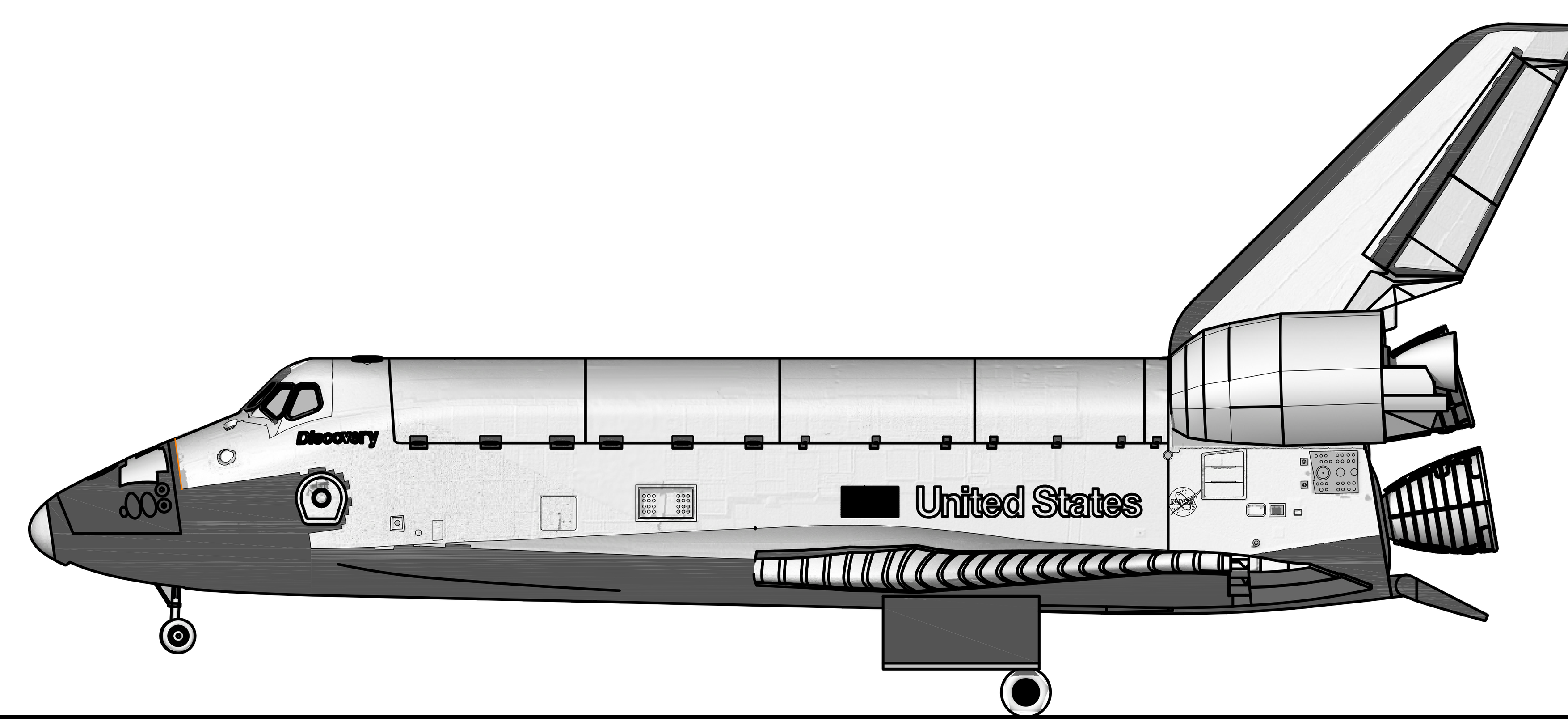
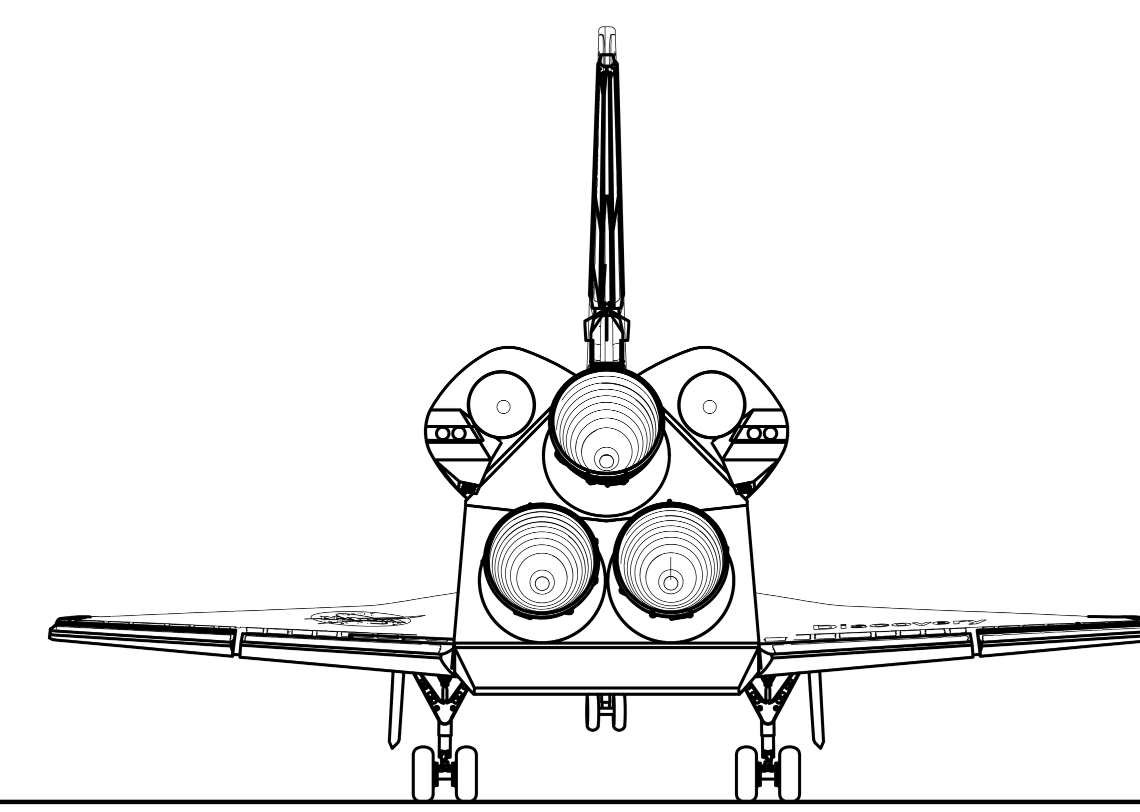


Front TPS Cover
3/32" = 1'-0"



PORT SIDE TPS COVER
3/32" = 1'-0"



Rear TPS Cover
3/32" = 1'-0"

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TX-116-A

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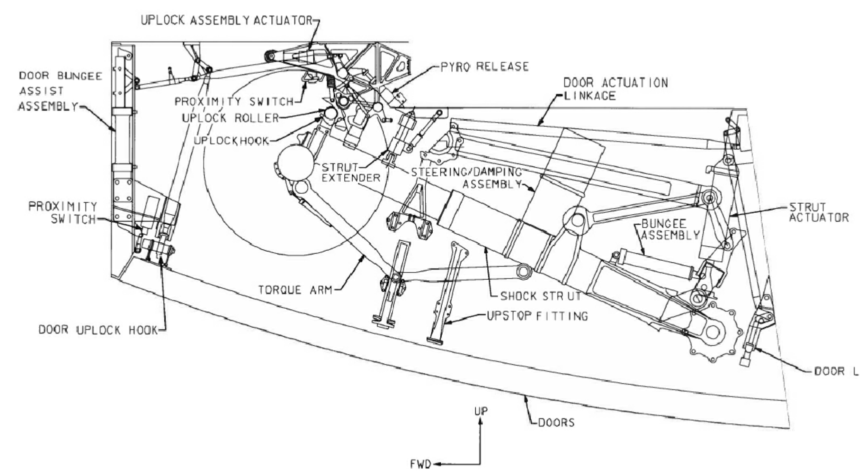
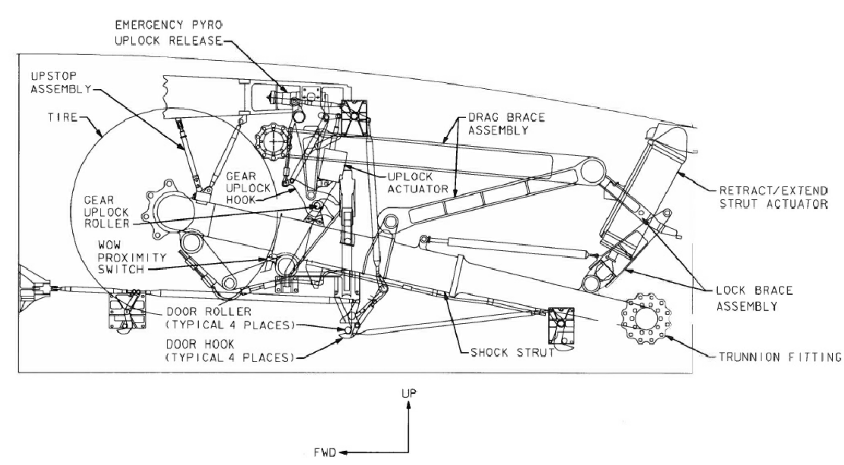
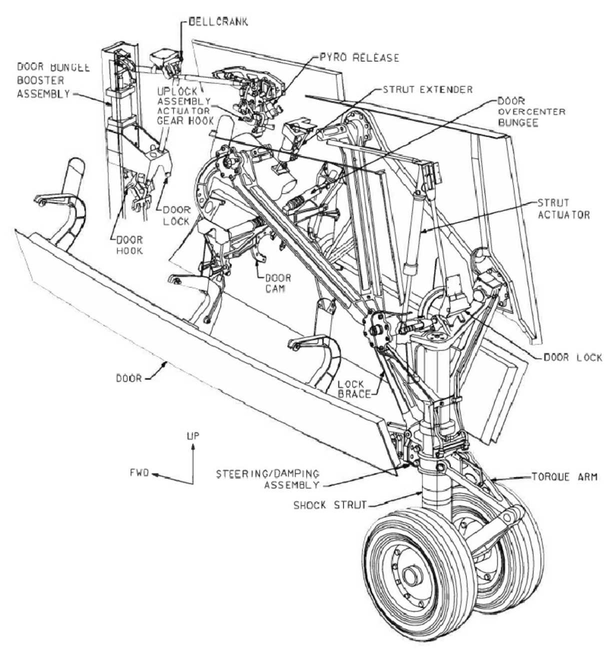
LANDING GEAR AND DROGUE CHUTE



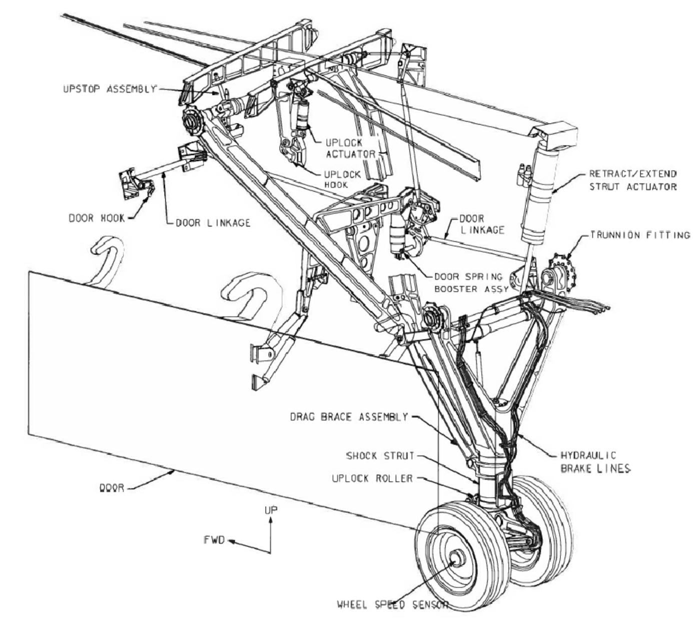
Nose Landing Gear Stowed



Main Landing Gear Stowed

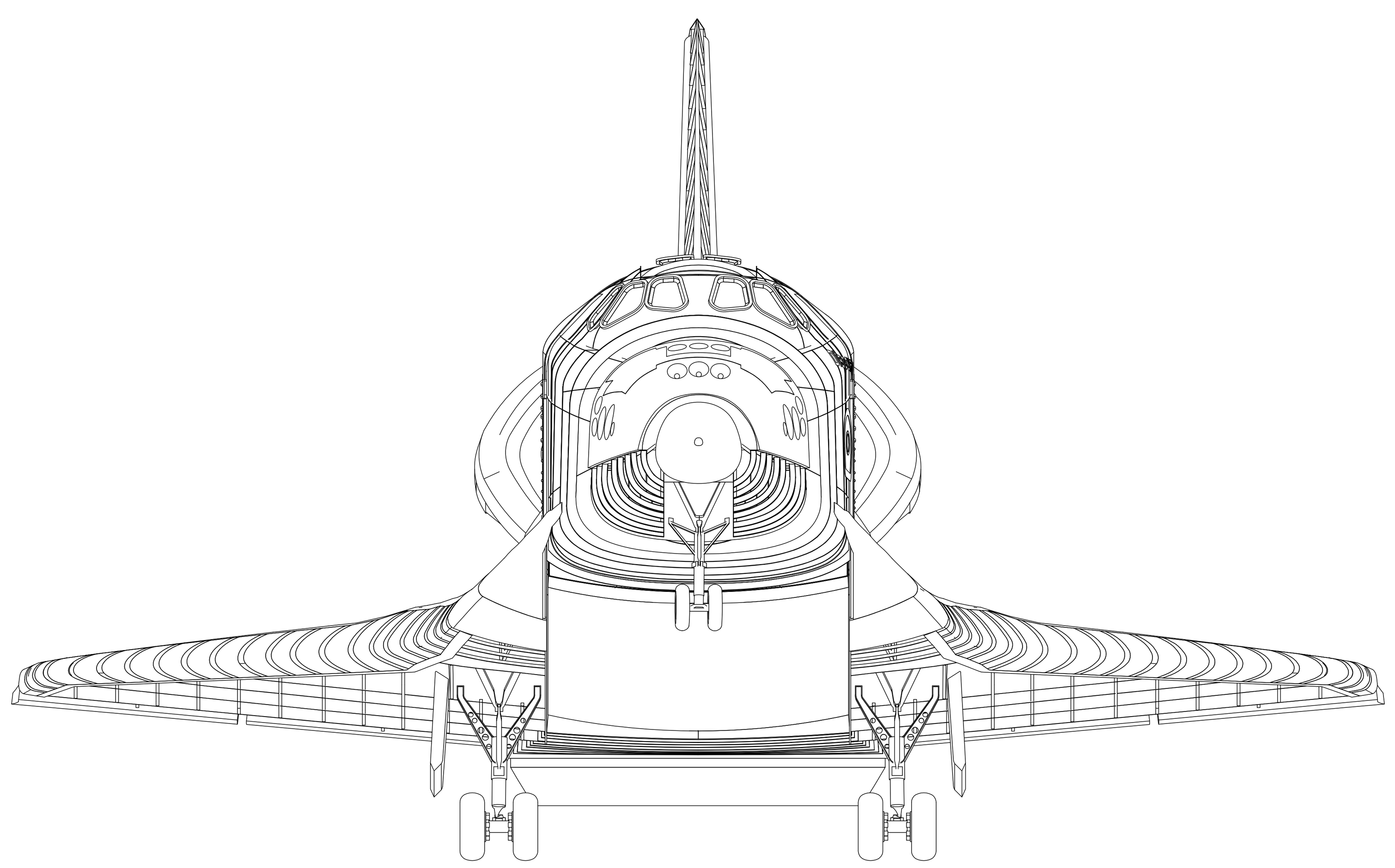


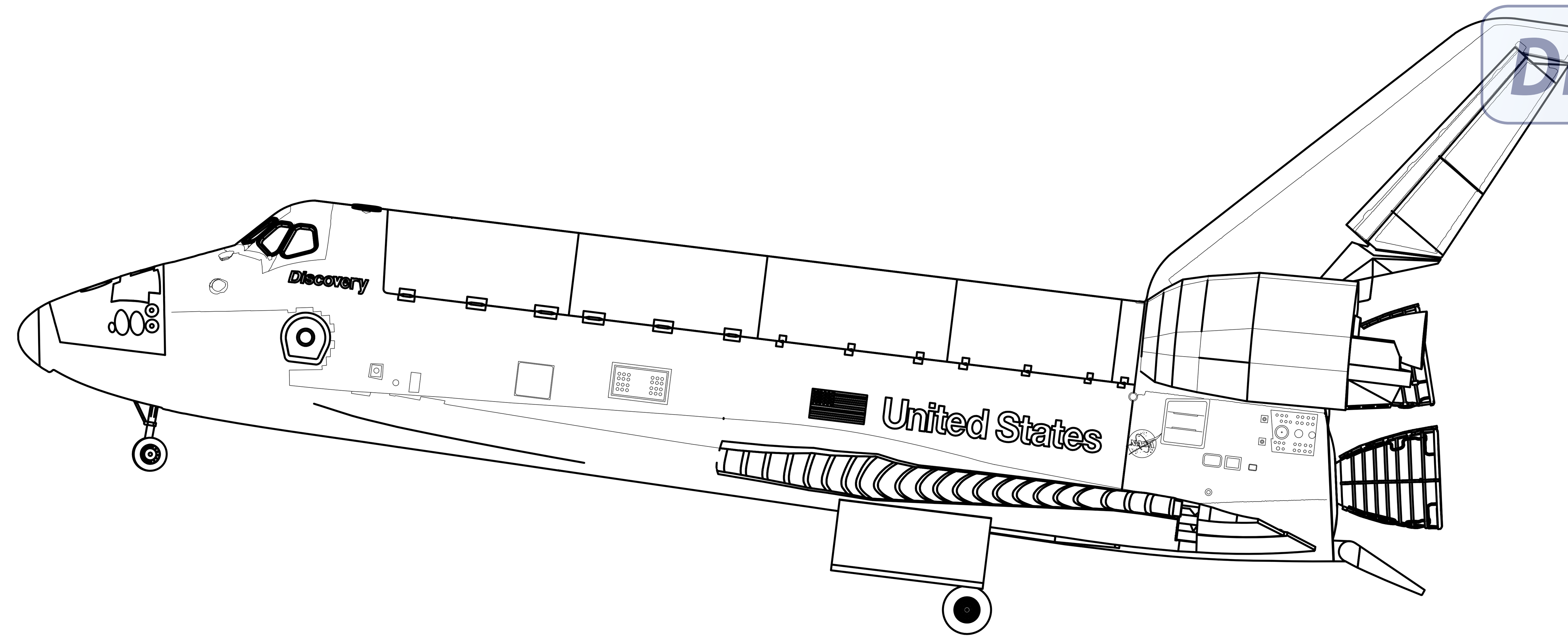
Nose Landing Gear Deployed

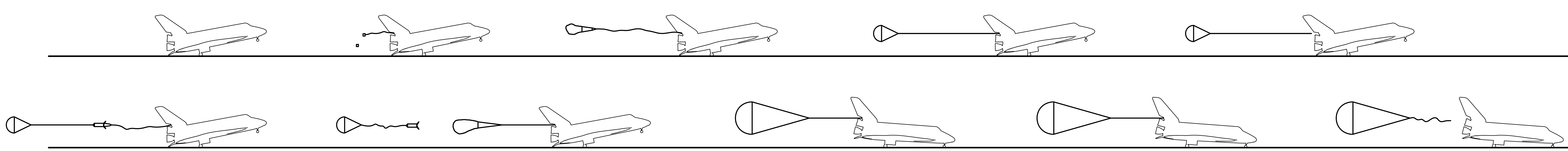


Main Landing Gear Deployed

PLACEHOLDER TEXT BOX







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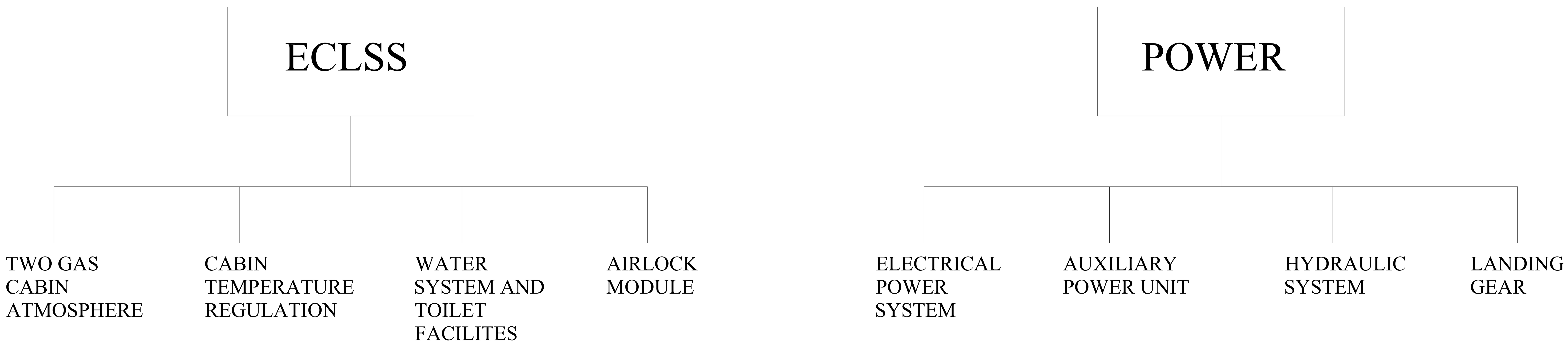

ECLSS AND POWER SYSTEMS

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Space Transportation System
Space Shuttle Main Engine

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NASA faced a unique challenge at the beginning of the Space Shuttle Program: to design and fly a human-rated reusable liquid propulsion rocket engine to launch the shuttle. It was the first and only liquid-fueled rocket engine to be reused from one mission to the next during the shuttle era. The improvement of the Space Shuttle Main Engine (SSME) was a continuous undertaking, with the objectives being to increase safety, reliability, and operational margins; reduce maintenance; and improve the life of the engine's high-pressure turbopumps.

The reusable SSME was a staged combustion cycle engine. Using a mixture of liquid oxygen and liquid hydrogen, the main engine could attain a maximum thrust level (in vacuum) of 232,375 kg (512,300 pounds), which is equivalent to greater than 12,000,000 horsepower (hp). The engine also featured high-performance fuel and oxidizer turbopumps that developed 69,000 hp and 25,000 hp, respectively. Ultra-high-pressure operation of the pumps and combustion chamber allowed expansion of hot gases through the exhaust nozzle to achieve efficiencies never previously attained in a rocket engine.

Requirements established for Space Shuttle design and development began in the mid 1960s. These requirements called for a two-stage-to-orbit vehicle configuration with liquid oxygen (oxidizer) and liquid hydrogen (fuel) for the Orbiter's main engines.

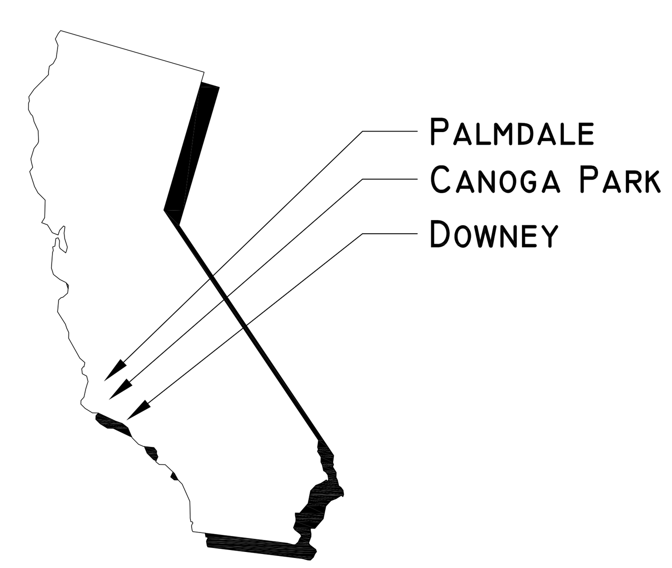
In 1971, the Rocketdyne division of Rockwell International was awarded a contract to design, develop, and produce the main engine.

The main engine would be the first production-staged combustion cycle engine for the United States. The staged combustion cycle yielded high efficiency in a technologically advanced and complex engine that operated at pressures beyond known experience. The design team chose a dual-preburner powerhead configuration to provide precise mixture ratio and throttling control. A low- and high-pressure turbopump, placed in series for each of the liquid hydrogen and liquid oxygen loops, generated high pressures across a wide range of power levels.

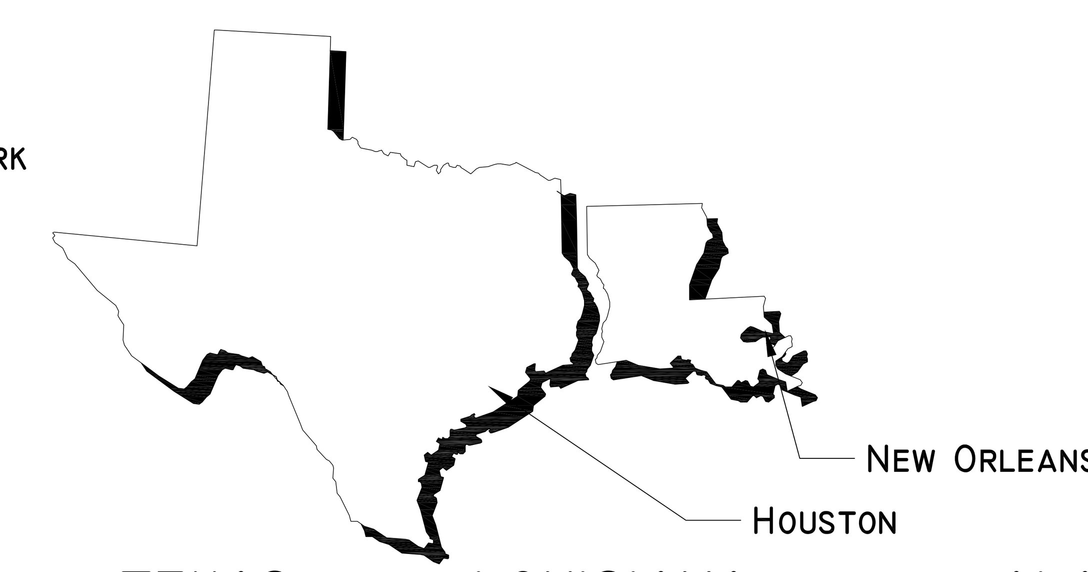
A major requirement in engine design was the ability to operate at various power levels. The original engine life requirement was 100 nominal missions and 27,000 seconds (7.5 hours) of engine life. Nominal thrust, designated as rated power level, was 213,189 kg (470,000 pounds) in vacuum. The life requirement included six exposures at the emergency power level of 232,375 kg (512,300 pounds), which was designated 109% of rated power level. To maximize the number of missions possible at emergency power level, an assessment of the engine capability resulted in reducing the number of nominal missions per engine to 55 missions at 109%. Emergency power level was subsequently renamed full power level.

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering, industrial, and maritime works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Space Transportation System recording project was cosponsored during 2011 by the Space Shuttle Program Transition and Retirement Office of the Johnson Space Center (JSC), with the guidance and assistance of Barbara Severance, Integration Manager, JSC, Jennifer Groman, Federal Preservation Officer, NASA Headquarters and Ralph Allen, Historic Preservation Officer , Marshall Space Flight Center. The field work and measured drawings were prepared under the general direction of Richard O'Connor, Chief, Heritage Documentation Programs, National Park Service. The project was managed by Thomas Behrens, HAER Architect and Project Leader. The Space Transportation System Recording Project consisted architectural delineators, John Wachtel, Iowa State and Joseph Klimek, Illinois Institute of Technology. This documentation is based high-definition laser scans provided by Smart GeoMetrics, Houston, Texas and documentation provided by NASA's Headquarters, Johnson Space Center and Marshall Space Flight Center. Written historical and descriptive data was provided by Archaeological Consultants Inc., Sarasota, Florida. Large-format photographs were produced by NASA's Imaging Lab at Johnson Space Flight Center with supplimental images provided by Jet Lowe, HAER photographer.

VICINITY MAP CANOGA PARK, CA



CALIFORNIA



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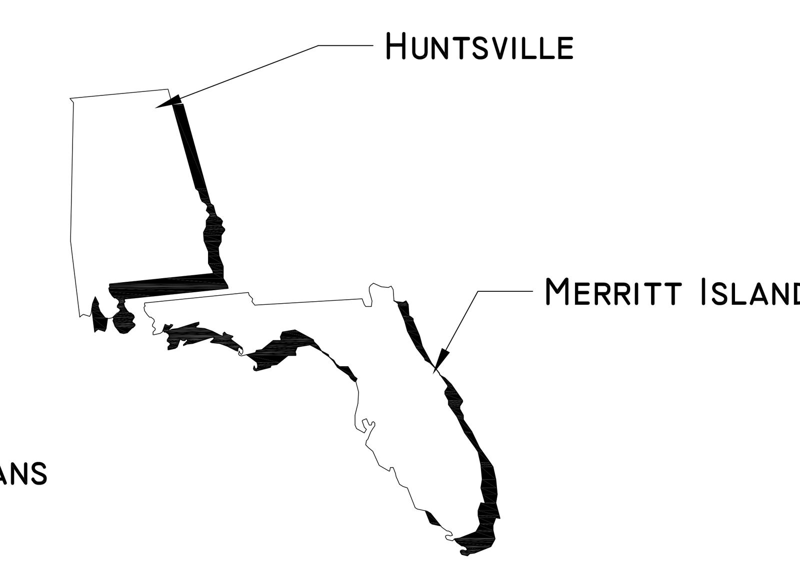

ALABAMA FLORIDA

DRAFT

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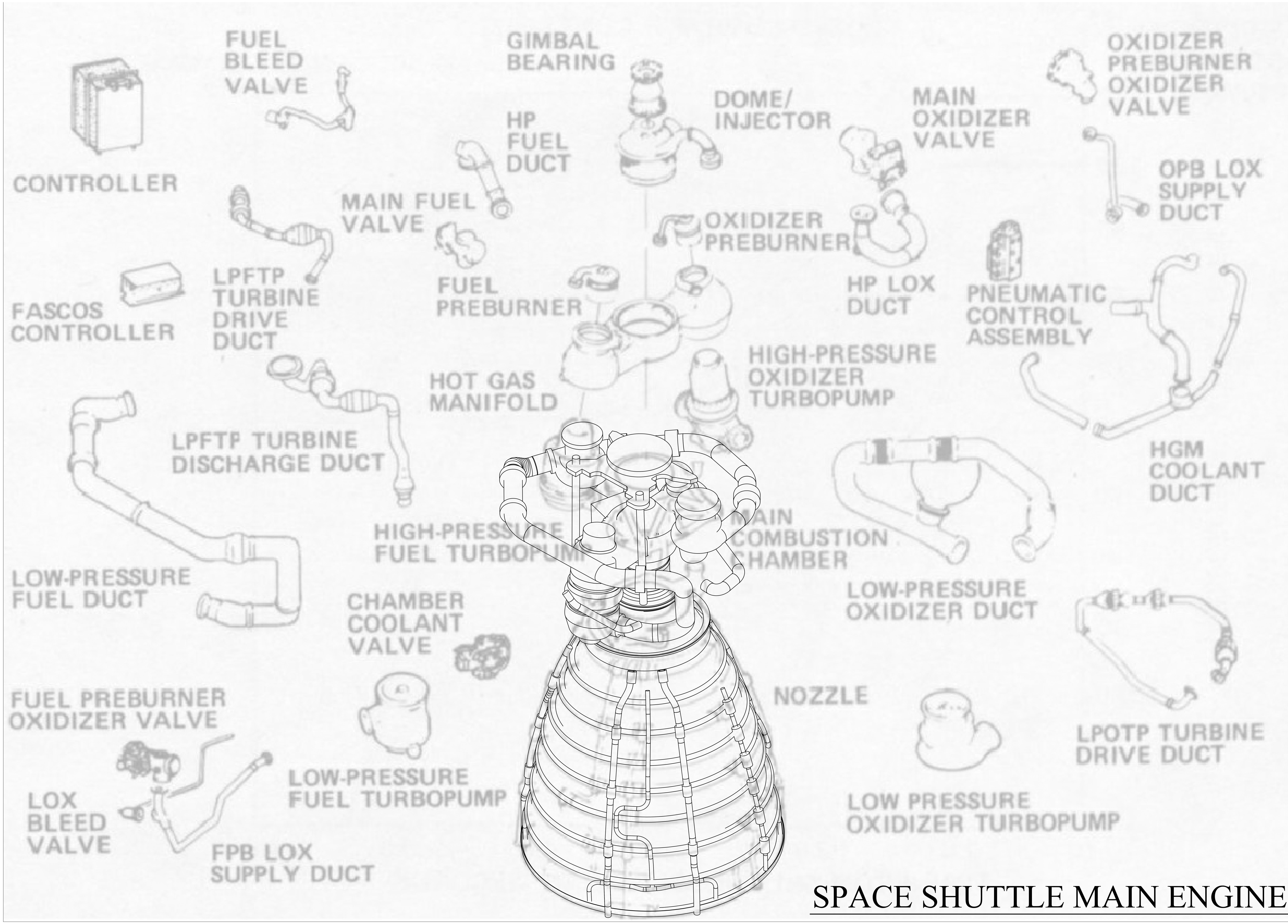

SPACE SHUTTLE MAIN ENGINE

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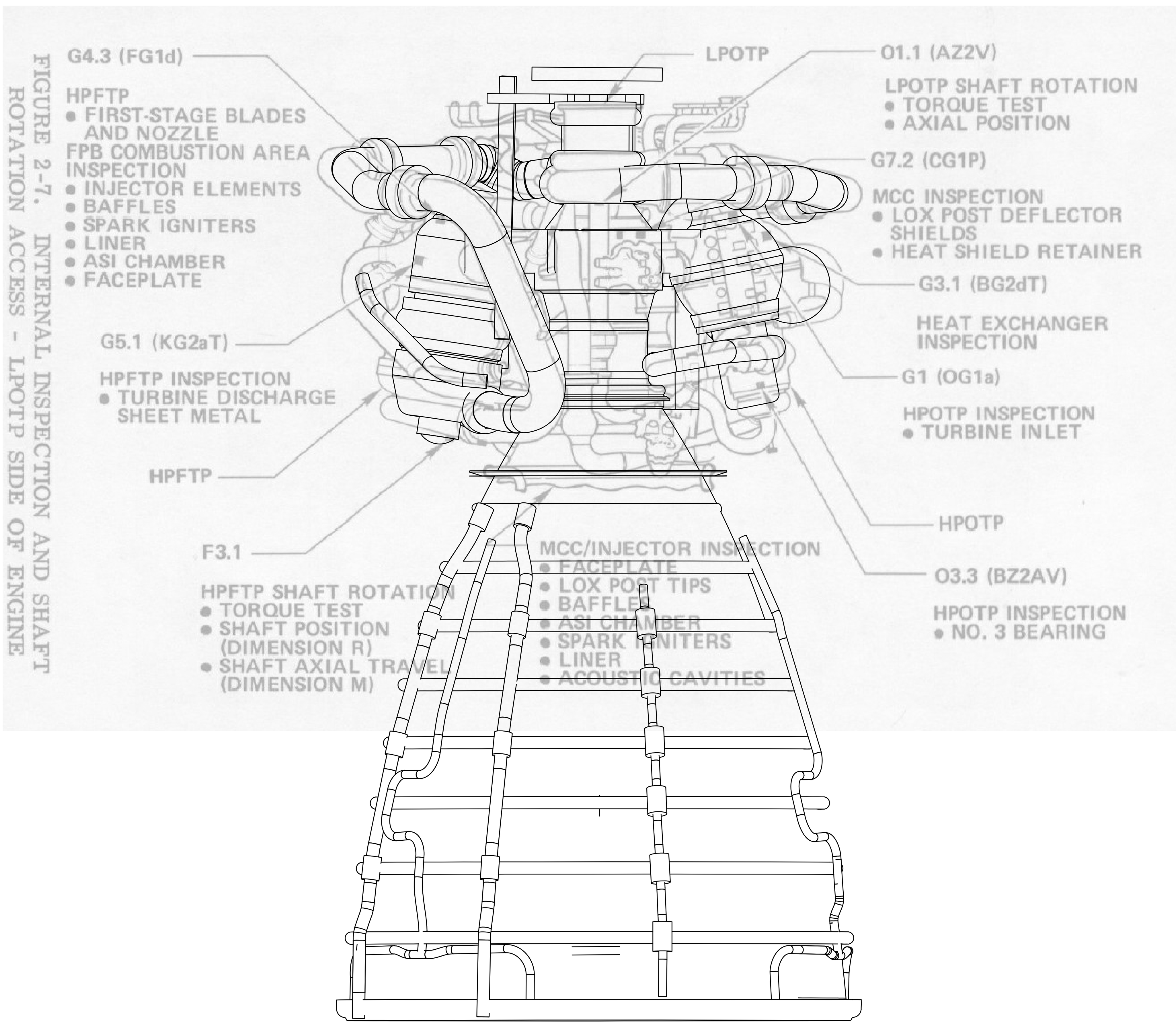

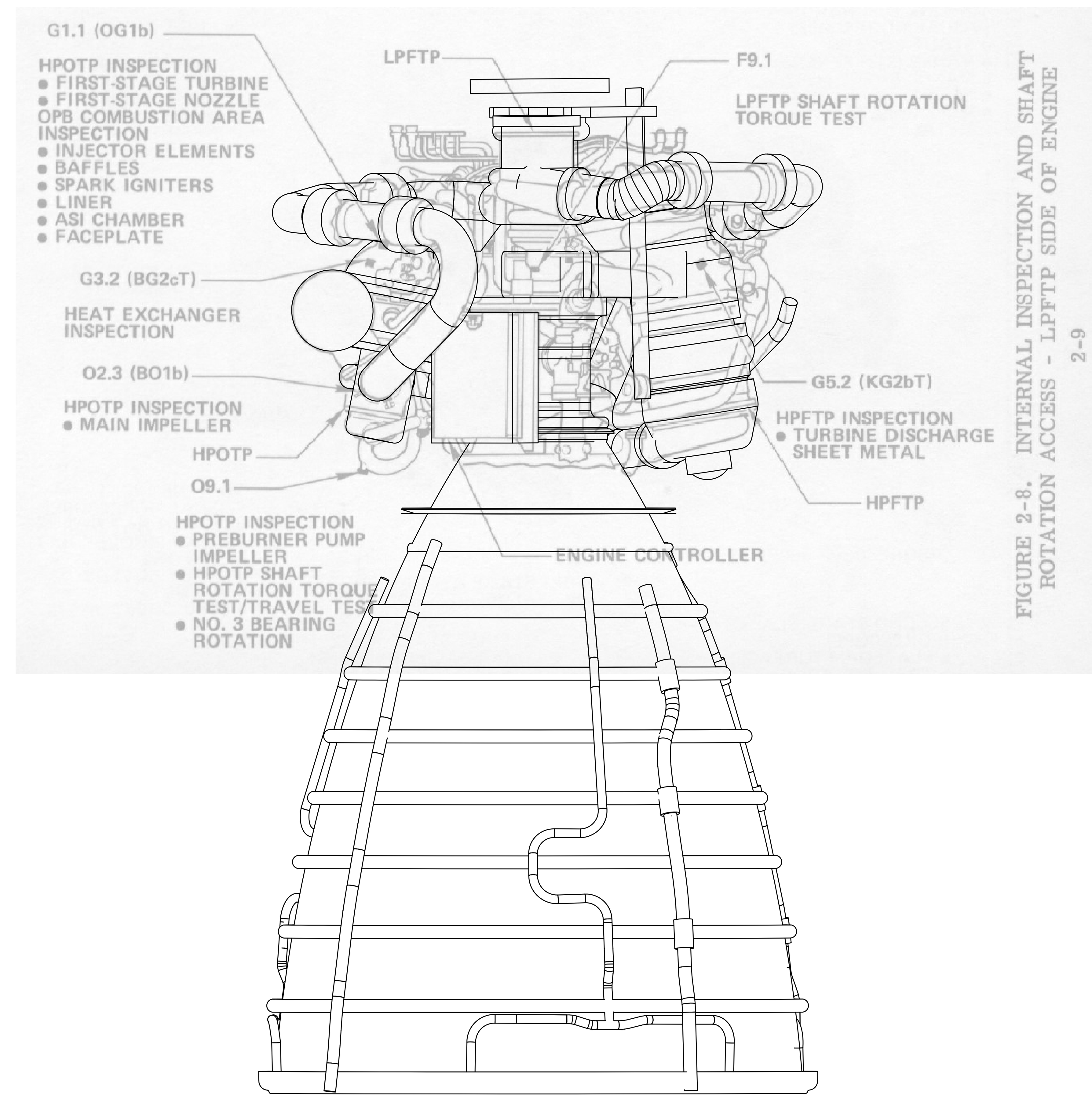

SPACE SHUTTLE MAIN ENGINE

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SPACE TRANSPORTATION SYSTEM, SPACE SHUTTLE MAIN ENGINE
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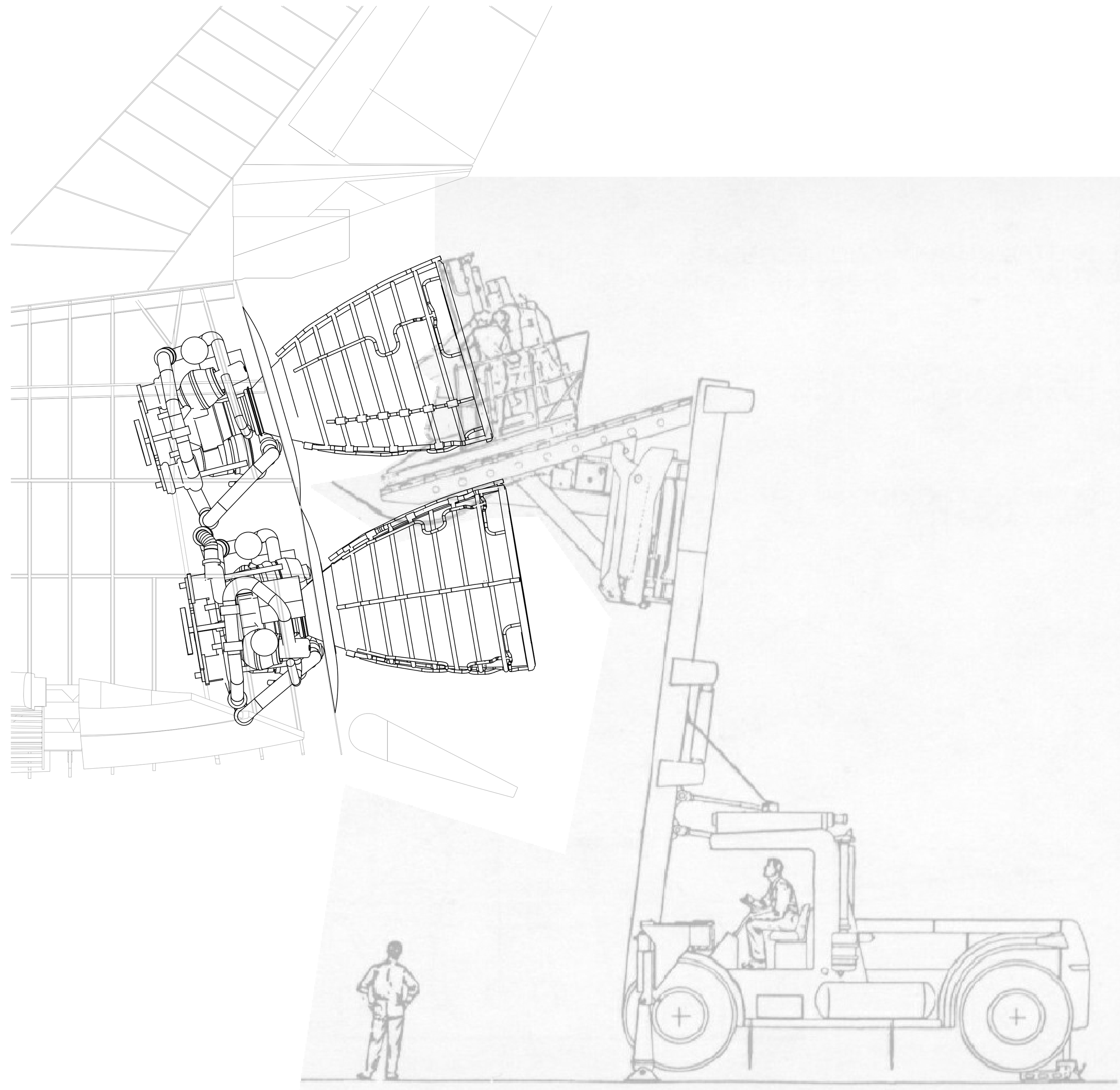

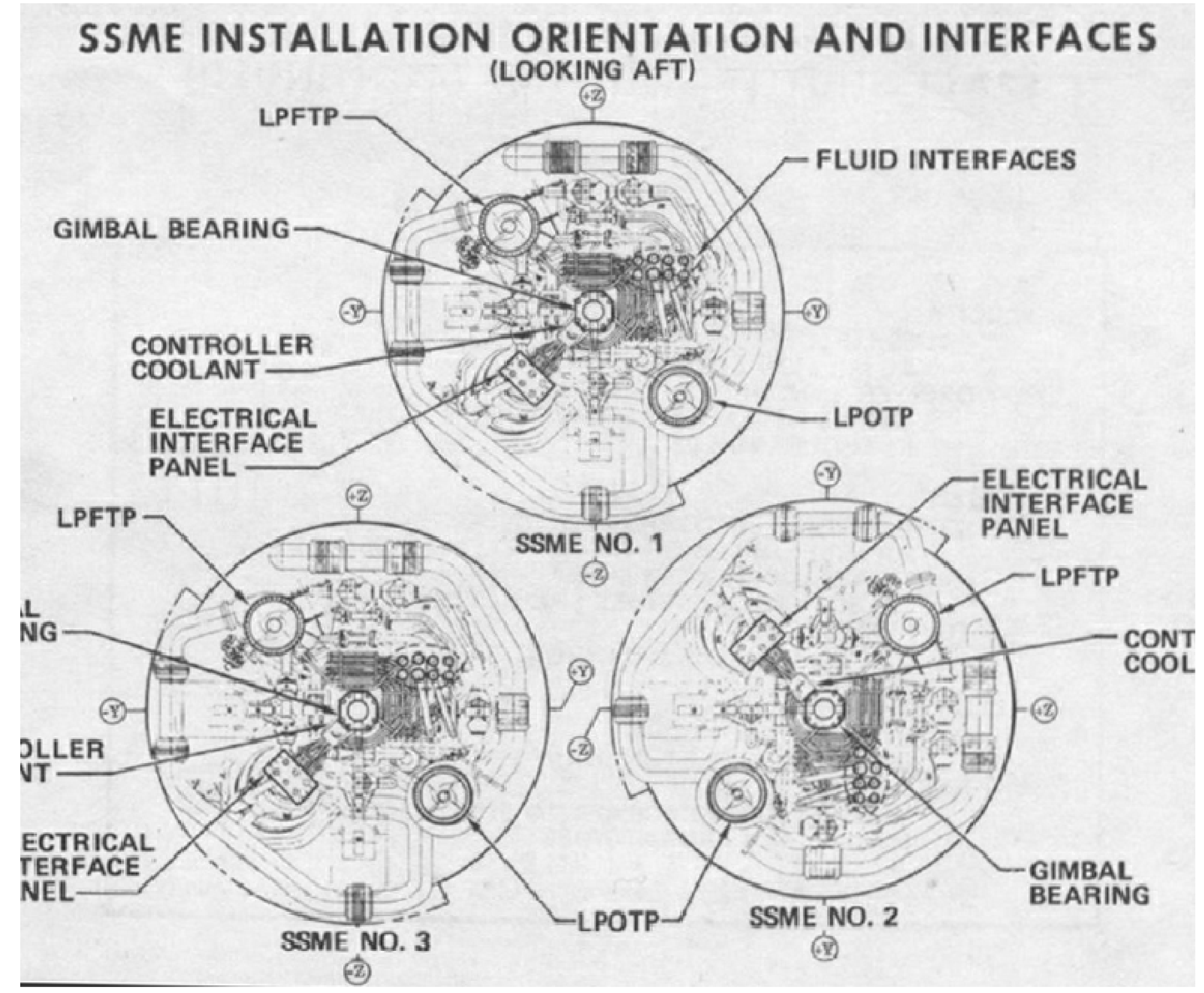

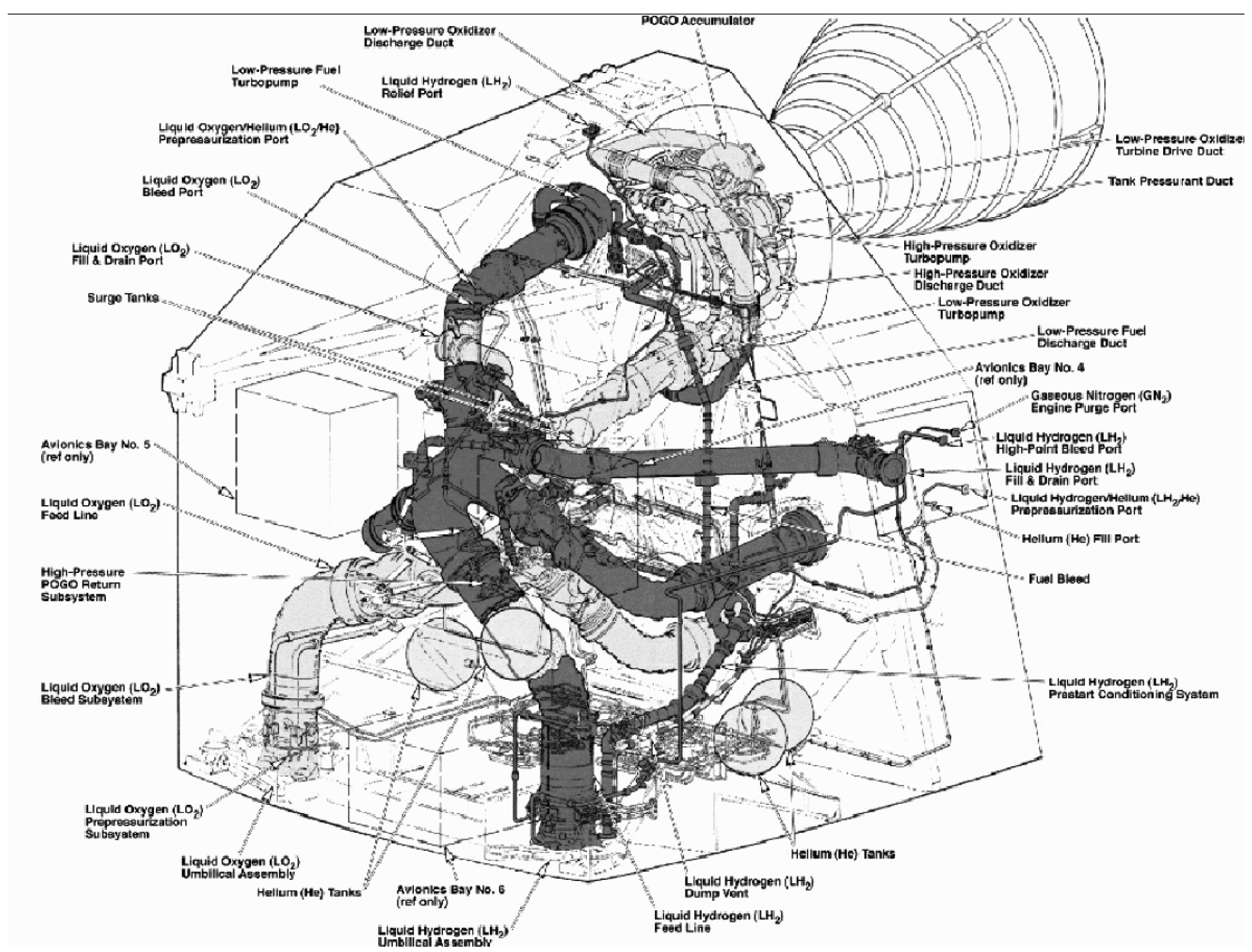

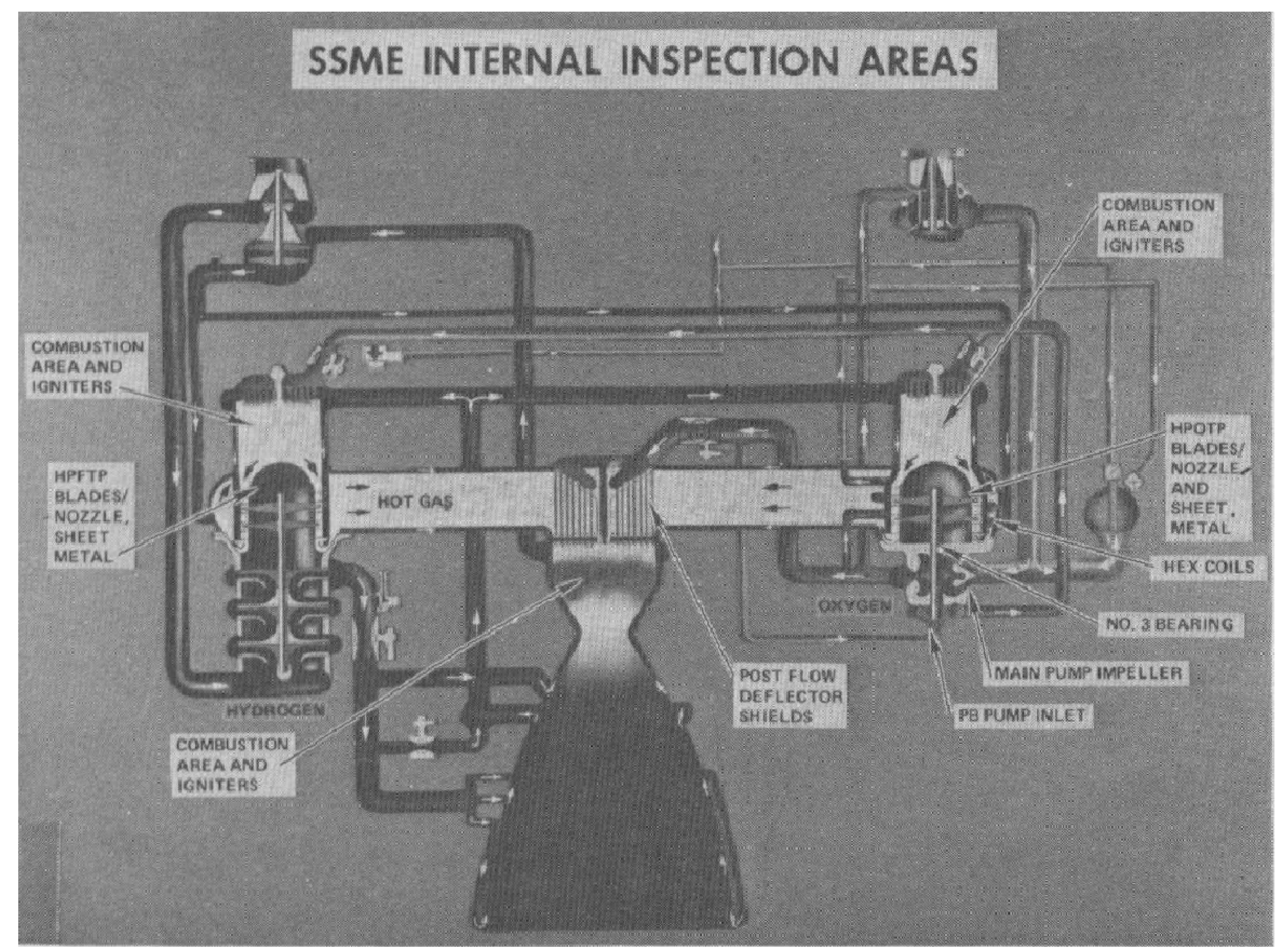

SSME DETAILS AND INSTALLATION

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SPACE TRANSPORTATION SYSTEM, SPACE SHUTTLE MAIN ENGINE
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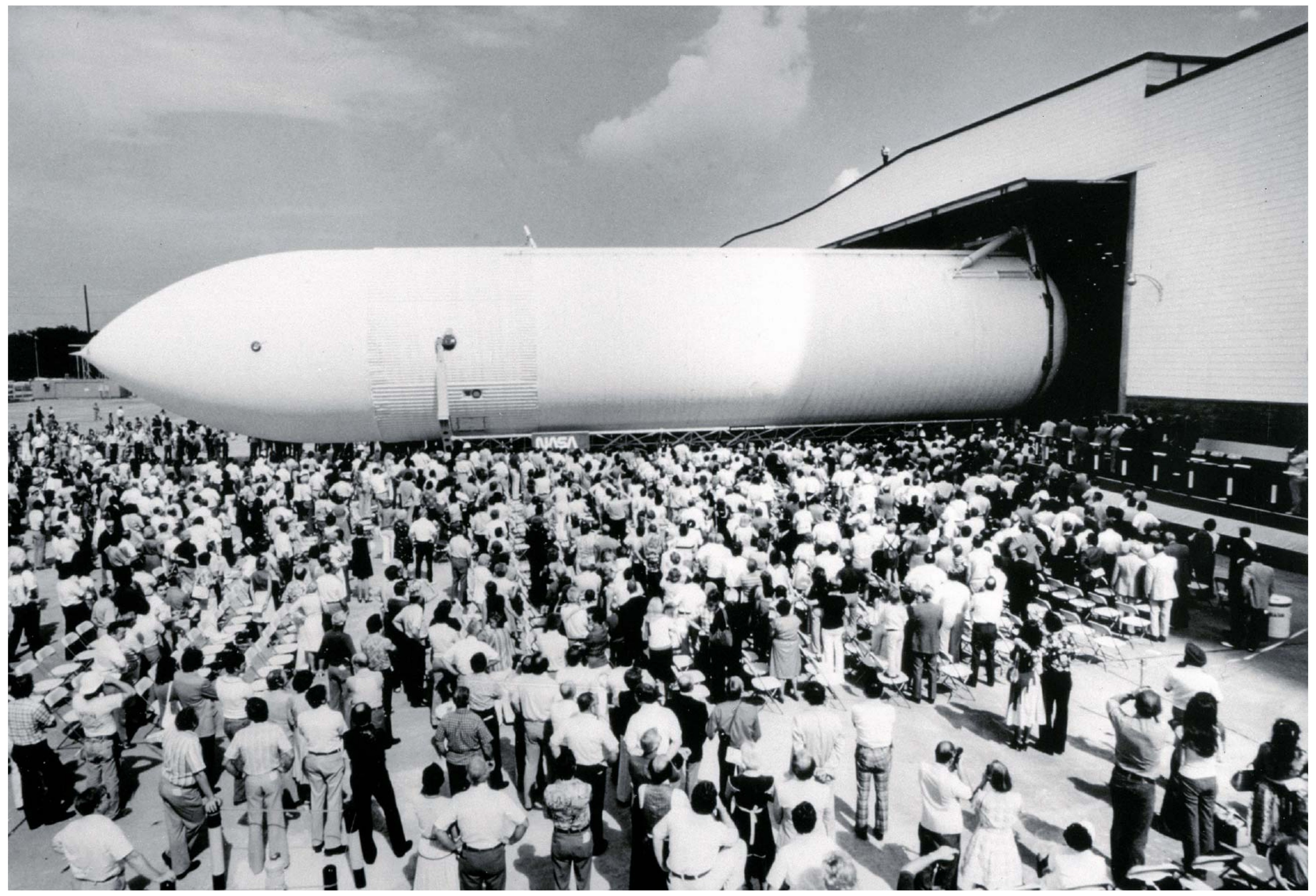
Space Transportation System External Tank



The tanks played two major roles during launch: containing and delivering cryogenic propellants to the Space Shuttle Main Engines, and serving as the structural backbone for the attachment of the Orbiter and Solid Rocket Boosters. The ET's Thermal Protection System, composed of spray-on foam and hand-applied insulation and ablator, was applied primarily to the outer surfaces of the tank. It was designed to maintain the quality of the cryogenic propellants, protect the tank structure from ascent heating, prevent the formation of ice (a potential impact debris source), and stabilize tank internal temperature during re-entry into Earth's atmosphere, thus helping to maintain tank structural integrity prior to its breakup within a predicted landing zone.

NASA applied two basic types of Thermal Protection System materials to the ET. One type was a low-density, rigid, closed-cell foam. This foam was sprayed on the majority of the tank's "acreage"—larger areas such as the liquid hydrogen and liquid oxygen tanks as well as the intertank—also referred to as the tank "sidewalls." The other major component was a composite ablator material (a heat shield material designed to burn away) made of silicone resins and cork. NASA oversaw the development of the closed-cell foam to keep propellants at optimum temperature—liquid hydrogen fuel at -253°C (-423°F) and liquid oxygen oxidizer at -182°C (-296°F)—while preventing a buildup of ice on the outside of the tank, even as the tank remained on the launch pad under the hot Florida sun.

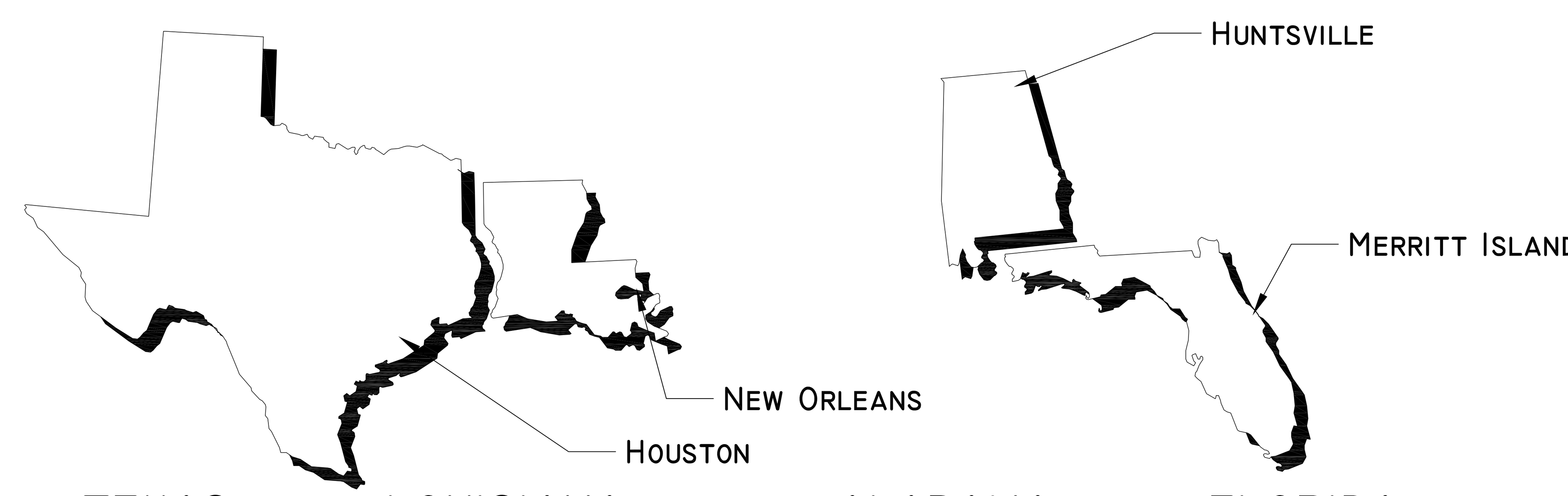
The foam insulation had to be durable enough to endure a 180-day stay at the launch pad, withstand temperatures up to 46°C (115°F) and humidity as high as 100%, and resist sand, salt fog, rain, solar radiation, and even fungus. During launch, the foam had to tolerate temperatures as high as 649°C (1,200°F) generated by aerodynamic friction and rocket exhaust. As the tank reentered the atmosphere approximately 30 minutes after launch, the foam helped hold the tank together as temperatures and internal pressurization worked to break it up, allowing the tank to disintegrate safely over a remote ocean location. Though the foam insulation on the majority of the tank was only about2.5 cm (1 in.) thick, it added approximately 1,700 kg (3,800 pounds) to the tank's weight. Insulation on the liquid hydrogen tank was somewhat thicker—between 3.8 and 5 cm (1.5 to 2 in.). The foam's density varied with the type, but an average density was 38.4 kg/m3 (2.4 pounds/ft3).

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering, industrial, and maritime works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Space Transportation System recording project was cosponsored during 2011 by the Space Shuttle Program Transition and Retirement Office of the Johnson Space Center (JSC), with the guidance and assistance of Barbara Severance, Integration Manager, JSC, Jennifer Groman, Federal Preservation Officer, NASA Headquarters and Ralph Allen, Historic Preservation Officer , Marshall Space Flight Center. The field work and measured drawings were prepared under the general direction of Richard O'Connor, Chief, Heritage Documentation Programs, National Park Service. The project was managed by Thomas Behrens, HAER Architect and Project Leader. The Space Transportation System Recording Project consisted architectural delineators, John Wachtel, Iowa State and Joseph Klimek, Illinois Institute of Technology. This documentation is based high-definition laser scans provided by Smart GeoMetrics, Houston, Texas and documentation provided by NASA's Headquarters, Johnson Space Center and Marshall Space Flight Center. Written historical and descriptive data was provided by Archaeological Consultants Inc., Sarasota, Florida. Large-format photographs were produced by NASA's Imaging Lab at Johnson Space Flight Center with supplimental images provided by Jet Lowe, HAER photographer.

THIS TEXT IS A SAMPLE TEXT, IT WAS COPIED VERBATIM FROM "WINGS IN ORBIT" AS A PLACE HOLDER!

The ET was 46.8 m (153.6 ft) in length with a diameter of 8.4 m (27.6 ft), which made it the largest component of the shuttle. The ET contained two internal tanks—one for the storage of liquid hydrogen and the other for the storage of liquid oxygen. The hydrogen tank, which was the bigger of the two internal tanks, held 102,737 kg (226,497 pounds) of hydrogen. The oxygen tank, located at the top of the ET, held 619,160 kg (1,365,010 pounds) of oxygen. Both tanks provided the fuel to the main engines required to provide the thrust for the vehicle to achieve a safe orbit. During powered flight and ascent to orbit, the ET provided about 180,000 L/min (47,000 gal/min) of hydrogen and about 67,000 L/min (18,000 gal/min) of oxygen to all three Space Shuttle Main Engines with a 6-to-1 mixture ratio of liquid hydrogen to liquid oxygen.

VICINITY MAP NEW ORLEANS, LA



TEXAS LOUISIANA ALABAMA FLORIDA

LIBRARY OF CONGRESS INDEX NUMBER

HISTORIC AMERICAN ENGINEERING RECORD TX-116-J

SHEET 1 OF X

SPACE TRANSPORTATION SYSTEM, EXTERNAL TANK
JOHNSON SPACE CENTER, 2101 NASA PARKWAY
HOUSTON HARRIS COUNTY TEXAS

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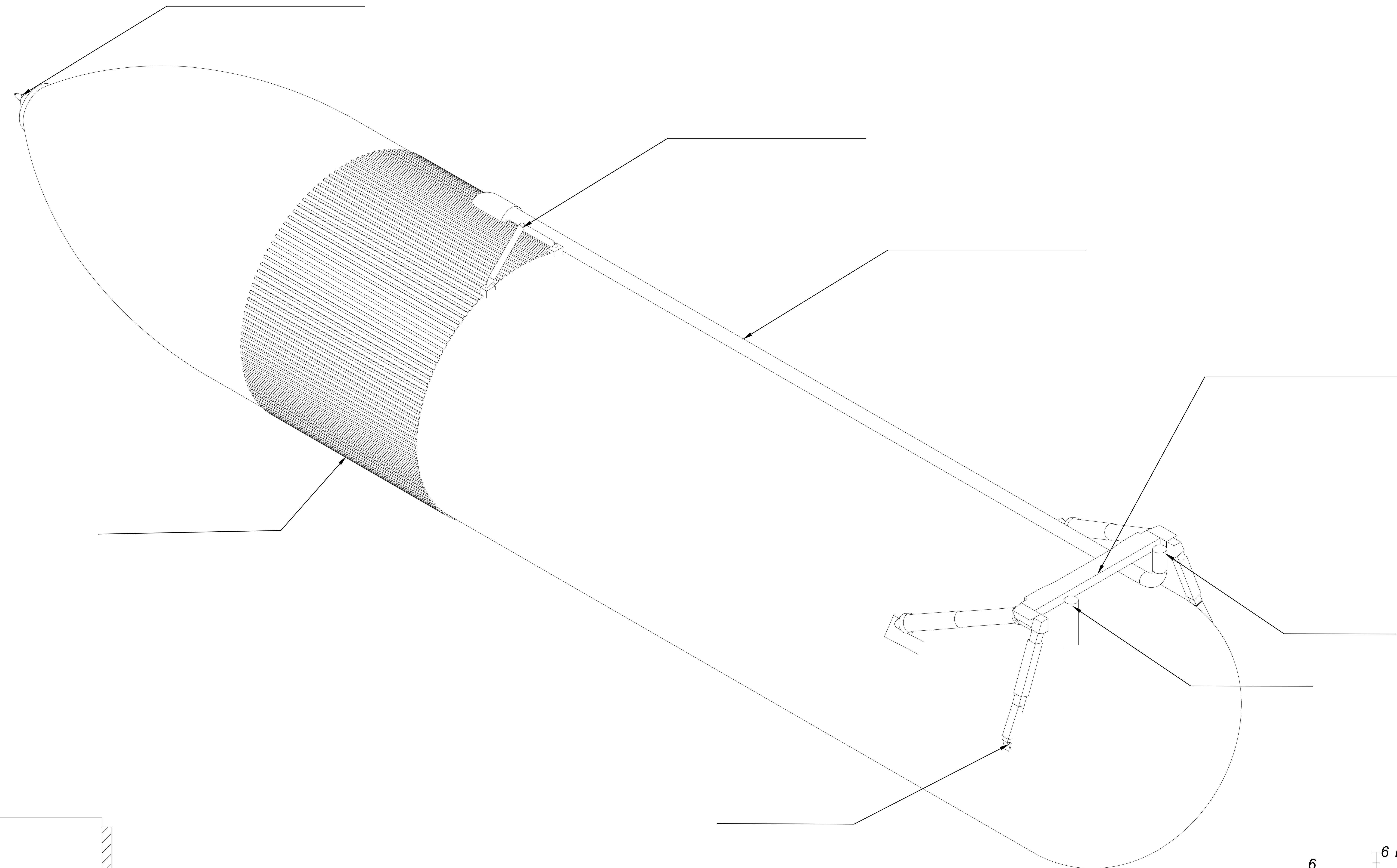
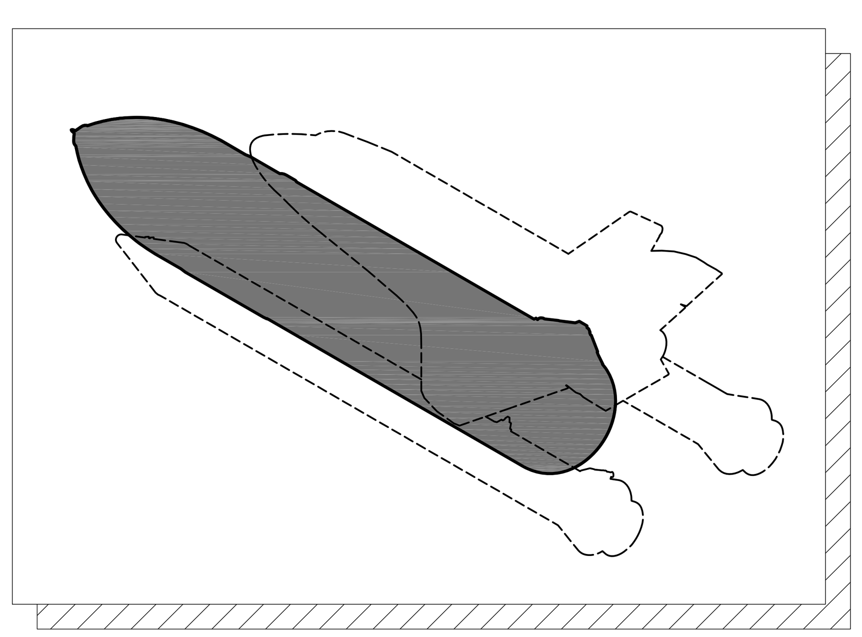
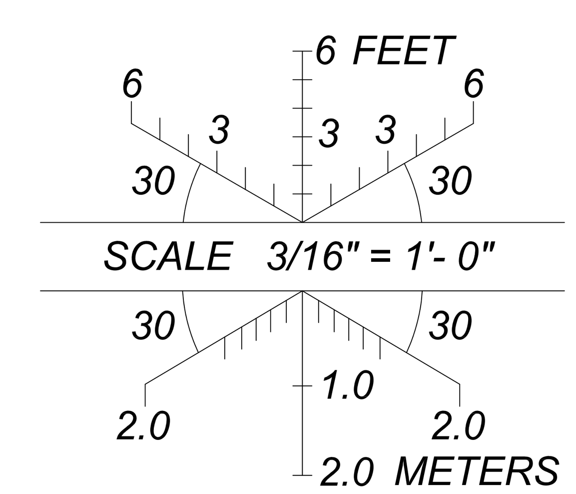
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR







EXTERNAL TANK

HISTORIC AMERICAN ENGINEERING RECORD
TX-116-J

SHEET 02 OF X

SPACE TRANSPORTATION SYSTEM, EXTERNAL TANK
JOHNSON SPACE CENTER, 2101 NASA PARKWAY
HOUSTON, HARRIS COUNTY, TEXAS

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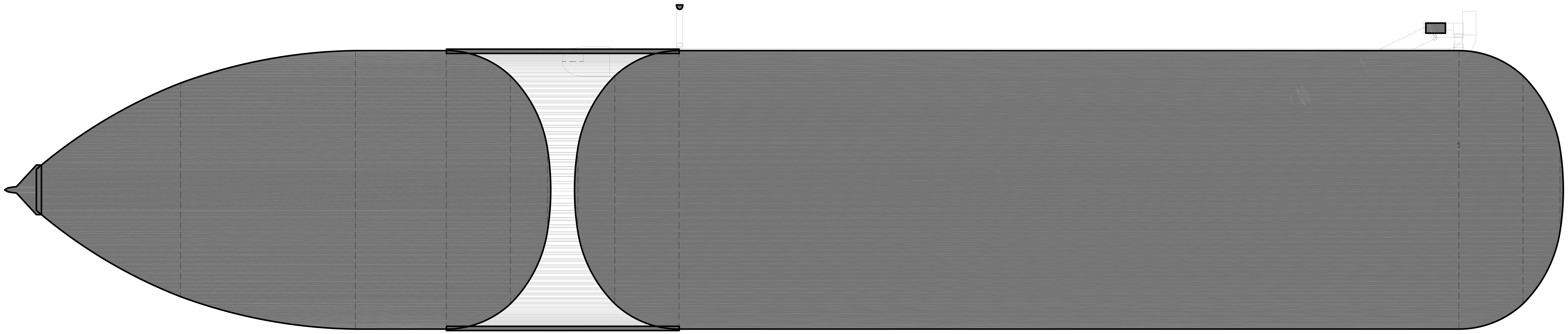
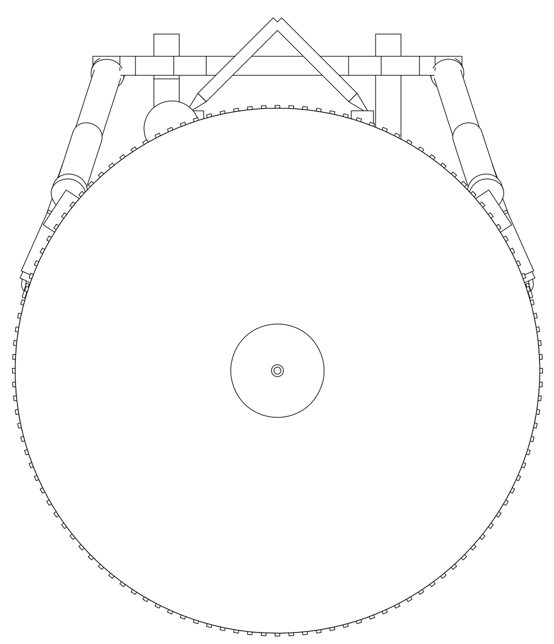
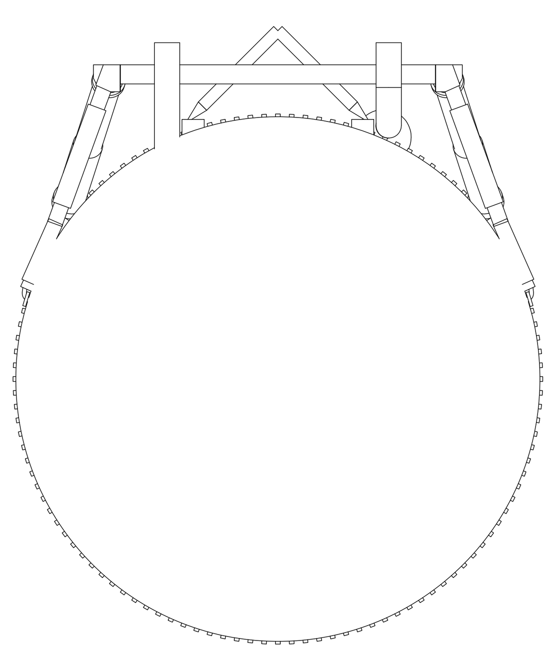


LONGITUDINAL SECTION

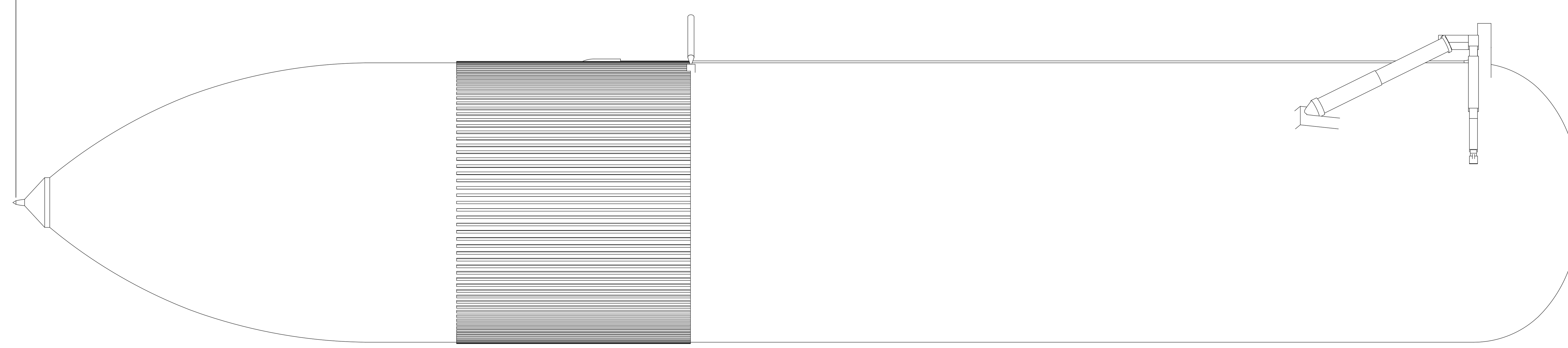
SCALE: 3/16" = 1'-0" 0 5 10 20 FEET / 0 1 2 3 4 5 METERS





PLACEHOLDER
TEXT BOX

154'-3 3/8" [47.03m.]



SCALE: 1/8" = 1'-0" 0 5 10 20 FEET / 0 1 2 4 METERS

EXTERNAL TANK

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SPACE TRANSPORTATION SYSTEM, EXTERNAL TANK
JOHNSON SPACE CENTER, 2101 NASA PARKWAY
HOUSTON HARRIS COUNTY TEXAS

SHEET 03 OF X

HISTORIC AMERICAN ENGINEERING RECORD
TX-116-J

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Space Transportation System
Solid Rocket Boosters

THIS TEXT IS A SAMPLE TEXT, IT WAS COPIED VERBATIM FROM "WINGS IN ORBIT" AS A PLACE HOLDER!

The Space Shuttle reusable solid rocket motors were the largest solid rockets ever used, the first reusable solid rockets, and the only solids ever certified for crewed spaceflight. In a class of its own, the Reusable Solid Rocket Motor Program was characterized from its inception by four distinguishing traits: hardware reusability, postflight recovery and analysis, a robust ground-test program, and a culture of continual improvement via process control.

The challenge NASA faced in developing the first human-rated solid rocket motor was to engineer a pair of solid-fueled rocket motors capable of meeting the rigorous reliability requirements associated with human spaceflight. The rocket motors would have to be powerful enough to boost the shuttle system into orbit. The motors would also need to be robust enough to meet stringent reliability requirements and survive the additional rigors of re-entry into Earth's atmosphere and subsequent splashdown, all while being reusable. The prime contractor— Morton Thiokol, Utah—completed its first full-scale demonstration test within 3 years.

To construct the reusable solid rocket motor, four cylindrical steel segments— insulated and loaded with a high-performance solid propellant—were joined together to form what was essentially a huge pressure vessel and combustion chamber.

The segmented design provided maximum flexibility in motor fabrication, transportation, and handling. Each segment measured 3.7 m (12 ft) in diameter and was forged from D6AC steel measuring approximately 1.27 cm (0.5 in.) in thickness.

Case integrity and strength were maintained during flight by insulating the case interior. The insulating liner was a fiber-filled elastomeric (rubber-like) material applied to the interior of the steel cylinders. A carefully formulated tacky rubber bonding layer—or "liner"—was applied to the rubber insulator surface to facilitate a strong bond with the propellant.

The propellant was formulated from three major ingredients: aluminum powder (fuel); ammonium perchlorate (oxidizer); and a synthetic polymer binding agent. The ingredients were batched, fed into large 2,600-L (600-gal) mix bowls, mixed, and tested before being poured into the insulated and lined segments. Forty batches were produced to fill each case segment. The propellant mixture had an initial consistency similar to that of peanut butter, but was cured to a texture and color that resembled a rubber pencil eraser—strong, yet pliable. The propellant configuration or "shape" inside each segment was carefully designed and cast to yield the precise thrust trace upon ignition.

Once each segment was insulated and cast with propellant and finalized, the segments were shipped from ATK's manufacturing facility in Utah to Kennedy Space Center (KSC) in Florida, on specially designed, heavy-duty covered rail cars. At KSC, they were stacked and assembled into the flight configuration.

This recording project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering, industrial, and maritime works in the United States. The HAER program is administered by the National Park Service, U.S. Department of the Interior. The Space Transportation System recording project was cosponsored during 2011 by the Space Shuttle Program Transition and Retirement Office of the Johnson Space Center (JSC), with the guidance and assistance of Barbara Severance, Integration Manager, JSC, Jennifer Groman, Federal Preservation Officer, NASA Headquarters and Ralph Allen, Historic Preservation Officer , Marshall Space Flight Center. The field work and measured drawings were prepared under the general direction of Richard O'Connor, Chief, Heritage Documentation Programs, National Park Service. The project was managed by Thomas Behrens, HAER Architect and Project Leader. The Space Transportation System Recording Project consisted architectural delineators, John Wachtel, Iowa State and Joseph Klimek, Illinois Institute of Technology. This documentation is based high-definition laser scans provided by Smart GeoMetrics, Houston, Texas and documentation provided by NASA's Headquarters, Johnson Space Center and Marshall Space Flight Center. Written historical and descriptive data was provided by Archaeological Consultants Inc., Sarasota, Florida. Large-format photographs were produced by NASA's Imaging Lab at Johnson Space Flight Center with supplimental images provided by Jet Lowe, HAER photographer.

VICINITY MAP CLEARFIELD, UTAH

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HISTORIC AMERICAN ENGINEERING RECORD
TX-116-K

SHEET 1 OF X

SPACE TRANSPORTATION SYSTEM, SOLID ROCKET BOOSTERS
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HOUSTON HARRIS COUNTY TEXAS

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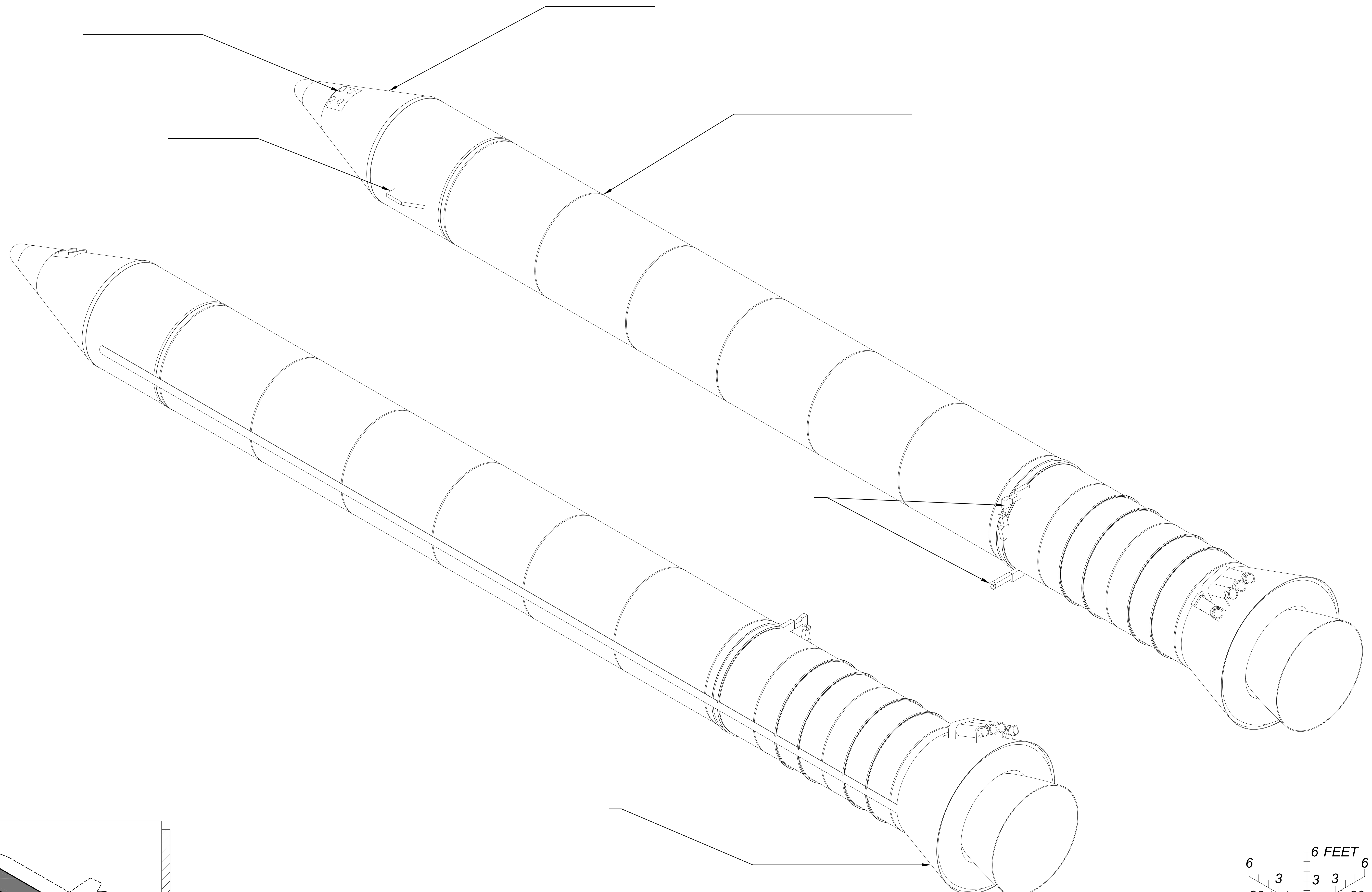
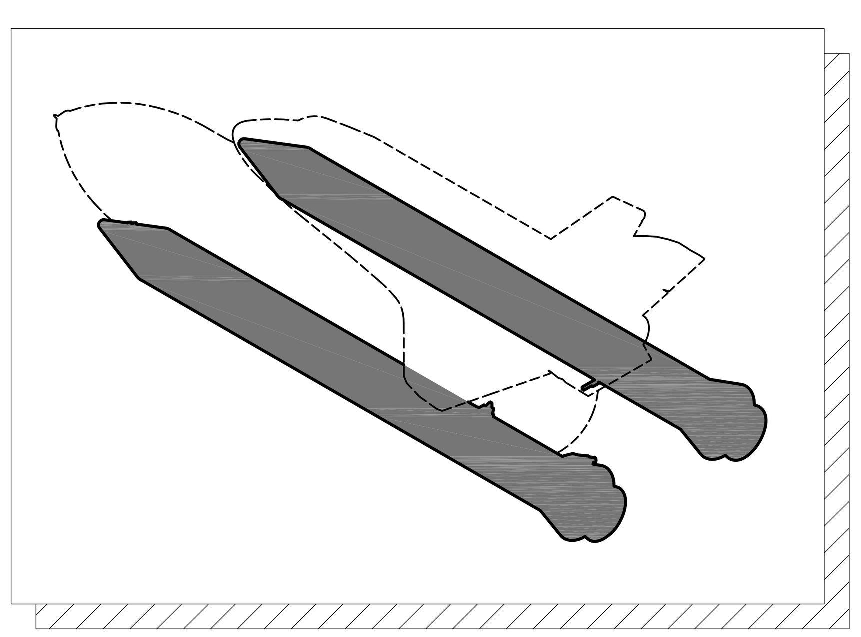
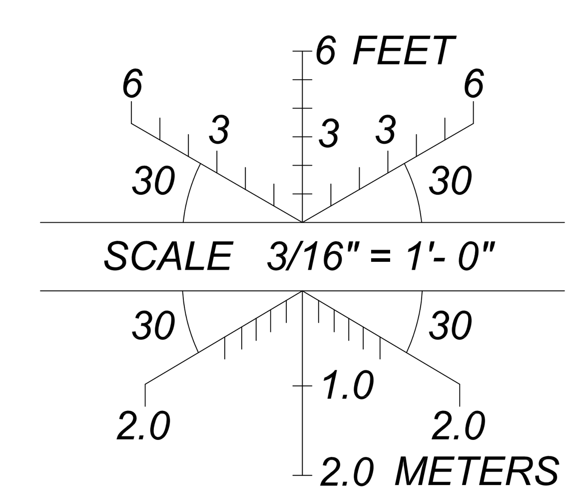
UNITED STATES DEPARTMENT OF THE INTERIOR







SOLID ROCKET BOOSTERS

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SPACE TRANSPORTATION SYSTEM, SOLID ROCKET BOOSTERS
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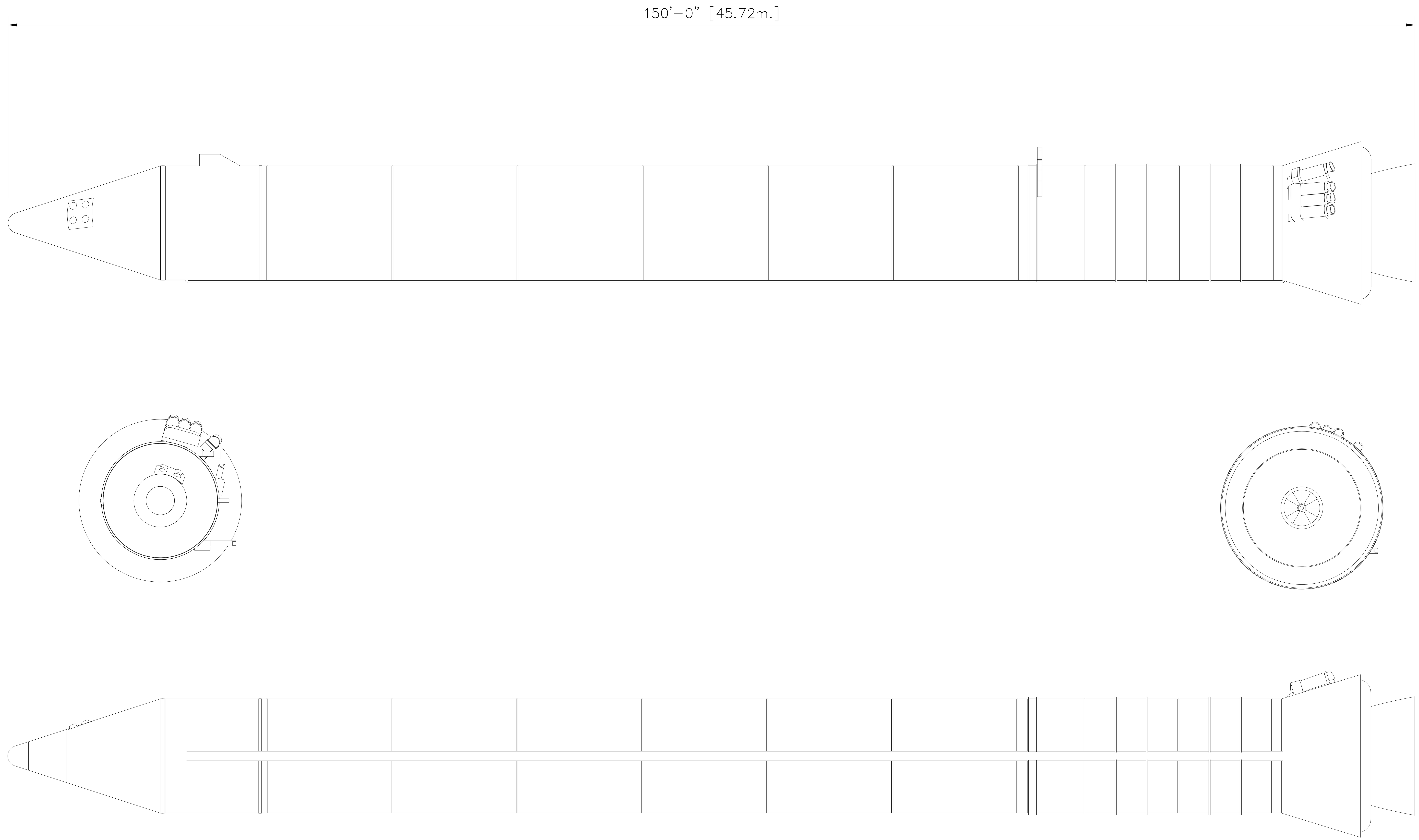

SOLID ROCKET BOOSTERS

SCALE: 3/16" = 1'-0"
0 5 10 20 FEET
0 1 2 3 4 5 METERS

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SPACE TRANSPORTATION SYSTEM, SOLID ROCKET BOOSTERS
JOHNSON SPACE CENTER, 2101 NASA PARKWAY
HOUSTON HARRIS COUNTY TEXAS

SHEET 03 OF X

HISTORIC AMERICAN ENGINEERING RECORD
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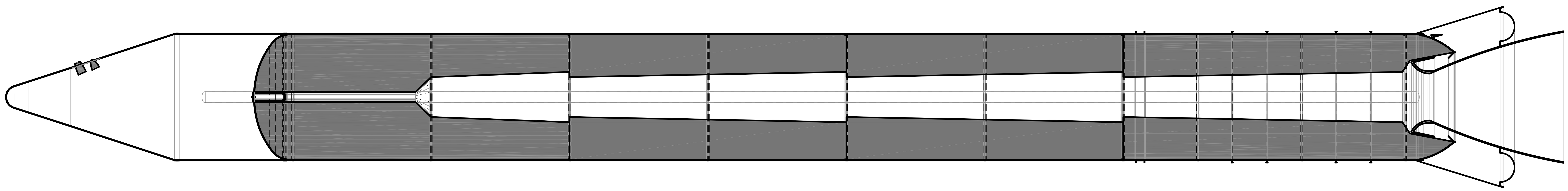
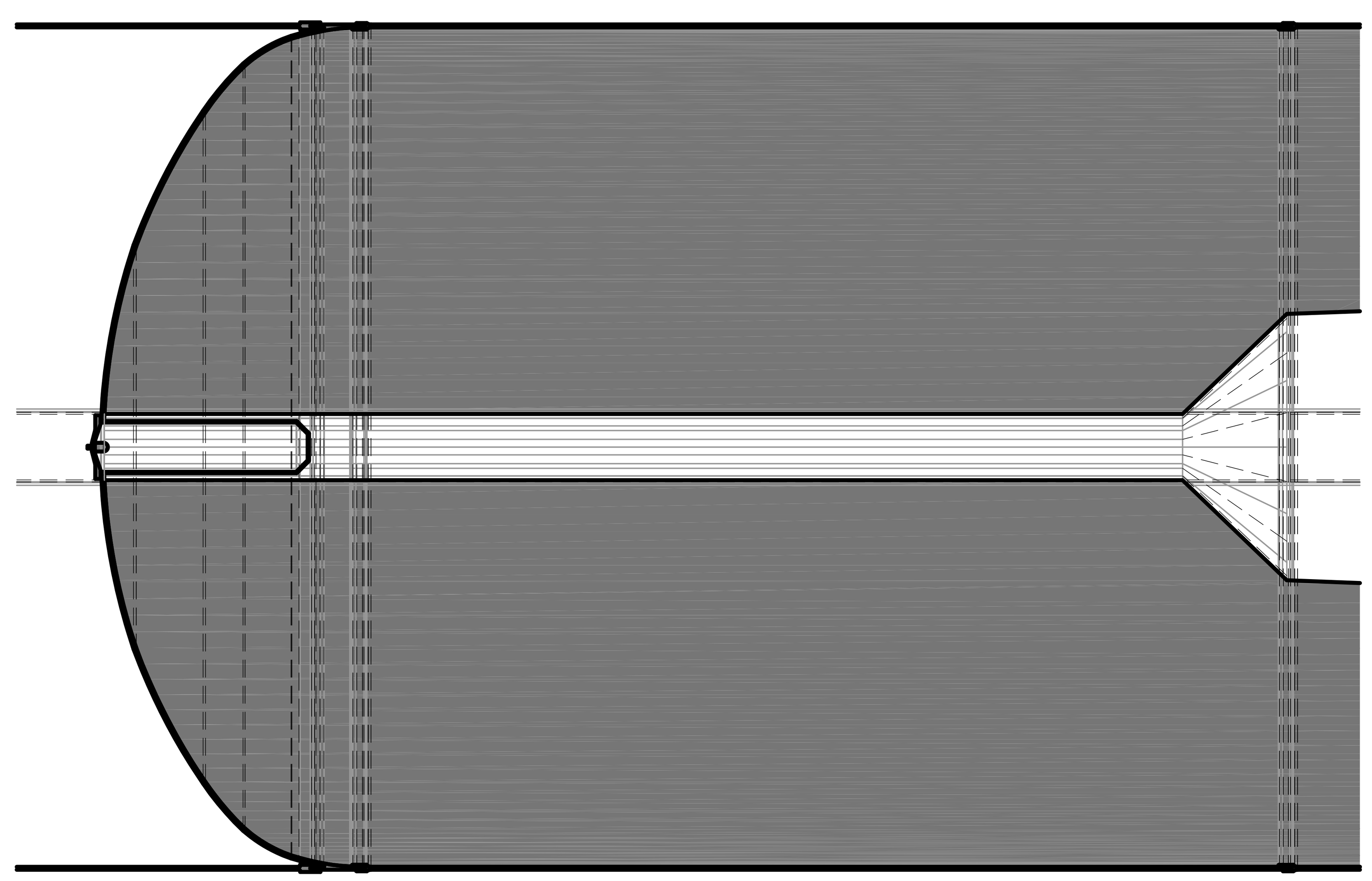


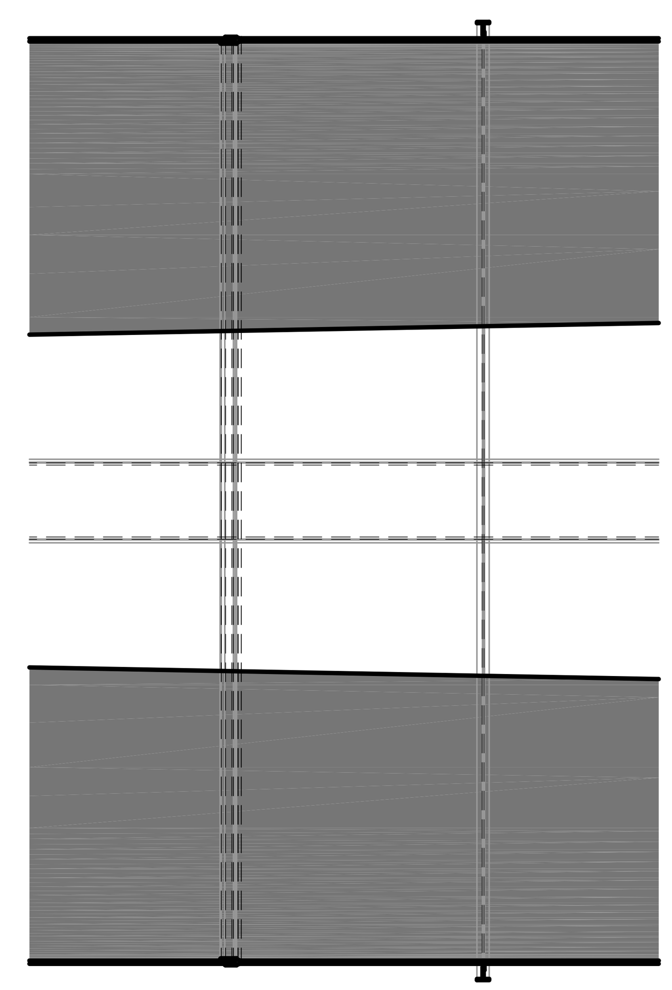
LONGITUDINAL SECTION

SCALE: 3/16" = 1'-0" 0 5 10 20 FEET / 0 1 2 3 4 5 METERS

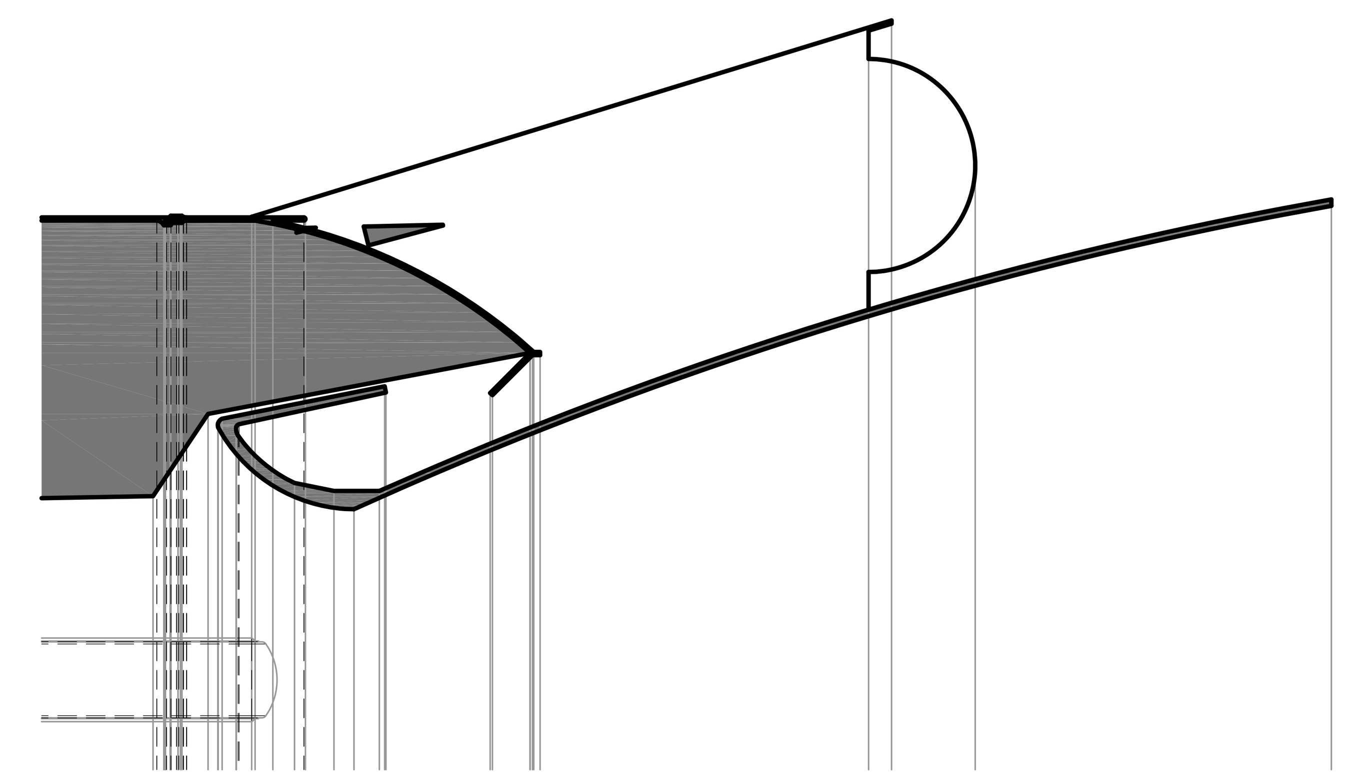


IGNITER DETAIL SECTION

SCALE: 1/2" = 1'-0" 0 1 2 3 4 5 FEET / 0 50 100 150 CENTIMETERS



O RING DETAIL SECTION



NOZZLE DETAIL SECTION

SCALE: 1/2" = 1'-0" 0 1 2 3 4 5 FEET / 0 50 100 150 CENTIMETERS

PLACEHOLDER TEXT BOX

SOLID ROCKET BOOSTERS

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