DOD SPACE SHUTTLE OPERATIONS

AT VANDENBERG AIR FORCE BASE

LAUNCH AND LANDING SITE

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ABSTRACT

This paper discusses the rationale for the existence at Vandenberg Air Force Base, CA of a launch and landing site for the NASA-developed Space Shuttle Vehicle (SSV), and outlines the operational flow for which the USAF Space Division is responsible. An overview of Space Shuttle Vehicle processing at Vandenberg Air Force Base Launch and Landing Site is presented.

SUMMARY

Our adventures in space, both those of the U.S. Air Force and NASA, will rely on the Space Transportation System (STS) for the next several decades. The immensity and complexity of this program challenges every facet of engineering and management.

Space Shuttle operations will be located at both the east coast and the west coast of the United States to provide orbital inclinations and corresponding launch azimuths required for projected payload requirements.

Kennedy Space Center FL STS operations began with the first launch of a Space Shuttle on 12 April 1981. Vandenberg Launch and Landing Site STS operations will begin with its initial launch capability of a Space Shuttle on 15 October 1985 with initial operational capability scheduled for February 1987.

The Vandenberg Launch and Landing Site (VLS) is an integral part of the national STS capability. Much of the VLS hardware, software, and procedures are NASA common, but there are some unique design, integration, activation and operational requirements at VLS, which are detailed below.

Due to a reduction in the projected VLS launch rate, and in order to maximize cost effectiveness, KSC processing capabilities will support early year VLS mission requirements.

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INTRODUCTION

Space Shuttle flights will be launched from two locations: Kennedy Space Center, Florida and Vandenberg Air Force Base, California Launch and Landing Sites. These sites were selected based upon both NASA and DOD needs for projected payloads and requirements for no land mass overflight during the boost phase of the Space Shuttle launch. Vandenberg Air Force Base (VAFB), CA was selected as the Western Launch and Landing Site for the NASA developed Space Shuttle Vehicle in order to obtain the most desirable combination of launch azimuths and planned orbital inclinations (Figure 1). Launches from Vandenberg Launch and Landing Site (VLS) will support both NASA and DOD missions, with classified or non-classified payloads, launched between azimuths of 158^{o} and 208^{o}. This launch capability is intended to accommodate polar and near polar orbital missions. The VLS will provide an initial launch capability of four launches per year and up to ten evenly spaced launches per year during full operational capability.

The VLS reference mission, to be used for development criteria, is a payload delivery and retrieval mission, consisting of a delivery mission of a modular spacecraft weighing 14,515 kg (32,000 lb) in a 278 km (150 nmi) circular orbit at 98^{o} inclination, and a retrieval of a passively cooperative, stabilized spacecraft weighing 10,205 kg (22,500 lb) from a similar coplanar orbit and returned to Vandenberg. The mission length, including contingencies, will be seven days. The allowable spacecraft dynamic envelope is 4.6 m (15 ft) diameter by 18.3 m (60 ft) long.

The USAF Space Division is responsible for acquisition, activation and operation of the DOD ground support systems for the STS at VAFB and nearby Port Hueneme, which will be used to recover the expended Solid Rocket Boosters. In keeping with the STS implementation philosophy, maximum practical use of existing VAFB facilities and NASA-developed ground support equipment and software is emphasized. Checkout and operations of the vehicle at the launch pad will essentially be the same as those at Kennedy Space Center, with any differences attributed to mission or geographic constraints.

Current STS launch planning calls for Kennedy Space Center to perform Orbiter processing for the first three VLS launches, and solid rocket booster processing and parachute refurbishment for all VLS launches. VLS facilities have been optimized to utilize resources at other locations such as NASA/KSC for the early missions. It is planned that full launch and landing capabilities will be available when mission requirements for capability beyond four launches per year is necessary.

The Space Shuttle Vehicle (SSV) consists of four major elements: a reusable manned Orbiter, three main engines, an expendable External Tank (ET), and two reusable Solid Rocket Boosters (SRBs). The basic Space Shuttle Vehicle characteristics are as in Figure 2.

The VLS ground support systems which support the Space Shuttle operations are divided into discrete geographical and functional Station Sets (Figure 3). Each geographical Station Set includes the aggregate of facilities, support equipment, operating and maintenance procedures and personnel required to perform all specified activities within each station set, such as Runway, Launch Pad, etc. The functional Station Sets include a totally functional element design procured as a system and then installed at appropriate locations, for example, Communications, Vandenberg Launch Processing System, Utilities, Logis- tics, etc. All required facilities, support equipment, computers, software, personnel, and procedures included within geographical and functional Station Sets are allocated in accordance with their respective Station Set Specifications. All ground Computer Application Programs are allocated to the test sequence software system in accordance with its system specification.

Space Shuttle operations flows at VAFB are depicted in Figure 4, and detailed below in roughly chronological order.

NORTH VANDENBERG OPERATIONS

Mate/Demate Facility. When the Orbiter arrives on a modified Boeing 747 Shuttle Carrier Aircraft (SCA), it will be towed to the Mate/Demate Facility and the Orbiter removed from atop the SCA by use of an Orbiter Lifting Frame (OLF). The OLF was designed and developed uniquely for VLS and performs the same functions as the KSC Mate Demate Device. Subsequent to removal from the SCA, the landing gear is extended and the Orbiter lowered to the concrete ramp and then towed via the towroute to the Orbiter Maintenance and Checkout Facility.

Landing Facility. The Orbiter will arrive at the runway at North Vandenberg Air Force Base (NVAFB) either on SCA or returning from orbit. The landing facility consists of a 200 foot wide by 15,000 foot-long concrete runway with a high-intensity approach lighting system and edge threshold. Both Tactical Air Navigational and a Microwave Scanning Beam Landing System transmits accurate directional and glide slope information to the Orbiter during the landing phase. As soon as an Orbiter lands and rolls to a stop, all necessary post-landing equipment is positioned around the vehicle to safe, secure, and supply the required purges, cooling, and electrical power preparatory to flight crew egress and subsequent towing to the Orbiter Maintenance and Checkout Facility (Figure 5).

Orbiter Maintenance and Checkout Facility. As a result of an optimization study, the Orbiter will be processed/checked out by KSC for the first three VLS launches in the KSC Orbiter Processing Facility and ferried to VLS by SCA. This checkout will minimize processing the Orbiter at the VLS Orbiter Maintenance and Checkout Facility (OMCF) (Figure 6).

Upon arrival at the OMCF, the Orbiter will be positioned on jacks and leveled, allowing the necessary positioning relative to the work platform for accessibility to the Orbiter. When fully operational, this facility will perform ordnance safing, main engine purge and drying, venting of high pressure gases, draining of the hypergolic manifolds and cryogenic systems, payload removal as required, and a data dump of on-board computers to ground recorders.

In addition, the hypergolic modules consisting of Orbital Maneuvering Subsystem (OMS), the Forward Reaction Control System (FRCS) and Aft Reaction Control System (ARCS) can be removed, and sent to KSC for processing if required.

Additional operations that are performed at the OMCF include payload removal, complete internal and external Orbiter inspection, checkout of the fluid and electrical systems, repair of thermal protection system tiles, and reinstallation of flight crew equipment and hypergolic modules. The Orbiter payload bay is reconfigured for the next flight by removing provisions from the last flight and installing electrical/mechanical systems including payload retention fittings for the next mission. After inspection, testing, maintenance, and repair is completed, the payload bay doors are closed, access panels and ports closed out, and the Orbiter lowered off its jacks onto a transporter (Figure 7) for towing to South VAFB launch pad, 17 miles distant. Vandenberg's OMCF has a second major work area to conduct payload safing and deservicing which is separated from the Orbiter by a blast wall.

Presently, the only payload planned to be placed in the Orbiter payload bay while the Orbiter is horizontal in this facility will be the European Space Agency Spacelab. All other scheduled civil and military payloads will be placed into the Orbiter while in its vertical position on the launch pad. Also included in the OMCF, but contained within a separate building will be an Orbiter Thermal Protection System (TPS) refurbishment facility. This facility will enable TPS repair and production of any required replacement tiles.

Vandenberg Launch Processing System. The Vandenberg Launch Processing System (VLPS) consists of a network of ground computers, data links, displays, controls, hardware interface devices, and ground computer software to process the Space Shuttle Vehicle from landing through launch (Figure 8). The VLPS is a functional station set and is divided into three subsystems: Checkout, Control and Monitoring System (CCMS), Central Data System (CDS); and Record and Playback System (RPS). Maximum use of existing NASA software, automation, and management information support will be utilized. The VLPS used at VAFB is functionally identical to that at KSC.

One set of VLPS hardware located in Bldg. 8510 is provided to process the Orbiter at NVAFB. Another set of VLPS hardware, located at South VAFB in the Launch Control Center adjacent to the launch pad, will accommodate launch operation functions.

Hypergolic Maintenance and Checkout Facility. The activation of this facility has been deferred as a result of the aforementioned optimization study. All OMS modules/Line Replacement Units (LRU) repair and refurbishment are to be performed at KSC.

Flight Crew Systems Facility. The Flight Crew facility is located at NVAFB where existing buildings are being modified to provide sleeping and medical facilities and flight crew equipment checkout. Also included will be a mission equipment kit building primarily devoted to equipment required to support cargo bay activities on a mission to mission basis.

Logistics Facility. This facility consists of a central supply facility which will house and control all flight and ground support systems component spares and material required to support VLS operations. Also forming a part of this facility is an Orbiter Space Shuttle Main Engine (SSME) shop and an Orbiter brake and tire shop. This facility will also support SSV Line Replacement Unit (LRU) maintenance and checkout, and material management.

SOUTH VANDENBERG OPERATIONS

While the Orbiter is processed at NVAFB, the ET and SRBs are processed at South Vandenberg Air Force Base (SVAFB) facilities.

Launch Control Center. This facility is an existing two-story, concrete blockhouse located approximately 1100 feet from the launch pad. The Launch Control Center houses the VLPS hardware, communication systems, closed circuit television, hazard monitors, payload operations areas, and accommodations for technical support personnel. This station set provides the capability to check out, control and monitor the Space Shuttle Vehicle at the launch pad, and payload operations in the Payload Preparation Room.

External Tank Processing and Storage Facility. The ETs are delivered by NASA barge from Michoud, LA. through the Panama Canal to a modified harbor at South Vandenberg, removed from the barge and towed to the External Tank Checkout Facility (TCF) (Figure 9). The ET consist of two tanks joined together by a collar-like intertank to form one large propellant storage container 47 m (154.2 ft) long and 8.4 m (27.5 ft) in diameter. The forward and aft tanks are for liquid oxygen and liquid hydrogen respectively. It weighs approximately 69,000 lb empty and approximately 1,630,000 lb at launch. Upon ET arrival at the TCF, the range safety receivers and decoders will be installed and checked out. Ordnance will then be installed, and thermal protection closeout initiated. Final ET checkout will be performed at the launch pad. In addition to the capacity for storing up to four of these tanks while maintaining internal blanket pressure, the facility has a checkout cell where inspection, cleaning, leak, humidity, range safety equipment checks can be conducted, and spray-on foam insulation applied at the closeout ports. The harbor, tow route, and processing facility are part of the TCF.

SRB Refurbishment and Subassembly Facility. SRB component storage, aft boost assembly, and limited SRB component checkout are accomplished at this station set (Figure 10). The overall length of the SRB is 45.5 m (149.2 ft), and the diameter is 3.7 m (12.2 ft). Each of the four SRM segments weighs up to 167,375 kg (369,000 pounds). The SRM propellant segments are received by rail and transferred to the storage area of the station set. The SRB forward assembly and aft skirts with TVC components installed are delivered by C5 aircraft from KSC where refurbishment, subassembly, and comprehensive checkout have been accomplished. The aft skirt is mated to the aft solid propellant segment and nozzle to form the aft booster assembly, and the aft and forward assemblies are connected together with electrical cabling at VLS for a limited end-to-end electrical systems checkout.

Launch Pad. The launch pad station set includes facilities, support equipment and services required to assemble, integrate, checkout and launch the Space Shuttle (Figure 11). Facilities include launch mount, exhaust ducts, Access Tower (AT), the Mobile Service Tower (MST), a mobile Shuttle Assembly Building (SAB), a mobile Payload Changeout Room (PCR), a fixed multi-cell Payload Preparation Room (PPR), and storage and holding areas for hypergolic and cryogenic propellants and gases. In addition, sound-suppression water storage and deluge systems, and an ice suppression system are included. This Station Set is used for assembly, integration, checkout, and launch of the SSV. The launch pad operation is supported from the Launch Control Center and divided into the following major phases:

1. Space Shuttle Vehicle Assembly and Interface Verification. The SSV assembly begins with the MST in position at the Launch Mount. Preparations for stacking of the SRM segments consist of transporting forward and aft assemblies and individual booster segments to the launch pad by a self-propelled, rubber-tired transporter (Figure 12). At the launch pad, the environmental covers and transporter tie-down restraints are removed, the SRB handling device installed, and grounding systems verified. Holddown-post release hardware is then pretensioned. Once support fixture alignment is confirmed, the first aft booster assembly is hoisted from its transporter and positioned on its support fixture using the MST bridge crane (Figure 13). The second SRB aft booster assembly is similarly installed and the alignment verified. The center segments, forward segments, and forward assemblies of each SRB are then alternately installed with leak checks performed to verify SRB seal integrity as each segment or assembly is installed. After completion of the SRB motor segment stacking, additional alignment checks are made to ensure that excessive loads are not induced into the ET when it is mated to the SRBs. SRB tunnel cables used to cover the electrical harness are installed and verified. Destruct ordnance is then installed but left in a safed condition using safe-arm devices.

During these operations, the ET and SRB-ET interface hardware is moved to the pad. Once physical verification of cabling is complete, SRB tunnel covers are installed and the SRB-ET interface hardware installed and checked out. The SRBs are then ready for ET mating.

The SAB, a high-bay structural steel building, moves on two sets of double tracks and mate with the MST to seal off the launch pad and provide a benign environment for ET and Orbiter erection, mating, and processing before launch.

The ET is transported from the TCF to the launch pad (Figure 14). The ET is lifted clear of the transporter, rotated to the vertical position and stabilized using the MST and SAB cranes (Figure 15). The ET-SRB aft stabilizing struts are installed and the ET lowered until the ET weight is transferred to the SRB forward attach fittings and secured.

The Orbiter is transported 17 miles from the OMCF to the launch pad on a rubber-tired transporter. At the launch pad, the Orbiter is lifted clear of the transporter by the MST and SAB cranes, rotated to the vertical, stabilized, and translated to the ET (Figure 16). After the two aft structural attachments are made the forward attachments are secured. This procedure transfers the Orbiter weight to the ET-SRB assembly. Following structural mating of the Orbiter, the Orbiter-ET and Orbiter-launch mount interfaces are established and verified, and (TPS) closeout starts.

Following establishment and verification of the various interfaces and environmental conditioning, ground power is applied to the vehicle. A Shuttle Interface Test (SIT) is performed to verify interface integrity and systems compatibility. The VLPS provides the stimuli/response verification, monitor status, and provides control and recording of test data. The SIT ends with the vehicle and support equipment configured for final ordnance installation, connections and verification activities.

2. Space Shuttle Vehicle Servicing. The SAB is rolled back prior to start of hazardous servicing. Hazardous servicing of the Orbiter and SRBs is controlled remotely by VLPS, and commences when all nonessential personnel have cleared the pad area following service preparations. Orbiter servicing consists of the loading of ARCS, FRCS, and OMS hypergols, plus the loading and pressurization of ARCS, FRCS and Main Propulsion System (MPS) helium bottles. When servicing is complete, ground crews return to the pad and disconnect APS servicing lines and install flight panels.

A Shuttle Range Safety System open loop test is performed, flight code plugs installed, and a closed loop test performed. This is followed by a power on/off stray voltage check of ordnance circuits, and then final connection of ordnance.

All ground services and platforms are secured, and at T-36 hours MST rollback to launch position occurs, and ground interfaces are re-established. The ET H_2 vent arm and GO_2 Vent Arm are positioned and interfaces connected. All ET vent arm interfaces are verified and leak checked. The Orbiter crew cabin access arm is moved back into position, and the clean room environment re-established.

3. Payload Installation. The Payload Preparation Room (PPR), which is part of the Launch Pad Station Set, consists of three checkout cells each with fixed platform levels, an erection room, an airlock and a transfer tower (Figure 17). During the early years, only two of the three checkout cells will be activated. The payload enters the PPR through the airlock and moves into the erection room for payload removal from transporter by overhead crane, rotation to vertical, and transfer to a checkout cell. Payload integration and checkout, ordnance installations, and fuel loading (if required) are performed in the checkout cell. The complete integrated cargo assembly including the payload strongback is moved to the transfer tower. The transfer area provides a support base from the erection room 75-ton bridge crane to the 75-ton transfer tower hoist. The transfer tower transfers the payload from the strongback to the Payload Ground Handling Mechanism (PGHM). The PGHM with cargo translates the cargo from the PPR tower to the PCR using the overhead rails. The PCR, which is a mobile structure, rolls to the Orbiter on the launch mount, and cargo installation into the Orbiter bay is performed utilizing the PGHM. Since the PPR and PCR facilities are located approximately 800 feet within the launch pad area, no payload retest within the PCR is required prior to transfer of the payload to the Orbiter payload bay.

4. Countdown and Launch. Precount operations place the SSV, support equipment and launch facility in a position of readiness to start the cryogenic loading and proceed to countdown. A final walkdown is performed. All non-flight hardware is removed, and SRB flight batteries and final ordnance installed. Final preparation for cryogenic loading is performed. Following retraction of the PGHM, the Orbiter payload bay doors are closed and seals verified.

The Payload Changeout Room doors are closed, and all mechanical and electrical interfaces between the PCR and launch pad are disconnected and stowed for movement. Access platforms and other movable support equipment are also retracted/stowed. The PCR is then moved back to the PPR at approximately T-12 hours.

Upon completion of the precount operations, the SSV is in a configuration either to proceed directly into the launch countdown or to be placed in a standby status for up to 24 hours. Countdown preparations can be held within this time.

The countdown is entirely under VLPS control except for the final seconds when operations are controlled by the onboard computer. The final countdown commences at approximately T-12 hours with loading of cryogenic propellants into the ET. The MPS/ET loading begins with LO_2/LH_2 chill down of the propellant transfer lines, and followed by slow fill to chill the ET. When slow fill is completed, fast fill is initiated. Fast fill is continued until the specified levels are reached, at which time a slow fill is again initiated to complete the MPS/ET loading. Upon completion of the cryogenic loading, the flight crew and passengers proceed to the Orbiter cabin where they secure and leak check the hatch and take their positions for launch. The terminal countdown is started after the crew and passengers report they are secured for launch. The terminal countdown includes performance of the flight crew checklist, verification of the guidance, navigation and control alignment, SSV subsystems status checks, transferring of SSV electrical power from ground to vehicle internal, and obtaining the required clearances for launch.

During the terminal count the following operations are also performed: termination of ET propellant replenishment, final flight pressurization of ET LO_2 and LH_2 tanks, retraction of the ET LO_2 tank vent arm, retraction of the Orbiter crew cabin access arm, arming of the required ordnance circuits, and the actions/verifications associated with the engine start sequence and the liftoff functions. Finally, the main engines are started. When the desired main engines thrust level is achieved, the SRB's are ignited, the holddown bolts and umbilicals are pyrotechnically released, and liftoff occurs.

At liftoff, operational command and control is transferred to the flight crew and NASA/JSC Mission Control Center. During flight, VLS will continue to provide range support, flight safety, contingency operations support, and monitoring of flight SSV status to prepare for landing and maintenance operations.

5. <u>Launch Pad Refurbishment, Reconfiguration and Facility Resupply</u>. Following liftoff, ground systems are deactivated and secured. Safety and preliminary damage inspections are conducted and when conditions permit, the SRB Refurbishment and Storage Facility and ET Storage Facility are reopened for normal work and the next launch pad cycle for launch begins.

Launch pad refurbishment consists primarily of inspection of the facility and equipment repair or replacement, as required. The first action required in refurbishment is to wash down the MST and pad structure as soon as possible after launch to remove the acid fallout resulting from the SRB exhaust products.

The crew cabin access arm is inspected and aligned after each launch to restore the clean room environment. The ET umbilical plates are removed and refurbished by disassembly, cleaning and replacing of seals and components. All non-reusable items such as pyrotechnic cables in the SRB holddown posts are replaced during refurbishment.

SRB Retrieval and Disassembly Facility. When the SRBs have expended all solid propellant, they separate from the ET and parachute back to the ocean. Beacons on the SRBs are activated at impact and provide guidance to the retrieval vessels. A nozzle plug is lowered into the water from the retrieval vessel and inserted by divers into each SRB nozzle. Air is pumped into the SRB to displace water and cause the SRB to float horizontally on the water surface. The SRB frustums are recovered, and parachutes wound onto reels on the retrieval vessel. The tugboat and the retrieval vessel each tow one expended SRB to the U.S. Naval Station at Port Hueneme (Figure 18). KSC will provide one retrieval vessel and recovery crew for the first three VLS launches, and the USAF will provide and outfit the leased tug. The USAF is responsible for management of the retrieval operations.

At Port Hueneme, two straddle-lift carriers remove each SRB from the water and place them on special rail car dollies riding on a leveled, continuously welded track. The ordnance is safed and any remaining thrust vector control system hydrazine is drained. The rail cars are towed into an initial wash facility and then into the main building for complete SRB disassembly. The forward and aft assemblies are sent back to the wash facility for insulation removal by a high-pressure water spray and subsequent drying. The empty propellant segments are shipped back to the manufacturer for installation of new propellant and the forward skirt, aft skirt, parachutes, and remaining components are sent to KSC for refurbishment.

Transportation, Communications and Utilities Station Sets. There are additional functional station sets for auxiliary services; these include the Transportation Station Set which consists of the roads and special transportation equipment to move the SSV elements around Vandenberg; the Communications Station Set which provides voice, TV and data transmission within and among the station sets and control centers; and the Utilities Station Set which provides electrical power and distribution as well as fire suppression water, and sanitary sewers to the geographical station sets.

Facility Verification Vehicle/System Test Vehicle (FFV/STV). The ground support system capability to support STS operations at VLS will be verified during the Activation phase. FVV/STV is one of the major tests conducted during the Activation. The FVV will consist of Orbiter 101 (Enterprise), a lightweight External Tank, and an inert set of Solid Rocket Motors assembled to a flight set of SRB structures. One aft skirt in the stack will be the structural test article. The System Test Vehicle (STV) is essentially a mechanical payload.

The objectives of the FVV/STV test are:

(1) Verify operational and handling interfaces between the various station sets and FVV/STV hardware. Of primary interest in operational interface verification is the demonstration of the vehicle erection and mating technique as well as the transportation routes.

(2) Validate operational plans and procedures.

(3) Ground crew training.

Each element of the FVV/STV will arrive at VLS and be processed through its respective station set. This paper will outline only FVV/STV testing at the launch pad.

FVV/STV launch pad operations will consist of SRB stacking, ET erection and Orbiter mating, and STV installation. Structural dynamic response (Twang) tests will be performed following the completion of SRB stacking. After completion of the Twang tests, the Forward Assemblies are stacked and the Influence Coefficient Test is completed. The ET will be positioned in the SAB, lifted, rotated to the vertical position, and mated with the SRBs stacked on the launch mount. The Orbiter will then be positioned, attached to the SAB lifting support equipment and lifted, rotated to the vertical position, and then mated to the ET/SRB stack on the launch mount. Operations methodology, clearances, and interfaces will be verified during the erection and mating operation.

The STV will be used as the payload verification vehicle for the PPR/PCR. The STV will provide checks for all clearances, interfaces and mechanical handling capabilities in the PPR/PCR. Finally, the STV will be transferred from the PPR to the PCR. The PCR will move foward through the SAB to the launch mount and transfer the STV into the Orbiter bay. Payload servicing, maintenance and equipment installation/removal within the payload bay will be checked. Then the STV will be removed from the Orbiter bay to the PCR, and from the PCR to the PPR to verify the capability to remove a payload.

Upon completion of all FVV/STV operations, the Orbiter 101, SRBs and ET will be destacked and returned to their respective station set. Orbiter 101 will be returned to NASA by the SCA.

VLS Integrated Assessed Timeline. Vandenberg Launch and Landing Site Shuttle Turn- around Analysis Report (VSTAR) is a formal presentation of results of KSC STAR and analytical studies of the ground turnaround processing capability under development by the USAF at Vandenberg Air Force Base (Figure 19). Those analyses and associated activities are performed by, or under auspices of, the VLS Shuttle Turnaround Analysis Group (VSTAG). The Launch Pad Station Set integrated assessed timeline have been developed by VSTAG (Figure 20).

Critical review of all tasks necessary to the ground processing effort is conducted on a continuing basis by the VSTAG. The reader is cautioned to review the ground rules that were used in the analysis before using Figure 19 and Figure 20 for other planning. Throughout the duration of the VLS program, continuous effort will be directed towards reducing the turnaround time. This will be accomplished through an enhancement program and may include suggested redesign, design changes, requirement changes, and additional or new support equipment.

VLS Program Plan. The activation of VLS facilities has been underway for several years. Figure 21 is an outline of the completely activated and partially activated facilities. The VLS initial launch capability of the Space Shuttle is 15 October 1985.

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FIGURES

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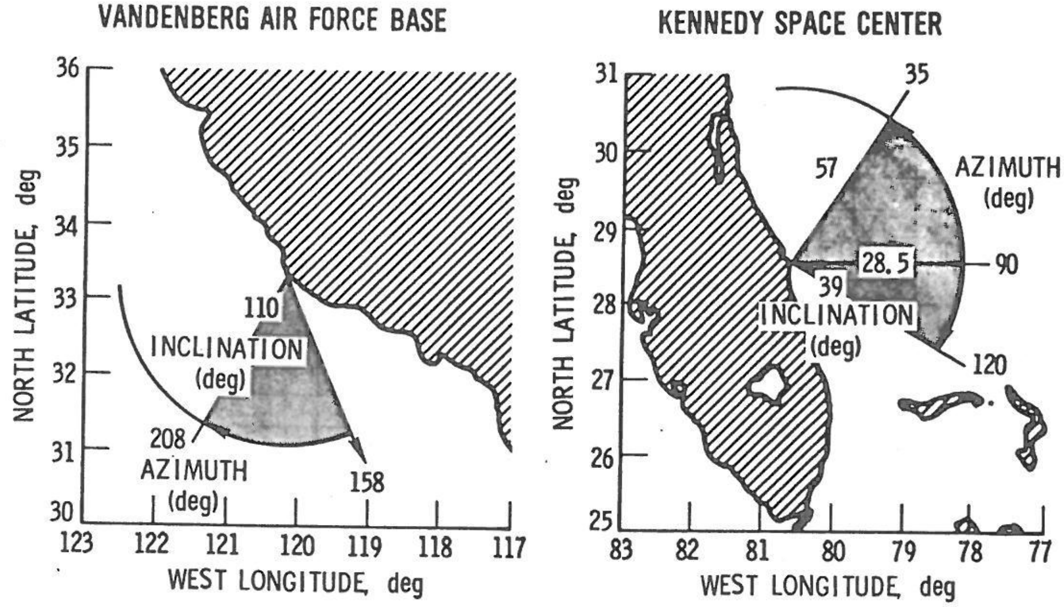


Figure 1. Launch Azimuths and Orbital Inclinations

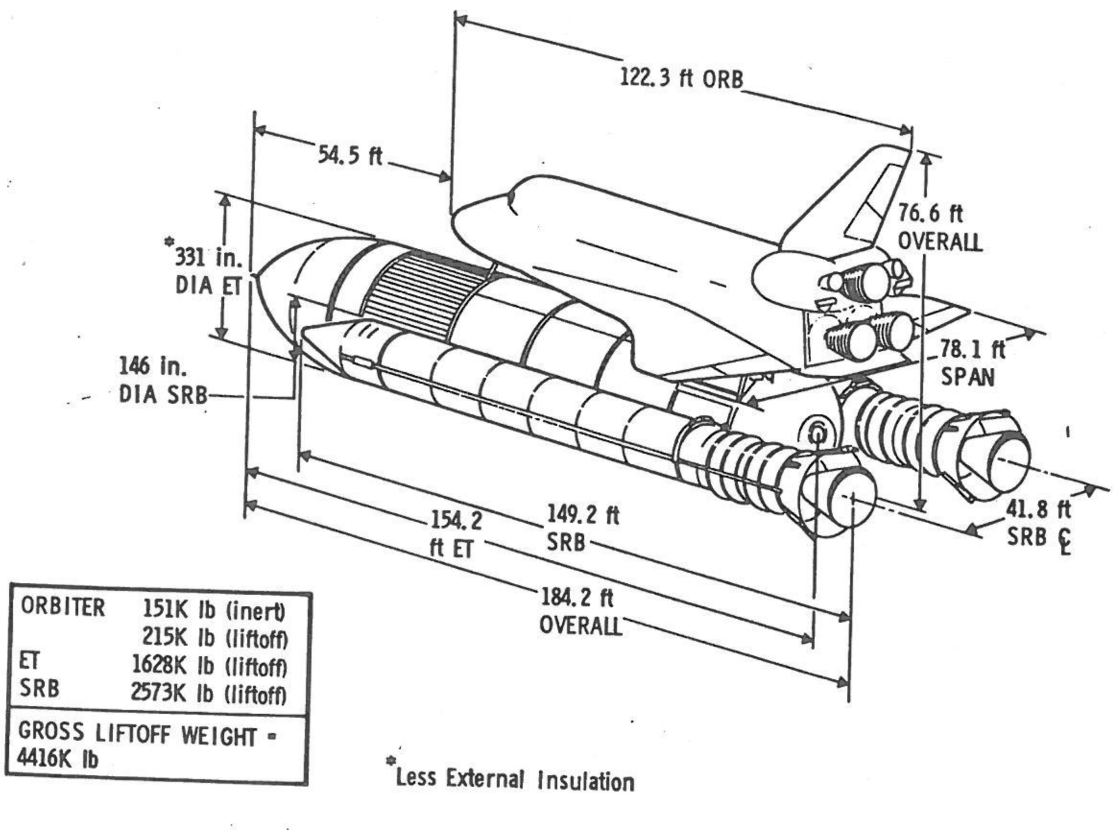


Figure 2. Space Shuttle Vehicle

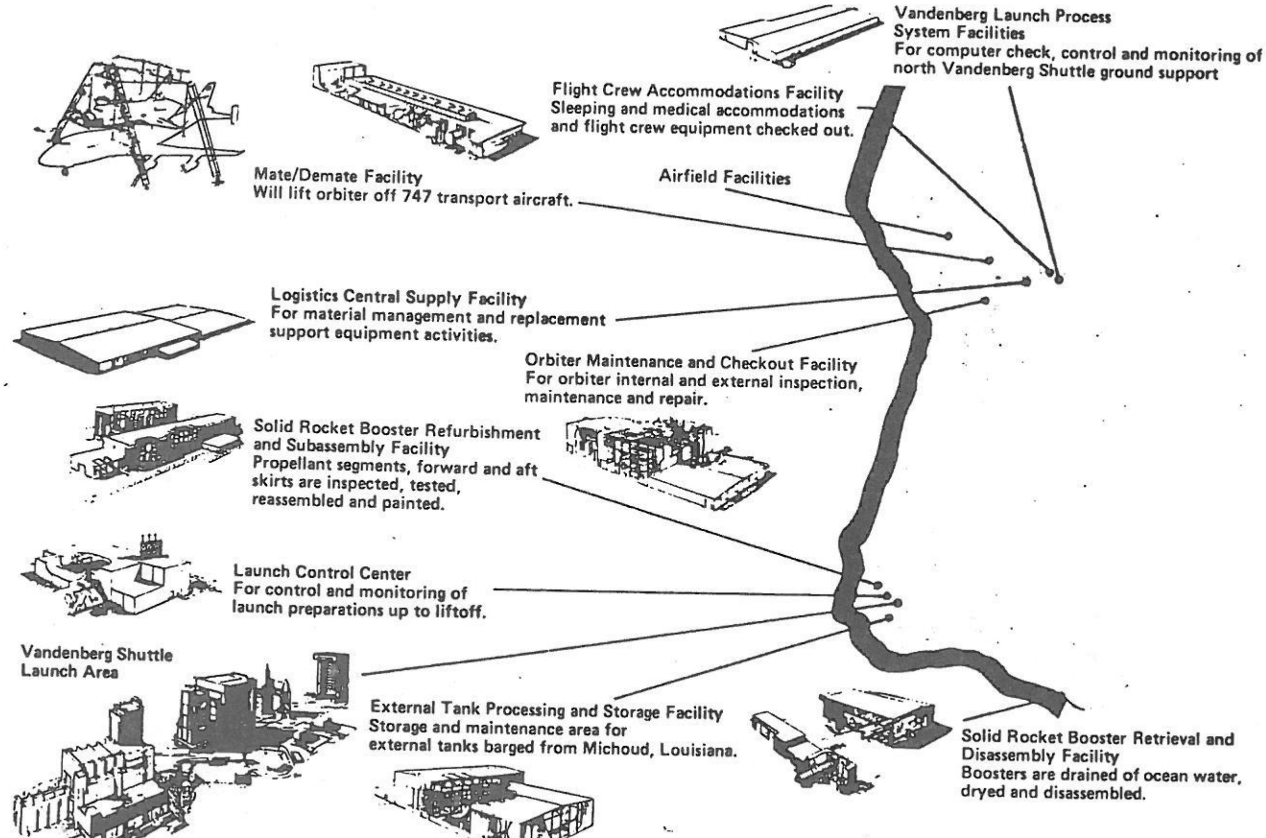


Figure 3. Vandenberg Station Set Geographic Locations

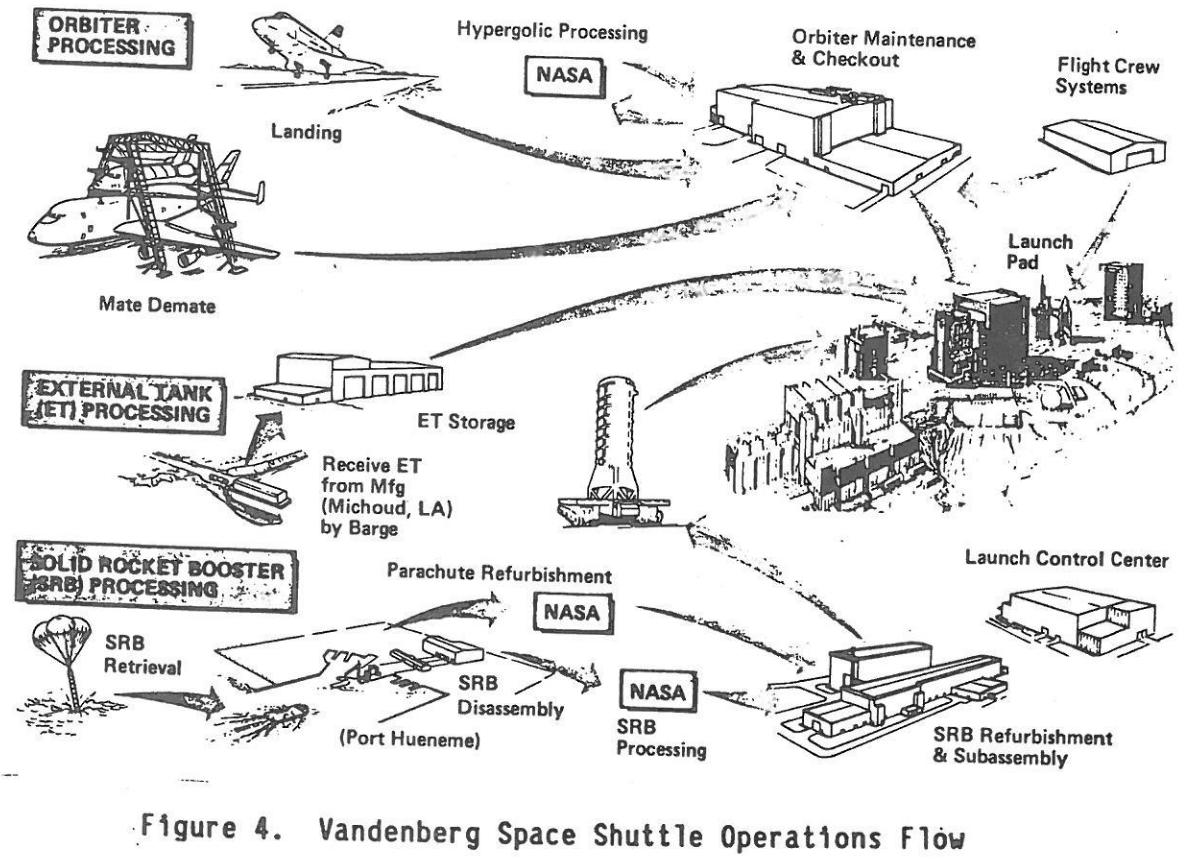


Figure 4. Vandenberg Space Shuttle Operations Flow

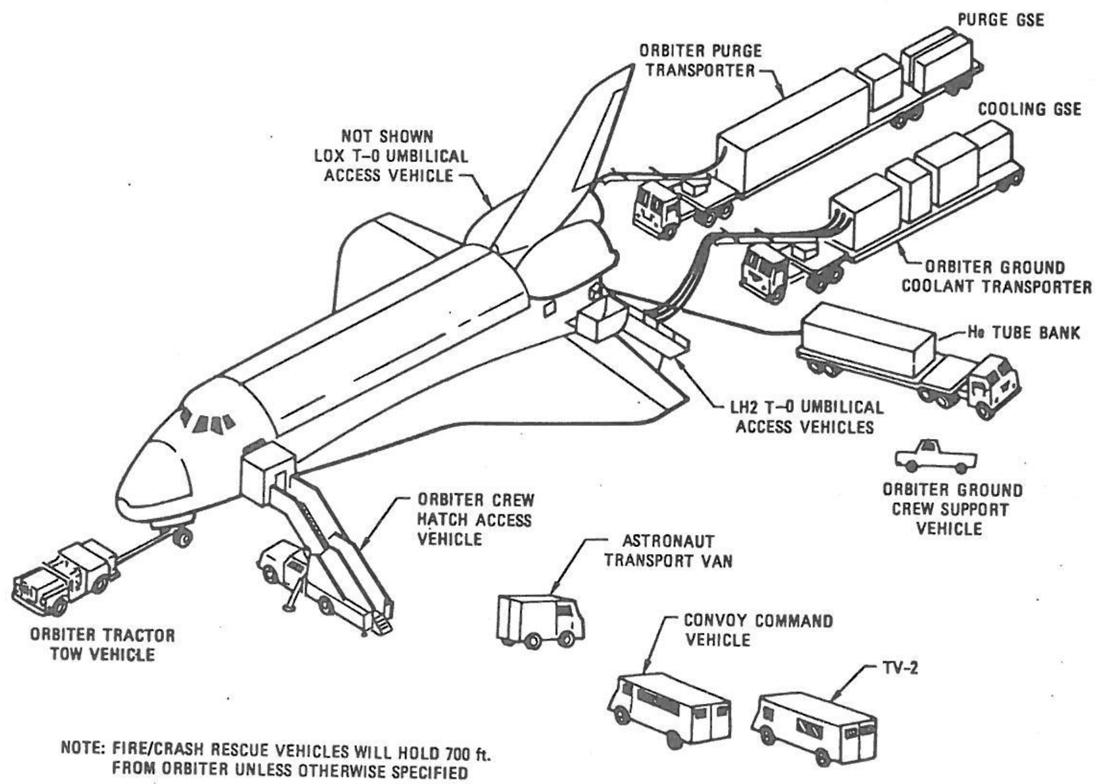


Figure 5. Orbiter Servicing Convoy

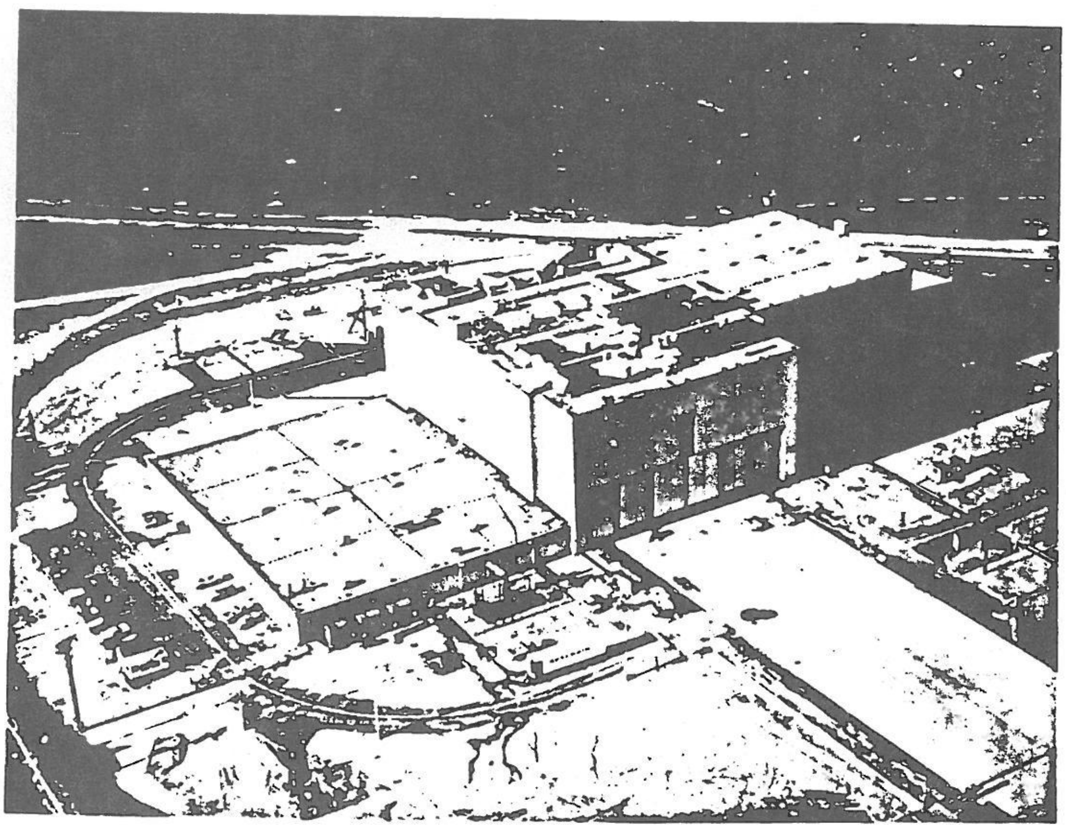


Figure 6. Orbiter and Maintenance Checkout Facility

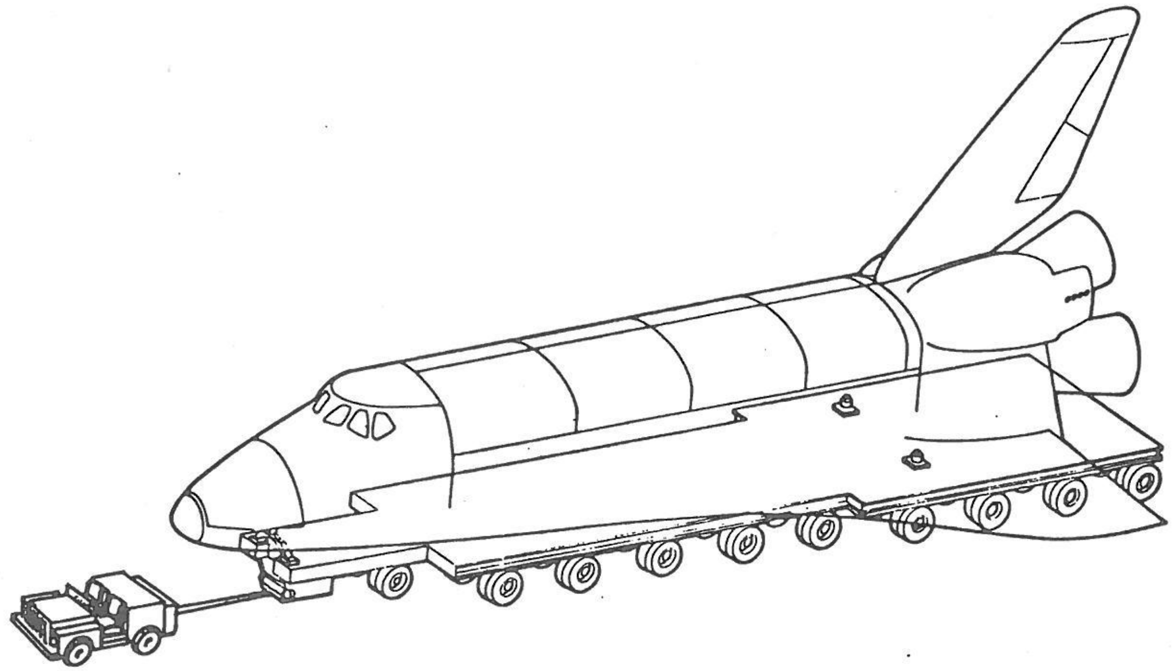


Figure 7. Orbiter on Transporter

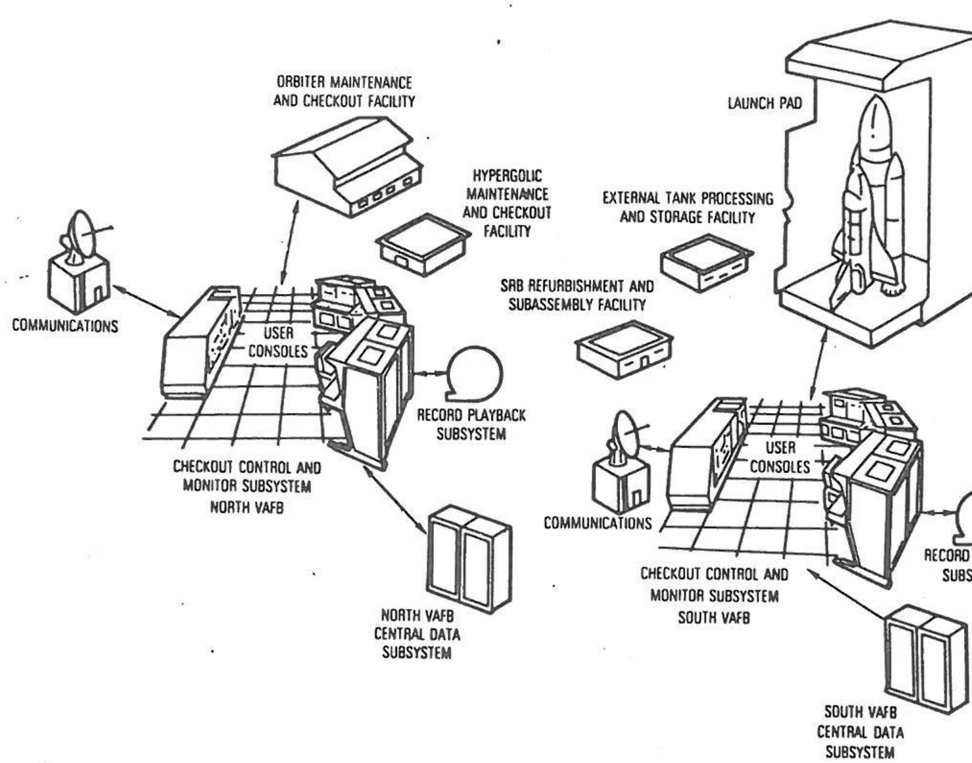


Figure 8. Vandenberg Launch Processing System

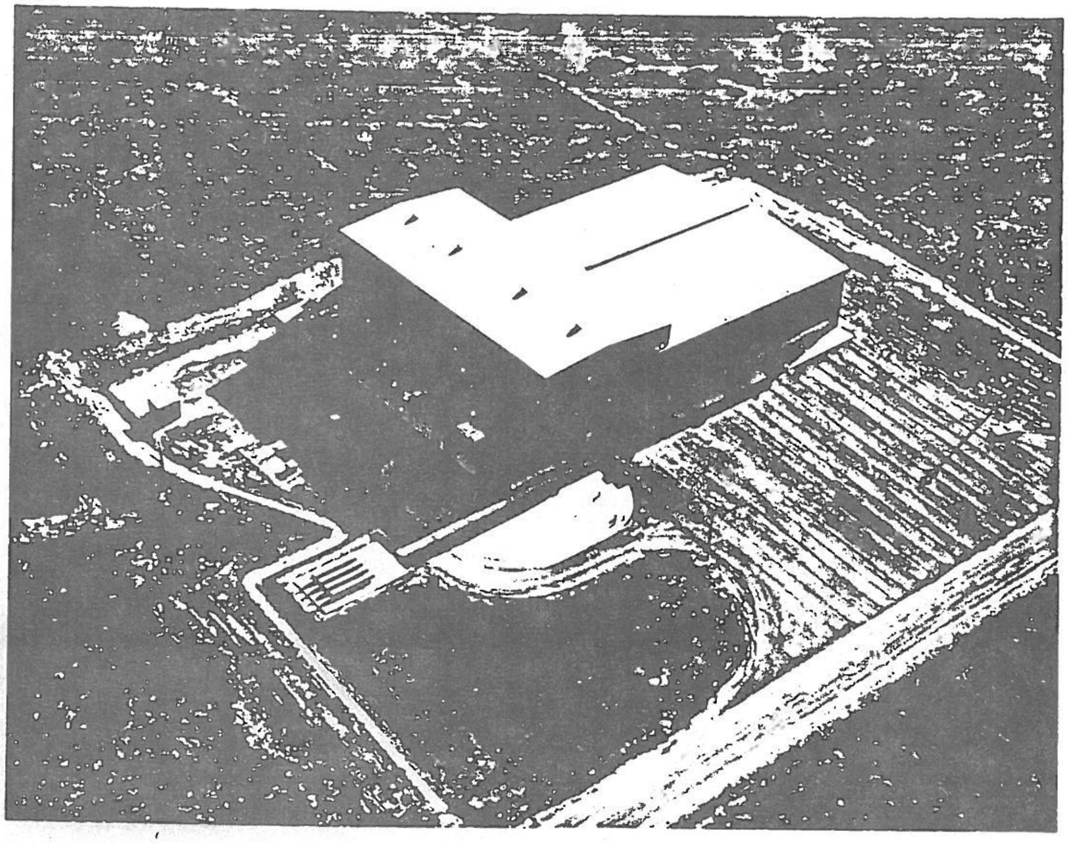


Figure 9. ET Processing and Storage Facility

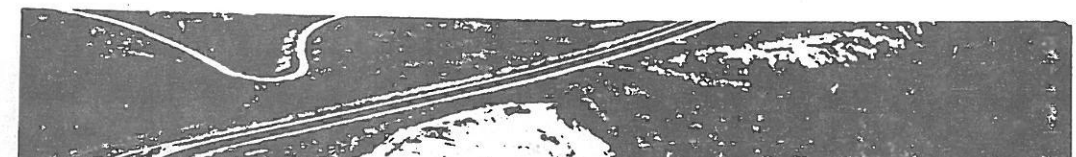


Figure 10. SRB Refurbishment and Subassembly Facility

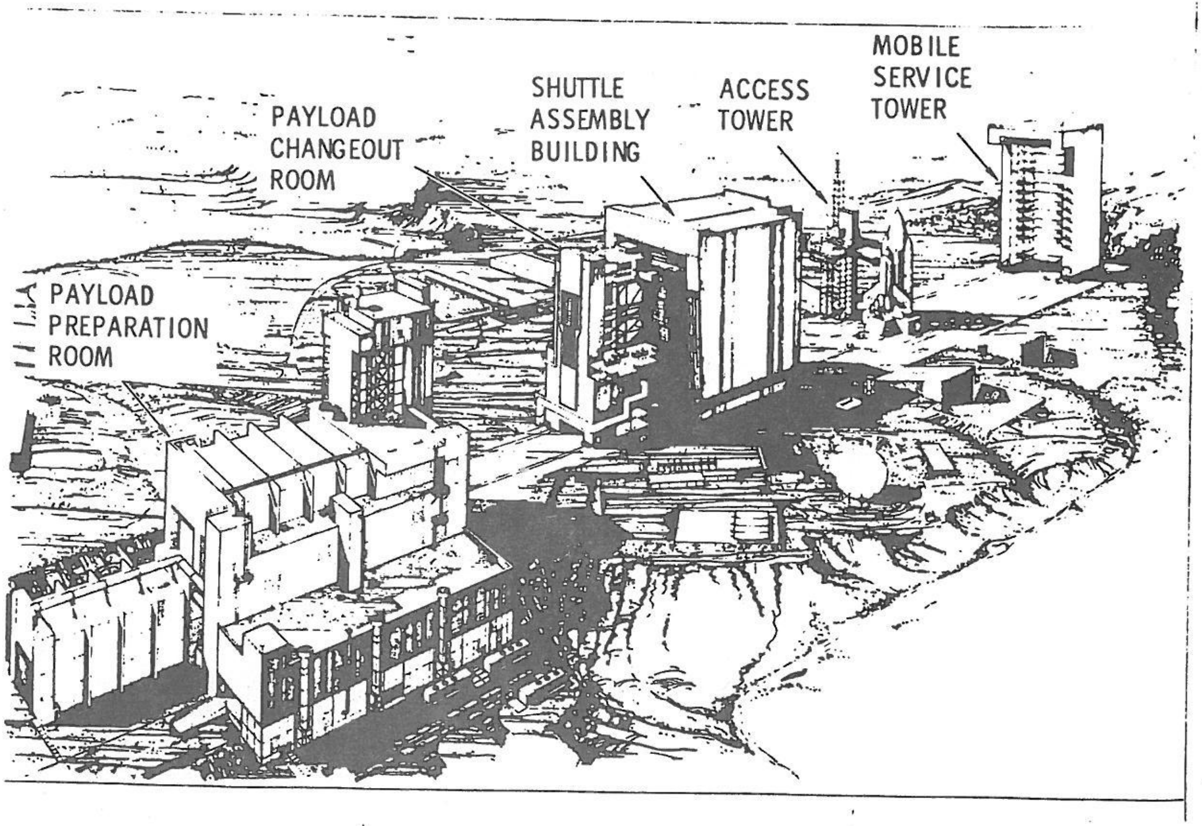


Figure 11. Launch Pad

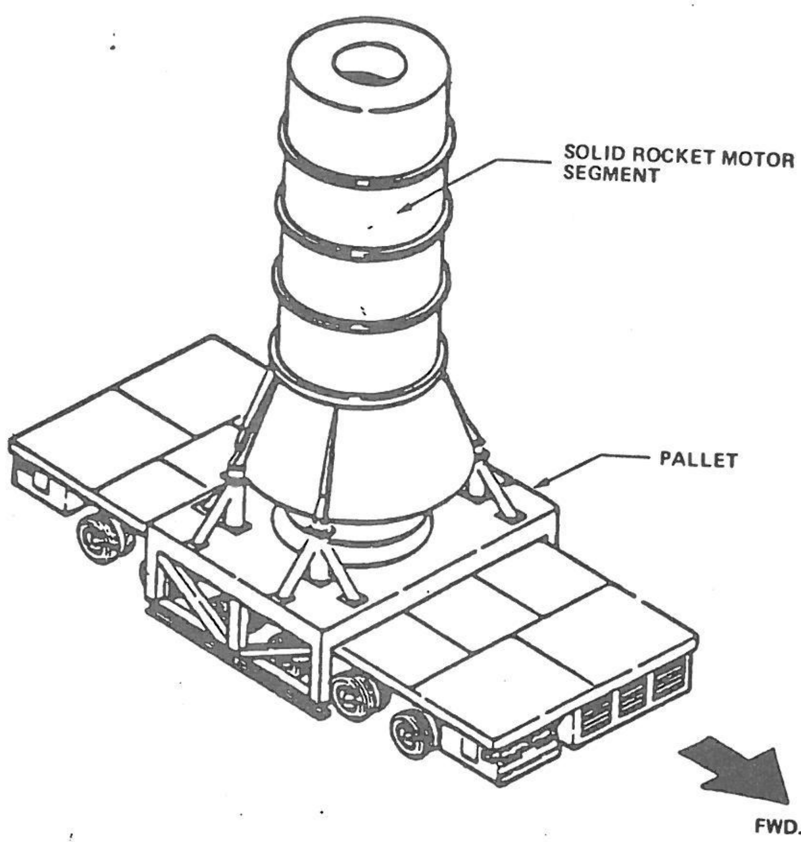


Figure 12. Solid Rocket Motor Transporter

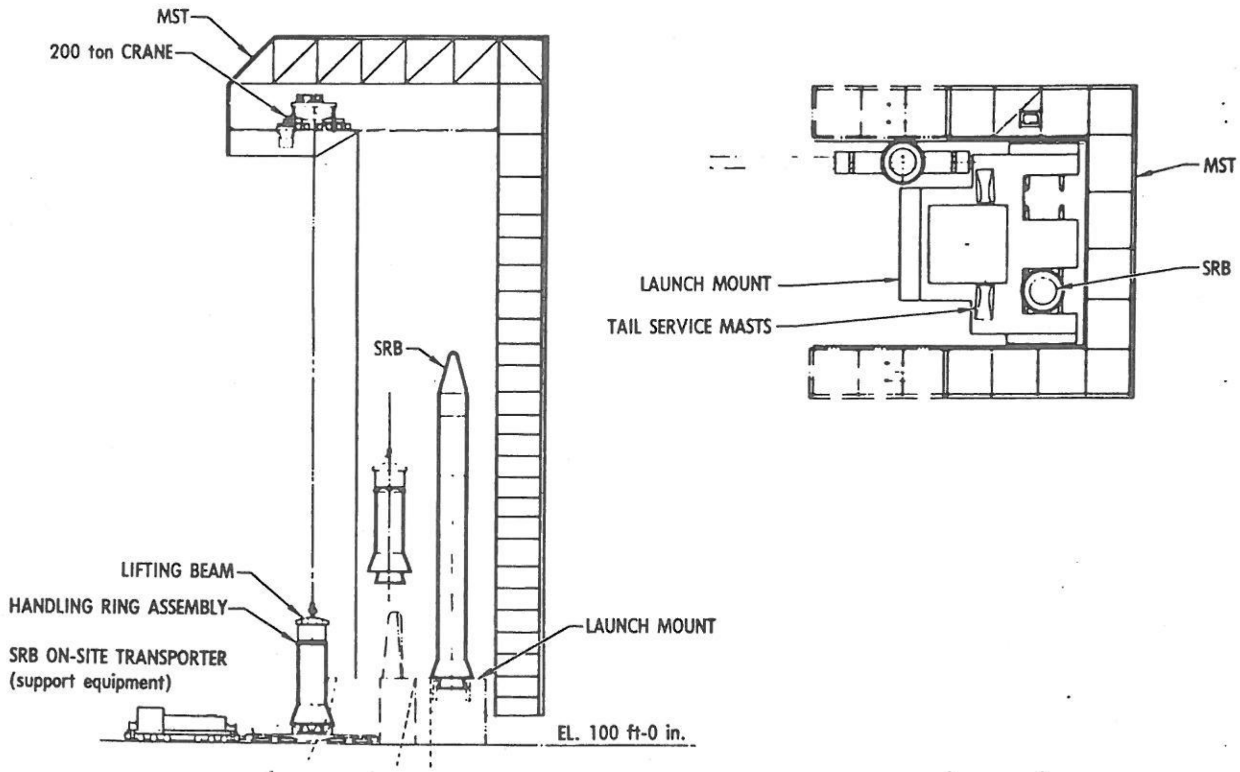


Figure 13. SRB Stacking And Alignment

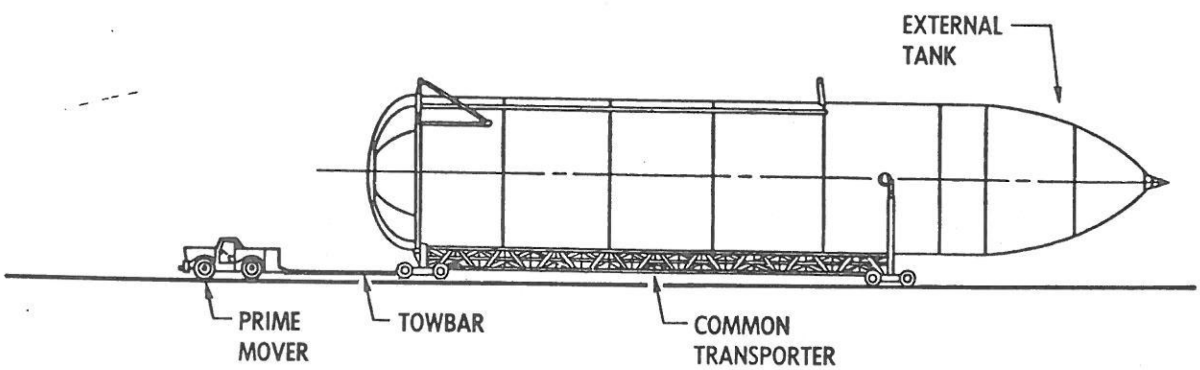


Figure 14. ET on Transporter

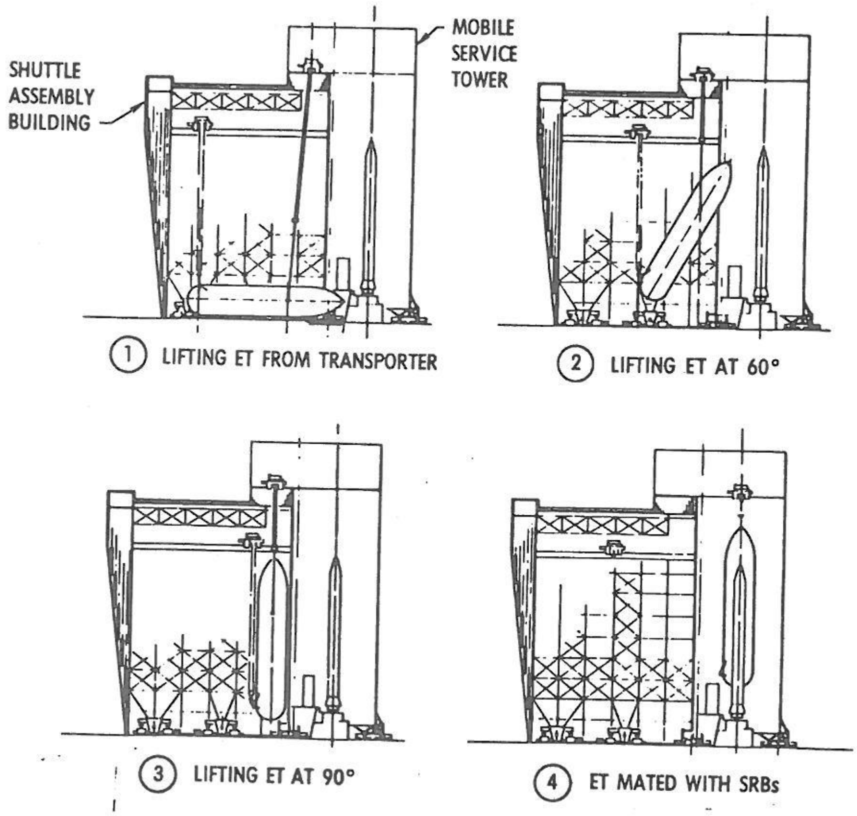


Figure 15. ET Erection and Mating

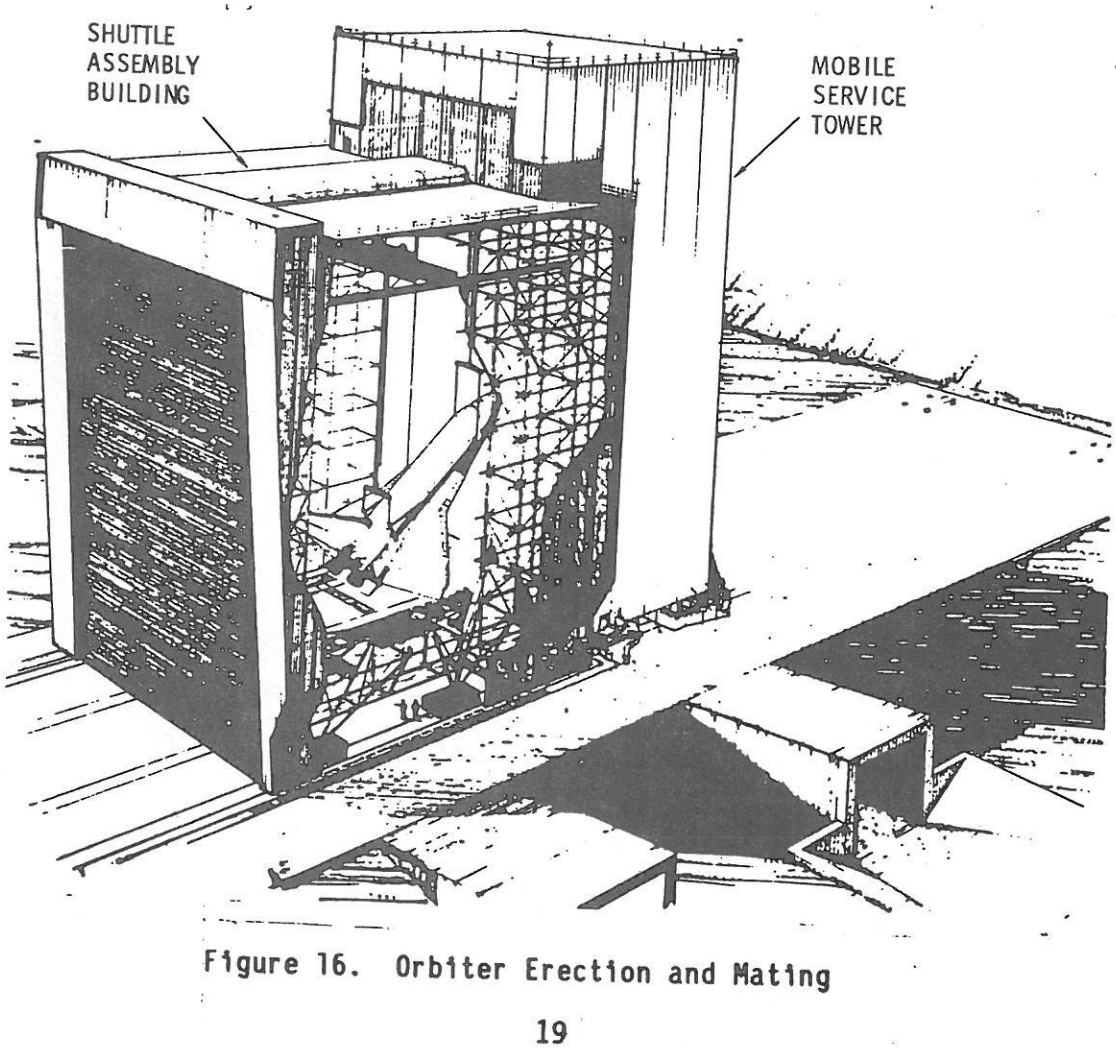


Figure 16. Orbiter Erection and Mating

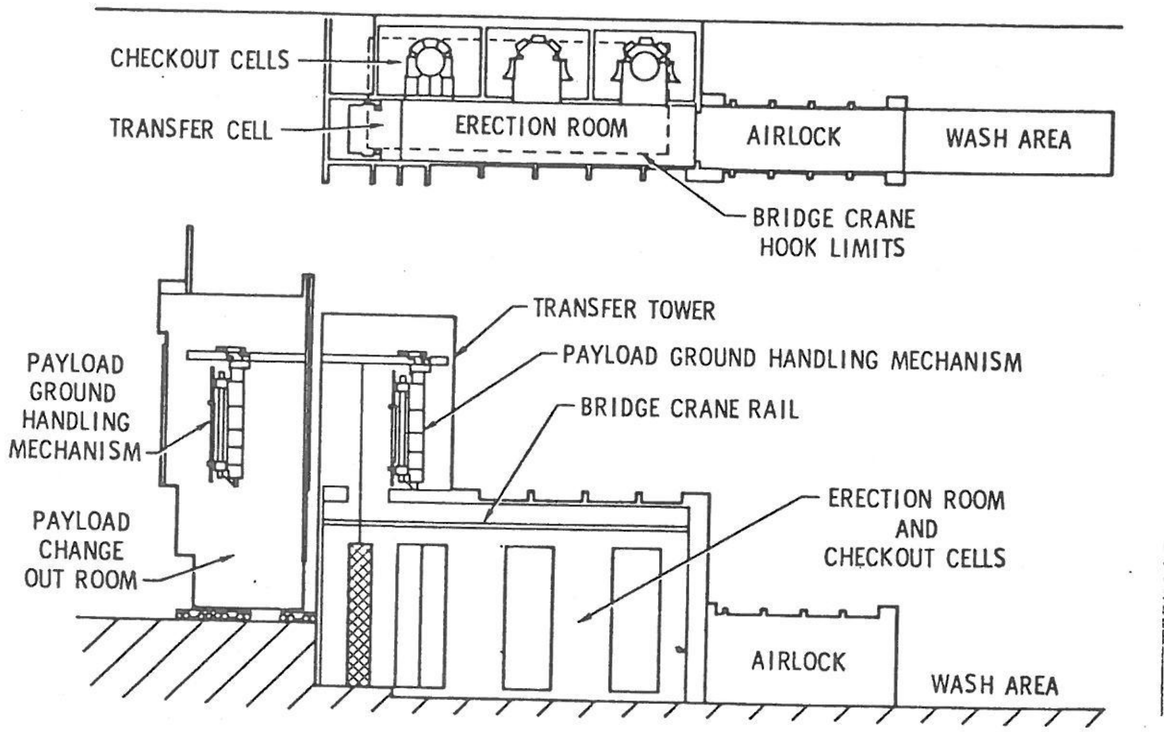


Figure 17. Payload Preparation Room

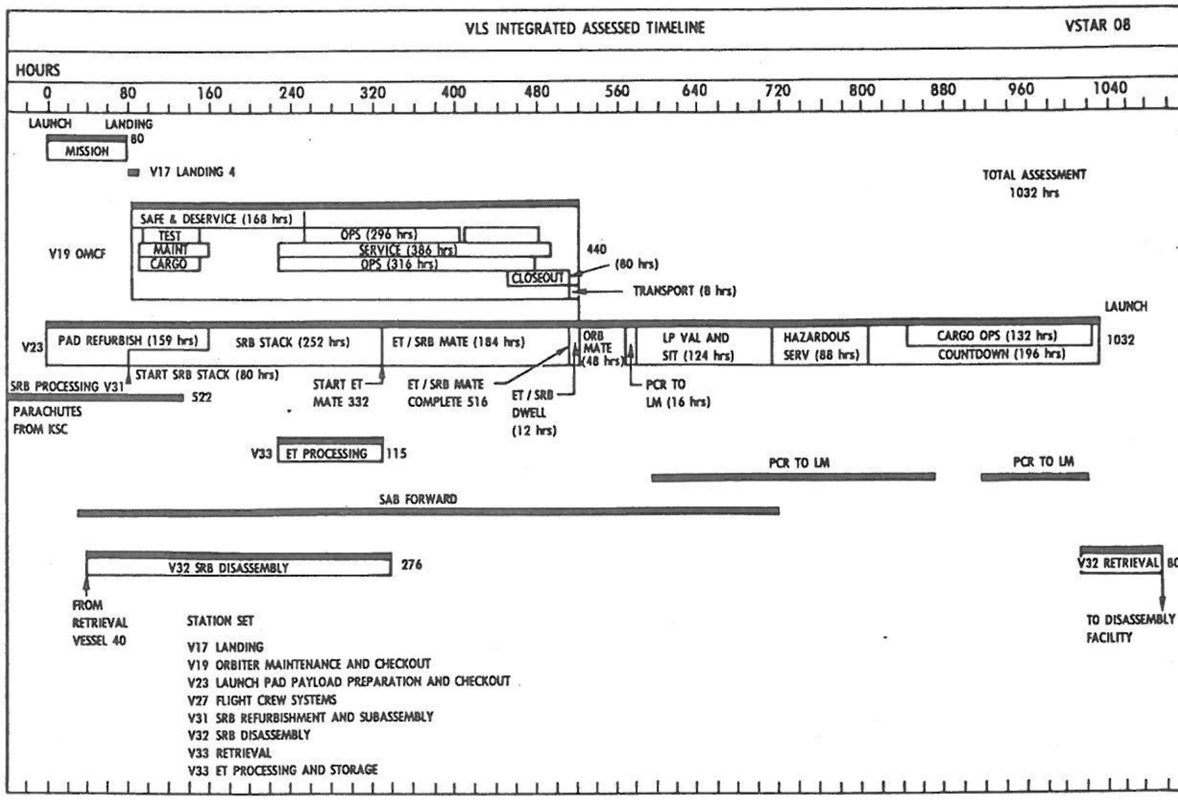


Figure 19. VLS Integrated Assessed Timeline

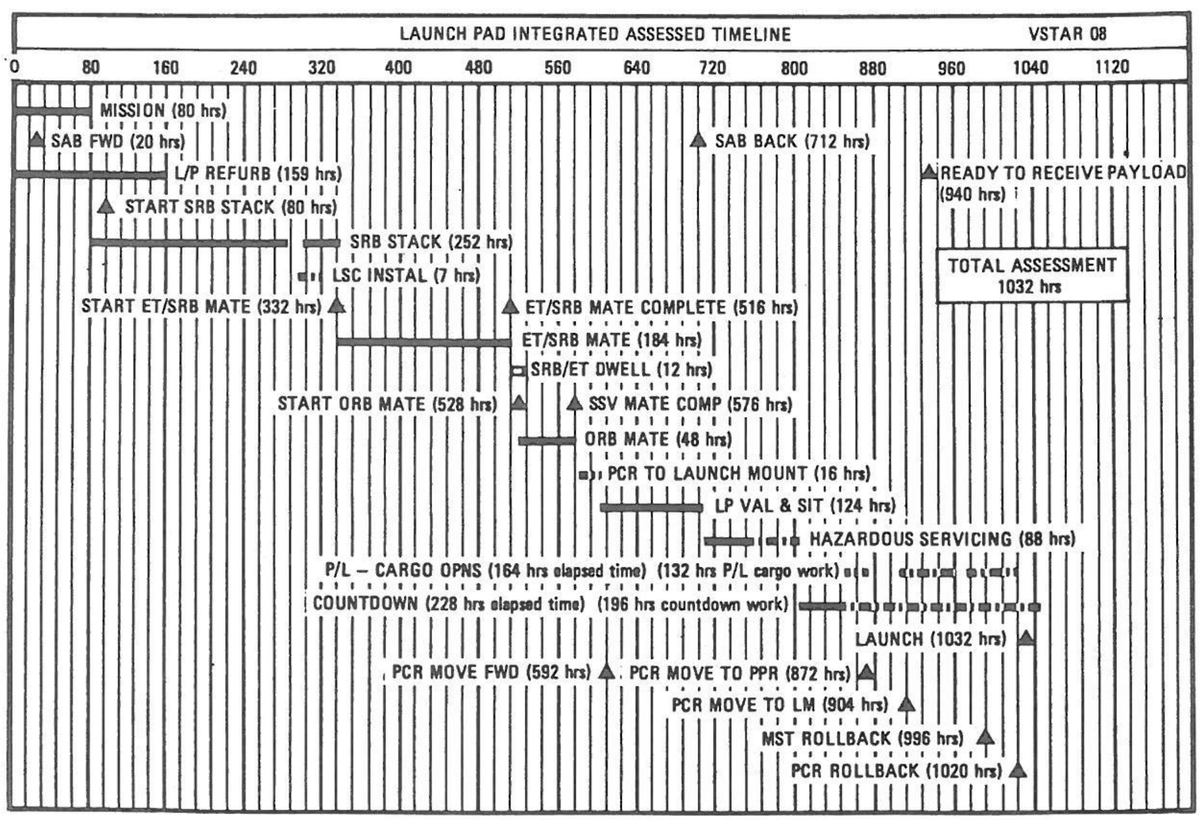


Figure 20. Launch Pad Integrated Assessed Timeline

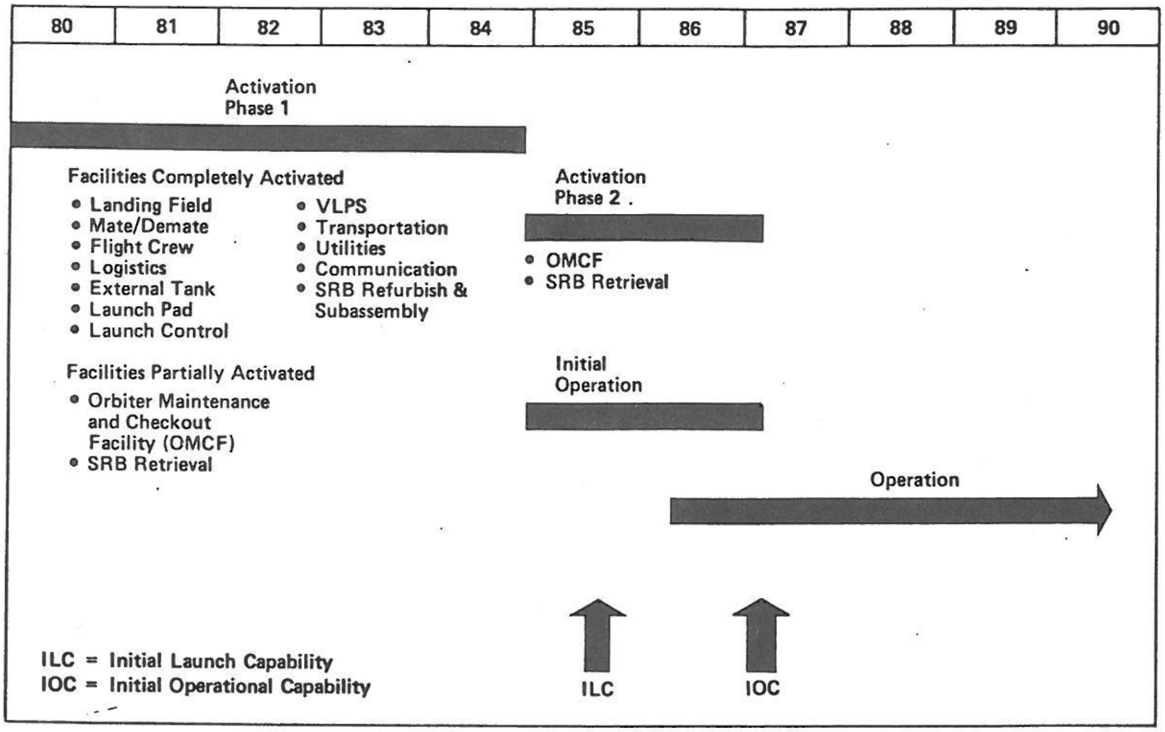
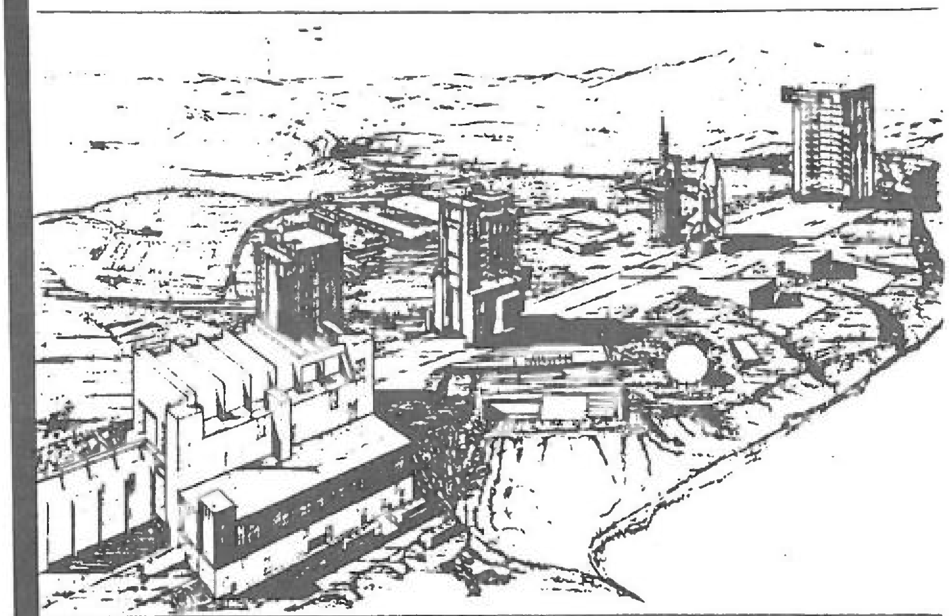
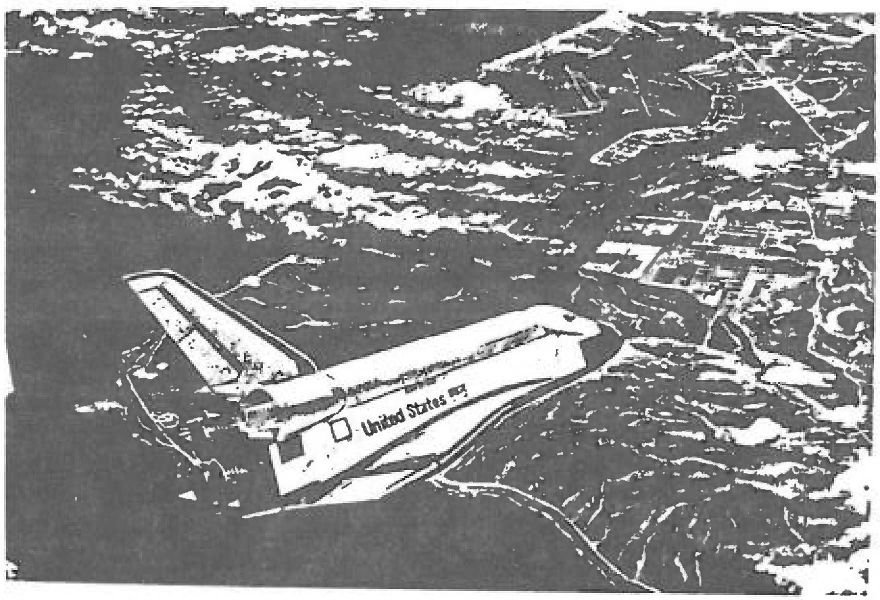


Figure 21. VLS Program Plan

DOD Space Shuttle Operations at Vandenberg Launch and Landing Site





Peter L. Portanova
Director, System Requirements
Shuttle Activation and Operations Directorate
The Aerospace Corporation

LAUNCH AZIMUTHS AND ORBITAL INCLINATIONS

0 THE LAUNCH AZIMUTHS AND ORBITAL INCLINATIONS AVAILABLE FROM VANDENBERG AIR FORCE BASE ARE COMPLIMENTARY TO THOSE AVAILABLE FROM THE KENNEDY SPACE CENTER

0 TAKEN TOGETHER, THE NATIONAL SPACE SHUTTLE CAPABILITY PERMITS OVER WATER LAUNCHES INTO ALL ORBITAL INCLINATIONS OF INTEREST.

0 THE EASTERLY MISSIONS TYPICALLY FLOWN FROM KENNEDY SPACE CENTER INCLUDE

/ PLANETARY
/ COMMUNICATION SATELLITES
/ OTHER GEOSYNCHRONOUS SATELLITES

0 SOUTHERLY MISSIONS FLOWN FROM VANDENBERG AIR FORCE BASE ARE GENERALLY OBSERVATIONAL IN NATURE AND INCLUDE

/ EARTH RESOURCES
/ WEATHER SATELLITE

0 SCIENTIFIC SATELLITES ARE LAUNCHE FROM BOTH SITES

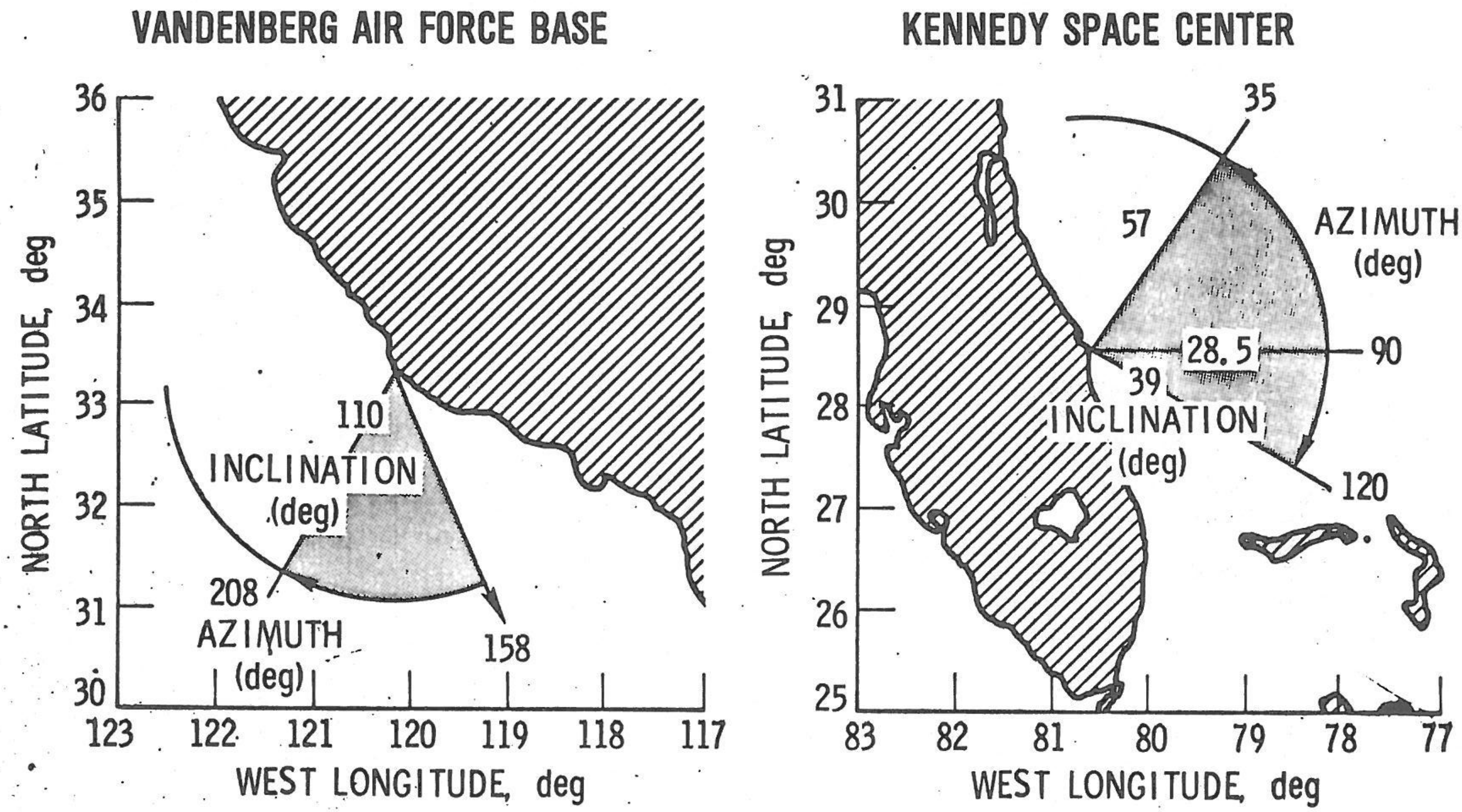
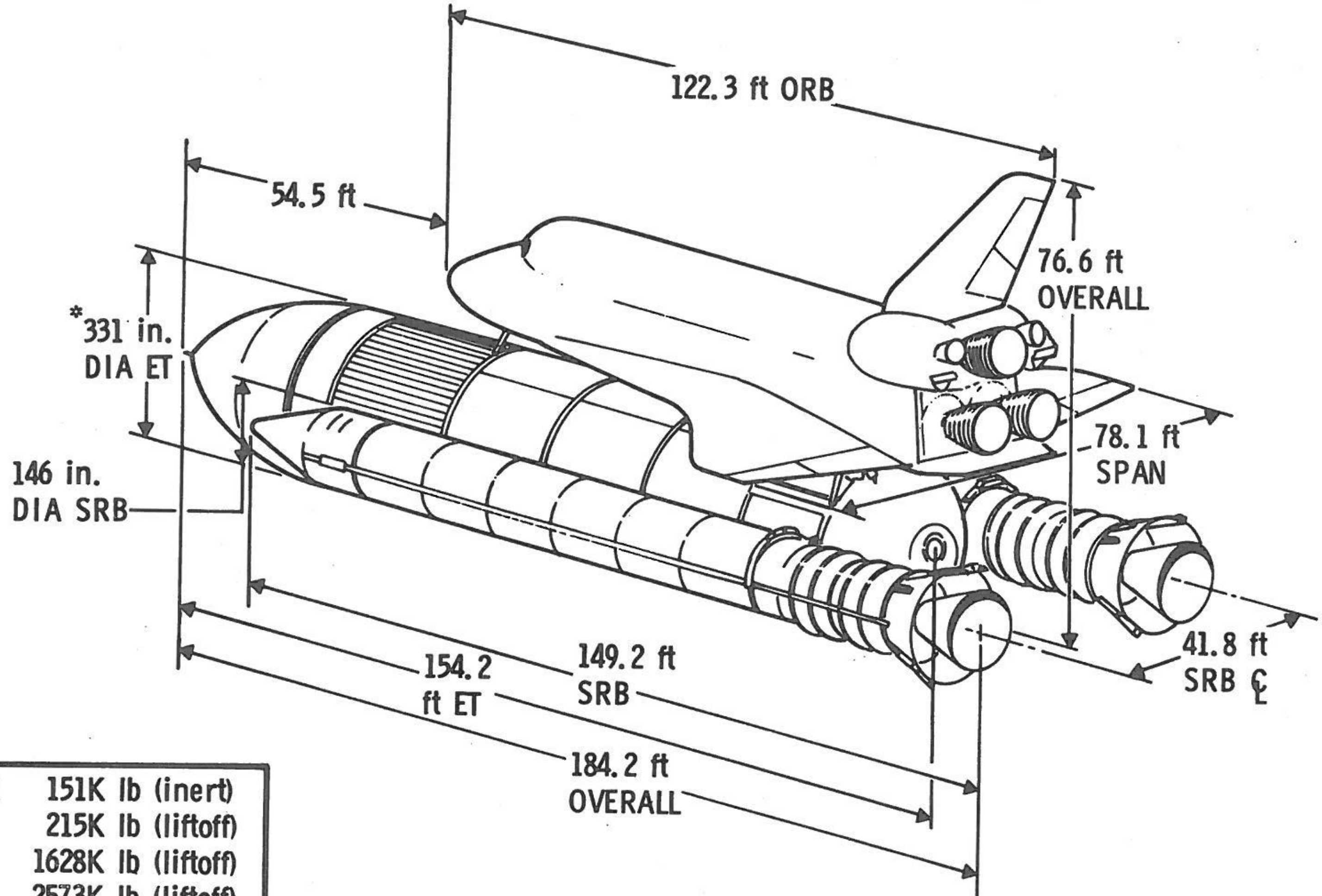


Figure 1. Launch Azimuths and Orbital Inclinations



ORBITER	151K lb (inert)	
	215K lb (liftoff)	
ET	1628K lb (liftoff)	
SRB	2573K lb (liftoff)	
GROSS LIFTOFF WEIGHT = 4416K lb		

*Less External Insulation

Figure 2. Space Shuttle Vehicle

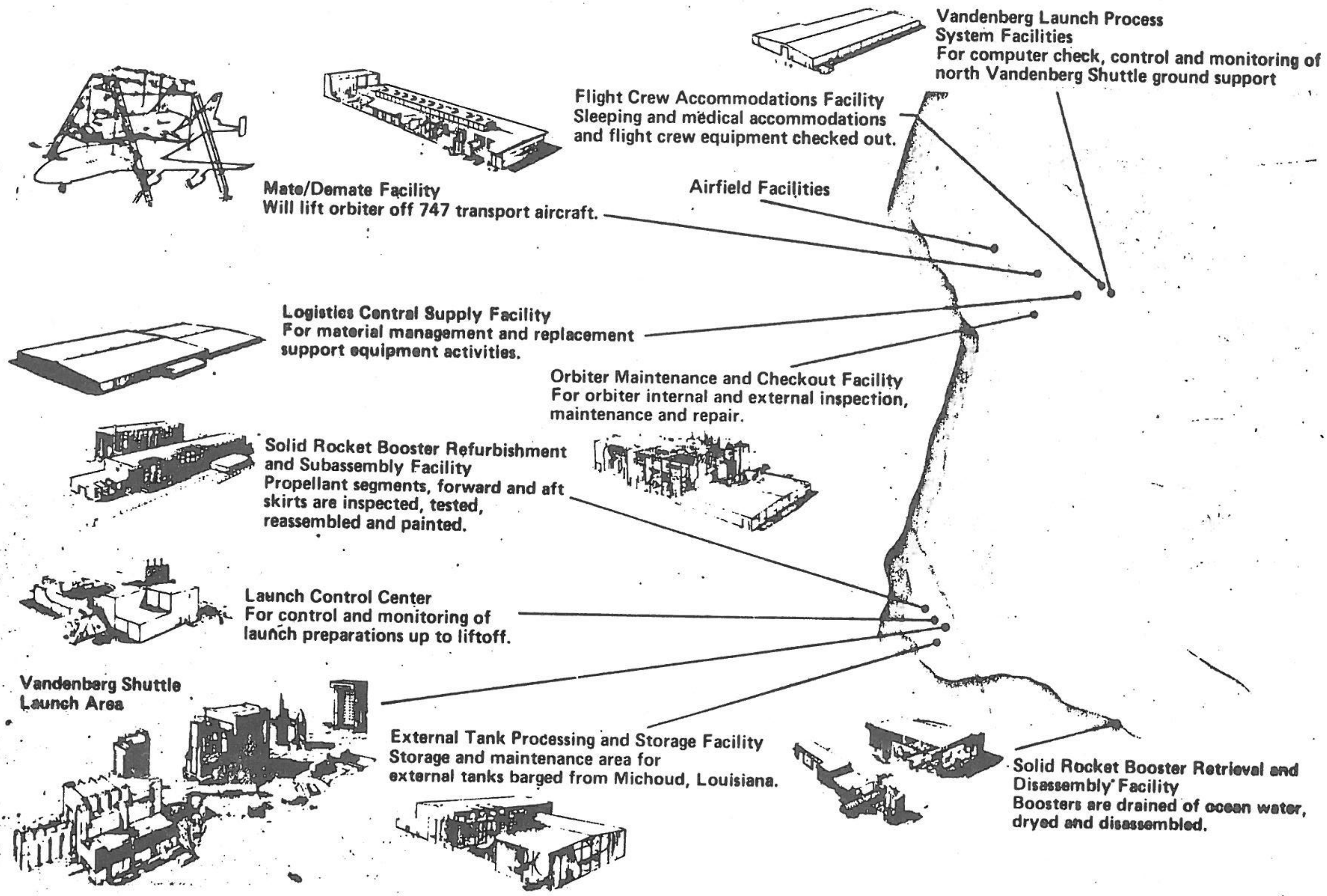


Figure 3. Vandenberg Station Set Geographic Locations

VANDENBERG SPACE SHUTTLE OPERATIONS FLOW

0 ELEMENTS BUILD UP ON LAUNCH PAD

/INTEGRATE, CHECKOUT & LAUNCH

0 PAYLOAD OPERATIONS - PAYLOAD PREPARATION ROOM (PPR)

/ CHECKOUT IN THE PPR

/ VERTICAL INSTALLATION

0 PAYLOAD OPERATIONS - ORBITER MAINTENANCE & CHECKOUT FACILITY (OMCF)

/ SPACELAB INSTALLATION

/ PAYLOAD REMOVAL & DESERVICING

0 FACILITIES OPTIMIZED TO UTILIZE RESOURCES AT NASA LOCATIONS

/ PARACHUTE PROCESSING

/ HYPERGOLIC PROCESSING

/ SRB PROCESSING

/ ORBITER PROCESSING FOR FIRST THREE VLS LAUNCHES

0 ELEMENT DELIVERY MODE

/ SRB COMPONENTS - RAIL & C5A

/ EXTERNAL TANK - BARGE

/ ORBITER - AIR FERRY ATOP 747

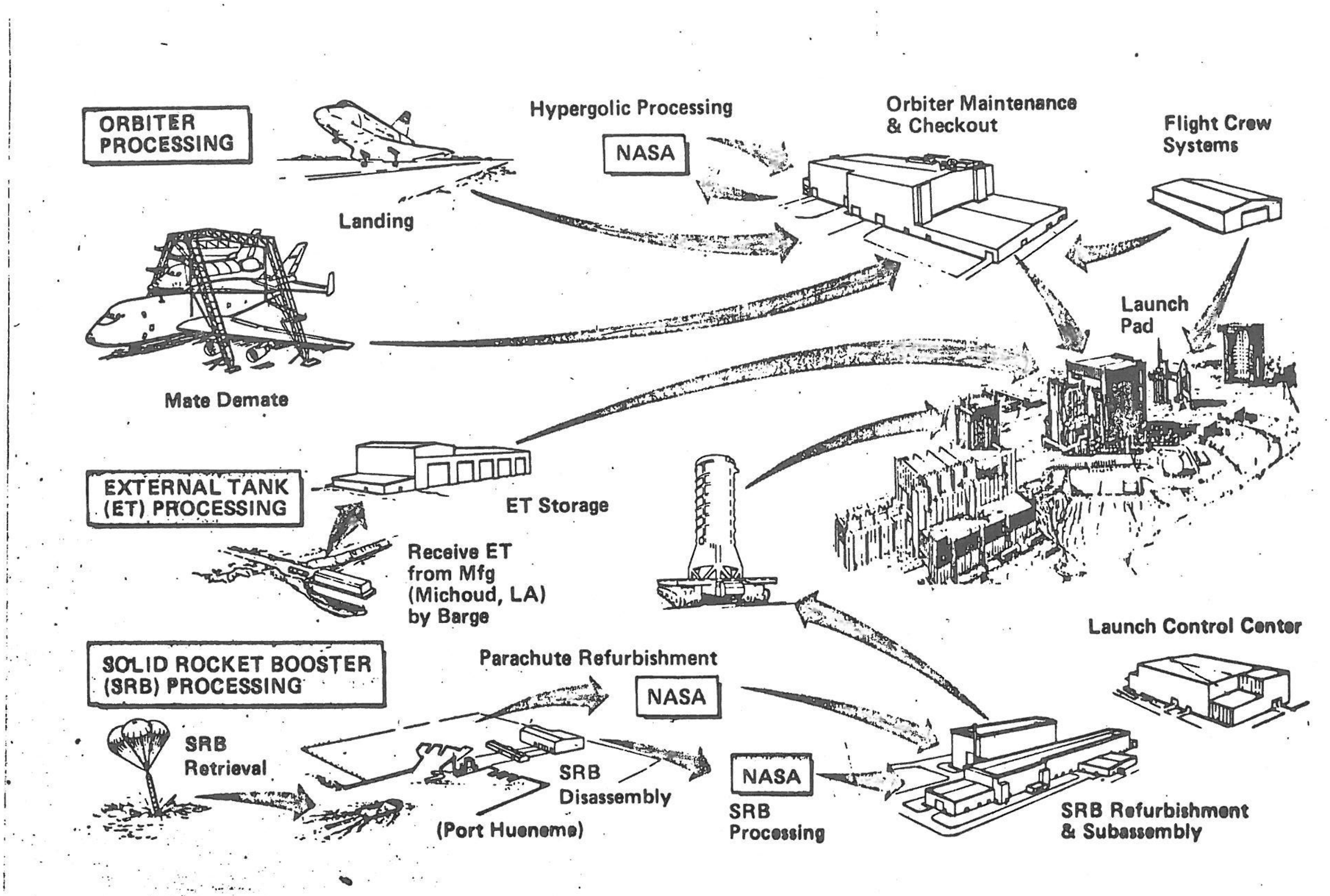


Figure 4. Vandenberg Space Shuttle Operations Flow

NORTH VANDENBERG AIR FORCE BASE

0 MATE/DEMATE

/ UNIQUE DESIGN

/ MATE/DEMATE ORBITER TO/FROM SHUTTLE CARRIER AIRCRFT MODIFIED 747

0 LANDING FACILITY

/ 15,000 FOOT RUNWAY WITH NAVIGATIONAL AIDS

/ POST LANDING OPERATIONS

o UPON COMPLETION OF LANDING ROLLOUT THE ORBITER IS MET BY A CONVOY OF SERVICING VEHICLES

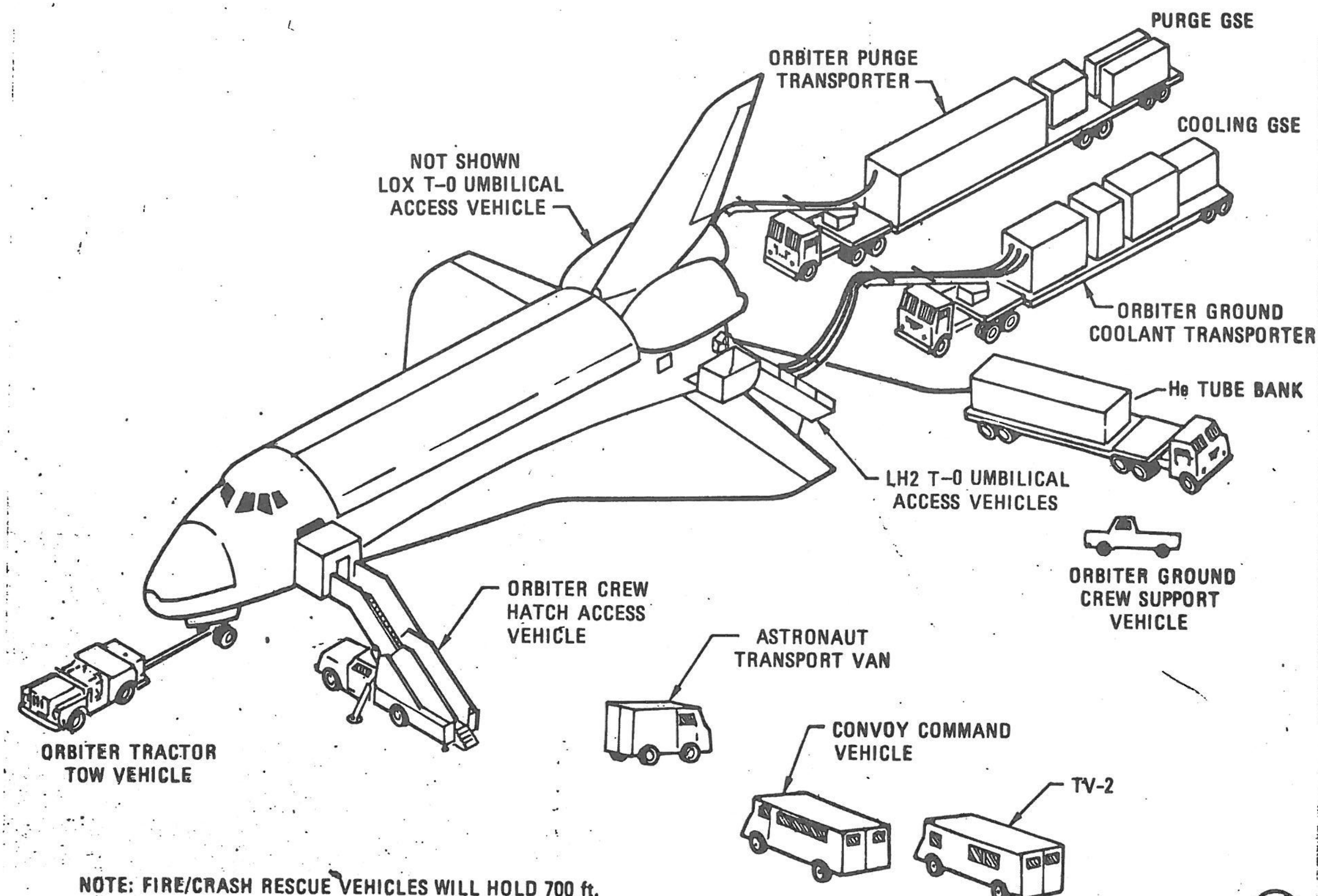
o ORBITER INSPECTION

o EGRESS FLIGHT CREW AND HOOKUP ORBITER SERVICING CONVOY

o TOW ORBITER TO OMCF

0 HYPERGOLIC MAINTENANCE AND CHECKOUT FACILITY

/ ACTIVATION HAS BEEN DEFERRED



NOTE: FIRE/CRASH RESCUE VEHICLES WILL HOLD 700 ft. FROM ORBITER UNLESS OTHERWISE SPECIFIED

Figure 5. Orbiter Servicing Convoy

NORTH VANDENBERG AIR FORCE BASE

- ORBITER MAINTENANCE & CHECKOUT FACILITY (OMCF)
  - HIGH BAY HANGAR-TYPE AREA
  - MULTI-LEVEL STEEL ACCESS PLATFORM
  - MEZZANINE AND ENVIRONMENTAL ENCLOSURE - CLASS 100,000
  - HAZARDOUS VAPOR DETECTION SYSTEMS
  - 60 TON BRIDGE CRANE WITH TWO 37.5 TON TROLLEY HOISTS FOR PAYLOAD HANDLING
  - ONE 10 TON BRIDGE CRANE, ONE 15 TON BRIDGE CRANE FOR MODULE HANDLING
  - LOW BAY STORAGE & OPERATIONAL SUPPORT AREA
  - HARDENED CLASS 100,000 HIGH BAY PAYLOAD DESERVICING AREA
  - PERFORM ORBITER LIMITED MAINTENANCE & CHECKS
  - REFURBISH THERMAL PROTECTION SYSTEMS
  - PAYLOAD REMOVAL & DESERVICING, SPACELAB INSTALLATION
  - INSTALL AND REMOVE MISSION EQUIPMENT KITS
  - INSTALL AND REMOVE HYPERGOLIC MODULES & COMPONENTS
  - ORBITER PREPARATIONS AND TRANSPORT TO LAUNCH PAD

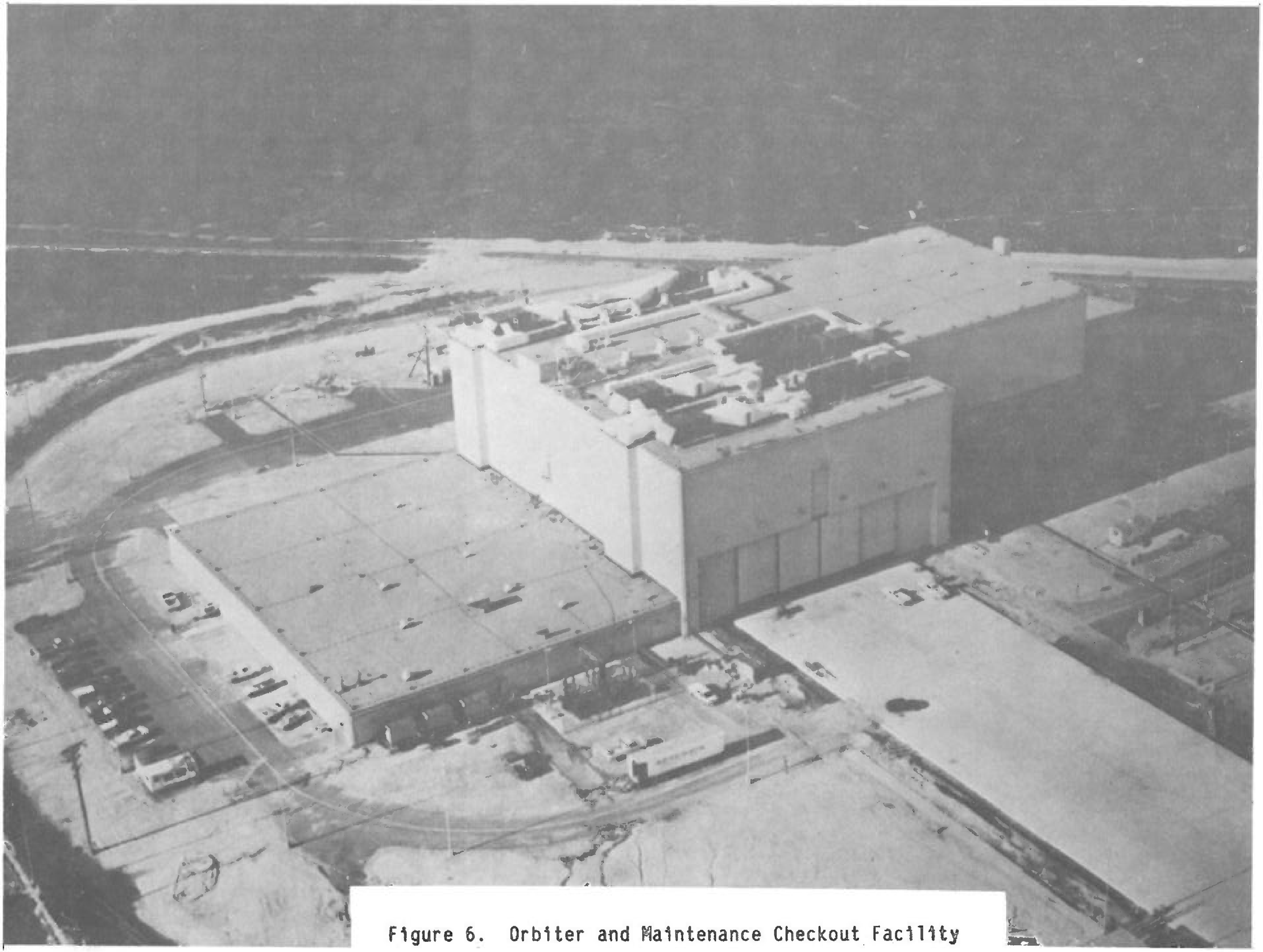


Figure 6. Orbiter and Maintenance Checkout Facility

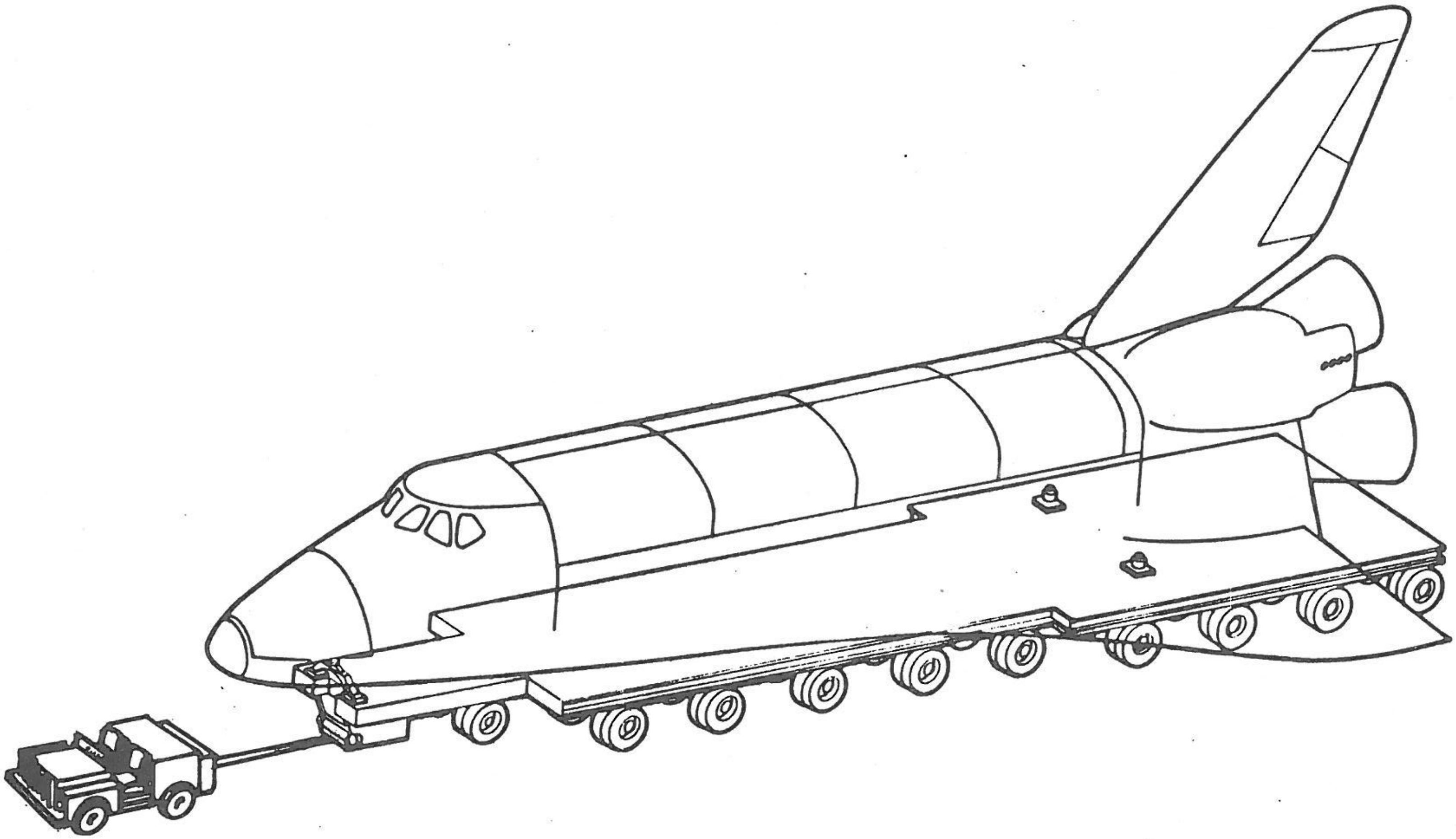


Figure 7. Orbiter on Transporter

NORTH VANDENBERG AIR FORCE BASE

0 VANDENBERG LAUNCH PROCESSING SYSTEM (VLPS) BUILDING 8510

/ NORTH VLPS CONTROL CENTER

/ CHECKOUT, CONTROL AND MONITOR SUBSYSTEM - MOD COMP II

/ CENTRAL DATA SUBSYSTEM - HONEYWELL 66/80

/ RECORD AND PLAYBACK SUBSYSTEM

/ SOFTWARE DEVELOPMENT

/ CHECKOUT, CONTROL AND MONITOR NVAFB OPERATIONS

/ DATA BASE ADMINISTRATION

/ TEST DATA ANALYSIS

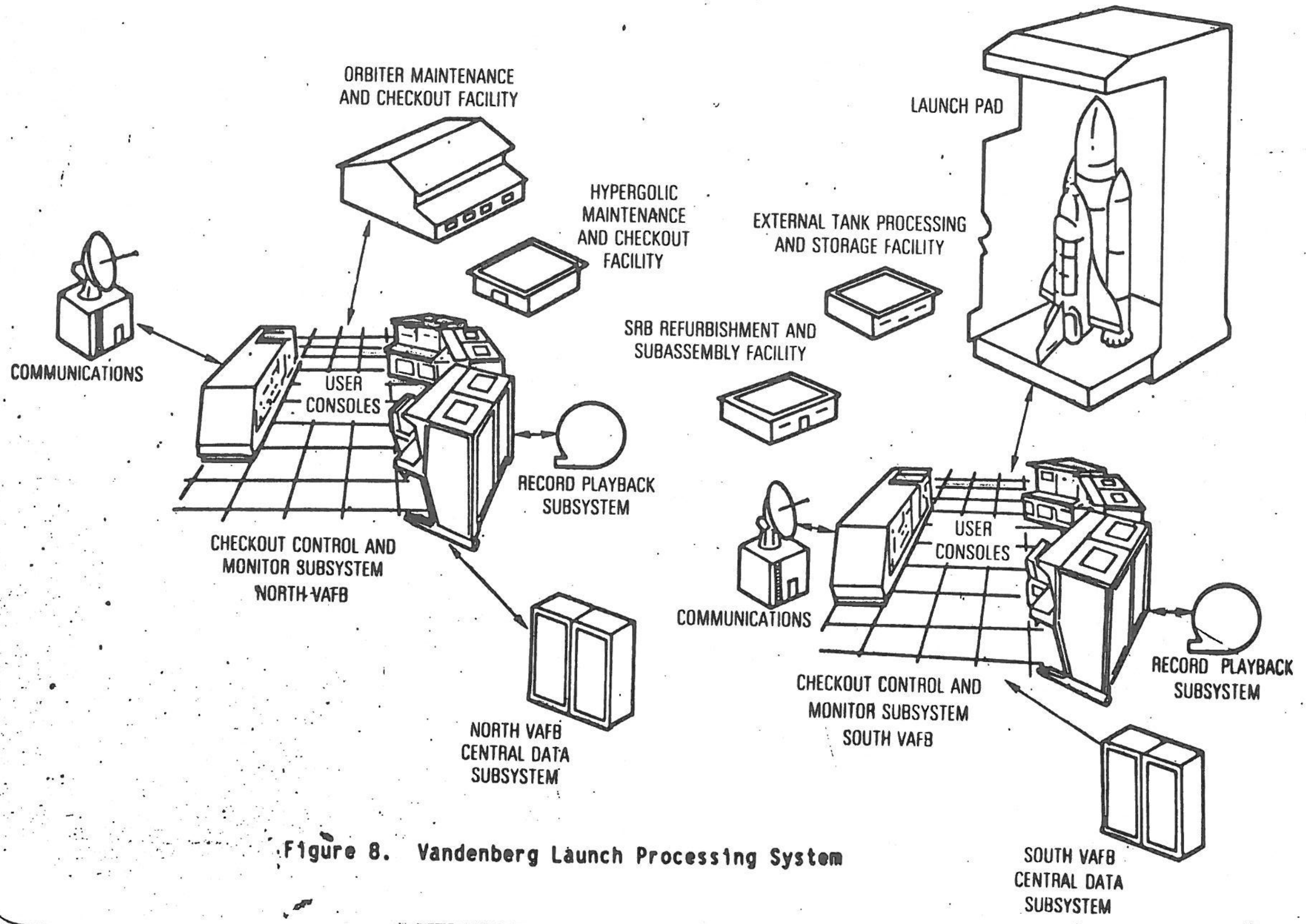


Figure 8. Vandenberg Launch Processing System

NORTH VANDENBERG AIR FORCE BASE

0 FLIGHT CREW SYSTEMS FACILITY

/ EXISTING BUILDING 8505 FOR FLIGHT CREW ACCOMMODATIONS

/ PROVIDES LIVING QUARTERS, COMMODITIES AND OTHER CREW ACCOMMODATIONS TO SUPPORT CREW TRAINING AND MISSION BRIEFINGS/DEBRIEFINGS

/ EXISTING BUILDING 6710 FOR FLIGHT CREW EQUIPMENT

0 TRANSPORTATION STATION SET

/ ROADS AND SUPPORT EQUIPMENT, I.E., RUBBER-TIRE TRANSPORTERS, ETC.

/ PROVIDES THE TRANSPORTATON ROUTE FROM NVAFB TO SVAFB AND BETWEEN STATION SETS

0 LOGISTICS FACILITY

/ CENTRAL SUPPLY FACILITY - 191,300 SQUARE FEET

/ INVENTORY CONTROL, ACQUISITION, STORAGE AND DELIVERY OF EQUIPMENT, SPARES, REPAIRABLES, MATERIALS AND CONSUMABLES

/ MANAGEMENT OF WORK CONTROL SYSTEMS AND MAINTENANCE DOCUMENTATION

16

SOUTH VANDENBERG AIR FORCE BASE

O EXTERNAL TANK PROCESSING AND STORAGE FACILITY

/ HIGH BAY CHECKOUT CELL

/ FOUR STORAGE CELLS

/ LOW BAY ADMINISTRATIVE, STORAGE AND EQUIPMENT AREA

/ RECEIVE ET BARGES FROM MICHOUD AT SVAFB DOCKING FACILITY

/ RANGE SAFETY SYSTEM COMPONENTS INSTALLATION AND SYSTEM CHECKOUT

/ ET FALLS BALLISTICALLY INTO THE SOUTH PACIFIC OR INDIAN OCEAN, DEPENDING ON MISSION

/ NO ATTEMPT IS MADE TO RECOVER ET

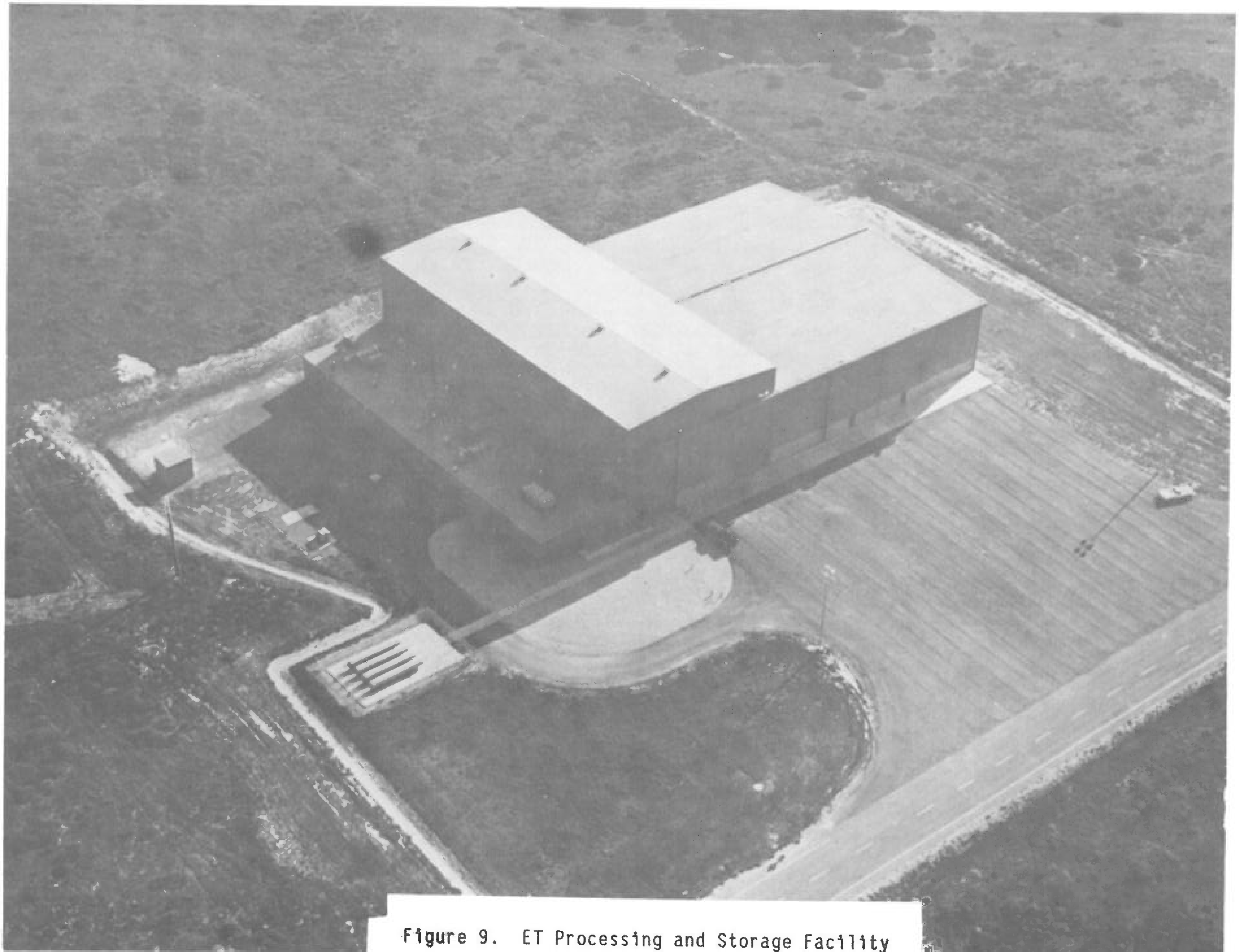


Figure 9. ET Processing and Storage Facility

SOUTH VANDENBERG AIR FORCE BASE

- O SRB REFURBISHMENT AND SUBASSEMBLY FACILITY
  - / HIGH BAY MAJOR ASSEMBLY BUILDUP AND STORAGE AREA
    - o 200 TON BRIDGE CRANE
    - o 125 TON FIXED HOIST
  - / STORAGE AND SUPPORT AREA
  - / LOW BAY AND RECEIVING/INSPECTION, ASSEMBLY AREA
    - o TWO 15 TON BRIDGE CRANES
  - / ADMINISTRATIVE/SUPPORT AREA
  - / RECEIVE, INSPECT, SOME CHECKOUT AND STORE MAJOR SRB COMPONENTS
  - / MATE AFT SKIRT ASSEMBLY/NOZZLE EXTENSION WITH AFT SRM SEGMENT
  - / AFT AND FORWARD ASSEMBLY ELECTRICAL SYSTEM CHECKOUT

19

SOUTH VANDENBERG AIR FORCE BASE

0 LAUNCH CONTROL CENTER

/ EXISTING TWO LEVEL REINFORCED CONCRETE BLOCKHOUSE

/ HOUSE THE VANDENBERG LAUNCH PROCESSING SYSTEMS

/ CHECKOUT, CONTROL AND MONITOR: SPACE SHUTTLE VEHICLE
SUPPORT EQUIPMENT
LAUNCH PAD FACILITIES

/ CLOSED CIRCUIT TV MONITORING

/ COMMUNICATIONS

/ RECORD AND PLAYBACK

/ TIMING AND COUNTDOWN SYSTEM

/ ORBITER COMMUNICATIONS AND TRACKING SYSTEMS

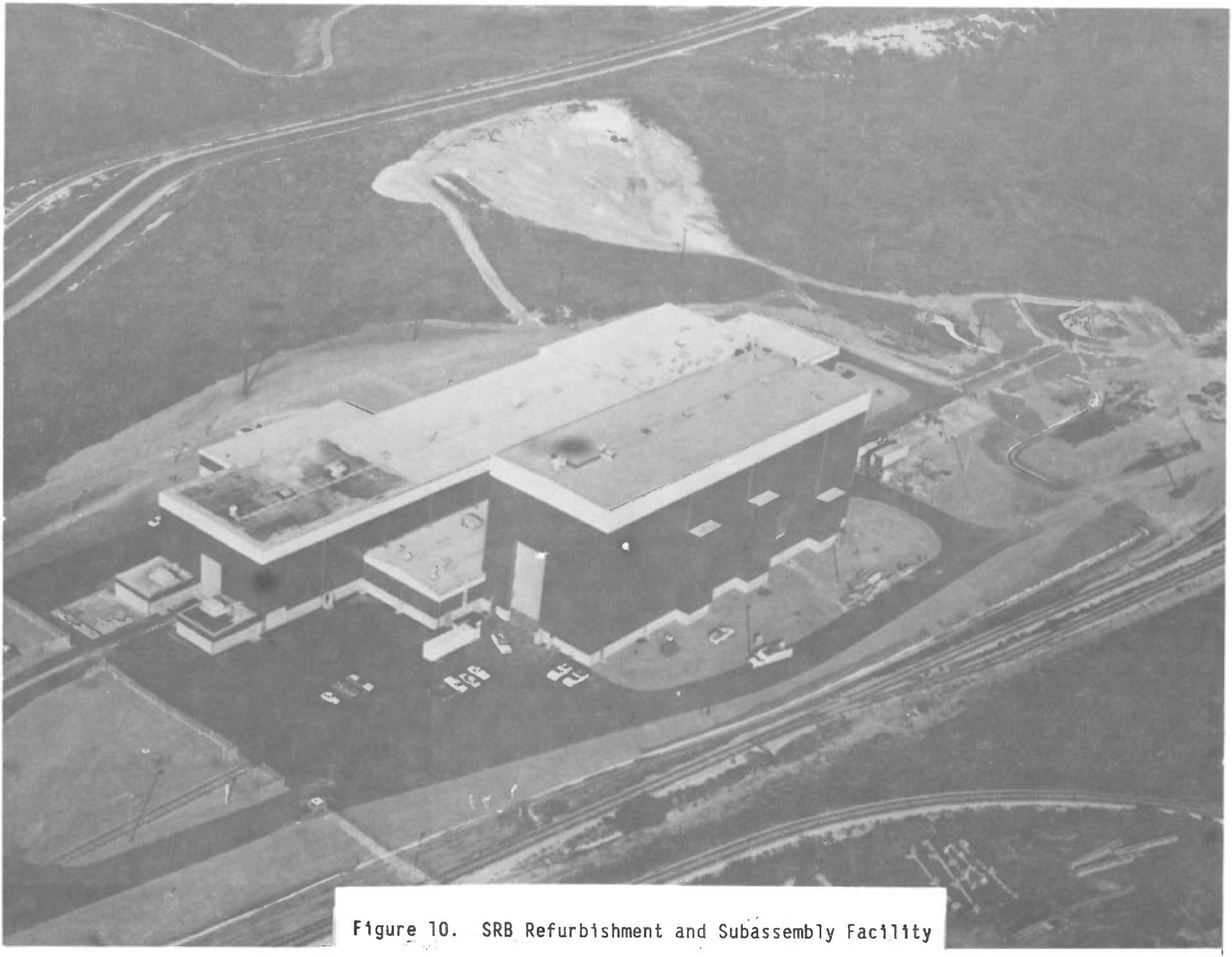


Figure 10. SRB Refurbishment and Subassembly Facility

SOUTH VANDENBERG AIR FORCE BASE

0 LAUNCH PAD

- / PAYLOAD PREPARATION ROOM
- / PAYLOAD CHANGEOUT ROOM
- / SHUTTLE ASSEMBLY BUILDING
- / LAUNCH MOUNT
- / ACCESS TOWER
- / MOBILE SERVICE TOWER
- / SUPPORT EQUIPMENT BUILDING
- / EMERGENCY EGRESS SYSTEM
- / STORAGE AREAS FOR CRYOGENIC AND HYPERGOLIC PROPELLANTS AND GASES
- / ICE SUPPRESSION SYSTEM

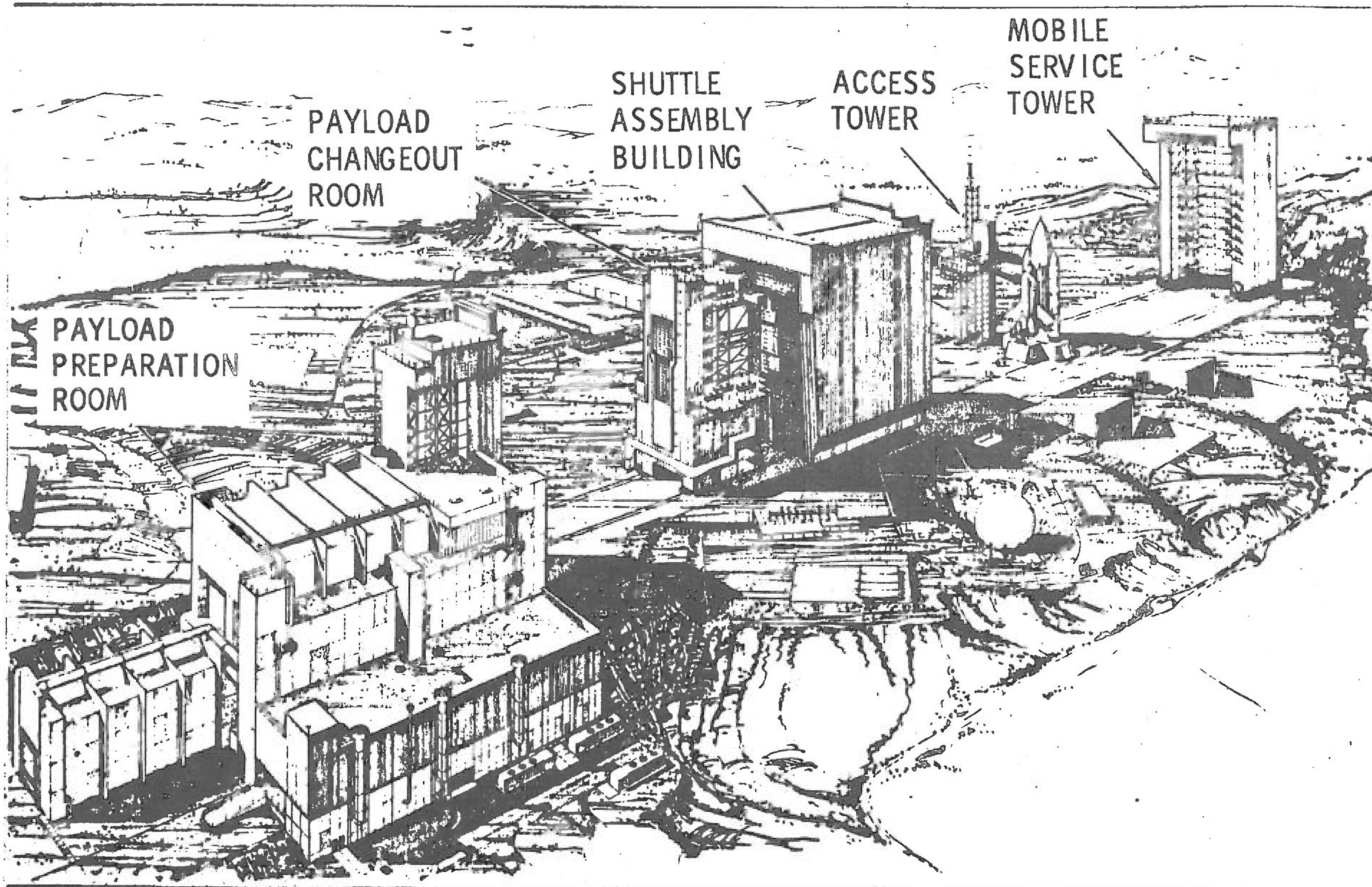


Figure 11. Launch Pad

SOUTH VANDENBERG AIR FORCE BASE

- O LAUNCH PAD (CONT'D)
  - / SSV BUILDUP CYCLE
    - o MST IS ROLLED FORWARD TO THE LAUNCH MOUNT
  - / SRM STACKING
    - o SRM SEGMENTS ARRIVE AT THE LAUNCH PAD ON SELF-PROPELLED RUBBER-TIRED TRANSPORTERS
    - o AFTER PREPS, THE FIRST AFT BOOSTER ASSEMBLY IS HOISTED FROM ITS TRANSPORTER AND STACKED USING THE MST BRIDGE CRANE
    - o SECOND SRB AFT BOOSTER ASSEMBLY IS SIMILARLY STACKED AND ALIGNMENT VERIFIED
    - o CENTER SEGMENTS, FORWARD SEGMENTS AND FORWARD ASSEMBLIES ALL ALTERNATELY STACKED AND JOINTS LEAK CHECKED
    - o ADDITIONAL ALIGNMENT CHECKS
    - o DESTRUCT ORDNANCE INSTALLED AND IN SAFED CONDITION
    - o SRB TUNNEL CABLES VERIFIED, TUNNEL COVERS AND INTERFACE HARDWARE INSTALLED
    - o READY FOR ET MATING

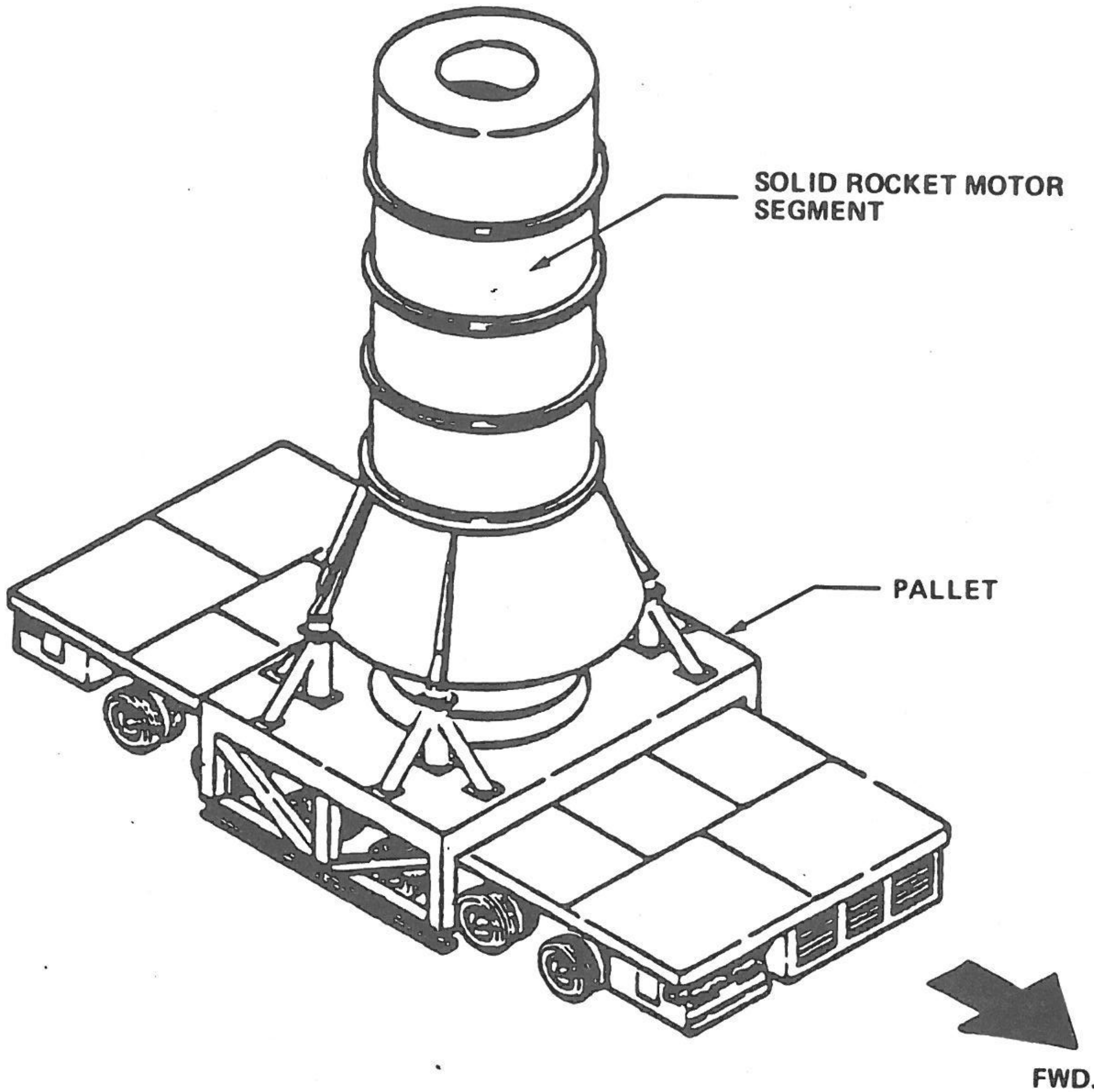


Figure 12. Solid Rocket Motor Transporter

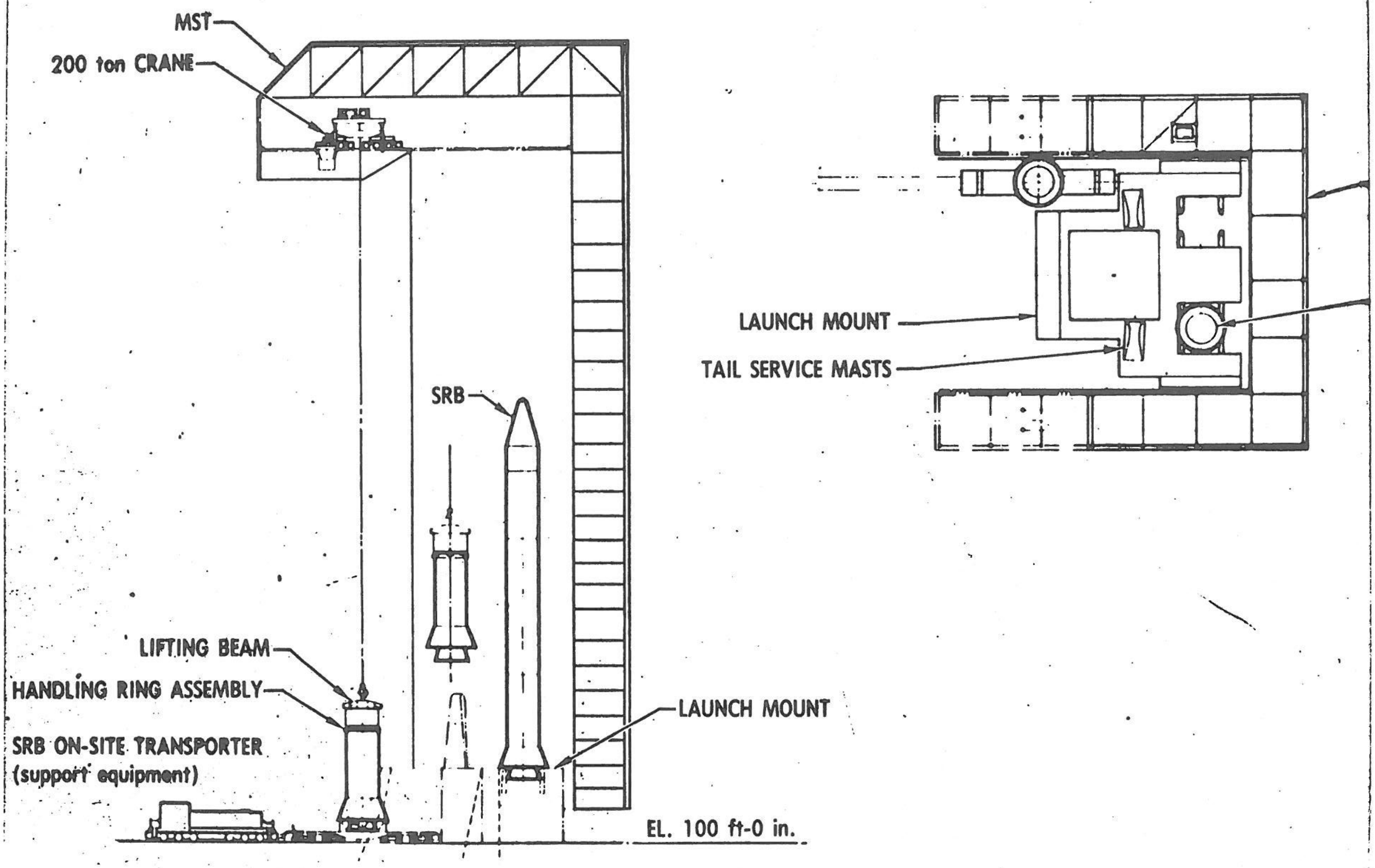


Figure 13. SRB Stacking And Alignment

SOUTH VANDENBERG AIR FORCE BASE

O LAUNCH PAD (CONT'D)

/ ET ERECTION AND MATING

- o THE SAB IS ROLLED FORWARD TO THE LAUNCH MOUNT AND MATED WITH MST TO SEAL OFF THE LAUNCH PAD AND PROVIDE A BENIGN ENVIRONMENT - SIMILAR TO KSC/VAB
- o TOW ET ON TRANSPORTER TO PAD
- o ET IS LIFTED CLEAR OF THE TRANSPORTER
- o ROTATED TO THE VERTICAL POSITION AND STABILIZED USING MST AND SAB CRANES
- o MATED TO THE SRB

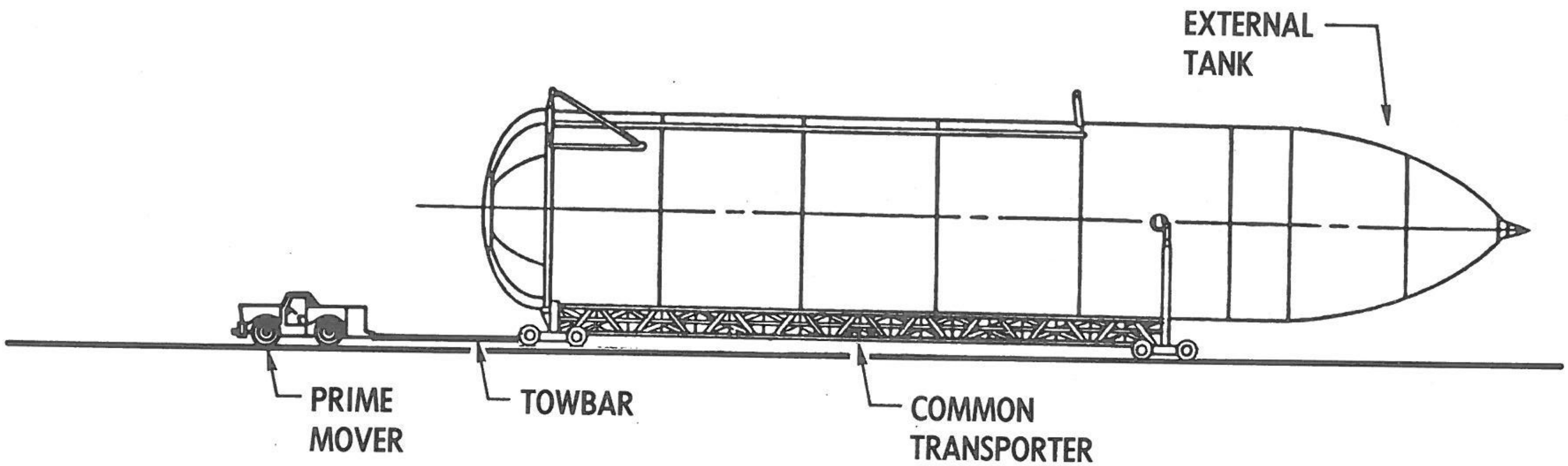


Figure 14. ET on Transporter

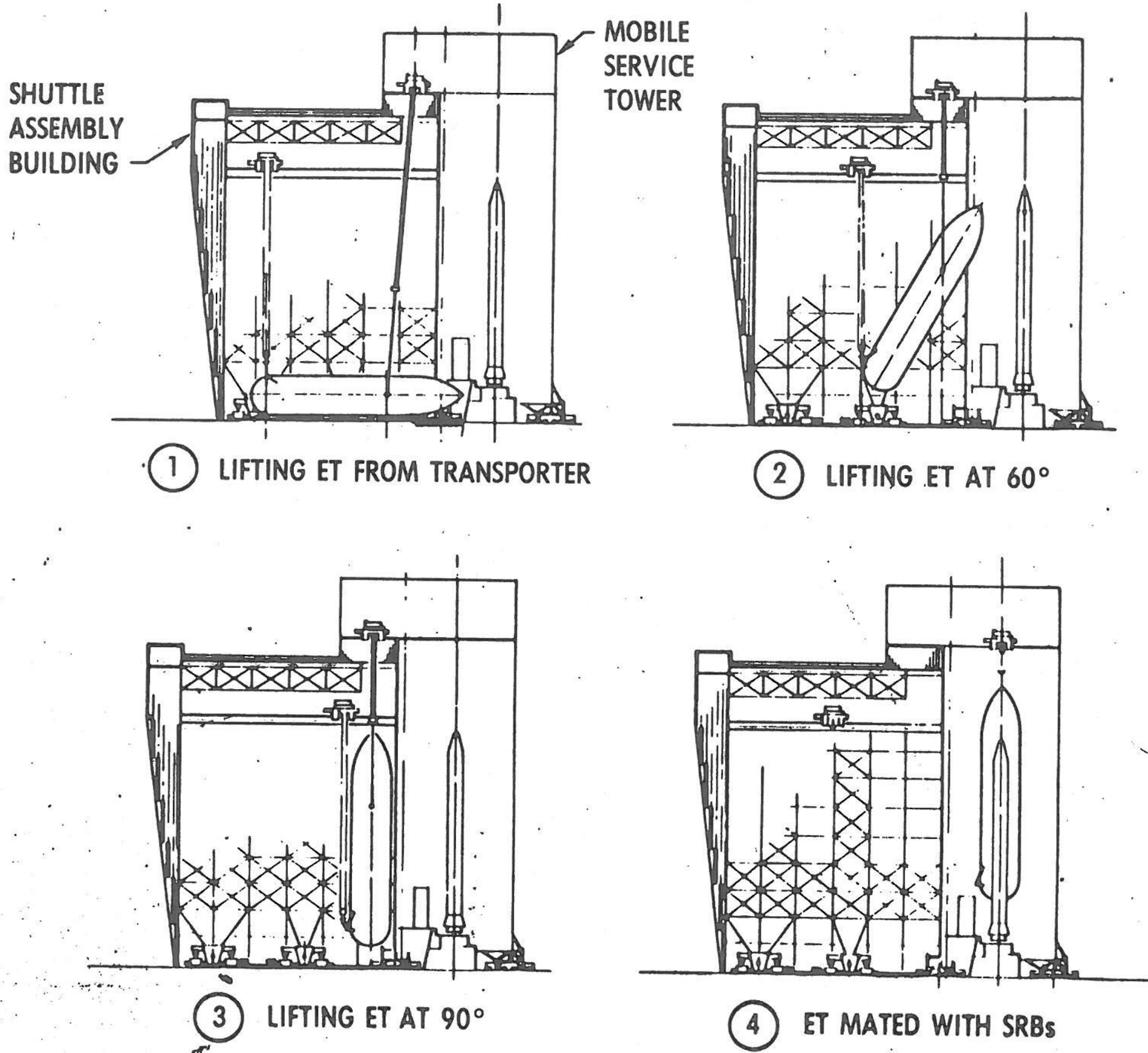


Figure 15. ET Erection and Mating

4

SOUTH VANDENBERG AIR FORCE BASE

O LAUNCH PAD (CONT'D)

/ ORBITER ERECTION AND MATING

- o ORBITER IS TRANSPORTED 17 MILES FROM OMCF TO THE LAUNCH PAD ON RUBBER-TIRED TRANSPORTER
- o ORBITER IS LIFTED CLEAR OF THE TRANSPORTER BY MST AND SAB CRANES
- o ROTATED TO THE VERTICAL AND STABILIZED
- o MATED TO THE ET
- o ALL INTERFACES ARE VERIFIED
- o ENVIRONMENTAL CONDITIONING AND GROUND POWER APPLIED TO SSV
- o SHUTTLE INTERFACE TEST IS PERFORMED
- o FINAL ORDNANCE INSTALLATION, CONNECTIONS AND VERIFICATION NOW READY
- o SAB ROLLED BACK PRIOR TO START OF HAZARDOUS SERVICING
- o PAD CLEAR OF NON-ESSENTIAL PERSONNEL
- o REMOTELY CONTROLLED BY THE VLPS
- o AFT RCS, FORWARD RCS AND OMS HYPERGOLS ARE LOADED
- o HELIUM BOTTLES ARE LOADED AND PRESSURIZED
- o GROUND CREW RETURN AFTER HAZARDOUS SERVICING COMPLETE

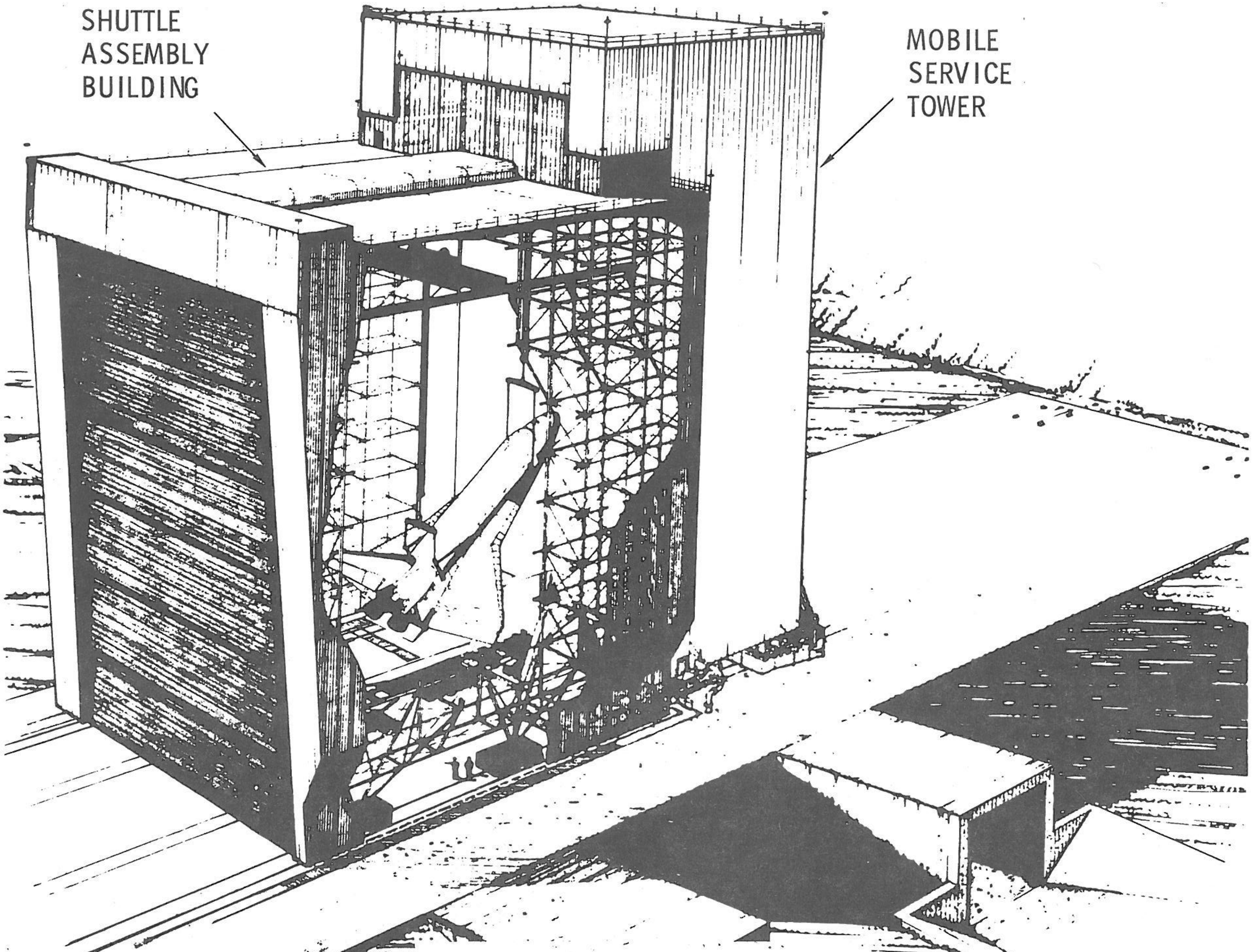


Figure 16. Orbiter Erection and Mating

SOUTH VANDENBERG AIR FORCE BASE

O LAUNCH PAD (CONT'D)

/ PAYLOAD INSTALLATION

- o PAYLOAD PREPARATION ROOM CONSISTS OF THREE CHECKOUT CELLS, ERECTION ROOM, AIRLOCK AND TRANSFER TOWER
- o ONLY TWO CELLS WILL BE ACTIVATED DURING THE EARLY YEARS
- o PAYLOAD ENTERS PPR THROUGH AIRLOCK, MOVES INTO ERECTION ROOM, LIFTED CLEAR OF TRANSPORTER BY OVERHEAD CRANES, ROTATED TO VERTICAL AND TRANSFERRED TO CHECKOUT CELL
- o WHILE IN THE CELL THE PAYLOAD IS INTEGRATED, TESTED, AND ORDNANCE INSTALLED - FUEL LOADING IF REQUIRED
- o OVERHEAD CRANE TRANSFERS THE COMPLETED CARGO INCLUDING STRONGBACK TO TRANSFER TOWER
- o TRANSFER TOWER TRANSFERS PAYLOAD FROM STRONGBACK TO PGHM
- o PGHM TRANSLATES THE CARGO FROM PPR TO PCR USING OVERHEAD RAILS
- o PCR ROLLS UP TO THE ORBITER ON THE LAUNCH MOUNT
- o CARGO INSTALLATION INTO THE ORBITER BAY USING PGHM

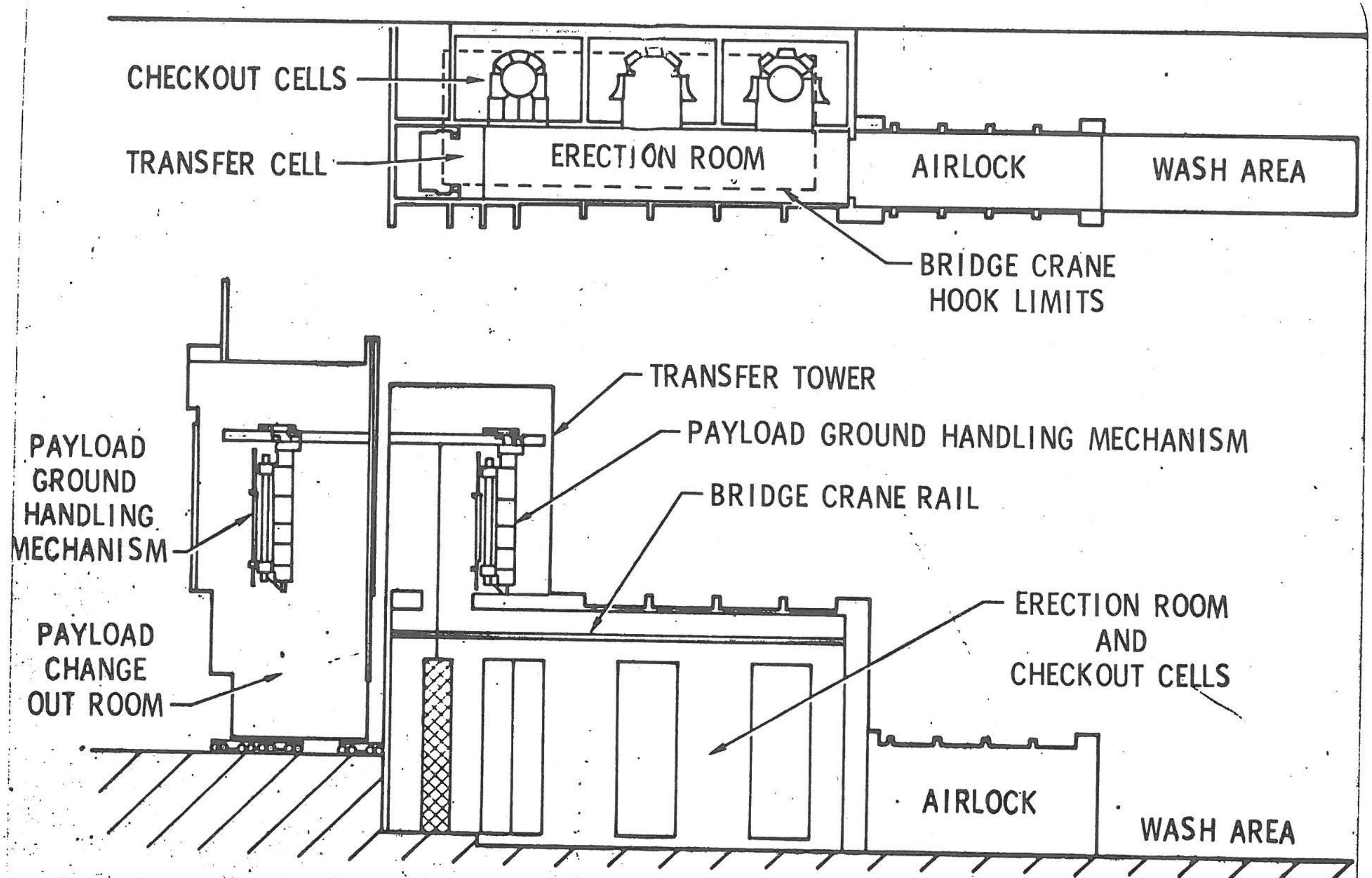


Figure 17. Payload Preparation Room

SOUTH VANDENBERG AIR FORCE BASE

O LAUNCH PAD (CONT'D)

/ COUNTDOWN AND LAUNCH

- O PRECOUNT OPERATIONS
- O SRB FLIGHT BATTERIES AND FINAL ORDNANCE INSTALLED
- O MST AND PCR ROLLBACK
- O UPON COMPLETION OF PRECOUNT OPERATIONS THE SSV CAN PROCEED INTO LAUNCH COUNTDOWN OR PLACED IN A STANDBY STATUS UP TO 24 HOURS
- O COUNTDOWN IS ENTIRELY CONTROLLED BY VLPS EXCEPT FOR FINAL SECONDS WHEN IT IS CONTROLLED BY ON-BOARD COMPUTERS
- O AT T-12 HOURS ET CRYOGENIC LOADING STARTS WITH CHILL-DOWN, SLOW FILL, FAST FILL AND A FINAL SLOW FILL
- O FLIGHT CREW INGRESS
- O TERMINAL COUNTDOWN
- O MAIN ENGINE START
- O SRB IGNITED
- O LIFT OFF

SOUTH VANDENBERG AIR FORCE BASE

O LAUNCH PAD (CONT'D)

/ LAUNCH PAD REFURBISHMENT, RECONFIGURED AND FACILITY RESUPPLY

- o GROUND SYSTEMS DEACTIVATED AND SECURED
- o SAFETY INSPECTION
- o WASH DOWN MST AND ALL PAD STRUCTURES
- o ALL NON-REUSABLE ITEMS REMOVED AND REPLACED
- o MAKE READY FOR NEXT LAUNCH

Facility Verification Vehicle/Systems Test Vehicle (FVV/STV)

- THE FVV / STV WILL BE USED DURING ACTIVATION TESTING AND PRIOR TO RECEIPT OF THE FLIGHT ELEMENTS
- FVV CONSIST OF:
  - ENTERPRISE (Orbiter 101)
  - LIGHTWEIGHT EXTERNAL TANK
  - TWO INERT SOLID ROCKET BOOSTERS
- STV IS ESSENTIALLY A MECHANICAL PAYLOAD
- TEST OBJECTIVES
  - DEMONSTRATE ERECTION AND MATING OF THE ORBITER, EXTERNAL TANK AND SOLID ROCKET BOOSTERS AND PAYLOAD HANDLING
  - VERIFY OPERATIONAL AND HANDLING INTERFACES BETWEEN THE VARIOUS FACILITIES AND FVV / STV
  - VALIDATE OPERATIONAL PROCEDURES
  - GROUND CREW TRAINING

SOUTH VANDENBERG AIR FORCE BASE

- SRB RETRIEVAL AND DISASSEMBLY FACILITY
  - / LOCATED AT PORT HUENEME
  - / CONCRETE RETRIEVAL WHARF AND SLIP
  - / WASH BUILDING
    - o HYDROLASER CLEANING
    - o POTABLE AND DEIONIZED WATER
    - o SURFACTANT WASH AND RINSE
  - / DISASSEMBLY BUILDING
    - o 40 TON AND 16 TON CRANES
  - / WATER TREATMENT FACILITIES
    - o 20,000 GALLON DEIONIZED WATER SYSTEM
    - o 100,000 GALLON INDUSTRIAL WASTE SYSTEM
  - / INITIAL WASH AND DRAIN RECOVERED SRB
  - / DISASSEMBLE FORWARD AND AFT SKIRTS, FRUSTRUM, AND COMPONENTS
  - / FINAL WASH, DRY AND PRESERVE COMPONENTS
  - / RETURN EMPTY SRM TO MANUFACTURER TO BE REFURBISHED AND REFILLED
  - / SHIP FORWARD SKIRT, AFT SKIRT, PARACHUTES AND OTHER SRB COMPONENTS TO KSC FOR REFURBISHMENT

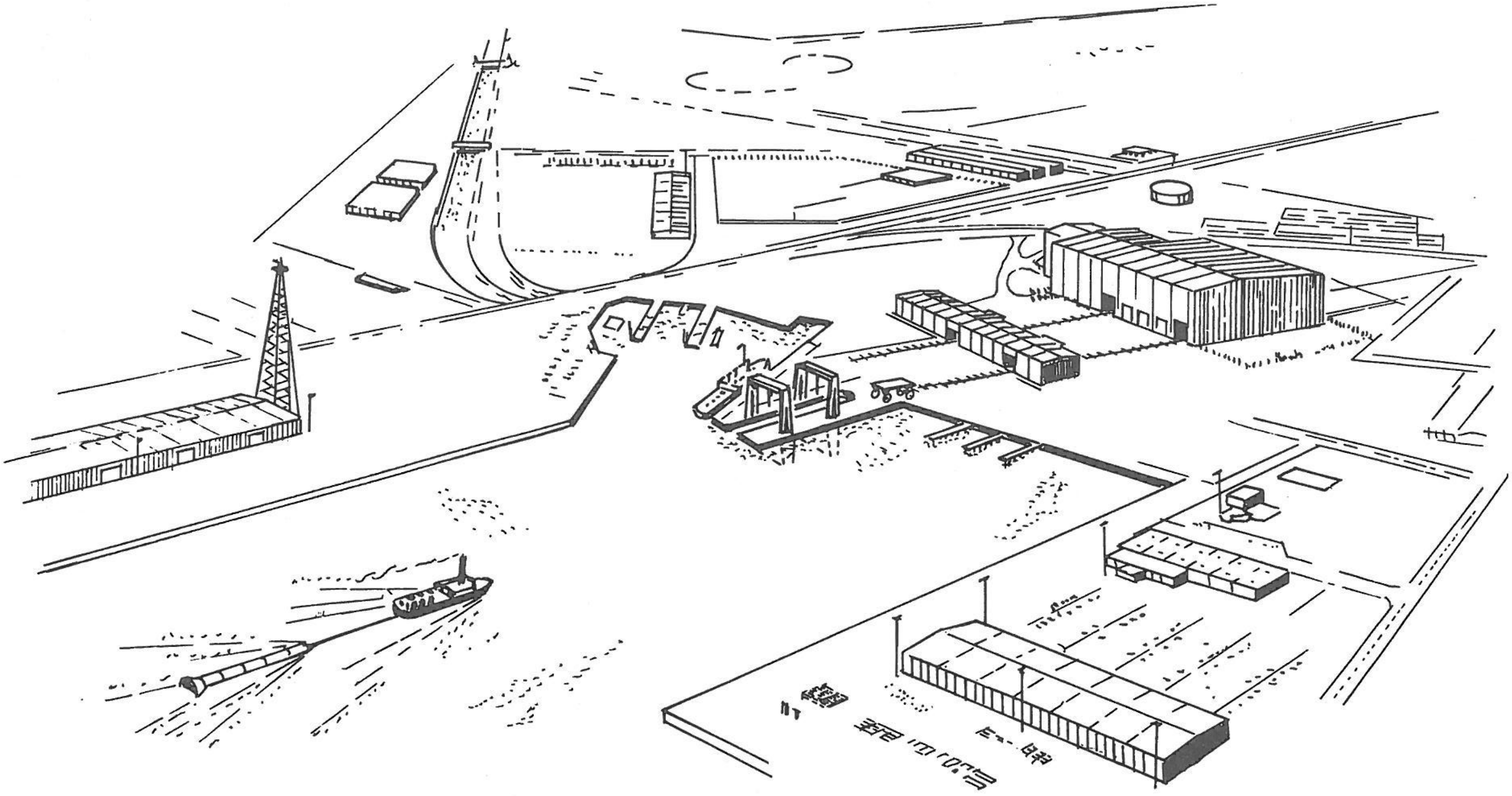


Figure 18. SRB Retrieval and Disassembly Facility - Port Hueneme Harbor

VLS ASSESSED TIMELINE

0 VLS SHUTTLE TURNAROUND ANALYSIS REPORT (VSTAR)

/ VLS ANALYTICAL STUDIES

/ KSC STAR

0 REVIEW ALL GROUND RULES THAT WERE USED IN THE ANALYSIS OF FIGURE 19 AND 20 (VSTAR 08).

0 CONTINUOUS EFFORT WILL BE DIRECTED TOWARDS REDUCING THE TURNAROUND TIME

0 ENHANCEMENT PROGRAM

/ REQUIREMENT CHANGES

/ REDESIGN

/ DESIGN CHANGES

/ ADDITIONAL OR NEW SUPPORT EQUIPMENT

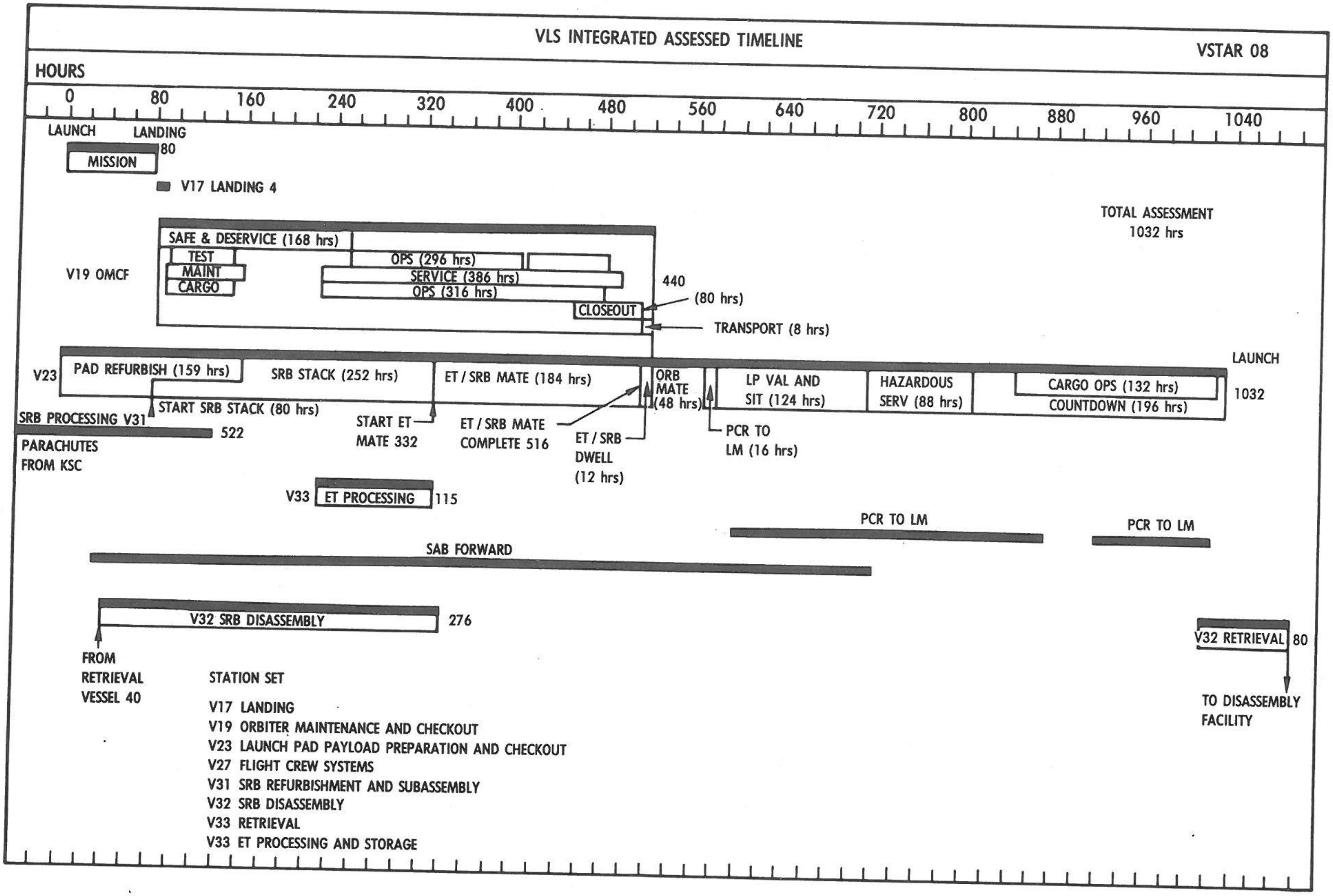


Figure 19. VLS Integrated Assessed Timeline

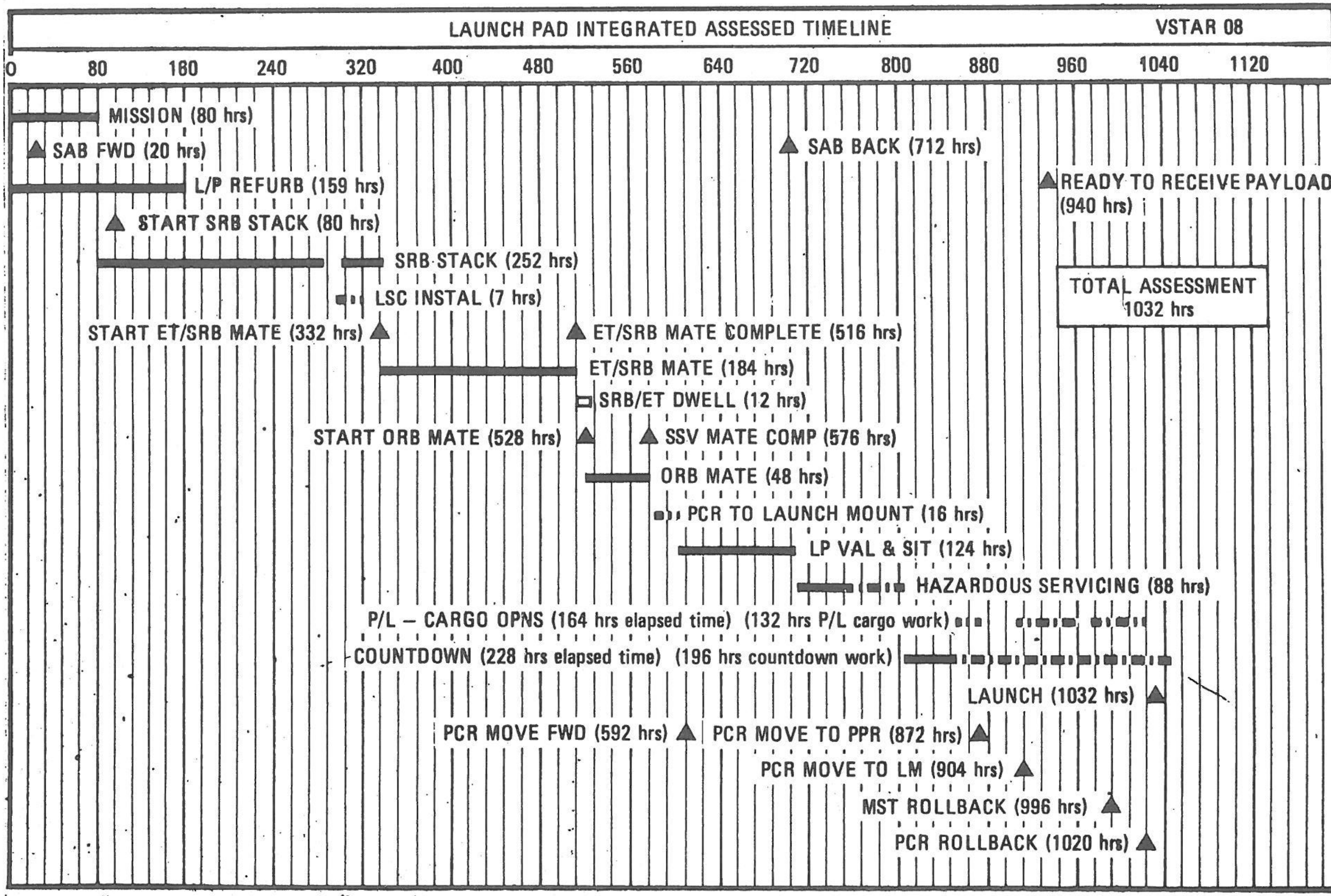


Figure 20. Launch Pad Integrated Assessed Timeline

VLS PROGRAM PLAN

- O ACTIVATION HAS BEEN UNDERWAY
- O FACILITIES COMPLETELY ACTIVATED
- O FACILITIES PARTIALLY ACTIVATED
- O VLS INITIAL LAUNCH CAPABILITY 15 OCTOBER 1985

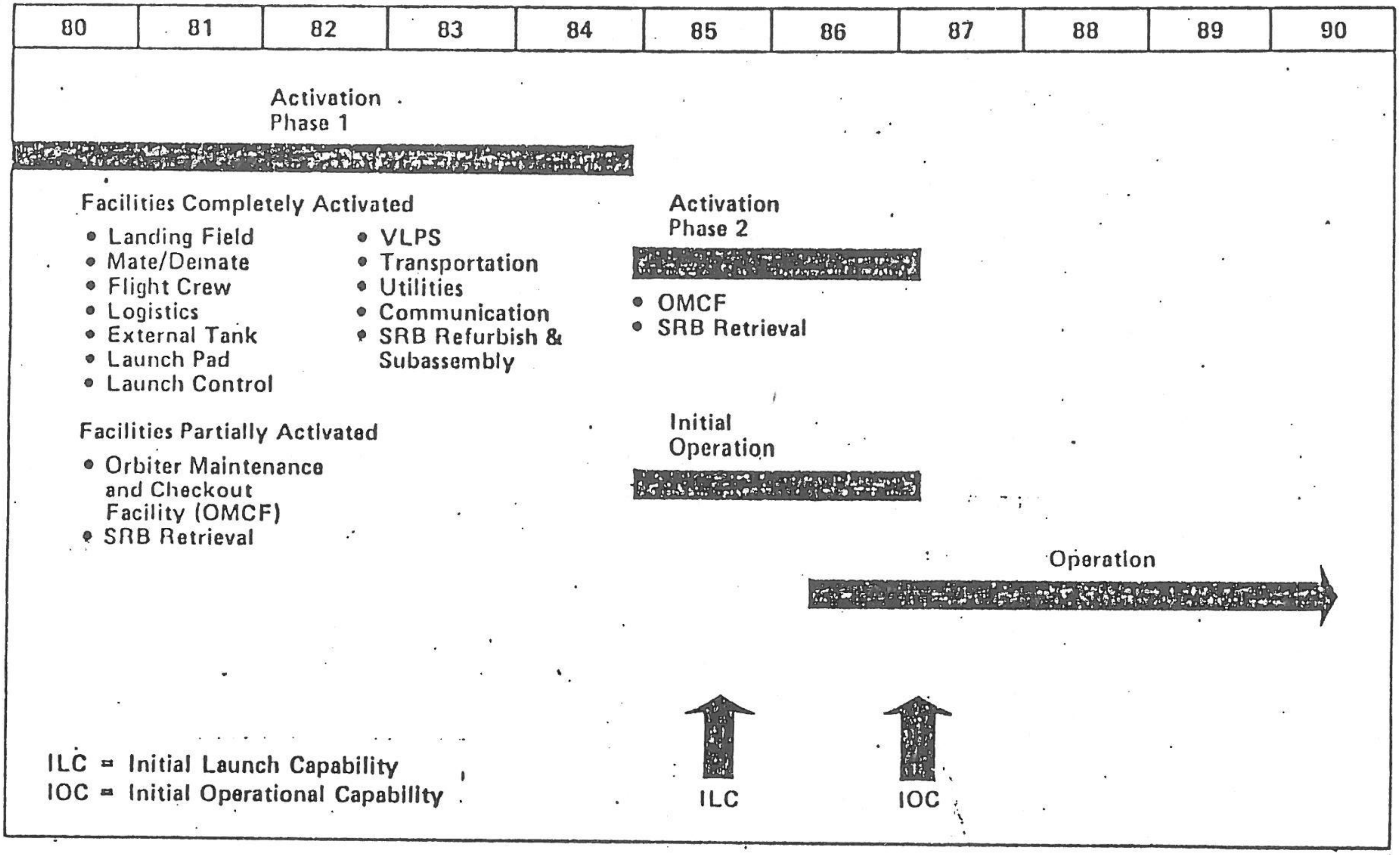


Figure 21. VLS Program Plan