TIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SPACE SHUTTLE
PROGRAM OVERVIEW

JUNE 1974

SPACE SHUTTLE

PROGRAM OVERVIEW

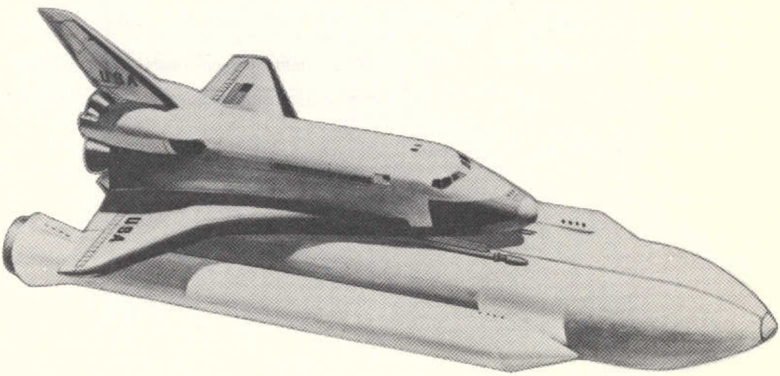
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE ERA

The Space Shuttle era will begin approximately 20 years after the first U.S. venture into space, the launching of Explorer I on January 31, 1958. Since that date, unmanned satellites have probed the near and distant reaches of space. Manned systems have been used to explore the lunar surface and expand the present knowledge of the Earth, the Sun, and the adaptability of man to extended space flight in near-Earth orbit. To serve the future needs of space science and applications, the technological and operational experience underlying these accomplishments is being applied to development of the Space Shuttle. This vehicle is the basic element in a space transportation system that will open a new era of routine operations in space.

The primary design and operations goal for the Space Shuttle Program is to provide low-cost transportation to and from Earth orbit. Spacelabs will be carried aloft by the Shuttle in support of manned orbital operations. Free-flying or automated satellites will be deployed and recovered from many types of orbits. Automated satellites with propulsive stages attached will be deployed from the Space Shuttle and placed in high-energy trajectories.

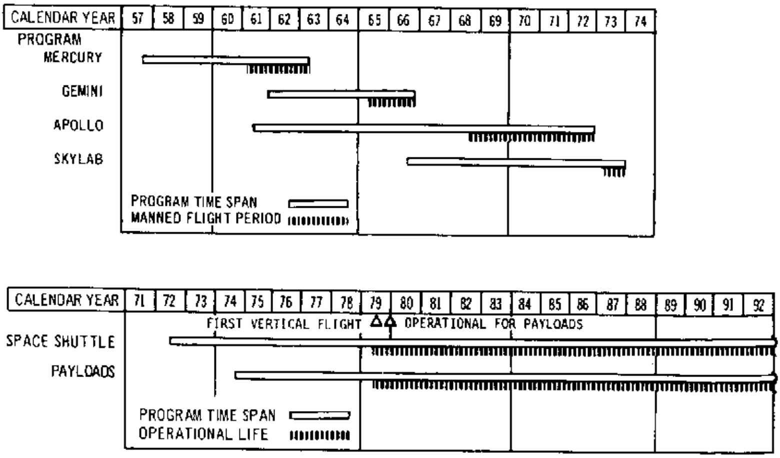
This approach to space operations will provide many avenues for conducting investigations in space. Many participants, representing diverse backgrounds and capabilities, will work routinely in these space operations of the future.



REUSABLE SPACE HARDWARE

The Space Shuttle era will emphasize operational reuse of flight hardware, which will result in low cost per flight to the users. Low cost was and continues to be the basic concept on which the total space transportation system is being developed. In addition, the Space Shuttle operational phase will last much longer than the developmental phase, as illustrated in the following figure.

MANNED SPACE FLIGHT PROGRAMS



SPACE SHUTTLE SYSTEM AND MISSION PROFILE

The Shuttle flight system is composed of the Orbiter, an external tank containing the ascent propellant to be used by the Orbiter main engines, and two solid-rocket boosters.

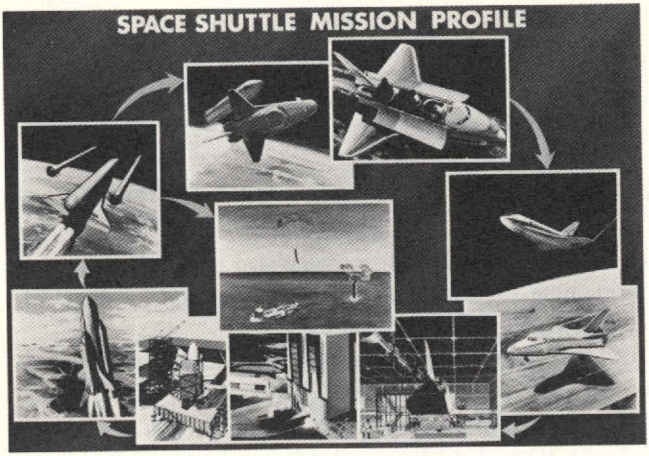
The Space Shuttle mission begins with the installation of the mission payload into the Orbiter payload bay. The payload will be checked and serviced before installation and will be activated on orbit. Flight safety items for some payloads will be monitored by a caution and warning system.

The solid-rocket boosters and the Orbiter main engine will fire in parallel at lift-off. The two solid rockets are jettisoned after burnout and are recovered for reuse by means of a parachute system. The large hydrogen and oxygen tank is jettisoned before placing the Space Shuttle Orbiter into orbit. The orbital maneuvering system of the Orbiter is used to attain the desired orbit and to make any subsequent maneuvers that may be required during the mission.

When the payload-bay doors located in the top of the Orbiter fuselage open to expose the payload, the crewmen are ready to begin payload operations. Payloads weighing 29 500 kilograms (65 000 pounds) can be carried to low Earth orbit. The duration of the initial missions will nominally extend to as many as 7 days. By adding consumables in mission kits, the mission duration can be extended to as long as 30 days.

On completion of orbital operations, deorbiting maneuvers are initiated. Entry is made into the Earth atmosphere at a high angle of attack. At low altitude, horizontal flight attitude is assumed for approach and execution of an aircraft-type landing.

A 2-week ground turnaround is the goal for reuse of the Space Shuttle Orbiter.



SPACE SHUTTLE SYSTEM

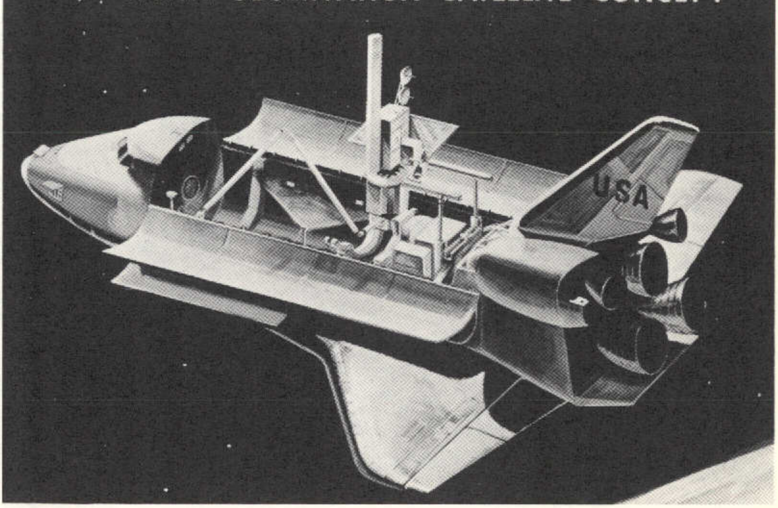
APRIL 1974

Parameter	Metric value	English value
Overall Space Shuttle system		
Length	55.2 m	185 ft
Height	23.2 m	76 ft
Weight at launch	~1 860 000 kg	~4 100 000 lb
Payload weight into orbit		
Inclination (lowest), 28.5°	29 500 kg	65 000 lb
Inclination (highest), 104°	14 500 kg	32 000 lb
Solid-rocker booster		
Diameter	3.6 m	11.8 ft
Length	44.2 m	145.1 ft
Weight		
Launch	527 800 kg	1 163 500 lb
Inert	70 000 kg	154 300 lb
Thrust at launch, each	11 210 000 N	2 500 000 lb
External tank		
Diameter	8.4 m	27.5 ft
Length	46.9 m	153.9 ft
Weight		
Launch	739 800 kg	1 631 000 lb
Dry	31 900 kg	70 400 lb
Orbiter		
Length	37.5 m	123 ft
Wing span	23.8 m	78 ft
Height to extended landing gear	17.4 m	57 ft
Payload bay		
Diameter	4.8 m	15 ft
Length	18.3 m	60 ft
Cross range	2 038 km	1 100 n. mi.
Main engines (3)		
Vacuum thrust, each	2 090 700 N	470 000 lb
Orbital maneuvering subsystem engines (2)		
Vacuum thrust, each	26 700 N	6 000 lb
Reaction control system		
Engines (40)		
Thrust, each	4 003.4 N	900 lb
Vernier engines (6)		
Vacuum thrust, each	111.2 N	25 lb
Weight		
Dry	68 000 kg	150 000 lb
Landing	~82 000 kg	~180 000 lb

ON-ORBIT SERVICE OF EARTH OBSERVATION SATELLITES

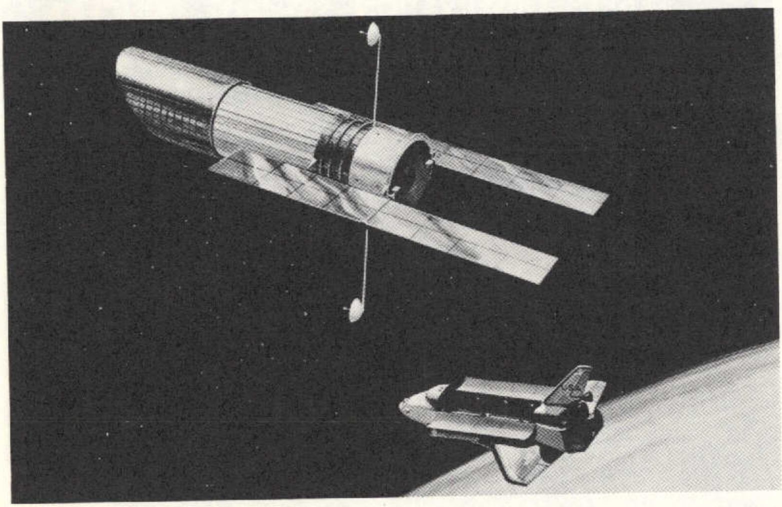
The NASA Goddard Space Flight Center is studying a family of application satellites to be placed in orbits of various inclinations and altitudes. Low-cost standard hardware is expected to comprise much of each satellite. Among other features, the design of this hardware will provide for on-orbit servicing by changeout of supporting subsystem assemblies and applications sensors. These system features, in association with the Shuttle-based equipment and Shuttle operational techniques, will permit on-orbit maintenance and updating of this family of satellites.

EARTH OBSERVATION SATELLITE CONCEPT



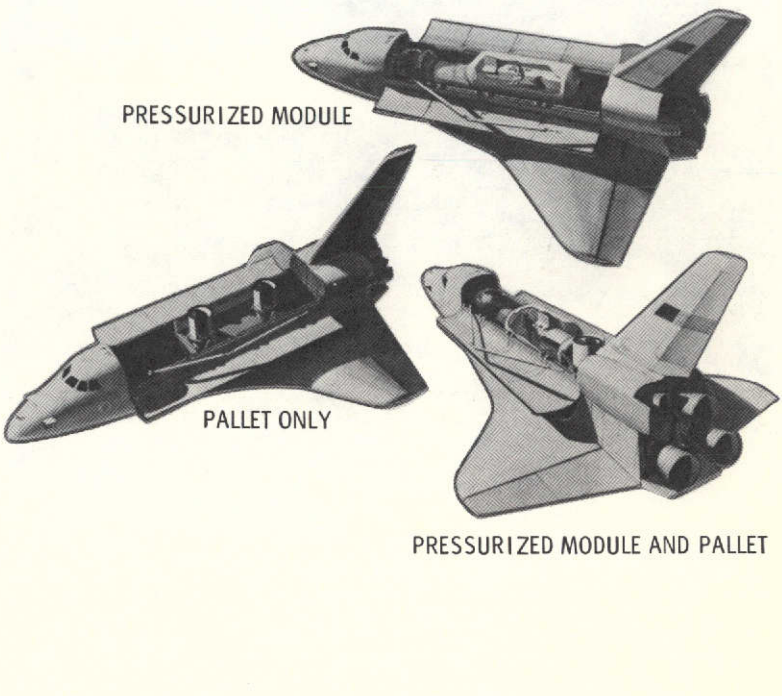
PLACEMENT OF FREE-FLYING SCIENTIFIC LABORATORIES IN SPACE

The large space telescope represents an international facility for on-orbit space research controlled by the investigating scientists on the ground. Design studies are now being conducted and sponsored by the NASA Marshall Space Flight Center and the Goddard Space Flight Center. The Space Shuttle will deliver the telescope to orbit, and the crewmen will assist in preparing the facility for operation. During scheduled revisits to the facility, the Space Shuttle crewmen will service supporting subsystems, exchange scientific hardware, and, several years later, return the facility to Earth at the end of its mission.



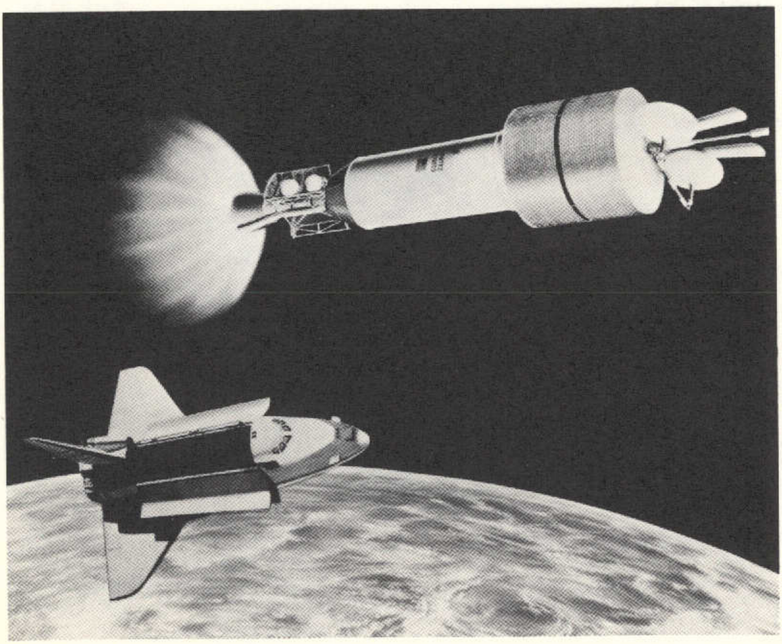
INTERNATIONAL COOPERATION IN SPACE

The large pressurized Spacelab module with an external equipment pallet will be a frequent payload carrier during the Space Shuttle era. Nine member nations of the European space community have agreed to commit almost $400 million to design and deliver one flight unit to the United States. Agreements provide for purchase of additional units by the United States. Many types of scientific, technological, medical, and applications investigations can be accomplished with this flight hardware. Each Spacelab may be flown as many as 50 times over a 10-year period.



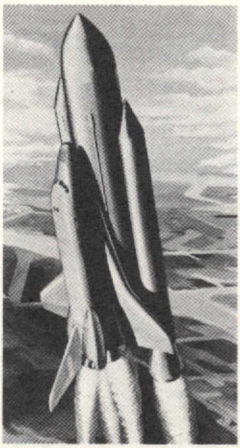
DELIVERY OF PAYLOADS THAT USE PROPULSION STAGES

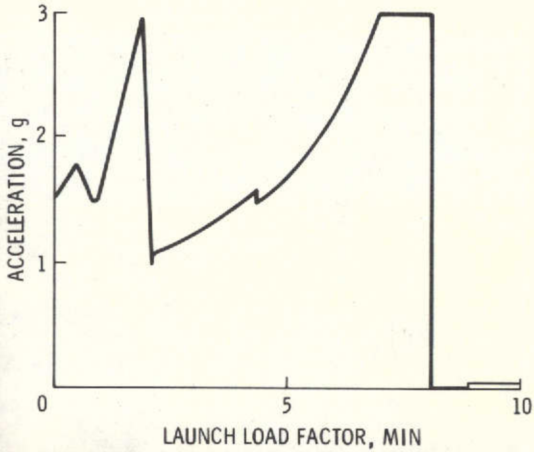
Major activity is forecast for geosynchronous orbits, deep-space missions, elliptical orbits, and higher circular orbits. Payloads with such destinations will require a propulsion stage in addition to the Shuttle. The Space Shuttle will deliver the payload with a propulsion stage to low Earth orbit and will stand by until a successful on-orbit launch is effected. Initially, an existing propulsion stage will be adapted for this on-orbit launch; an advanced reusable propulsion stage called the Space Tug is being studied for later inclusion in the space transportation system.

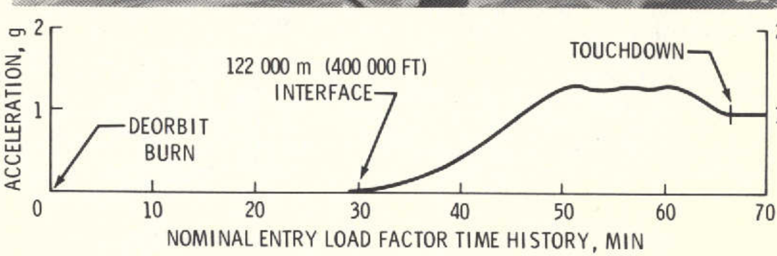


REDUCED LAUNCH AND ENTRY ACCELERATIONS

Crewmembers, who will include scientists and payload-related support specialists, will experience a designed maximum gravity load of only 3g during launch and less than 1.5g during a typical entry. These accelerations are about one-third the levels experienced on previous manned flights. Many other features of the Space Shuttle, such as a standard sea-level atmosphere, will welcome the nonastronaut space worker of the future.

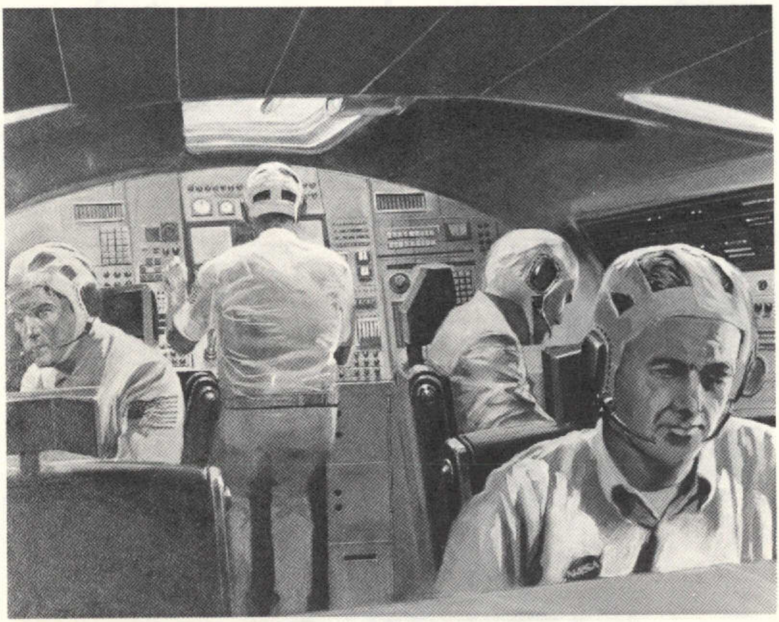


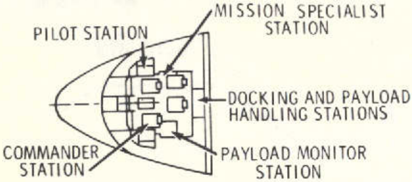




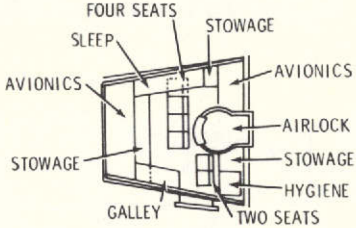
CREW CABIN

The Orbiter crew cabin has a flight section from which the mission is flown. The flight section seats as many as four crewmen. In the midsection area, eating, sleeping, and housekeeping functions are accommodated. Depending on the mission requirements, an additional six seats can be placed in this area.





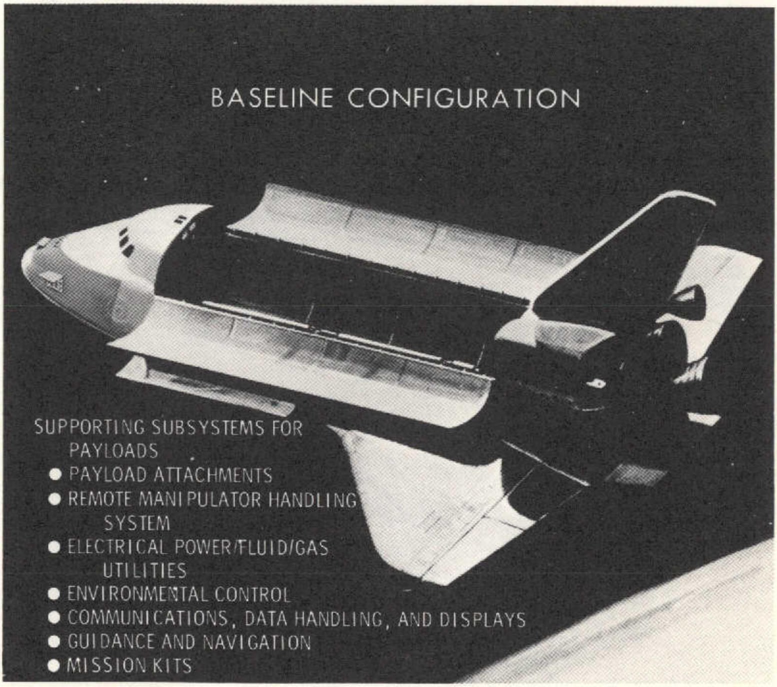
FLIGHT SECTION



MIDSECTION

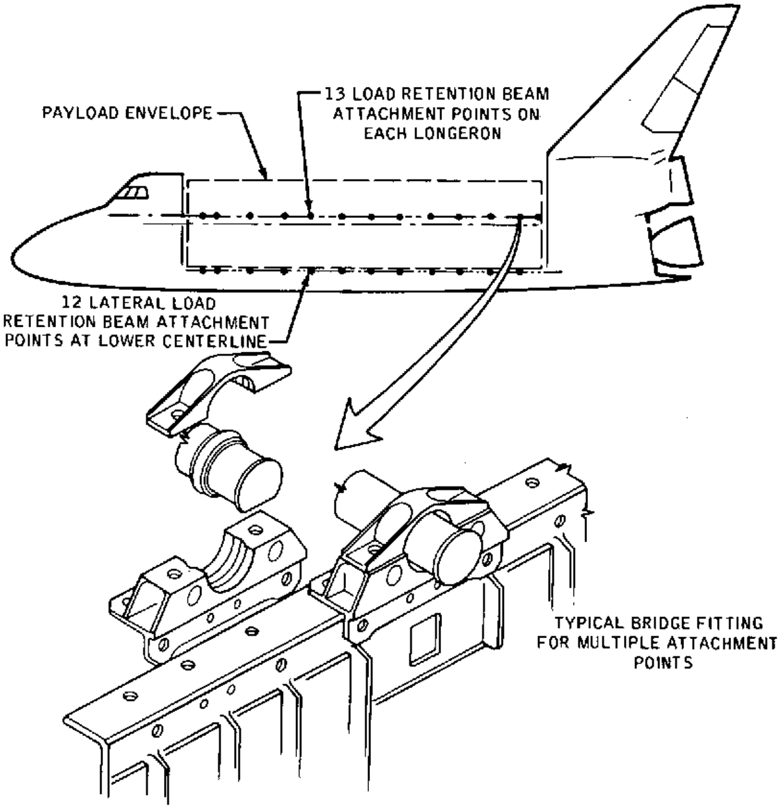
PAYLOAD ACCOMMODATIONS

The Orbiter systems are being designed to handle various payloads and to support a variety of payload functions. The payload and mission specialist stations on the flight deck provide command and control facilities for payload operations required by the cognizant scientist (the user). Remote-control techniques can be employed from the ground when desirable. The Spacelab payload provides additional command and data management capability plus a work area in the payload bay for the payload specialists. The crew will be able to use a manipulator to handle complete payloads or selected packages.



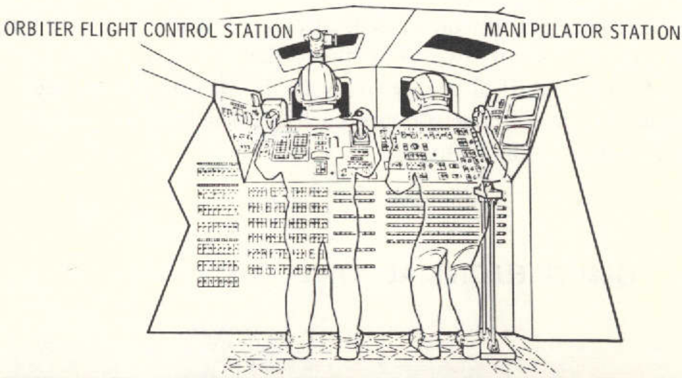
PAYLOAD ATTACHMENTS

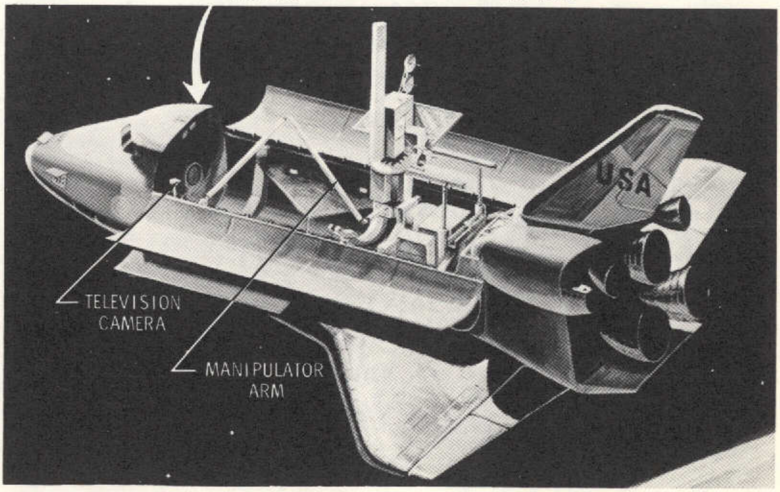
Numerous attachment points along the sides and bottom of the 18.2-meter (60-foot) payload bay provide places for the many payloads to be accommodated. Thirteen primary attachment points along the sides accept longitudinal and vertical loads. There are twelve positions along the keel that take lateral loads. The proposed design of the standard attachment fitting will also have some adjustment capability to adapt to specific payload weight distributions in the bay.



PAYLOAD HANDLING DURING ON-ORBIT OPERATION

Many payloads to be transported to orbit will require complete deployment and separation (and some retrieval) or some handling of equipment within the payload bay. A remote manipulator arm that can use various end effectors is being tested to be operated from the Space Shuttle flight deck. Windows are located in such a way to permit direct viewing of the operation. One television camera on the manipulator arm and two cameras within the payload bay also assist the operator. Rapid deployment and retrieval procedures of large payloads are being evaluated together with the delicate handling techniques for sensitive equipment.





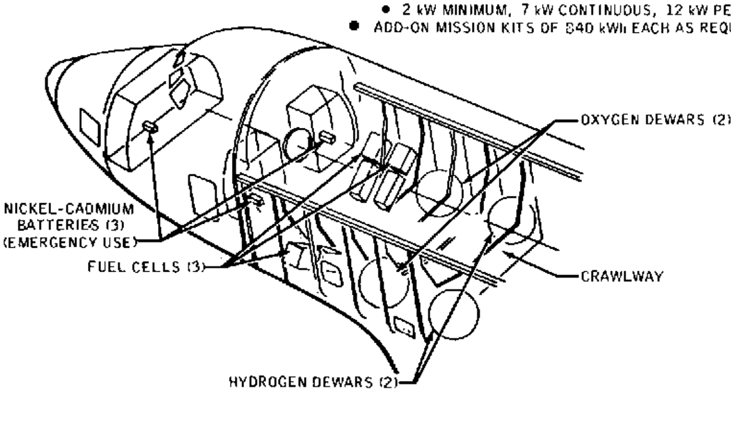
ELECTRICAL POWER SERVICE

The operational use of fuel cells for manned space flight evolved during the Gemini and Apollo Programs. The Space Shuttle fuel cells will be serviced between flights and reflown until each one has accumulated 5000 hours of online service.

The electrical power requirements of the payloads will vary throughout the mission. During the 10-minute launch-to-orbit phase and the 30-minute deorbit-to-landing phase when most of the experiment hardware is in a standby mode or completely turned off, 1000 watts (average) to 1500 watts (peak) are available from the Orbiter. During payload equipment operation on orbit, the capability exists to provide as much as 7000 watts (average) to 12 000 watts (peak) for major energy-consuming payloads. There are three fuel cells on board the Space Shuttle; one is dedicated to payloads with switching capability to the other two. For the 7-day mission payload, 50 kilowatt-hours of electrical energy are available. Mission kits containing consumables for 840 kilowatt-hours each are available in quantities required according to the flight plan.

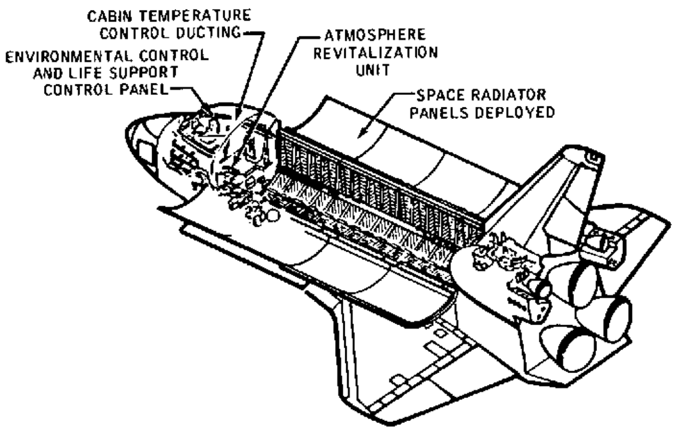
ORBITER ELECTRICAL POWER SUBSYSTEM

- SUBSYSTEM PERFORMANCE
  - 14 kW CONTINUOUS WITH 24 kW PEAK CAPABILITY
  - 27.5 TO 32.5 V dc
  - 1530-kWh MISSION ENERGY
  - 264-kWh ABORT/SURVIVAL ENERGY
- ONE FUEL CELL DEDICATED TO PAYLOADS
  - 2 kW MINIMUM, 7 kW CONTINUOUS, 12 kW PEAK
- ADD-ON MISSION KITS OF 840 kWh EACH AS REQUIRED



COOLING

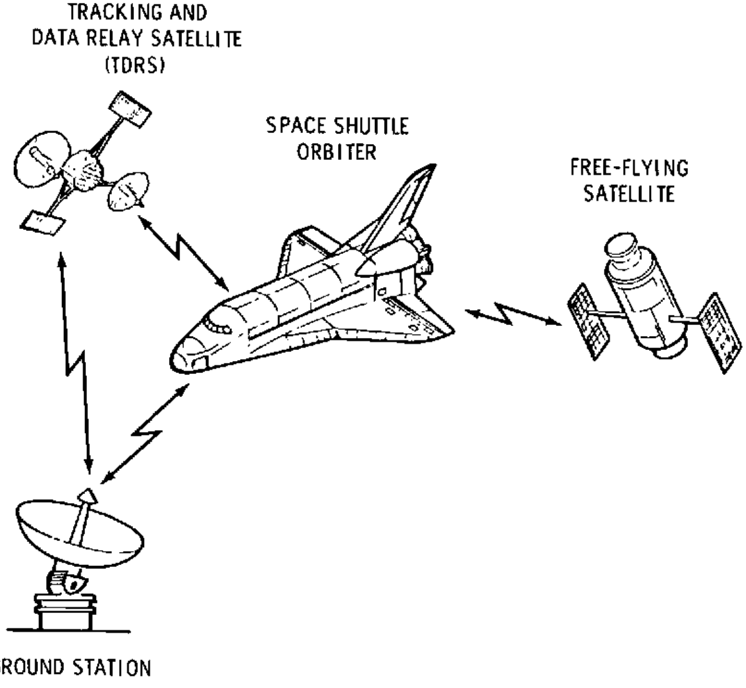
Cooling services are provided to payloads by the Space Shuttle. Ground support equipment provides a selectable temperature range during prelaunch activities. After landing, ground support equipment similar to airline support hardware will be connected to the Orbiter cabin and the payload bay to control temperature levels. The radiator system located on the inside of the payload-bay doors will be the primary on-orbit heat-rejection system.



FLIGHT PHASE	COOLING SUPPORT
PRELAUNCH	SELECTABLE RANGE USING GROUND SUPPORT EQUIPMENT
LAUNCH	1.5 kW THERMAL
ON ORBIT	6.3 kW THERMAL 8.5 kW THERMAL WITH MISSION KIT
ENTRY	1.5 kW THERMAL
POSTLANDING	COOLING SUPPLIED FROM GROUND SUPPORT EQUIPMENT

COMMUNICATIONS, TRACKING, AND DATA MANAGEMENT

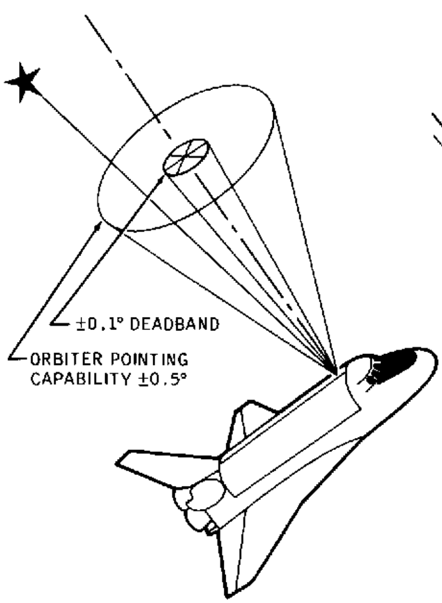
The Orbiter systems are being designed to handle various payloads and to support a variety of payload functions. Voice, television, and data handling capabilities support onboard control or remote control from the ground when desirable. All payload support requirements result in a standard on-orbit and ground facility handling system that must be very efficient to support the many payloads to be flown.



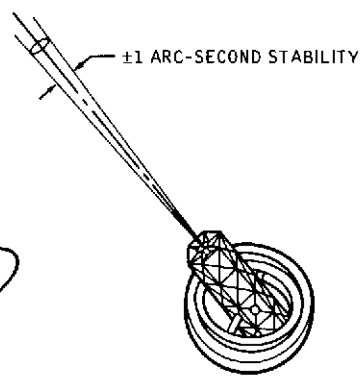
FUNCTION	GROUND TO ORBITER	ORBITER TO GROUND	GROUND TO ORBITER VIA TDRS	ORBITER TO GROUND VIA TDRS	ORBITER TO SATELLITE (PRIME OR RELAY)	SATELLITE TO GROUND VIA ORBITER
VOICE	X	X	X	X		
TELEVISION		X		X		
TRACKING DATA	X	X	X	X	X	X
COMMANDS	X		X		X	
OPERATIONAL DATA		X		X		X
PAYLOAD WIDE-BAND DATA		X		X		

PAYLOAD POINTING AND STABILIZATION SUPPORT

The Orbiter is capable of achieving and maintaining any desired attitude. This capability permits the pointing of payload sensors mounted in the payload bay at any selected celestial or Earth object with an accuracy of ±0.5°. The greatest pointing accuracy using the Orbiter control system is achieved when a payload pointing sensor is operated in a closed loop with the Orbiter guidance, navigation, and control system. In this mode, pointing accuracies approaching ±0.1 deg/axis are possible. The Orbiter can be stabilized at a rate as low as ±0.01 deg/sec within a deadband of ±0.1 deg/axis. Payloads that require more stringent pointing requirements must provide their own added stabilization hardware for that particular experiment.



ORBITER PROVIDED



TYPICAL CONCEPT FOR
THREE-AXIS EXPERIMENT
POINTING BASE

PAYLOAD PROVIDED

MISSION KITS

A group of mission kits to provide special or extended services for payloads is being studied. These kits will be added only when required and are designed to be quickly installed and easily removed. The major mission kits are as follows.

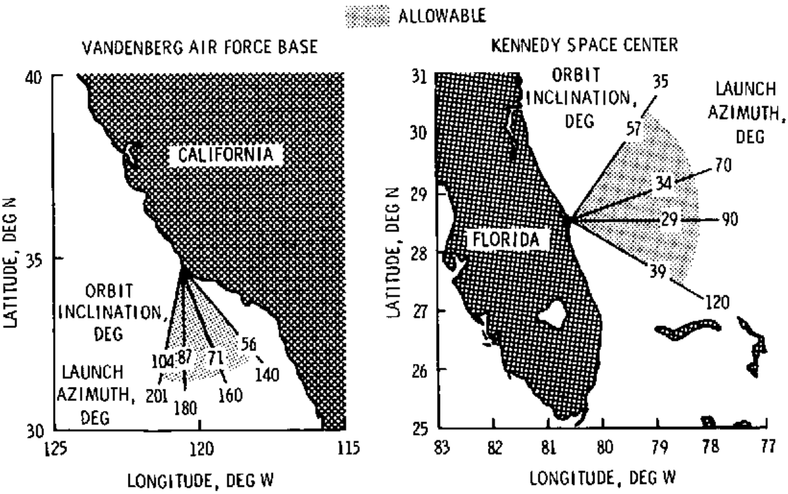
- Oxygen and hydrogen for fuel-cell usage to generate electrical energy
- Life support for extended missions
- Added fuel tanks for special on-orbit mission maneuvers
- Extra or specialized attachment fittings
- Transfer tunnels and docking modules
- A second remote manipulator arm and extra antennas

SPACE SHUTTLE LAUNCH SITES, OPERATIONAL DATES, AND INCLINATION LIMITS

Space Shuttle flights will be launched from two locations, the NASA John F. Kennedy Space Center (KSC) in Florida and the Vandenberg Air Force Base (VAFB) in California. Present program planning calls for a gradual buildup of 40 to 60 total flights per year into many varying orbits and inclinations. The expected mission capability for a crew of four to seven is 7 days on orbit with growth to 30 days.

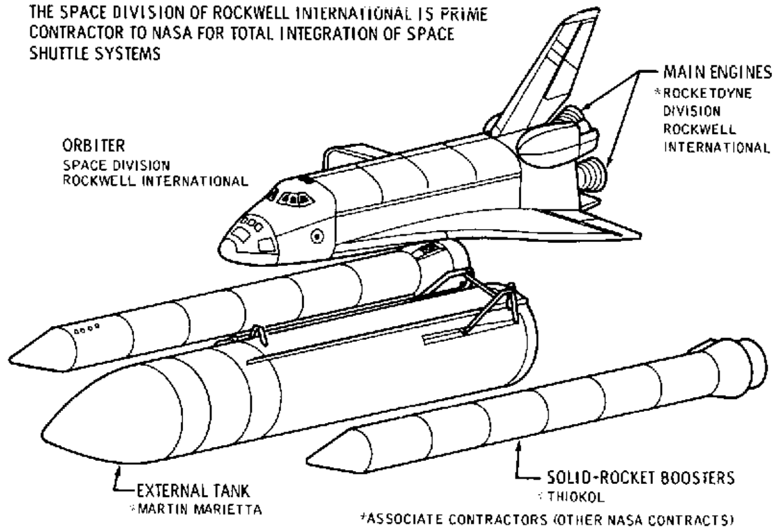
To attain operational status by 1980, Space Shuttle orbital test flights are scheduled to begin from KSC during 1979; VAFB is planned to be available in the early 1980's. The various orbital inclinations and their related launch azimuths are illustrated for each site. Together, these capabilities satisfy all known future requirements. Payloads as large as 29 500 kilograms (65 000 pounds) can be launched due east from KSC into an orbit of 28.5° inclination. 14 500-kilogram (32 000-pound) payloads can be launched from VAFB into the highest inclination orbit of 104°. Polar orbiting capabilities up to 18 000 kilograms (40 000 pounds) can be achieved from VAFB.

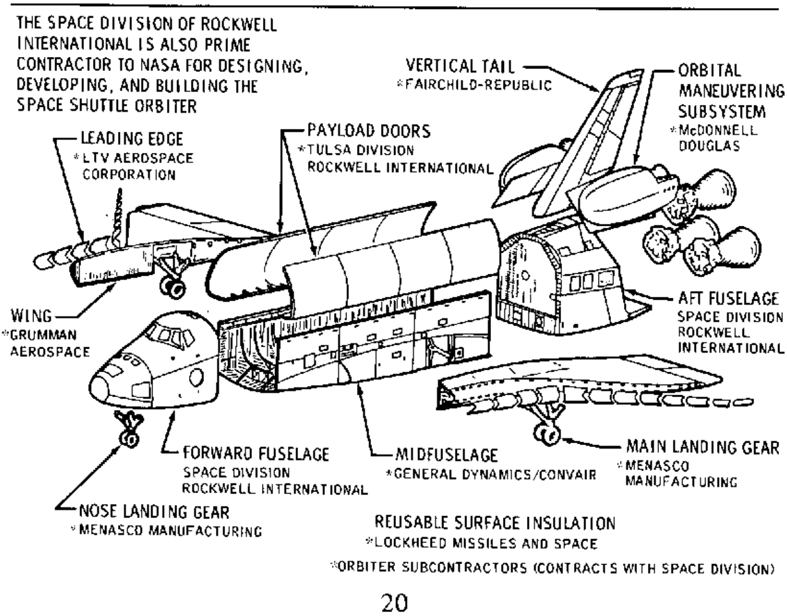
ORBIT INCLINATIONS AND LAUNCH AZIMUTHS FROM VAFB AND KSC



STATUS OF SPACE SHUTTLE CONTRACTING

The primary contracts for the design, development, and integration of the Space Shuttle system and the majority of the key subcontracts have been awarded. A summary of this progress is highlighted as follows.





SPACE SHUTTLE PROGRAM
SIGNIFICANT SUBCONTRACTS

SUBSYSTEM	SUBCONTRACTOR
AVIONICS	
FLIGHT CONTROL SYSTEM	HONEYWELL, INC. ST. PETERSBURG, FLORIDA
MASS MEMORY/MULTIFUNCTION CATHODE RAY TUBE DISPLAY SET	IBM OSWEGO, NEW YORK
GENERAL PURPOSE COMPUTER/ INPUT-OUTPUT PROCESSOR	IBM OSWEGO, NEW YORK
INERTIAL MEASUREMENT UNIT	SINGER KEARFOTT LITTLE FALLS, NEW JERSEY
FUEL CELL POWERPLANT	PRATT & WHITNEY EAST HARTFORD, CONNECTICUT
POWER REACTANT STORAGE ASSEMBLY	BEECH AIRCRAFT BOULDER, COLORADO
MASTER TIMING UNIT	WESTINGHOUSE BALTIMORE, MARYLAND
AUXILIARY POWER UNIT	SUNDSTRAND ROCKFORD, ILLINOIS
MULTIPLEXER DEMULTIPLEXER (MDM)	SPERRY RAND PHOENIX, ARIZONA
MULTIPLEXER INTERFACE ADAPTER (MIA)	SINGER KEARFOTT LITTLE FALLS, NEW JERSEY
AIR DATA TRANSDUCER ASSEMBLY	AIRESEARCH, GARRETT TORRANCE, CALIFORNIA
MICROWAVE SCANNING BEAM LANDING SYSTEM	A.I.L., CUTLER HAMMER FARMINGDALE, L.I., NEW YORK
TACAN (TACTICAL AIR NAVIGATION)	HOFFMAN ELECTRONICS CORP. NAVCOM SYSTEMS EL MONTE, CALIFORNIA
ENVIRONMENTAL	
ATMOSPHERE REVITALIZATION SUBSYSTEM/FREON COOLANT LOOP/WATER BOILER	HAMILTON STANDARD WINDSOR LOCKS, CONNECTICUT
ATMOSPHERE REVITALIZATION PRESSURE CONTROL SUBSYSTEM	CARLETON CONTROLS EAST AURORA, NEW YORK
PROPULSION	
ORBITAL MANEUVERING SYSTEM/ REACTION CONTROL SYSTEM AFT INTEGRATED MODULE	McDONNELL DOUGLAS ASTRONAUTICS COMPANY ST. LOUIS, MISSOURI
ORBITAL MANEUVERING SYSTEM ENGINES	AEROJET GENERAL SACRAMENTO, CALIFORNIA

SPACE SHUTTLE PROGRAM

SIGNIFICANT SUBCONTRACTS (CONCLUDED)

SUBSYSTEM	SUBCONTRACTOR
STRUCTURES	
MIDFUSELAGE	GENERAL DYNAMICS/CONVAIR SAN DIEGO, CALIFORNIA
VERTICAL TAIL	FAIRCHILD REPUBLIC FARMINGDALE, L.I., NEW YORK
WING	GRUMMAN AEROSPACE BETHPAGE, L.I., NEW YORK
LEADING EDGE STRUCTURE	LTV AEROSPACE CORPORATION DALLAS, TEXAS
LOW AND HIGH TEMPERATURE REUSABLE SURFACE INSULATION	LOCKHEED MISSILES AND SPACE SUNNYVALE, CALIFORNIA
WINDOWS	CORNING GLASS WORKS CORNING, NEW YORK
MAIN/NOSE LANDING GEAR AND STRUTS	MENASCO MANUFACTURING BURBANK, CALIFORNIA
SERVOACTUATORS	HYDRAULIC RESEARCH VALENCIA, CALIFORNIA
RUDDER SPEED BRAKE ACTUATION UNIT	SUNDSTRAND ROCKFORD, ILLINOIS
MAIN ENGINE GIMBAL ACTUATOR	MOOG EAST AURORA, NEW YORK
MAIN/NOSE WHEEL AND BRAKE ASSEMBLY	B. F. GOODRICH TROY, OHIO
12 IN. PREVALVE	FAIRCHILD STRATOS MANHATTAN BEACH, CALIFORNIA
17 IN. DISCONNECT	PARKER HANNIFIN IRVINE, CALIFORNIA
SMOKE DETECTION	CELESCO INDUSTRIES, INC. COSTA MESA, CALIFORNIA
OTHER	
GROUND MAINTENANCE AND OPERATIONS SUPPORT	AMERICAN AIRLINES TULSA, OKLAHOMA
DATA PROCESSING AND SOFTWARE REQUIREMENTS	IBM OSWEGO, NEW YORK