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SPACE STATION FREEDOM RESEARCH CAPABILITIES

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ABSTRACT

NASA's plan for enhancing space-based research capabilities begins with extended-duration Space Shuttle missions that will double the research capability currently provided by Spacelab and culminate in Space Station Freedom. The 14-day USML 1 mission flown on the Space Shuttle in June 1992 was a space station precursor mission, dedicated to microgravity and life science research.

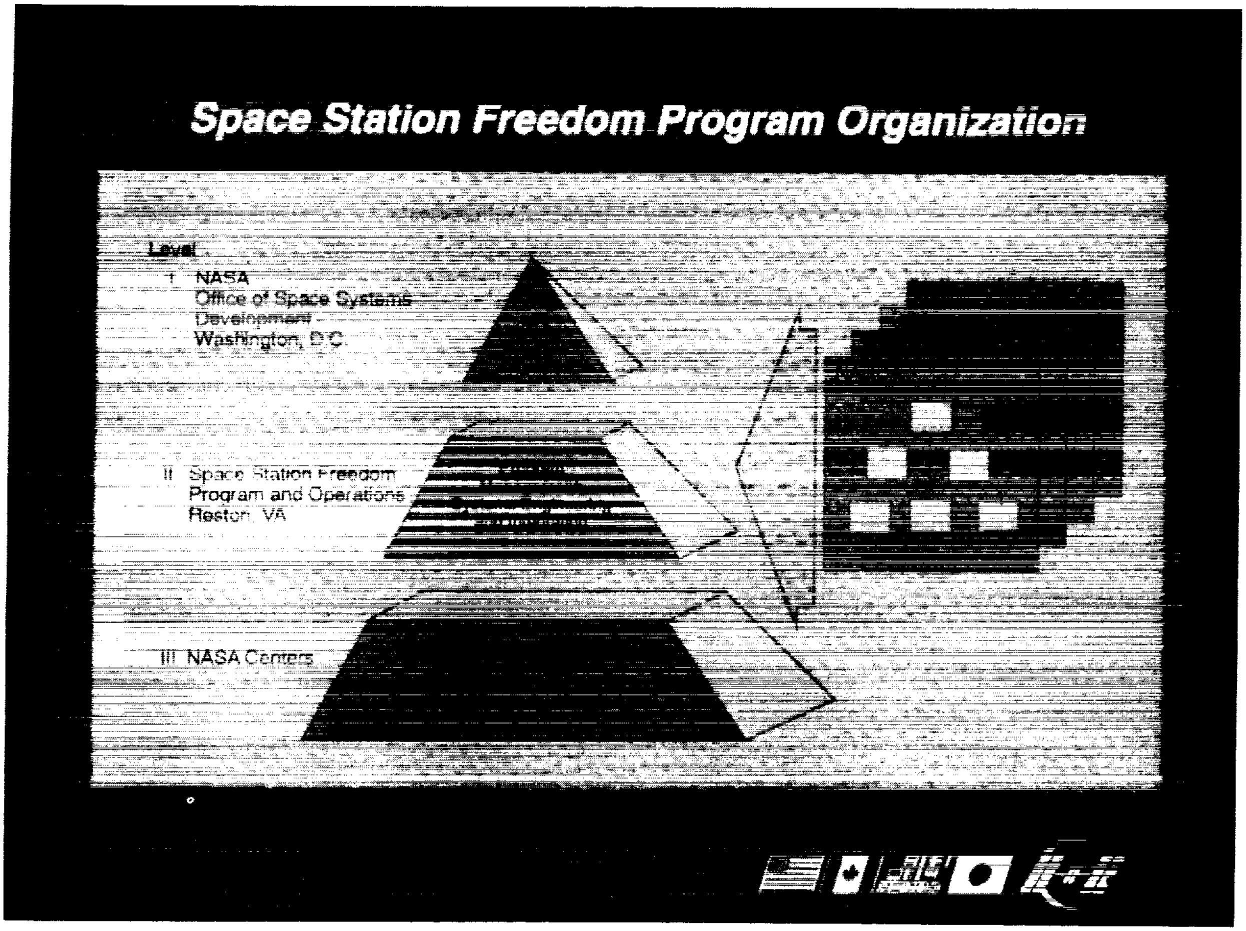
Freedom will be a permanent space-based research facility, providing a working environment nearly free of buoyancy-driven convection, sedimentation, and hydrostatic pressure and featuring access to the ultra-high vacuum of space (for external payloads). In its crew-tended phase, Space Station Freedom will provide 40 times Spacelab's capability, and in its permanently occupied phase, Freedom will provide 110 times Spacelab's capability. (The Russian space station, Mir, offers 26 times Spacelab's capabilities.)

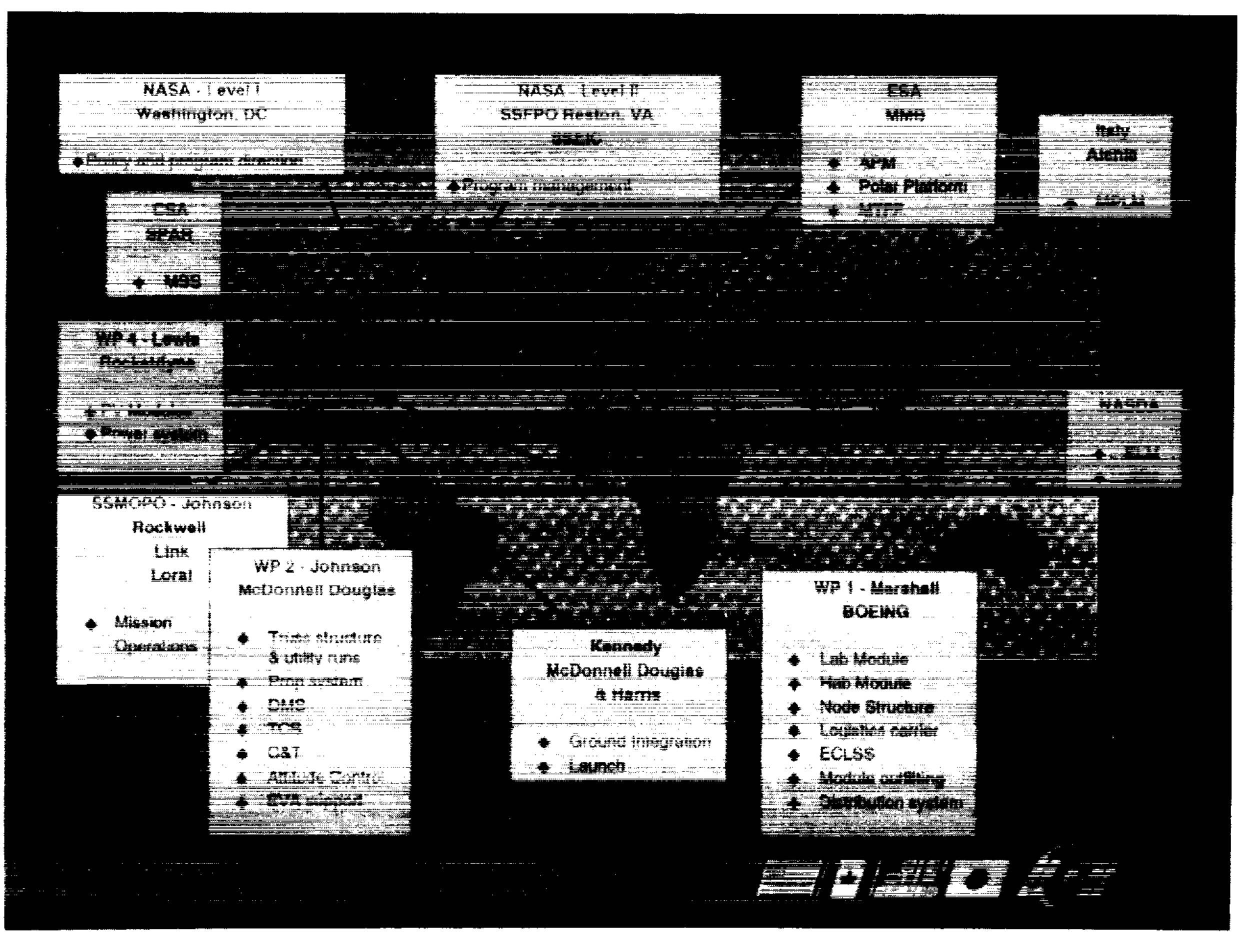
According to NASA's current schedule, the first launch of a space station element will take place in November 1995, with permanently occupied capability planned for September 1999. This year, NASA will conduct space station critical design reviews (CDRs). Work package design reviews will take place from February to April 1993, followed by a systems CDR.

Space Station Freedom

Objectives

- Establish preeminent manned space laboratory:
  - Life & material sciences
  - Technology advancement
  - Earth & space observation
- Build infrastructure for man's evolving space exploration
- Expand our nation's leadership in civil space programs
- Promote international participation and cooperation
- Develop commercial opportunities and applications


Space Station Freedom Program Organization
Level
I NASA
Office of Space Systems
Development
Washington, DC
II Space Station Freedom
Program and Operations
Reston, VA
III NASA Centers


NASA - Level I
Washington, DC
NASA - Level II
SSFPO Reston, VA
ESA
MMB
◆ APM
◆ Polar Platform
Italy
Alenia
CSA
SPAR
◆ MSS
WP 4 - Lewis
Rocketdyne
◆ Power system
SSMOPO - Johnson
Rockwell
Link
Loral
◆ Mission Operations
WP 2 - Johnson
McDonnell Douglas
◆ Truss structure & utility runs
◆ Prop system
◆ DMS
◆ C&T
Kennedy
McDonnell Douglas
& Harris
◆ Ground Integration
◆ Launch
WP 1 - Marshall
BOEING
◆ Lab Module
◆ Hab Module
◆ Node Structure
◆ Logistics carrier
◆ ECLSS
◆ Module outfitting
◆ Distribution system

Space Station Freedom: Scope

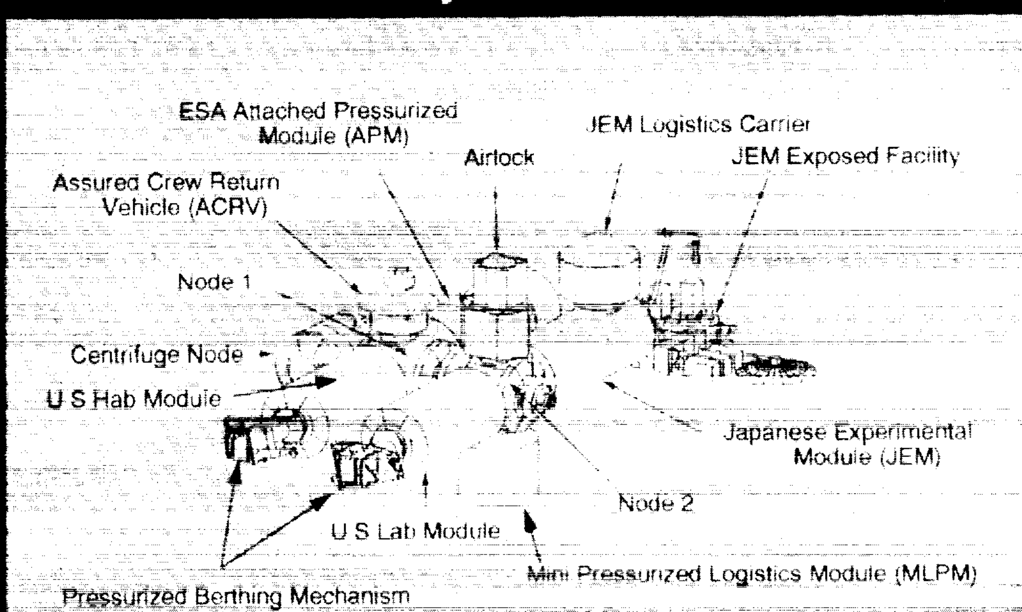
Flight System

- **Architectural Elements**
  - US Laboratory
  - European Laboratory
  - Japanese Laboratory & Exposed Facility
  - Habitat Module
  - Resource Nodes
  - Centrifuge Node
  - Pre-integrated Truss
  - Logistics Carriers
- **Distributed Systems**
  - Electric Power
  - Thermal Control
  - Data Management
  - Guidance, Navigation & Control
  - Communication & Tracking
  - EVA Support Equipment
  - Environmental Control
  - Fluids Management
  - Propulsion

Ground System

- **Facilities**
  - Space Station Control Center
  - Payload Operations Integration Center
  - Space Station Processing Facility
  - Space Station Training Facility
  - Payload Training Complex
  - Engineering Support Centers
- **Adjuncts**
  - Test Checkout and Monitoring System
  - Mission Planning System
  - Trajectory, Command, Analysis and Timeline System

Key Elements



PMC Module Cluster

Research Objectives Overview

Design Drivers

Life Sciences

- ❑ Space Biology
- ❑ Space Medicine
- ❑ Exobiology and Biospherics

Material Sciences

- ❑ Fundamental Mass Transport
- ❑ Inorganic Materials
- ❑ Organic Materials

Inherent Capabilities

Earth Sciences

- ❑ Global Hydrology
- ❑ Climatology
- ❑ Geophysics

Astronomical Sciences

- ❑ Plasma Physics
- ❑ Solar Physics
- ❑ Astrometric Observations

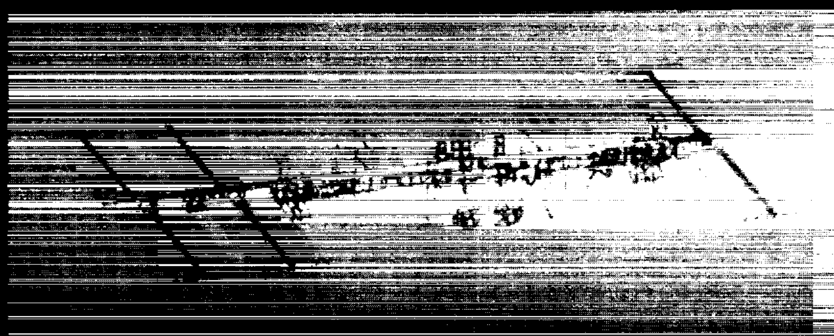
MTC Capability

- ❑ 18.75 kW power
  - ◆ 11 kW to users
- ❑ Pressurized volume
  - ◆ US Lab - 12 racks
  - ◆ Node - 4 racks
- ❑ Man-tended operations

- ❑ SSRMS control
- ❑ High and low data rate communication
- ❑ Orbiter berthing with pressurized crew transfer

PMC Capability

- 56.25 kW power
  - 30 kW to users
- Pressurized volume
  - US Lab
  - ESA APM
  - NASDA JEM
  - US Hab
  - 2 Nodes
- Continuous manned presence
  - 4 person crew
- Redundant orbiter berthing locations
- Full MSC capability
- Crew return capability
- Centrifuge



Payload Resources Overview

PRESSURIZED VOLUME:	15 Payload Racks at MTC 46 Payload Racks at PMC
ATTACHED PAYLOAD ACCOMMODATIONS:	2 sites at MTC 4 sites at PMC
LAUNCH CAPACITY:	8 Utilization Flights deliver 64 Payload Racks and 80,000 lbms 3 Mission Build flights provide accommodations for an additional 25 Payload Racks
POWER:	10 kW with 1 Photovoltaic Array 15 kW with 2 Photovoltaic Arrays 30 kW with 3 Photovoltaic Arrays
CREW-TIME:	4 Payload Crew per 16-Day Utilization Flight ? Payload Crew Planned at PMC
DOWNLINK:	50 Megabits / Second at MTC

Attached Payload Accommodations

Four Payload Accommodation Sites with Resource Ports

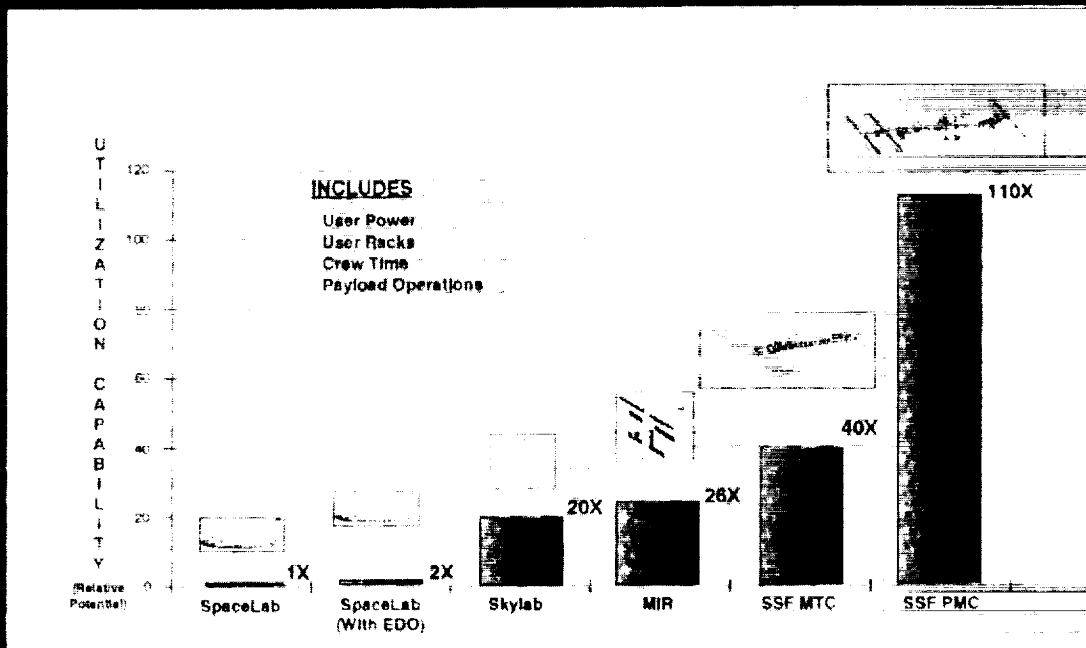
- Zenith, nadir, ram, and wake viewing
  - Nadir sites support equatorial and Earth limb remote sensing
- 120 vdc, 3.0 kW, at each site
- 1000 - 3000 cubic feet clearance envelope
- 400 - 700 kbps data downlink, scarred for growth to 10 Mbps

Payload Resource Allocations

- Establishes Top-Level Allocation of both Resources and Accommodations Among the Four Partners
- Applicable to "Utilization" Resources Only (i.e., does not apply to "housekeeping" resources for respective station elements)

	NASA U.S.	MOSST Canada	ESA Europe	STA Japan
1. Utilization Resources	71.4%	3.0%	12.8%	12.8%
2. User Accommodations				
a. NASA Lab Module	97%	3%		
b. NASA Attached Payload Accommodations	97%	3%		
c. ESA Attached Pressurized Module (APM)	46%	3%	51%	
d. Japanese Experiment Module – Pressurized Module – Exposed Facility – Experiment Logistics Module	46%	3%		51%

Greater Utilization Capabilities



FREEDOM

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Benefits of the Space Environment

- Absence of buoyancy-driven convection
- Absence of sedimentation
- Absence of hydrostatic pressure
- Presence of ultra-high vacuum

Research Objective:

Technology advances through improved control of process variables, such as temperature, composition and flows

Absence of Buoyancy-Driven Convection

- Microgravity conditions eliminate convective flows in molten metals, liquids and gases due to density differences
- Diffusion becomes the primary mechanism for thermal and mass transport
- Diffusion processes can be accurately predicted and controlled
- Important applications:
  - Dopant distribution in crystal growth
  - Identification of mechanisms for segregation in alloys
  - Prevention of mixing in purification processes
  - Understanding of fluid dynamic effects in systems undergoing phase changes

Absence of Sedimentation

- **In Earth gravity it is possible to maintain a suspension of particles in a fluid if the particles are < 1 m**
- **Microgravity conditions permit suspensions involving particles >>1 m**
- **Important applications:**
  - **Chemical refinement of glasses**
  - **Preparation of unique foams (ultra-light structures)**
  - **Control of floculation processes**
  - **Preparation of immiscible alloys**
  - **Improved polymerization processes**

Absence of Hydrostatic Pressure

- Microgravity conditions eliminate the tendency for a liquid or solid to deform under its own weight
- Important applications:
  - Modification of critical points in solid, liquid, and gas phase transitions
  - Ability to form stable floating zones large in length and diameter (an important crystal growth technique)
  - Formation of thin oxide skins to produce intricate casting molds
  - Growth of large complex macromolecules, such as proteins, for structural analysis and drug design

Presence of Ultra-High Vacuum

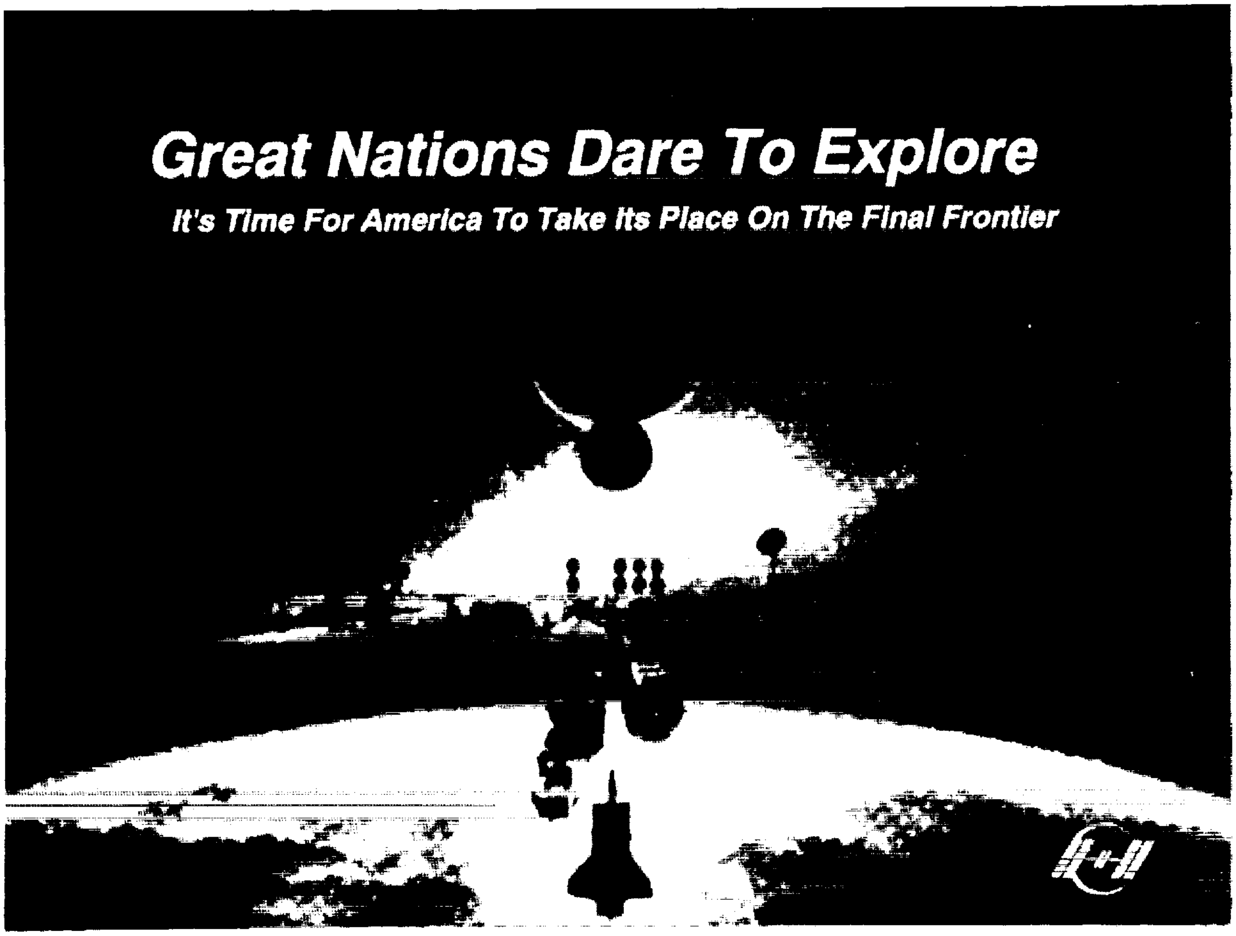
- Vacuum chambers on earth approach 10^{-13} torr, however, pumping capacity is limited unless large cryogenic panels are used (incompatible with high heat loads in molten systems)
- Space vacuum approaches 10^{-18} torr with virtually infinite pumping capability
- Important applications:
  - High temperature materials purification
  - Vapor deposition on ultraclean surfaces
  - Preparation of thin single crystal films
  - Use of container less techniques to avoid container contamination

Near Term Milestones

September 1992	Canadian Mobile Servicing Center (MSC) Phase 1 CDR
2nd Qtr 1993	Man Tended Capability (MTC) Critical Design Review (CDR)
4th Qtr 1993	Permanently Manned Capability (PMC) CDR
October 1993	Canadian MSC Phase 2 CDR
November 1994	European Space Agency (ESA) Attached Pressurized Module (APM) CDR
December 1994	Japanese Experimental Module (JEM) CDR
4th Qtr 1995	First Element Launch (FEL)

Summary

- Space Station Freedom satisfies our manned space research objectives
  - Life & material sciences
  - Technology advancement
  - Earth & space observation
- Space Station Freedom represents mans evolving exploration in space
- Space Station Freedom demonstrates our nation's leadership in international space programs
- Space Station Freedom can serve as a model for all future multi-national space endeavors


Great Nations Dare To Explore
It's Time For America To Take Its Place On The Final Frontier