Space Station Freedom

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ACCESS TO SPACE

SPACE STATION FREEDOM AND COMMERCIALIZATION

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SPACE STATION FREEDOM
BALANCED COMMERCIAL ACCESS TO SPACE
EVOLUTIONARY APPROACH

- Drop Tubes/Towers (MSFC, LeRC)
- Microgravity Aircraft (KC 135)
- Suborbital Sounding Rockets (Joust, Consort)
- Orbital Rockets (COMET)
- Shuttle - Based Facilities (Middeck, SPACEHAB, Wakeshield)
- Space Station Freedom
Space Station Freedom

Elements:
- Pressurized laboratory module
- Polar platform
- Man-Tended Free Flyer (MTFF)

Systems:
- ECLSS
- Internal thermal control
- Internal audio/video

Japan

Elements:
- Pressurized laboratory module & exposed facility
- Experiment logistics module

Systems:
- Truss
- Mobile transporter (Phase I)
- Nodes (Pressure shell - MSFC)
- Airlocks

NASA/Lewis (Ohio) - Rockwell

Elements:
- Power modules - PV

System:
- Electrical power distribution

NASA/Johnson (Texas) - McDonnell Douglas

Elements:
- Mobile servicing center (Phase I)

Canada

Elements:
- Mobile servicing center (Phase I)

NASA/Marshall (Alabama) - BOEING

Elements:
- Pressure shells for nodes
- U.S. Laboratory module
- Habitation module (outfitting TD by JSC)
- Logistics module (press & unpress)
Phased Space Station Freedom Program

Future evolution

2000 – 8-man crew capability, all systems
(Proposed)

1999 – Permanently manned with 4 crew

1998 – International modules, expanded capabilities

1996 – Man-tended operations begin

1995 – First element launch

Budget pressure

Restructuring

Augustine Committee
Man-Tended Capability

Science mode like Spacelab with equipment on orbit all year

Shuttle-based crew operates experiments during two 2-week visits per year

<table>
<thead>
<tr>
<th></th>
<th>Spacelab</th>
<th>Man-Tended Capability Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>User racks on orbit</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Days/year of operation</td>
<td>39</td>
<td>365</td>
</tr>
<tr>
<td>Available crew</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Average user power (kW)</td>
<td>2.5-3.5</td>
<td>12-45</td>
</tr>
</tbody>
</table>

Add power, truss, logistics, and international modules during this phase
Permanently Manned Capability

Science mode like Skylab or Mir with more power, international laboratories, and logistics

4-person crew rotates every 2 to 3 months

<table>
<thead>
<tr>
<th></th>
<th>Skylab</th>
<th>Mir* (estimated)</th>
<th>Permanently Manned Capability Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>User racks on orbit</td>
<td>295 m³ workshop</td>
<td>10-25</td>
<td>14-45</td>
</tr>
<tr>
<td>Available crew</td>
<td>2-3</td>
<td>2-3</td>
<td>2-3</td>
</tr>
<tr>
<td>Average user power (kW)</td>
<td>7.5</td>
<td>5-10</td>
<td>31-54</td>
</tr>
</tbody>
</table>

Add habitation modules, environmental control systems, and user systems during this phase
Eight-Man Crew Capability

Full power and three laboratories with 8-person international crew

8-person crew rotates every 2 to 3 months

<table>
<thead>
<tr>
<th></th>
<th>Mir* (estimated)</th>
<th>Freedom Station</th>
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</thead>
<tbody>
<tr>
<td>User racks</td>
<td>10-25</td>
<td>60</td>
</tr>
<tr>
<td>Available crew</td>
<td>2-3</td>
<td>6</td>
</tr>
<tr>
<td>Average user power (kW)</td>
<td>5-10</td>
<td>30</td>
</tr>
</tbody>
</table>

• Ready for growth missions
• Commercial processing
• Life sciences
• Missions from planet Earth
Standard Payload Rack Dimensions

889 mm

2026 mm

1054 mm
# Resource Capabilities

<table>
<thead>
<tr>
<th></th>
<th>Man Tended</th>
<th>Permanently Manned</th>
<th>Eight-Man Crew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Size</td>
<td>7 with Orbiter docked</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Power, kW</td>
<td>18.75</td>
<td>56.25</td>
<td>75</td>
</tr>
<tr>
<td>Pressurized Volume, m³</td>
<td>100</td>
<td>600</td>
<td>800</td>
</tr>
<tr>
<td>User Racks</td>
<td>15</td>
<td>46</td>
<td>60</td>
</tr>
<tr>
<td>Thermal Control</td>
<td>3°C</td>
<td>3°C and 17°C</td>
<td>3°C and 17°C</td>
</tr>
<tr>
<td>Process Fluids</td>
<td>Vacuum vent</td>
<td>Vacuum vent</td>
<td>Vacuum + Ultrapure water</td>
</tr>
<tr>
<td>Pressurized Logistics Modules</td>
<td>8-rack</td>
<td>8-rack + 20-rack</td>
<td>8-rack + 20-rack</td>
</tr>
</tbody>
</table>
BOEING COMMERCIAL PROJECT

(JOINT ENDEAVOR AGREEMENT)
CRYSRTALS BY VAPOR TRANSPORT EXPERIMENT (CVTE)

- Joint Endeavor Agreement signed with NASA - May 1986
  - Entitles Boeing to three Shuttle experiment flights and options for two more
  - Quid pro quo entitles NASA to samples in CVTE furnaces
- Purpose of CVTE is to investigate materials processing technologies in microgravity
  - Build and integrate hardware
  - Initial investigations focus on vapor transport processing of electro-optic materials
  - Assess commercial viability of materials processing
- First flight scheduled for STS-49 - April 1992
- Program challenges
  - Integration to a manned flight system
  - Interface requirements and schedule changes
CVTE – A Cooperative Venture

CCDSs
- Science/research support
- Material samples

Boeing
- Design, test, performance and safety of CVTE payload
- Specimen processing
- Integration and mission support
- MAR/CVTE ICD certification
- Flight data recording
- Post flight report

Quid pro quo specimens

Code C – JEA
- Three experimentation flights
- Two optional commercial prototype flights

JSC
- Integration and mission management
- Crew support

MSFC
- JEA management
- Science support

KSC
- Final assembly, installation, and checkout

Furnace

MAR

Camera equipment

Computer

Electronics

Integration and crew
COMMERCIAL SPACE PROJECTS
INTERFACES

NASA

Infrastructure, Interfaces, specs, integration & safety criteria

Cost, policy, legal, proprietary & other limiting factors

Science/User Requirements

Hardware Design & Fabrication

ACADEMIA

INDUSTRY
LESSONS LEARNED
LESSONS LEARNED
ESSENTIAL ELEMENTS FOR SPACE STATION COMMERCIALIZATION

- Stable and Encouraging Pricing Policy
- Firm Commitments for Manifesting Payloads and Use of Infrastructure
- Established Requirements and Specifications
- Streamlined Management and Documentation
- Coordinated Interfaces Between NASA, Industry and Academia
STABLE AND ENCOURAGING PRICING POLICY

- Early establishment of pricing policy for SSF needed to permit commercial business analysis (cost/benefit)
- Pricing policy should be encouraging to commercial interests
  - Options may include initial reimbursement for direct services only, deferred payments, payments from revenue, and quid pro quo arrangements (such as used with Joint Endeavor Agreements for the Shuttle)
  - May not be able to provide long term pricing policy today, but NASA should establish "limited period" pricing policy
FIRM COMMITMENTS FOR MANIFESTING PAYLOADS AND USE OF INFRASTRUCTURE

- Important to know that you have guaranteed opportunity to fly within certain time period
  - Investment decisions based on prospective returns and payback periods
  - If opportunity to fly in space is in question, business interests will not support project
- Similarly, guaranteed access to adequate resources (eg - power, volume, time) on orbit is critical to commercialization
ESTABLISHED REQUIREMENTS AND SPECIFICATIONS

- Designers, developers and users of Space Station Freedom based hardware need baselined requirements and specifications early to efficiently take full advantage of its resources
  - Unclear or changing requirements results in inefficient and costly designs and redesigns
- Restructured Space Station Freedom presents opportunity to establish and disseminate user requirements
- Academic and industrial users need to become knowledgeable of the requirements so they scope their projects properly
STREAMLINED MANAGEMENT AND DOCUMENTATION

- Single layer of both management and requirements documents are crucial to efficient, lower cost, and timely development of commercial projects

- Interface, integration and safety documents for users prepared by multiple offices and NASA Centers causes confusion
COORDINATED INTERFACES BETWEEN NASA, INDUSTRY AND ACADEMIA

- Coordinate hardware and programmatic requirements and interfaces to optimize use of Space Station Freedom resources and economize the commercialization project are needed early.

- Coordination applies to both government provided hardware projects as well as commercially developed hardware.
  - In the case of government procurement programs, input from science and industrial user communities is important to meaningful capability built into hardware.
  - Industry funded programs overlook important requirements due to lack of NASA incentive to communicate.
RECOMMENDATIONS

- NASA needs to establish early pricing policies, administrative procedures, and cooperative agreements to encourage commercialization

- System for "guaranteeing" access to Space Station Freedom needs to be developed; otherwise, business risk is too high

- Interface control documentation and payload accommodations books need to be published early to permit designers and users to properly scope their projects

- Integration management and documentation should be out of one office or Center (e.g., Space Station Freedom Office) without allowing cross-referencing, duplication or modification by other offices or NASA Centers

- Coordinate and develop interface requirements, pricing policies, procedures, etc. to encourage cooperation between NASA, commercial, and academic communities
SUMMARY

- Space Station Freedom has abundant resources and can serve as important element in commercialization of space

- NASA, Industry and Academia cooperation is key to successful commercial ventures - CCDS's serve as a role model

- Lessons learned to date, by Boeing and others, ought to be incorporated into Space Station Freedom commercialization planning

- NASA can best stimulate commercialization with early pricing and use policy and early documentation of interfaces and requirements for Space Station Freedom use

- Commercial space strategy should include consideration of commercialization of Space Station Freedom systems and services