# Architectural Considerations in a Space Station

<table>
<thead>
<tr>
<th>Uses (Missions)</th>
<th>Science, Applications, Commerce, Defense (Integrated and Isolated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupants</td>
<td>Scientists, Engineers, and Technicians</td>
</tr>
</tbody>
</table>
| Activities      | **Interior:** Habitation, Control, Research, Production, Maintenance, Logistics with IVA  
|                 | **Exterior:** Berthing, Sensing, Assembly/Checkout, Maintenance, and Logistics with EVA |
| Interfaces      | Shuttle, Attached Payloads, Free-Flight Payloads, and Long- and Short-Range Excursion Vehicles |
| Utilities       | Atmosphere, Water, Power, Data, Communications, Thermal          |
| Locomotion      | Orientation, Reboost, Manipulation, Excursion                     |
| Environments    | **Exterior:** Low Earth Orbit and Operations                      |
|                 | **Interior:** Life Sustaining and Protecting Stage and Payload Storage |
| Technology/Cost | Budget-Dependent: Development vs Operations                      |
DEVELOPMENT OF SPACE STATION ARCHITECTURE

Objective
- Definition of User and Payload Needs
- Development of Mission Scenario

Approach
- Profiling of User and System Functions
- Characterization of Interfaces
- Preliminary Grouping of Functions

Solution
- Packaging of Functions Into Modules
- Design of System and User Accomodations

Evaluation
- Analysis of Mission Accomplishment
MANNED PLATFORM ACTIVITY SPECTRUM

(Science) (Technology) (Commercial)
(National and International)

**Interior**
- Payload Operations
  - Life Science
  - Material Processing Applications
  - Technology Demonstrations
- Control Center(s) for:
  - Interior Operations
  - Exterior Operations/Accessories
  - Exterior Payloads
  - Maneuvering Vehicles
- Habituation/Recreation
- Maintenance/Logistics
- Traffic (Daily Routine and Periodic
- Safe Haven
- Exterior Viewing
  - Operations
  - Sight-Seeing

**Exterior**
- Attached Payload Operations
  - Science Instruments
  - Applications Instruments
  - Large Space Systems
  - Development of:
    - Technology (Prototypes, Performance Measurement)
    - Operations (Assembly, Alignment, EVA)
  - Assembly Accessories
  - Hi-Alt-Vehicle Buildup/Stowage/Launch Spacecraft Servicing
- Attached/Detached Payload Operations (Tended/Tethered/Teleoperated)
  - Material-Processing
  - Free Flyers
  - Rendezvous Testing, Tow/Dock Services and Low-G Payloads
  - Co-Orbiting Platform
- Sustaining Resource Installations
- Shuttle Interaction Operations
**REQUIREMENTS FULFILLMENT CONGREGATION**

(*HIGH-MODULARITY CONCEPT*)

- POWER (11 - 25 kW)
- COMM/DATA
- THERMAL RADIATION
- ATTITUDE CONTROL
- ALTITUDE REDUCTION
- EXTERIOR PAYLOAD INSTALLATIONS

- CENTRAL BUILDUP POINTS & PASSAGE
- UTILITIES DISTRIBUTION
- LIFE SUSTAINANCE (90 DAYS)
- BASIC COMM (2) ACCOMMODATIONS
- MANNED CONTROL CENTER
- SAFE HAVEN

- LOGISTICS
  - CHEW SUPPLIES
  - PAYLOADS
  - PAYLOAD SUPPLIES
  - MANNED PLATFORM AND SPACE PLATFORM SPACES

- SUBSYSTEMS MODULE (SPACE PLATFORM)
- CENTRAL SUPPORT AND BUILDUP MODULE
- BASIC CHEW MODULE
- INTERIOR ACCESS LOGISTICS MODULE

- EXPANDED CREW ACCOMMODATIONS AND CONTROL CENTER
- EXPANDED EXTERIOR PAYLOAD INSTALLATION
- EXPANDED INTERIOR PAYLOAD INSTALLATION
- SUBSYSTEM UPGRADES
- LOGISTICS ASCENT
  - PLANNED
  - UNPLANNED
- EMERGENCY STATION ABANDONMENT
- EXTENDED REACH LOADING

- HABITAT MODULE
- EXTERIOR OPERATION MODULE
- DEDICATED PRESSURE PAYLOAD MODULE
- IVA INSTALLED SUBSYSTEM MODULE
- SHUTTLE (90 DAY CYCLE) EXPENDABLE LAUNCH VEHICLE
- REENTRY CAPSULE
- PLATFORM MOUNTED REMOTE MANIPULATOR
## CONFIGURATION ASPECTS OF PAYLOAD ACCOMMODATIONS

### Payload Type
- Internal
  - Built-In
  - Transient
- External
  - Non-Viewing
  - Viewing
    - Stellar
    - Solar
    - Earth
  - Large Assembly
  - Periodically Serviceable
  - Small Reusable Stages
  - Large Reusable Stages
  - Large Propellant Storage

### Location Type
- Pressurized Module
- Any Berth
- Space-Directed
- Earth-Directed
- Large Free Volume
- Close-in Access Aids
- Possibly Enclosed
- Semi-Remote Berth
- Semi-Remote Berths (Near Station Centerline)

### Constraints
- Approach/Exit Movement Corridors
- Solar Array Shadowing
- Radiator Reflections
- Manipulator Access (Shuttle/Space Station)
- Multiple Orbiter Berthing Ports
- Interim Berthing During Assembly or Exchange

### Exterior Payload Operations/Time Impact Configuration Significantly
# Architecture Options for Payload Accommodations

<table>
<thead>
<tr>
<th>Laboratory Module(s) (Interior Payloads)</th>
<th>Service Center (Exterior Payloads)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Functions Only</td>
<td>Integrate With Multiple Docking Adapter</td>
</tr>
<tr>
<td>Lab and Crew Qtrs Hybrid</td>
<td>Separate Multi-Berth Unit (Trusswork) (Tunnel)</td>
</tr>
<tr>
<td>Lab and Sta-Control Hybrid</td>
<td>One Unit/10 Berths (All-In-One)</td>
</tr>
<tr>
<td>Dedicated Types</td>
<td>Two Units/5 Berths (i.e. Modular)</td>
</tr>
<tr>
<td>General Purpose Types</td>
<td>Incorporates Big Manipulator</td>
</tr>
<tr>
<td>Short Module</td>
<td>Incorporates Radiators</td>
</tr>
<tr>
<td>Long Module/Unpartitioned</td>
<td>Articulating (For Broad Op's Flexibility)</td>
</tr>
<tr>
<td>Long Module/Partitioned</td>
<td>Central, Top or End-Mounted</td>
</tr>
<tr>
<td>Some Long, Some Short</td>
<td>Rotating Berths For Maximum Viewing Payload, or Assembly Op's Flexibility</td>
</tr>
<tr>
<td><strong>Accessories:</strong></td>
<td>Hangar Provisions (Pressurized/Unpressurized)</td>
</tr>
<tr>
<td>Built-In Radiator</td>
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<tr>
<td>Scientific Airlock</td>
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## SPECTRUM OF SERVICES SCENARIOS
(RELATED TO SPACE STATION)

### User Types and Service Locations:

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<tr>
<th>On Station</th>
<th>Off Station</th>
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<tr>
<td>✔</td>
<td>Via TMS</td>
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- Space Station: Attached Payloads
- Free Flying Spacecraft
- Teleoperated Maneuvering System
- Space Platform
- Space Platform Attached Payloads
- Reusable Orbit Transfer Vehicles
- RDTV-Boosted Free-Flying Spacecraft
- RDTV-Boosted Servicer
SPACE STATION SERVICE CENTER

Objective

- Provide a Broad Range of Enabling and Sustaining Services to Resident and Transient Payloads

Service Functions (in Graduated Capability/Time)

- Berthing
- Activation
- Deployment
- Diagnosis
- Alignment
- Replenishment
- Enclosure
- Replacement
- Modification
- Assembly
- Stowage
- Checkout and Launch
- Manipulation
- Maintenance
- Surface Treatment

Types of Payloads (NASA, DoD, Commercial, Foreign)

- Self-Propelled Spacecraft
- Propulsion-Staged Spacecraft
- Teleoperator Maneuverer
- Orbit Transfer Vehicle(s)
- Reusable Orbit Transfer Vehicle
- Palletized Payloads (Resident/Non-Resident)
  - Science
  - Earth Applications
  - Technology
- Space Platforms (?)
SPACE STATION SERVICE CENTER (CONT.)

Major Configuration Elements

- Servicing Control Centers (General and Dedicated)
- Articulated, Truss Beams(s) with Berthing Ports
- Power, Data and Communications Distribution
- Liquid, Gas Storage and Distribution Systems
- Manipulator(s): Major and Localized — Minor Types
- Enclosure(s): Permanent and Portable
- EVA Access/Assistance Equipment
- Interior Stowage (Replacement/Modification Items)
- Exterior Stowage (Interim and Long Term Berthing)
- Tool and Supplies Stowage
- Diagnostic and Checkout Equipment
- Work Bench Areas
- Directed Lighting

Configuration Constraints

- Extensive Crew Visibility of Operations
- Safe Rendezvous and Exit Flight Corridors
- Efficient Shuttle RMS Loading Access or Handover
- Extensive Payload (Berth) Separation for Viewing or Movement Freedom
- Minimal Solar Array Shadowing and Radiator Reflection
LARGE DIAMETER REFLECTOR ASSEMBLY

Space Station Accommodations
- Large Span Mounting Beam With Utilities and Articulation
- Long Reach Manipulator
- Interim Stowage Locations For Construction Elements
- Operational Viewing

- Internal Control Center
- EVA Crew Capabilities
- Possible Enclosure/Contamination Shield Provisions
# SPACE STATION MISSIONS
## EARLY SET (1991-93)

<table>
<thead>
<tr>
<th>Missions Externally Attached to SS Base (Or Co-Orbiting Platform)</th>
<th>Missions Accommodated Inside SS Laboratory Modules</th>
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<tbody>
<tr>
<td><strong>SAA</strong> 0001 Cosmic Ray Nuclei</td>
<td><strong>SAA</strong> 0307 Life Science Laboratory</td>
</tr>
<tr>
<td><strong>SAA</strong> 0002 Space Plasma Physics</td>
<td><strong>COM</strong> 1201 MPS Lab #1</td>
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<tr>
<td><strong>SAA</strong> 0003 Solar Optical Telescope</td>
<td><strong>TDM</strong> 2020 Materials Processing</td>
</tr>
<tr>
<td><strong>SAA</strong> 0004 Shuttle IR Telescope Facility</td>
<td><strong>TDM</strong> 2520 Habitation Technology</td>
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<tr>
<td><strong>SAA</strong> 0006 Starlab</td>
<td><strong>TDM</strong> 2530 Medical Technology</td>
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<tr>
<td><strong>SAA</strong> 0201 LIDAR Facility</td>
<td><strong>TDM</strong> 2580 On-Board Operations Technology</td>
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<tr>
<td><strong>SAA</strong> 0306 CELS Pallet</td>
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<tr>
<td><strong>COM</strong> 1202 EOS Production Units</td>
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<tr>
<td><strong>COM</strong> 1203 ECG Production Units</td>
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<tr>
<td><strong>COM</strong> 1105 Communications Test Lab</td>
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<tr>
<td><strong>TDM</strong> 2010 Materials Performance</td>
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<tr>
<td><strong>TDM</strong> 2060 Deployment/Assembly/Construction</td>
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<td><strong>TDM</strong> 2070 Structural Dynamics</td>
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<tr>
<td><strong>TDM</strong> 2080 Design Verification</td>
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<tr>
<td><strong>TDM</strong> 2210 Large Space Antenna Technology</td>
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<tr>
<td><strong>TDM</strong> 2260 Earth Observation Instrument</td>
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<tr>
<td><strong>TDM</strong> 2310 Fluid Management Technology</td>
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<td><strong>TDM</strong> 2410 Attitude Control Technology</td>
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<td><strong>TDM</strong> 2420 Figure Control Technology</td>
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<td><strong>TDM</strong> 2460 Telepresence and EVA Technology</td>
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<tr>
<td><strong>TDM</strong> 2470 Interactive Human Factors</td>
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<tr>
<td><strong>TDM</strong> 2510 Environmental Effects Technology</td>
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<tr>
<td><strong>TDM</strong> 2560 Satellite Servicing Technology</td>
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<tr>
<td><strong>TDM</strong> 2570 OTV Servicing Technology</td>
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<tr>
<td><strong>Free-Flyer Missions Serviced At/By SS Base</strong></td>
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<tr>
<td><strong>SAA</strong> 0012 Space Telescope</td>
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<td><strong>SAA</strong> 0013 Gamma Ray Observatory</td>
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<td><strong>SAA</strong> 0014 X-Ray Timing</td>
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<td><strong>SAA</strong> 0016 Solar Max Mission</td>
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<td><strong>SAA</strong> 0017 AXAF</td>
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<tr>
<td><strong>SAA</strong> 0019 Far UV Spectroscopy</td>
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<tr>
<td><strong>Planetary Missions Supported at SS Base</strong></td>
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<tr>
<td><strong>SAA</strong> 0102 Lunar Geochemical Orbiter</td>
<td></td>
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<tr>
<td><strong>SAA</strong> 0105 Titan Probe</td>
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<tr>
<td><strong>Missions Supported By Polar Platform</strong></td>
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<tr>
<td><strong>SAA</strong> 0202 Earth Sciences Research</td>
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<tr>
<td><strong>COM</strong> 1019 Stereo Multi-Linear Array</td>
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</table>
CUSTOMER ACCOMMODATION CONSIDERATIONS IN ARCHITECTURE

Customer Equipment and Operation Profile and Support Needs

- Individual
- Aggregate

Crew, Subsystem and Basic Operations Accommodation Needs

- Basic Multi-Service Space Station Concept

- Shuttle Design and Operational Modes

Direct Customer Accommodation

(Impact Tradeoffs)

Optimized Space Station Concept

Supporting Operations and Logistics Concept

Customer Concept Validation or Modification
<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Pages</th>
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<tr>
<td>Ames Mock-up Ideas</td>
<td>M. Cohen</td>
<td>5-1 to 5-3</td>
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<tr>
<td>Simulation for Human Factors Research</td>
<td>D. Nagel</td>
<td>5-4 to 5-7</td>
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<tr>
<td>EVA Orbital Servicing Equipment</td>
<td>H. Vykukal</td>
<td>5-8 to 5-10</td>
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<td>SS Models, Mockups and Simulators</td>
<td>K. Miller</td>
<td>5-11 to 5-18</td>
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<tr>
<td>Mock-up and Human Productivity Studies</td>
<td>T. Fisher</td>
<td>5-19 to 5-38</td>
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<td>Experiences with Neutral Buoyancy Testing Mockups</td>
<td>R. Dellacamera</td>
<td>5-39 to 5-47</td>
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<tr>
<td>Rockwell Experience Applications to Ames Space Station Mockup Habitability/Productivity Studies</td>
<td>J. Roebuck</td>
<td>5-48 to 5-64</td>
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<tr>
<td>Role of Mock-ups in the Development of Orbital Replaceable Units (ORU)</td>
<td>G. Johnson</td>
<td>5-65 to 5-90</td>
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