Accommodations for Space Science on the International Space Station

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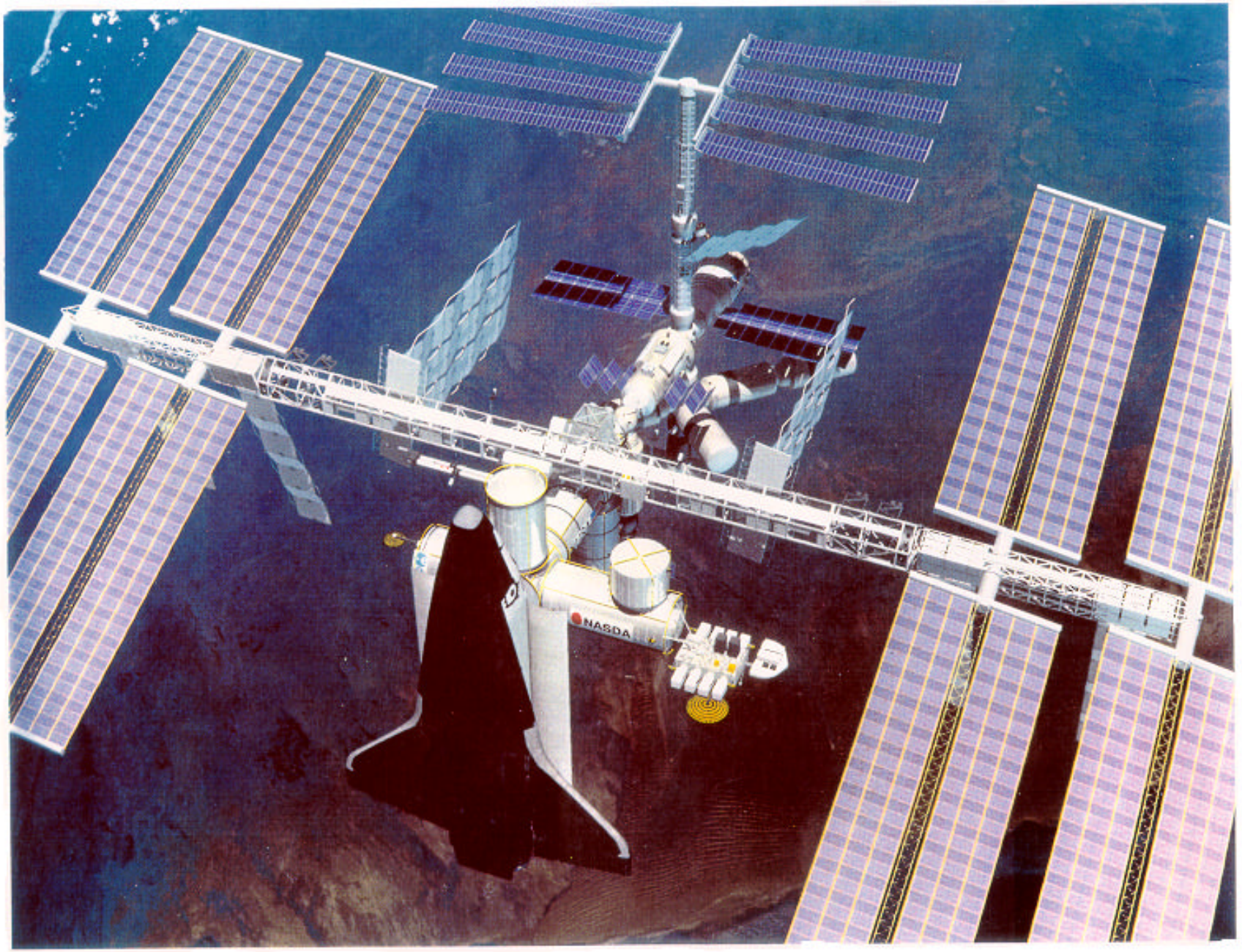
MIDEX Pre-Proposal Conference

8/10/01

Agenda

RPO Role
ISS Vehicle
U.S. Truss – Full Attach Site
EXPRESS Pallet
Japanese Experiment Module-Exposed Facility
Considerations on Unpressurized ISS Use
WORF
Additional Considerations on Pressurized ISS Use for Earth Science Research
General ISS Payload Consideration:
- Manned Flight Safety
- Crew Training
- Operation Concept
- Retrieval
- STS and ISS Reviews and Deliverables

Manifest Opportunities
RPO Website


NASDA

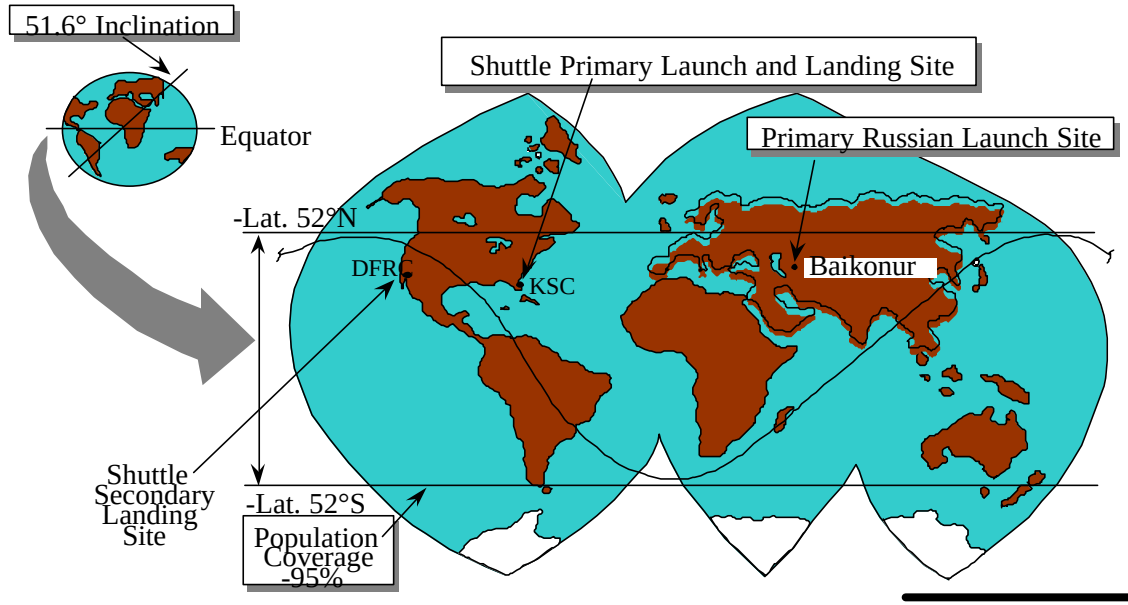
RPO Role for Payload Support

- Coordinate payload planning, accommodations, allocations, manifesting, development, integration, and operations, and any associated issues between HQ, payload developers, international partners, other NASA centers, and the ISS Program
- Assist ISS Program/Boeing in defining payload interface requirements including thermal, mechanical, electrical, data, contamination, operations, crew training, programmatic (schedules, data deliverables, documentation, reviews)
- Shepherd payload developers through the STS/ISS systems, procedures, and reviews

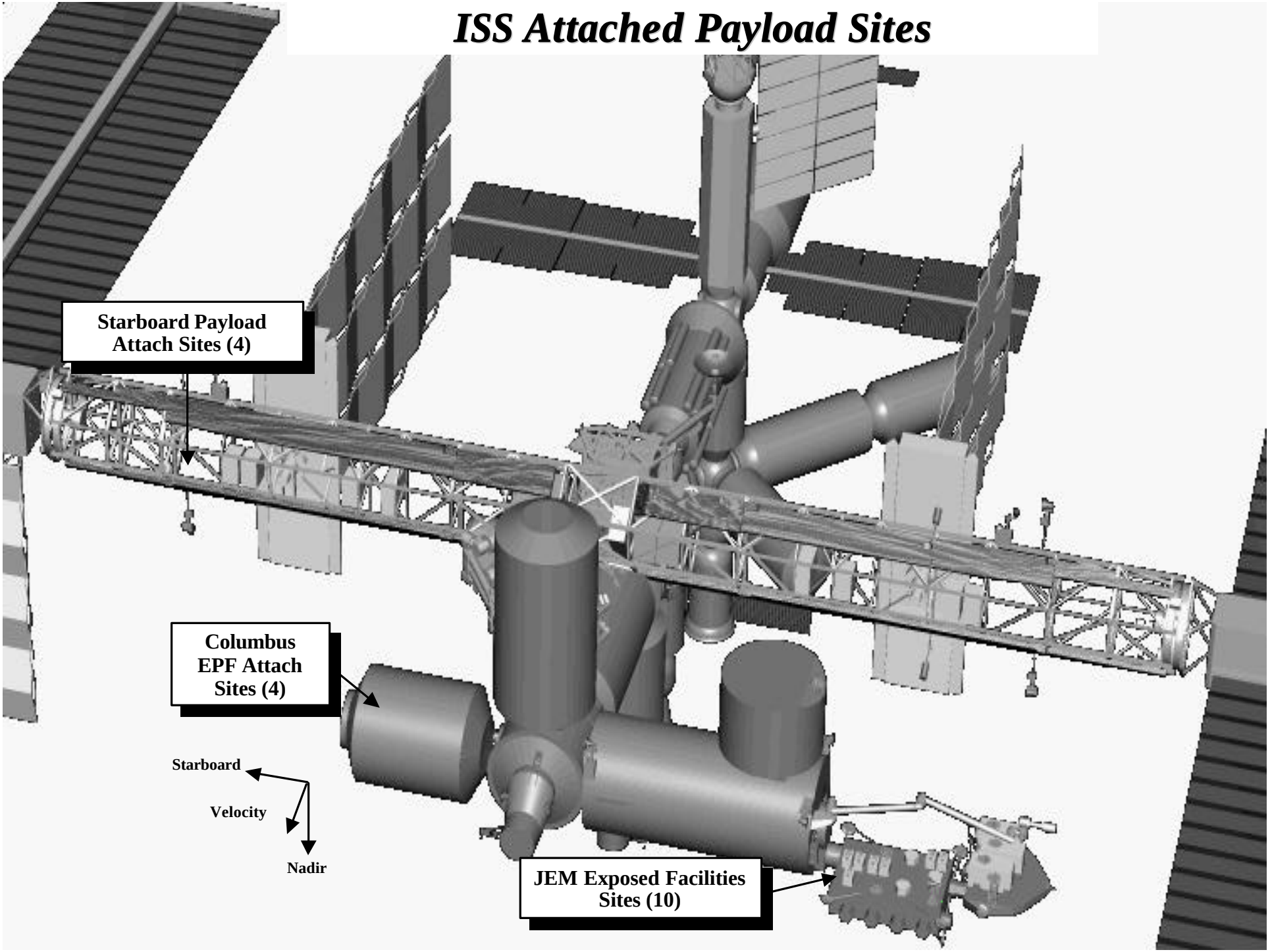
ISS Vehicle

Orbit

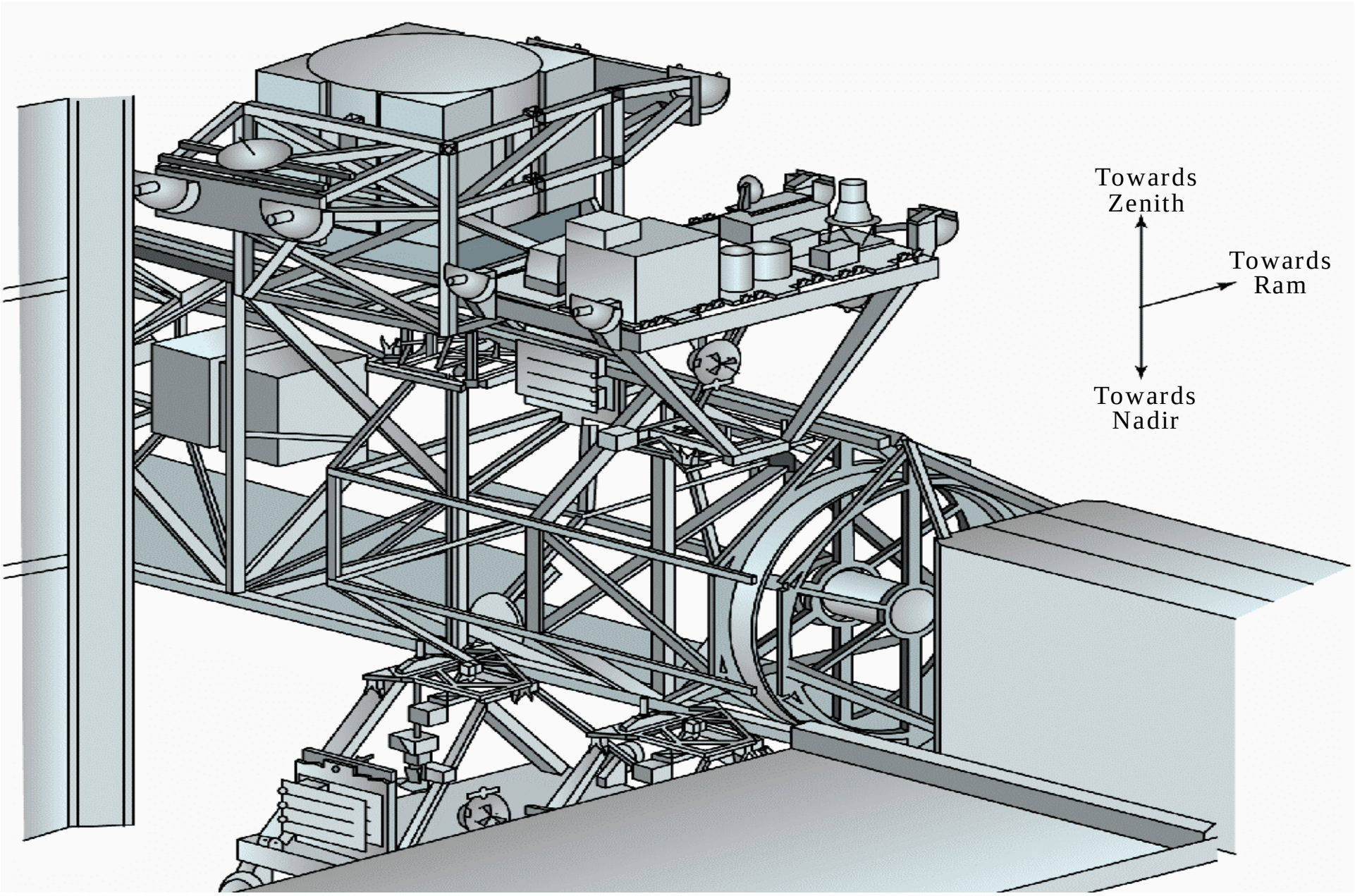
- Nearly circular, inclination 51.6 deg
- Altitude 189 to 248 nautical miles (350 - 460 Km)
- Reaches maximum 52° latitude north and south
  - Covers 85% of globe, 95% Earth's population
- Flies over same spot approximately every 3 days, with the same lighting every 3 months



ISS Attached Payload Sites



U.S. Truss



U.S. Truss – Full Attach Site

- 1 zenith site on starboard truss currently planned programmatically
- Mass
  - Dependent on payload center of gravity up to ~ 6,360 Kg
- Payload Envelope
  - 2.23m along truss
  - 4.3m ram/wake
  - Height determined by CG enveloped STS bay limits
  - EVA translation corridors between payload and truss must be maintained
- Power
  - Max capability 3 kW
  - Actual power allocations less based on integrated payload vehicle requirements
  - Keep-alive power to be negotiated

U.S. Truss – Full Attach Site (Con't)

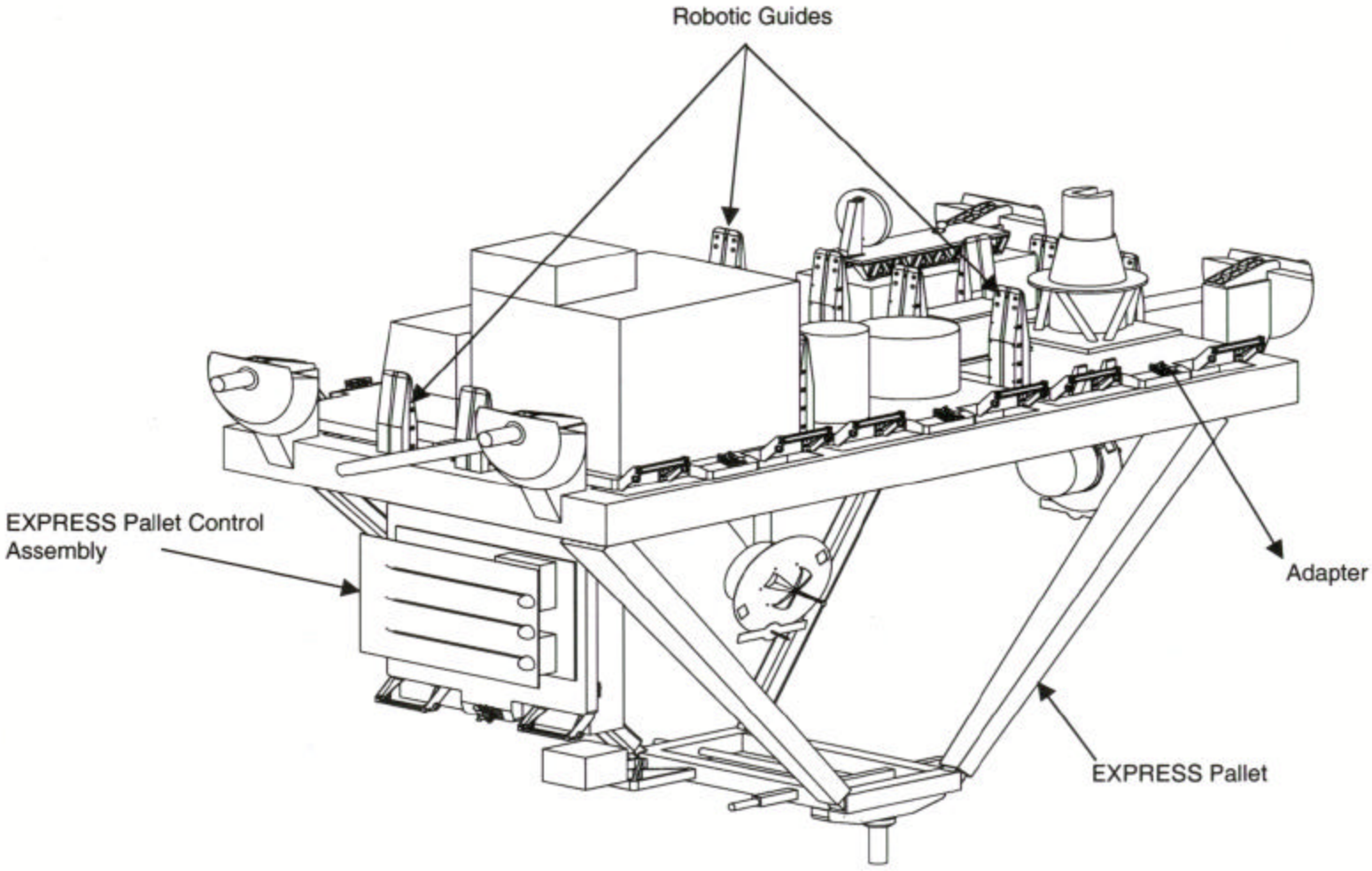
- Data
  - Low rate command, control, telemetry via MIL-STD-1553B bus, <20 Kbps max
  - High rate data via fiber optic
    - Assume average data generation rate ≤ 1-2 Mbps
  - Downlink not real-time, at best every few orbits
  - Plan to internally store and dump data
- No active thermal control provided
- Robotic installation and retrieval primary, EVA contingency
- Carrier
  - Must provide own structure on-orbit
  - Over 2500 Kg, payload provides carrier/interface to Shuttle

U.S. Truss – Full Attach Site (Con't)

Pointing

- Knowledge 0.1 deg at GPS sites
  - Degrades with distance to ~1-2 deg at S3 attach sites
  - Working on improving knowledge at S3 truss site
- Stability 2.5 deg/axis/orbit
  - Pointers are being developed for specific EXPRESS Pallet adapter payloads
    - Earth viewing SAGE III
    - Solar viewing EXPORT

EXPRESS Pallet



U.S. Truss - EXPRESS Pallet

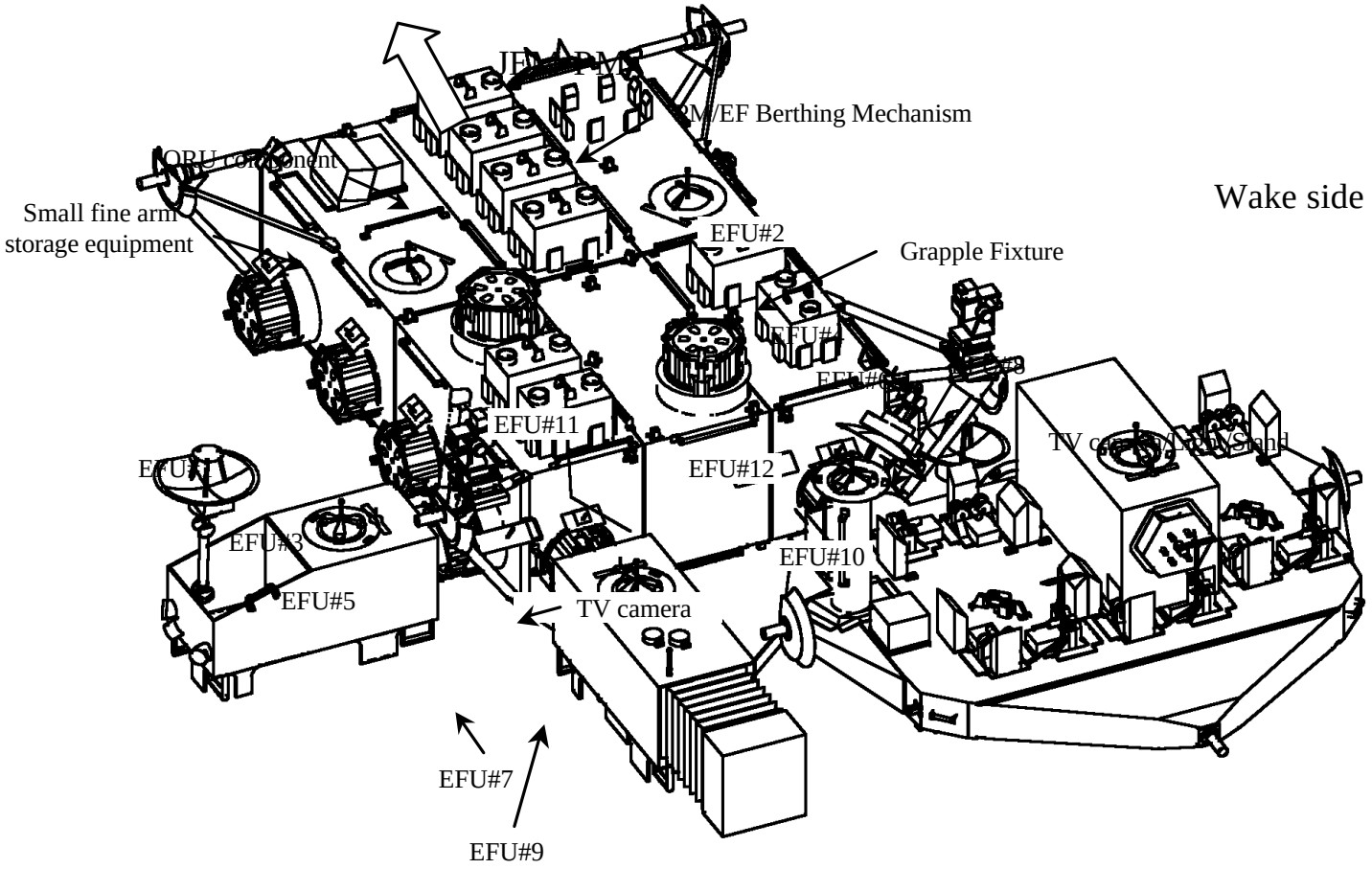
- 2 nadir pallets and 1 zenith pallet on starboard truss currently planned
- 6 adapter plates per pallet
- All sites are allocated to NASA
  - Exceptions for the Canadian Space Agency (CSA) and barter arrangements with International Partners
- Mass 227 Kg per adapter payload
- Payload Envelope
  - 1.1m ram/wake
  - 0.86m inboard/outboard
  - 1.2m zenith/nadir
- Power
  - 2.5 kW of combined 120 Vdc and 28 Vdc to be shared by 6 adapter payloads
  - 750 W of 120 Vdc and 500 W of 28 Vdc available per site, however power will be limited by ability to dissipate heat
  - 120 Vdc keep-alive power during ISS reduced power modes and 120 Vdc contingency power provided

U.S. Truss - EXPRESS Pallet (Con't)

- Data
  - Low rate telemetry via MIL-STD-1553B bus, max 20 Kbps available to Pallet, assume 2 Kbps per adapter payload
  - 6 analog signals and 6 bi-level discretes available per adapter payload monitored by Pallet Controller Assembly
  - High rate science data provided via Pallet Ethernet, assume
    - 6 Mbps max throughput for Pallet
    - 250 Kbps average data generation rate per payload
    - Payloads buffer data
    - Transmit at 1 Mbps average rate or 6 Mbps burst

U.S. Truss - EXPRESS Pallet (Con't)

- No thermal control provided by Pallet
- Pallet/Payload mechanical interface hardware and use of shipping container provided by ISS Program
- Robotic installation and retrieval primary, Extravehicular Activity (EVA) contingency only
- Carrier
  - First payload set launches on Pallets
  - Returning payloads and future individual payloads ride on carriers provided by ISS Program



Japanese Experiment Module – Exposed Facility

Japanese Experiment Module-Exposed Facility (JEM-EF)

- 10 payload sites – 5 NASA, 5 NASDA
  - 8 sites can view zenith and nadir simultaneously, 2 zenith viewing only
- Mass
  - Eight 500 Kg sites
  - Two 2500 Kg sites
- Payload envelope
  - 1.85m ram/wake
  - 0.8m inboard/outboard
  - 1.0m zenith/nadir
- Power and data site dependent
  - Generally 3 kW capability per site
  - 100 W keep-alive power
  - MIL-STD-1553B bus, high rate Ethernet available

Japanese Experiment Module-Exposed Facility (JEM-EF)

- Active thermal cooling available
- Robotic installation
  - Grapple fixture must be located on zenith face
- Carrier
  - Launched by STS with ULC
  - 2nd option launched by Japanese HTV with Mixed Logistics Carrier
  - Must return via STS with ULC
- Capability for crew access via JEM airlock

Considerations on Unpressurized ISS Use

- Contamination
  - Need to be concerned about molecular deposition (long-term and sporadic)
    - Molecular Deposition of the ISS Environment = 130 A/yr
    - Use of retractable aperture covers can help
  - Outgassing requirements not yet defined for payload-to-payload and payload-to-ISS interfaces except at full truss sites
    - Stringent cleanliness control during payload development necessary to meet current requirements
- Altitude
  - Can vary from 190 to 250 nmi with smaller short-term variations superimposed on longer solar-cycle induced variation
  - Altitude reboost anticipated approximately every 3 months (nominally)

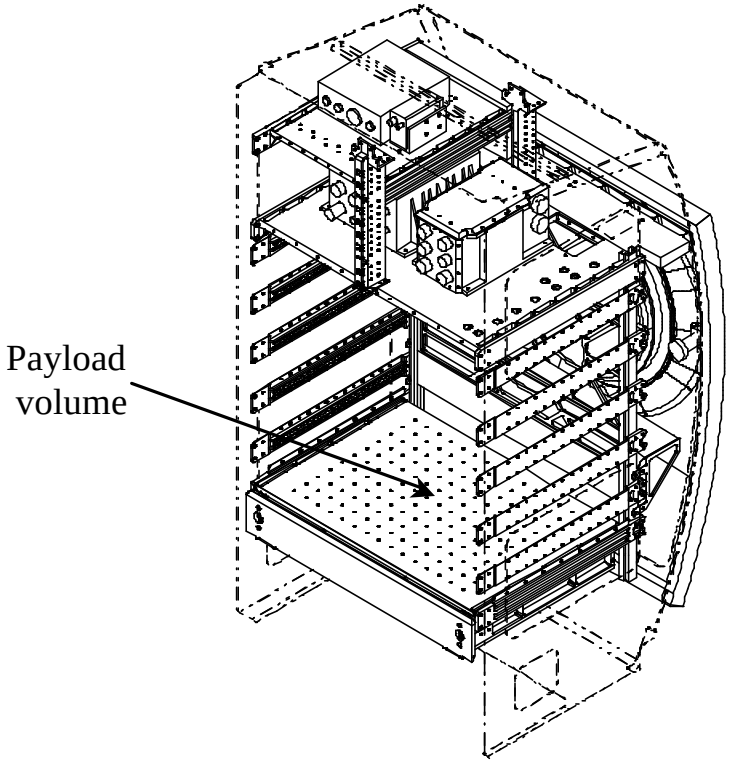
Considerations on ISS Use (Con't)

- Attitude Knowledge/Pointing
  - ISS attitude knowledge will be reasonable well known and stable, but fine pointing knowledge/control at the location of instrument may need to be augmented by the payload
  - ISS attitude holding capability (2.5 degrees per axis per orbit) may need to be augmented by payload pointing
- Microgravity requirements (payload induced disturbances) will be levied on all payloads
- Viewing
  - Possibility exists for partial or periodic obstruction of viewing by Shuttle visits, solar panels, other instruments, etc.

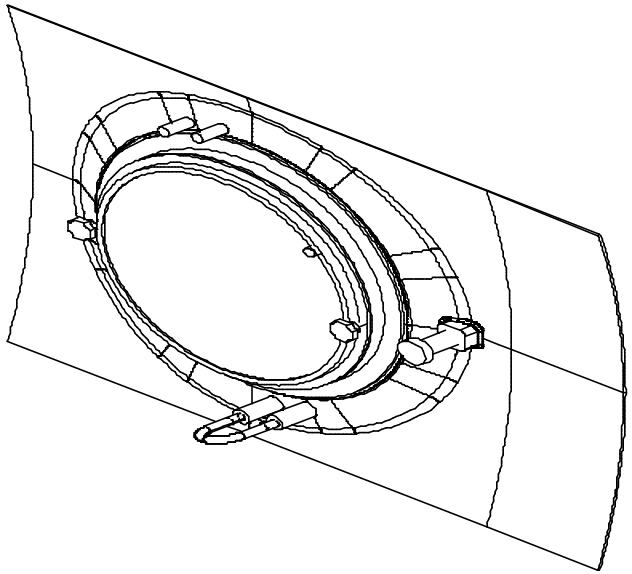
Considerations on ISS Use (Con't)

- Power
  - Have significant power available but will need to share with other instruments
  - Will be periods of low keep-alive power, e.g., during shuttle/ELV dock/undock
    - Power duty cycle not yet characterized
- Data Handling/Communication
  - Can command via S-band, get downlink via Ku band with good but not complete coverage
  - Payloads need capability to store and dump high rate science data

Window Observational Research Facility (WORF)

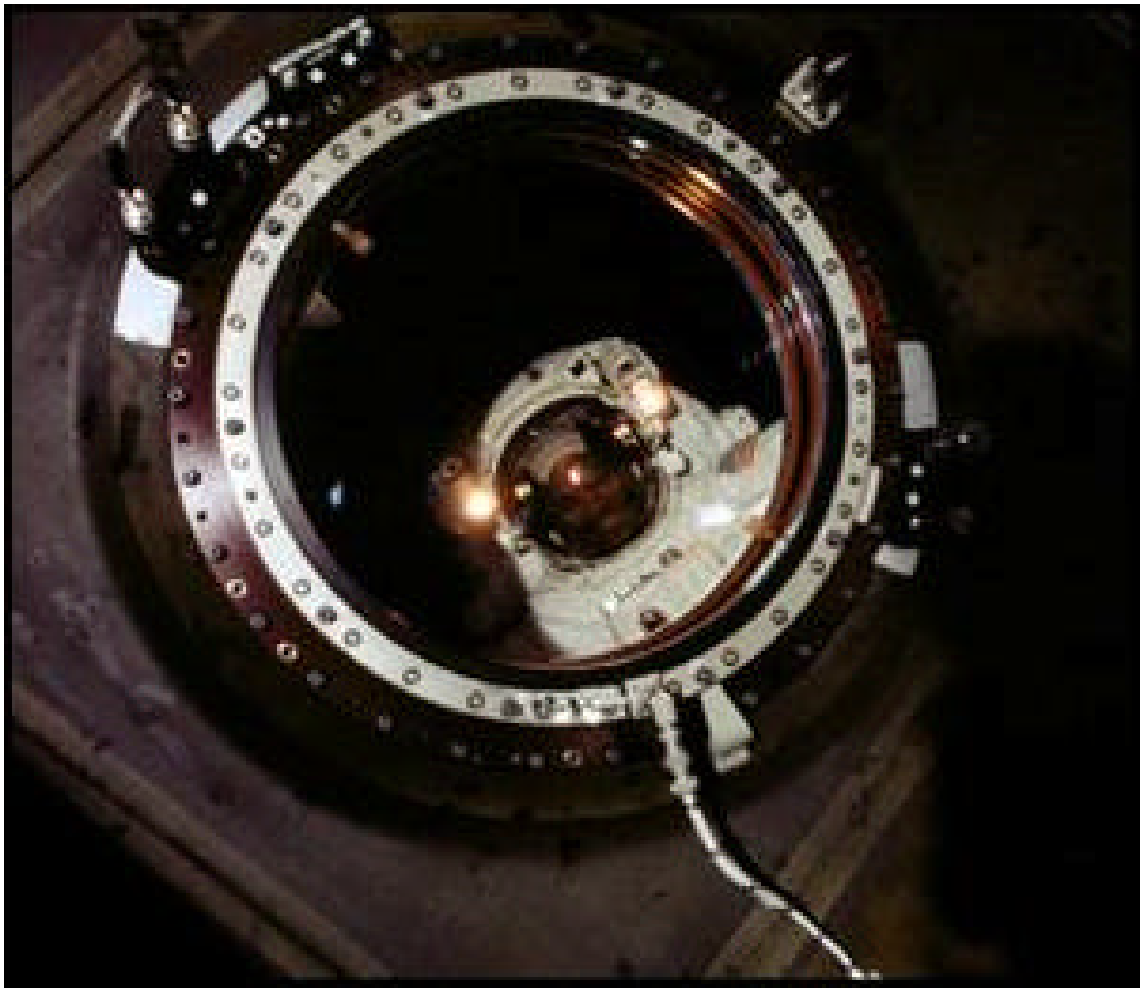


WORF 3/4 schematic view showing the relationship between payload volume and avionics bays.

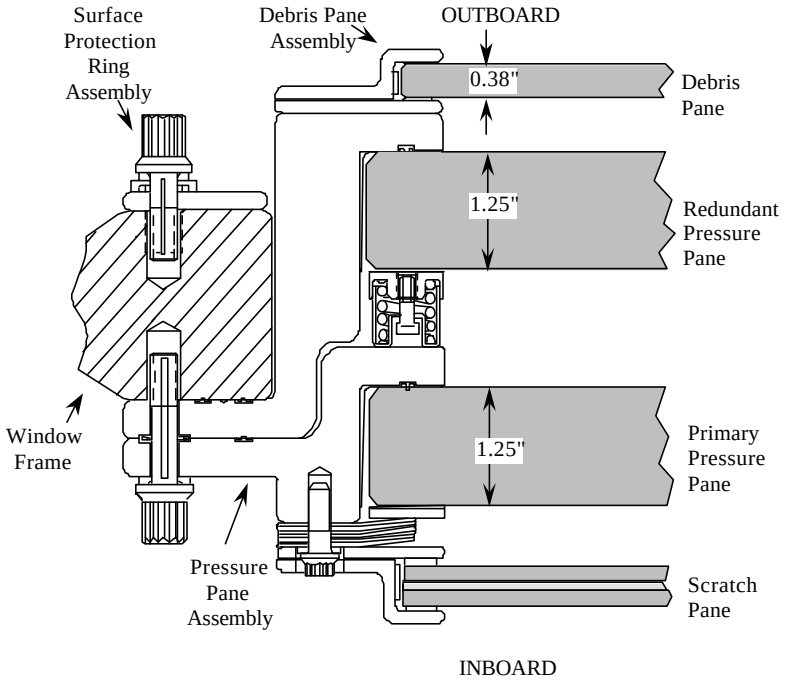


US Laboratory nadir window; the pane (Fused Silica) has a 20” (50.8cm) clear viewing area. To the right of the window is the handwheel for opening the window shutter. The “U”-shaped structure below the window is a quick disconnect (QD) that controls the pressure between the two pressure panes.

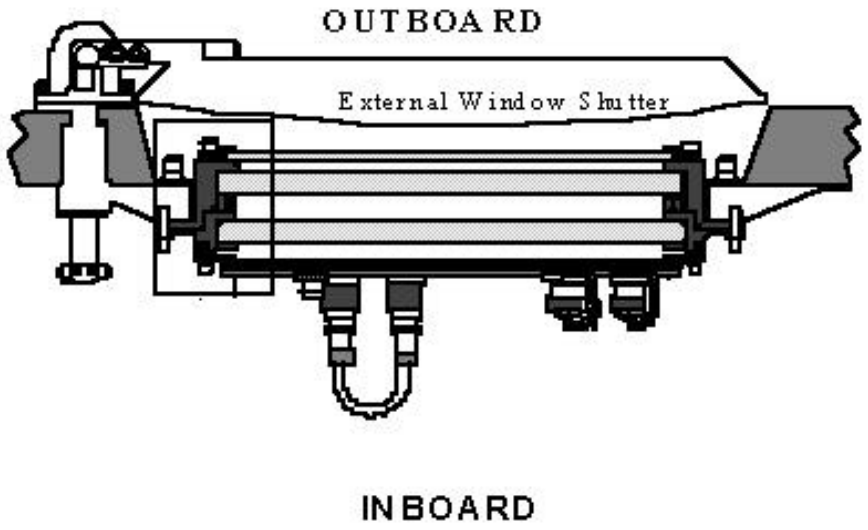
Window on Orbit



ISS WORF



Schematic showing the construction of the nadir window and its Integration into the window mount. The kick pane will be removed for during window research operations.



Window/mount integration into the Space Station structure. The external cover can be moved out of the way by use of the hand wheel located to the left.

ISS WORF

- 20-inch diameter fused silica window located in nadir side of the US Laboratory Module
- Optical quality of window is superior to any window flown on a manned mission
  - Measured optical quality confirms wavefront error of λ / 14 over 6-inches, peak to valley, reference λ = 632.8nm, with scratch pane removed for payload operations
- WORF rack adjacent to window provides support infrastructure for camera/remote sensor operations
- WORF is light-tight and low-reflectance to enable observations of low-light-level phenomenon, e.g. aurora

ISS WORF

- Payload Mass
  - 136 Kg
- Payload Envelope
  - 53.3cm x 76.2cm x 50.8cm
- Power
  - 28 Vdc, 560 W maximum to any payload interface
  - 2 kW total available for payloads
    - Thermal system capacity determines allowable power draw
- Data
  - Maximum data rate 8 Mbps with approximately 1.3 Gb storage provided
  - Low and medium rate telemetry and video available
  - 2 analogs and 3 discretes per payload
- 2 Primary means of thermal control
  - Forced air cooling
  - Water cooling
- Payloads can be operated in any combination of crew operated, crew tended, ground commanded, or fully autonomous

Additional Considerations on Pressurized ISS Use for Earth Science Research

- Attitude/Pointing Knowledge
  - Pointing knowledge is available in the ISS data stream but may need to be augmented by payloads
- Vibration Isolation
  - Window facility designed to mitigate vibration input from ISS environment, payloads with large optics may need augmentation for vibration isolation
- Viewing
  - Viewing limited to Window Field-Of-View but with no obstructions
- Transport to ISS via various possible carriers:
  - Multi-Payload Logistics Module (MPLM)
  - Middeck Locker(s)
  - SPACEHAB Locker

General ISS Payload Considerations: Manned Flight Safety

- STS and ISS safety review system combined for flight and ground
- Substantial documentation increase over ELVs
- Significant safety oversight required
  - Safety and hazard verification
- Level of rigor independent of payload size or $ value
  - 3 step review process
  - Phase 1 review within 3 months of PDR

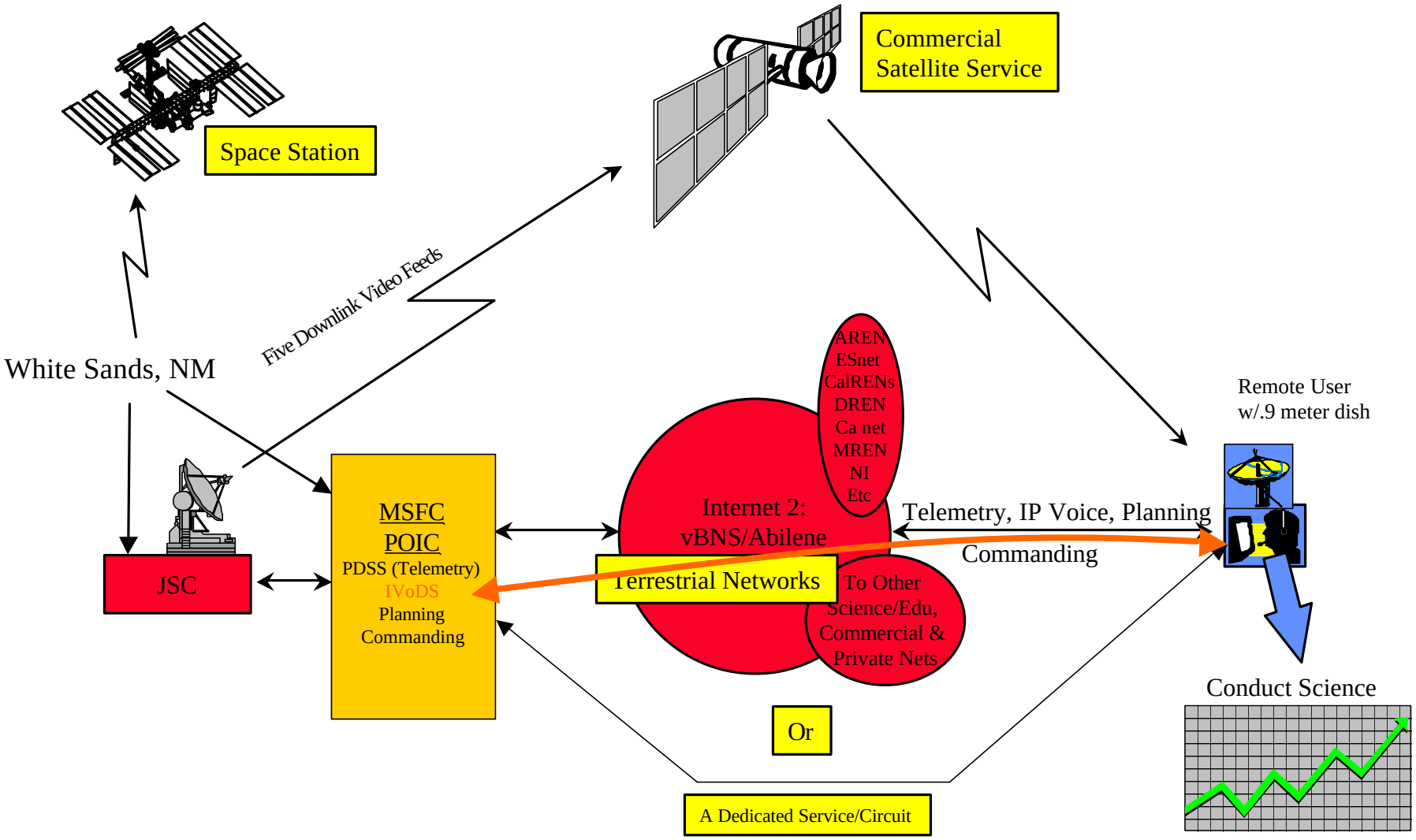
General ISS Payload Considerations: Crew Training

- "Standard" operations don't require Payload Developer (PD) input, e.g. robotic placement
- Unique payload handling on-orbit requires training procedures, documentation
- Crew familiarization package to be provided by PD
- Contingency operations involving crew intervention will require ground or on-board training

General ISS Payload Considerations: Ops Concept

- PI operates payload and receives data through MSFC via a workstation at a secure location of PI's choice
- Increment = crew rotation period, ~ 3 months
- Planning Period ~ 1 year
- "Increment Scientist" (IS) represents all Code S payloads operating on ISS for a planning period and works directly with PIs
- IS is part of a team with a Lead Increment Scientist who represents all payloads to ISS Program during ops and contingencies
- Reporting required after each increment with additional post flight reporting

ISS TO SCIENCE USER END TO END CONNECTIVITY



General ISS Payload Considerations: Retrieval

- Payloads must be returned to ground
- Retrieval planning must take place prior to launch
- Payload anomalies and configuration changes must be tracked while on-orbit
- Safety re-assessment requires original design documents and operations records be maintained
- Retrieval Certification of Flight Readiness (CoFR) and Safety review required
- De-integrate from STS and return payload to PI
- Payload's MO & DA budget must include payload team support to complete retrieval activities

Payload Supported STS/ISS Reviews and Deliverables

- The payload developer must support a certain template of ISS Program reviews and deliverables
- Typical templates for EXPRESS Pallet and WORF reside on the RPO website
- Full truss templates are in work and will be placed on the web shortly

Manifest Opportunities

- Assembly Sequence is currently being reworked
- Zenith EXPRESS Pallet launch likely to be early 2006 but is NOT confirmed
- First JEM-EF launch opportunity could be late 2005
- OSS full truss payload follows the Alpha Magnetic Spectrometer
  - Launch likely to be early 2008 - unconfirmed

Contact Us

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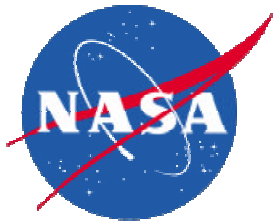
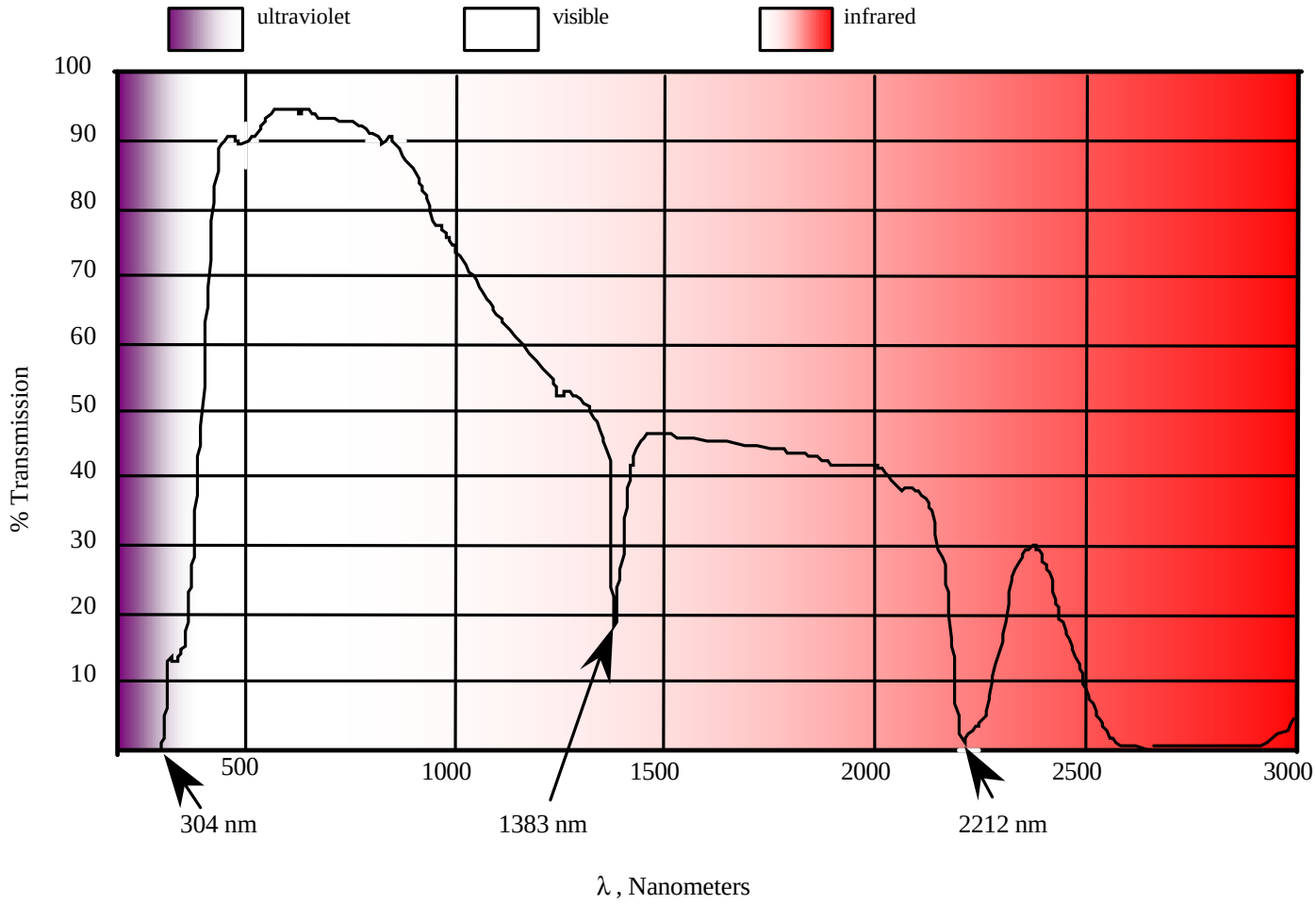
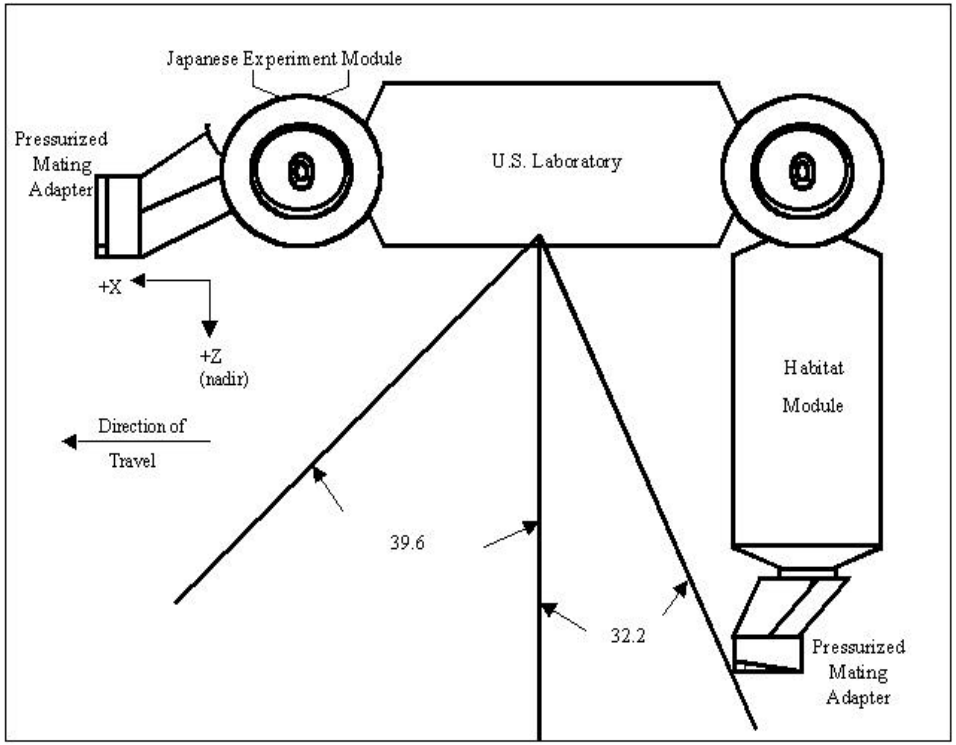


Backup

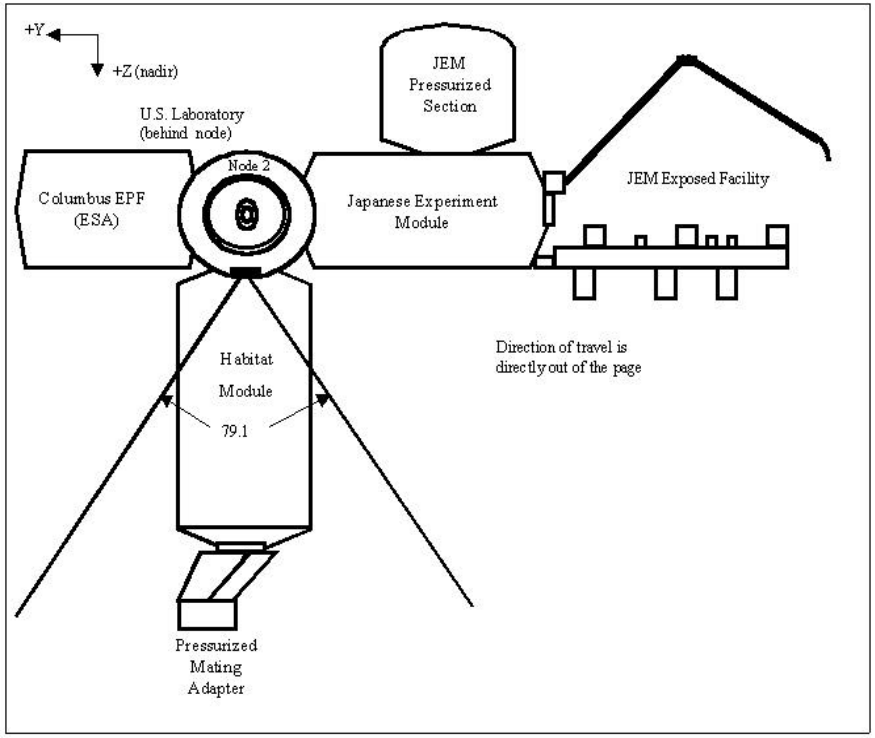
Window Transmittance Curve



WORF Field-Of-View Schematic



Schematic of the International Space Station, showing the field of view for the window in the X-Z plane.



Schematic of the International Space Station, showing the fields of view for the window in the Y-Z plan, orthogonal to the view shown in figure 2.