# Preliminary ISS Assembly Sequence Rev B as of 1 March 1996

| Planned Launch Date | Flight | Delivered Elements |
|---|---|---|
| 11/97 | 1A/R | FGB (Launched on PROTON launcher) |
| 12/97 | 2A | Node 1 (1 Storage racks), PMA1, PMA2 |
| 4/98 | 1R | Service Module |
| 5/98 | 2R | Soyuz |
| 7/98 | 3A | Z1 truss, CMGs, Ku-band, S-band Equipment, PMA3, EVAS (Spacelab Pallet) |
| 11/98 | 4A | P6, PV Array (4 battery sets) / EATCS radiators, S-band Equipment |
| 12/98 | 5A | Lab (4 Lab Sys racks) |
| 12/98 | 4R | Docking Compartment (DC) |
| 1/99 | 6A | 7 Lab Sys racks (on MPLM), UHF, SSRMS (on Spacelab Pallet) |
| 3/99 | UF-1 | ISPRs, 1 Storage rack (on MPLM), 2 PV battery sets (Spacelab Pallet) |
| 4/99 | 7A | Airlock, HP gas (3 O2, 1 N2) (on Spacelab Pallet) |
| **Phase 2 Complete** | | |
| 6/99 | 8A | S0, MT, GPS, Umbilicals, A/L Spur |
| 8/99 | UF-2 | ISPRs, 2 Storage Racks (on MPLM), MBS |
| 9/99 | 9A | S1 (3 rads), TCS, CETA (1), S-band |
| 11/99 | 9A.1 | Science Power Platform w/4 solar arrays |
| 1/00 | 11A | P1 (3 rads), TCS, CETA (1), UHF |
| 2/00 | 12A | P3/4, PV Array (4 battery sets), 2 ULCAS |
| 3/00 | 10A | Node 2 (4 DDCU racks), P5 w/radiator OSE |
| 4/00 | 3R | Universal Docking Module (UDM) |
| 6/00 | 1J/A | JEM ELM PS (5 JEM Sys, 2 ISPR, 1 Storage racks), SPDM, ULC w/HP Gas (1 O2, 1 N2) |
| 8/00 | 13A | S3/4, PV Array (4 battery sets), 4 PAS |
| 11/00 | 1J | JEM PM (3 JEM Sys racks), JEM RMS |
| 12/00 | UF-3 | ISPRs, 1 Storage Rack (on MPLM) |
| 1/01 | UF-4 | 2 ULCs with attached payloads, ATA, NTA, 1 O2 tank |
| 5/01 | 2J/A | JEM EF, ELM-ES, 4 PV battery sets (on ULC) |
| 5/01 | 8R | Research Module #1 (RM-1) |
| 6/01 | UF-5 | S5, Cupola (on mini-ULC), Port Rails, Attached payloads (on ULC) |
| 9/01 | 14A | Centrifuge |
| 11/01 | 2E | 2 U.S. Storage, 7 JEM racks, 7 ISPRs (on MPLM) |
| 12/01 | 15A | S6, PV Array (4 battery sets), Stbd MT/CETA rails |
| 12/96 | 10R | Research Module #2 (RM-2) |
| 2/02 | 16A | Hab (6 Hab racks) |
| 2/96 | 11R | Life Support Module (LSM) |
| 4/96 | 13R | Research Module #3 (RM-3) |
| 4/02 | UF-6 | ISPRs, 1 Storage Rack (on MPLM) |
| 5/02 | 17A | 1 Lab Sys, 1 Storage, 8 Hab Sys racks (on MPLM), ULC w/1 O2 tank, 2 PV battery sets |
| 6/02 | 18A | CTV #1 (Launch Vehicle TBD) [refered to as CRV in protocol] |
| 6/02 | 19A | 3 Hab Sys, 11 U.S. Storage racks (on MPLM) |
| **U.S. Assembly Complete** | | |
| early 2003 | 1E | Columbus Orbital Facility |

June 11, 1996

# International Space Station
## NASA/RSA Contributions and Services which Cross the Interface

## DURING ASSEMBLY (through flight 19A)

| NASA PROVIDING to RSA |
|---|

1. Sufficient electrical power transfer required to augment Russian generated power in order to maintain essential Russian segment core systems (up to 4 kw) for the period between the delivery of P-6 on flight 4A until the SPP is delivered, installed, and operational in accordance with mutually agreed schedules for power transfer
2. Delivery and return of international crew, on 6 Shuttle flights (up to 11 if mutually agreed), to support the traffic model documented and approved in the Multi-Increment Manifest (MIM)
   a) Required training for up to 51 crewmembers for Station, plus backup necessary for shuttle launch and/or return
3. NASA Wide Area Network (NWAN) communications systems in Russia
   a) Design, procurement, and installation (including labor and travel), per the Joint Institutiona Communications Requirements Working Group document (WG-9/NASA-RSA/001 of June 21, 1995), as amended, through assembly complete
   b) All recurring costs through assembly complete
4. Lead role in ISS systems engineering and integration
   a) Integrated design analyses cycles performed biannually (DAC)
   b) Vehicle Master Data Base (VMDB) development and maintenance
   c) Documentation for requirements, interfaces, and configuration
   d) Schedule integration
   e) Assembly sequence management
   f) Station level safety and mission assurance
5. Lead role in ISS operations integration and Russian segment payload integration into ISS
   a) Control center operations
   b) Control center interfaces (Remote Extension Moscow {REM})
   c) Cargo integration
   d) Integrated vehicle sustaining engineering analyses
   e) Multi-segment training facilities development
   f) Strategic, tactical, and execution planning
6. Non-propulsive attitude control via Control Moment Gyros (CMGs)
7. Functional Cargo Block (FGB) functions and services to RSA
8. Integration of Science Power Platform (SPP) on shuttle, launch on shuttle, hand-off to SSRMS, and on orbit assembly on a cooperative basis with RSA
9. Integration of SPP solar arrays on shuttle, launch on shuttle, and delivery to ISS
10. Delivery of 3,000 kg of water by Shuttle to the Russian segment
11. 500 kg of upmass on Shuttle
12. 1,500 kg of recoverable downmass on Shuttle

APPENDIX 2

June 11, 1996

# International Space Station
# NASA/RSA Contributions and Services which Cross the Interface

## DURING ASSEMBLY (through flight 19A)

| RSA PROVIDING to NASA |
|---|

1. Crew rescue capability and required training for entire international crew by the provision of 11 Soyuz TM
2. Supply and delivery of 44 MT of propellant (of which NASA's share is 31 MT)
3. Delivery of 28 MT of Life Support Systems (LSS) resupply for a three person international crew (of which NASA's share is 14 MT)
4. Delivery and return of international crew on up to 11 Soyuz TM vehicles to support the traffic model documented and approved in the Multi-Increment Manifest (MIM)
   a) Required training, sokol suits, seat liners, and necessary equipment for up to 51 crewmembers, plus backup
5. FGB launch, integration within the Russian Segment, trainers and training, on-orbit maintenance (including up to 1.5 MT of spares), operations, and sustaining engineering per February 1995 FGB protocol
6. Accommodations/Life Support (in the Service Module [SM]) for entire International crew until US Hab Module is fully outfitted (from flight 2R to flight 19A estimated to be 5/98 to 6/02)
7. Data transmission from American segment until US lab is activated (flight 2A to 5A)
8. Ground system modifications (communication sites and MCCM) to remove limitations on commands to node 1 through the FGB
9. Up to 800 watts power transfer from service module to node 1 until P-6 delivery (flight 1R to 4A estimated to be seven months)
10. Reboost, propulsive and non-propulsive attitude control
11. Support to NASA in ISS systems engineering and integration
    a) Integrated design analyses performed biannually (DAC)
    b) Vehicle Master Data Base (VMDB) maintenance
    c) Documentation for requirements, interfaces, and configuration
    d) Schedule integration
    e) Assembly sequence management
    f) Station level safety and mission assurance
12. Support to NASA in ISS operations integration and Russian segment payload integration into ISS
    a) Control center operations
    b) Cargo integration
    c) Integrated vehicle sustaining engineering analyses
    d) Multi-segment training facilities development
    e) Strategic, tactical, and execution planning

APPENDIX 2

June 11, 1996

# International Space Station
## NASA/RSA Contributions and Services which Cross the Interface

## ASSEMBLY COMPLETE (after flight 19A)

| NASA PROVIDING to RSA |
|---|

1. Contingency electrical power (up to 5 kw) to maintain Russian segment core systems
2. Lead role in ISS systems engineering and integration
   a) Integrated design analyses cycles performed biannually (DAC)
   b) VMDB maintenance
   c) Documentation for requirements, interfaces, and configuration
   d) Schedule integration
   e) Station level safety and mission assurance
3. Lead role in ISS operations integration and Russian segment payload integration into ISS
   a) Control center operations
   b) Control center interfaces (REM)
   c) Cargo integration
   d) Integrated vehicle sustaining engineering analyses
   e) Multi-segment training facilities development
   f) Strategic, tactical, and execution planning
4. Non-propulsive attitude control via CMG's
5. Reboost function
6. Delivery of 24 MT of propellant
7. 3 MT recoverable down mass on Shuttle
8. Delivery of 20 MT of cargo for the Russian Segment
9. Delivery of 5 MT of water

APPENDIX 2

June 11, 1996

# International Space Station
## NASA/RSA Contributions and Services which Cross the Interface

## ASSEMBLY COMPLETE (after flight 19A)

| RSA PROVIDING to NASA |
|---|

1. Supply and delivery of 44 MT of propellant (of which NASA's share is 24 MT)
2. FGB on-orbit operations, maintenance (including up to 3 MT of spares), and sustaining engineering per February 1995 FGB protocol
3. Reboost and propulsive and non-propulsive attitude control
4. Support to NASA in ISS systems engineering and integration
   a) Integrated design analyses performed biannually (DAC)
   b) VMDB maintenance
   c) Documentation for requirements, interfaces, and configuration
   d) Schedule integration
   e) Station level safety and mission assurance
5. Support to NASA in ISS operations integration and Russian segment payload integration into ISS
   a) Control center operations
   b) Cargo integration
   c) Integrated vehicle sustaining engineering analyses
   d) Multi-segment training facilities development
   e) Strategic, tactical, and execution planning

# Appendix 3

| # | ITEM | FUNDING Responsibility | TECHNICAL Responsibility |
|---|---|---|---|
| 1 | **All EVAs required to assure Berthing/Docking of SPP to SM** | | |
| 1.1 | - Installation of the Stand on the FGB | RSA | RSA |
| 1.2 | - Installation of FGB Power & Data Grapple Fixture (PDGF) on the Stand | NASA | NASA |
| 1.3 | - Removal of the SPP PDGF **(T&C 1.1)** | RSA | RSA |
| 1.4 | - Development & T&V of an EVA backup method for SPP/SM Berthing/Docking operation **(T&C 1.2)** | RSA | RSA |
| 2 | **FGB PDGF Implementation (a), (T&C #'s 2.1, 2.2, 2.3, 2.4)** | | |
| 2.1 | - PDGF ORU & Video Signal Converter (VSC) **(a1)** | NASA | NASA |
| 2.2 | - Canadian Manufact. H/W, T&V **(a2), (T&C #2.3)** | NASA | NASA |
| 2.3 | - NASA Manufact. H/W & T&V (video/data cables, conn's.) **(a3)** | NASA | NASA |
| 2.4 | - RSA Manufactured H/W (data cables, connectors) **(a4)** | RSA | RSA/NASA |
| 2.5 | - PDGF H/W Integration & Prime H/W Modifications, T&V, Integration (SSCN 303) **(a5)** | NASA | NASA |
| 2.6 | - RACU to SSRMS power testing at SPAR **(a6)** | NASA | RSA/NASA |
| 2.7 | - Launch/Delivery of PDGF & associated H/W to ISS | | |
| 2.8 | - PDGF Stand Dsgn, Development, T&V, & Delivery **(T&C 2.4)** | RSA | RSA |
| 3 | **SPP PDGF Implementation (b)** | | |
| 3.1 | - PDGF ORU & PDGF Canadian Manufact. H/W/T&V **(b1)** | NASA | NASA |
| 3.2 | - Flight Releasable Grapple Fixture (FRGF) **(b2)** | NASA | NASA |
| 3.3 | - US/CSA SSRMS Software Modifications **(b3)** | NASA | NASA/CSA |
| 3.4 | - System Level NASA/Prime SSRMS/SPP Configuration Verification **(b4)** | NASA | NASA |
| 4 | **Transfer/Berthing of SPP to SM w/ SSRMS (T&C #'s 4.1)** | | |
| 4.1 | - Integrated ISS Operational Analysis & Modeling | NASA | NASA |
| 4.2 | - SPP/SM Interface T&V (Using results of ISS Ops Analysis) | RSA | RSA |
| 5 | **SVS Targets (c)** | | |
| 5.1 | - SM Targets and Orientation Survey **(c1)** | NASA | RSA/NASA |
| 5.2 | - SPP Targets And Orientation Survey **(c2)** | NASA | RSA/NASA |

# Appendix 3

| # | ITEM | FUNDING Responsibility | TECHNICAL Responsibility |
|---|---|---|---|
| 6 | **Non-Standard Shuttle Services (T&C 6.1)** | NASA | NASA |
| 6.1 | - Remotely Operated Electrical Umbilical (ROEU) | | |
| 6.2 | - Thermal Model Development & Analysis | | |
| 6.3 | - Design Coupled Loads Analysis/Finite Element Modeling | | |
| 6.4 | - Orbiter Cabling | | |
| 6.5 | - SRMS Manipulator Demonstration Facility Mockup | | |
| 7 | **Second Set of SPP Solar Arrays (SA) (T&C #7.1)** | | |
| 7.1 | - Design, Development, Manufacturing, & T&V of SPP SA's | RSA | RSA |
| 7.2 | - SA Carrier | NASA | NASA |
| 7.3 | - Carrier Flight Support Equipment (FSE) to attach SA | RSA | RSA |
| 7.4 | - SPP attach point to accommodate Carrier & SA's | RSA | RSA |
| 7.5 | - EVAs required for Installation of SAs | RSA | RSA |
| 7.6 | - SSRMS Operational Analysis & Modeling | NASA | NASA |
| 7.7 | - Delivery/Launch of SPP SA's On-orbit by Shuttle | NASA | NASA |
| 7.8 | - Return of SA Carrier on the Shuttle | NASA | NASA |
| 8 | **SPP Pre-launch Processing at KSC for SPP & SAs (T&C 8.1)** | NASA | NASA |
| 9 | **TCS Two-Phase Flight Demo (T&C #9.1)** | | |
| 9.1 | - H/W Design, Manufacturing, T&V | RSA | RSA |
| 9.2 | - Flight Demo Carrier | NASA | NASA |
| 9.3 | - Carrier Flight Support Equipment (FSE) to attach Flight Demo | RSA | RSA |
| 9.4 | - Installation & Analysis of Flight Demo | NASA | NASA |
| 9.5 | - Pre-launch processing at KSC | NASA | NASA |
| 9.6 | - Delivery of Experiment On-orbit on STS-87 | NASA | NASA |
| 9.7 | - Return of the Flight Demo experiment on Shuttle | NASA | NASA |
| 10 | **SPP On-orbit Assembly EVAs** | RSA | RSA |

# Appendix 3

1.1 RSA is responsible for removal of the SPP PDGF and return to the US segment for relocation to the HAB. NASA is responsible for installation of the PDGF on the HAB.

1.2 NASA/RSA agrees to have two methods for accomplishing the SPP Berthing/Docking operation that do not exceed the capabilities of the SSRMS as defined in SSP 50227. One of these methods is to be an EVA backup which would be fully tested and verified prior to launch.

2.1 RSA and NASA agree to the development of requirements in joint documents NASA/RSCE/3411-SPP and SSP 50227. Existing SSRMS interface and operational requirements as defined in SSP 42003 and SSP 42004 will be incorporated. RSA is responsible for assurring that all requirements defined in the above documents are met.

2.2 The FGB PDGF will remain permanently installed on the FGB. The FGB PDGF will also be used for the installation of the SPP Solar Arrays.

2.3 RSA also requires that a PDGF be installed on the SPP. NASA will procure the PDGF and associated hardware by June 1, 1996 in order to utilize existing the NASA/SPAR contract at a significant discounted cost and meet the ISS Assembly Sequence schedule.

2.4 As agreed at TIM 17, RSA is responsible for the development, test, verification, delivery and installation on the FGB, a support structure/stand to which a PDGF can be mounted.

4.1 NASA agrees to perform an Integrated Analysis of the SPP transfer and berthing operation. RSA agrees to provide Docking Mechanism (Hybrid Probe/Cone) characteristic data as required by the NASA in order to accurately model the Docking Mechanism. Results of this analysis will be provided to RSA for incorporation in the Docking Mechanism test stand. NASA and RSA agree to the joint responsibility for the certification of the transfer and berthing operation.

6.1 Items identified under section 6 are the main areas listed for Non-Standard Shuttle services. Specific items will be identified as the SPP design matures.

# Appendix 3

7.1 RSA is responsible for the development, test, verification and installation of the remaining 4 SPP solar arrays. NASA agrees to deliver on orbit these arrays utilizing a US developed carrier. RSA agrees to provide NASA required information for integrating the solar arrays onto the carrier and into the Shuttle Payload Bay.

NASA is responsible for the SSRMS handover of the carrier/arrays to the Russian Segment. RSA agrees that if the transfer, removal of the Solar Arrays, and return of the carrier is not possible within the defined mission timeline, RSA is responsible for providing an attach/stowage location for the carrier on the Russian Segment.

8.1 NASA is responsible for Prelaunch processing, including ammonia servicing, CITE testing, battery servicing and other applicable SPP services at KSC. RSA is responsible for financing Russian Segment personnel required to support planning and processing operations at KSC.

9.1 NASA and RSA agree to fly the Russian TCS Two Phase Flight Experiment on the Shuttle based on RSA's commitment that the Flight Experiment will be delivered to KSC by Septemeber, 1997 in support of STS-89. Final agreement for NASA to fly the Russian Two Phase Experiment is conditional pending RSA submittal of payload mass properties and dimensions data for feasibility assessments.

A.1 The SPP will undergo the Joint ISS/Shuttle Safety Review Process. RSA agrees to support the Joint Review Panel as required.

A.2 RSA agrees to provide an approved SPP schedule and to provide bi-weekly status updates as well as formal updates upon changes to the schedule. RSA further agrees to conduct periodic Joint Detailed Design Reviews to assess that the SPP is meeting all applicable Shuttle/ISS requirements and schedules. RSA and NASA agree to provide detailed documentation (schedules, drawings, Preliminary Design Documentation, Test and Verification documents, etc.).

Appendix 3

## (a) - FGB PDGF H/W LIST (Including T&V & USOS Modifications)

| ITEM | COMMENTS | SOURCE | PROCUREMENT NEED DATE |
|---|---|---|---|
| PDGF ORU Assembly | Includes Thermal Blankets, Grapple Shaft ORU Assembly, & Connector Saver Set (Consists of 6 Harness Assemblies. Used to simulate SSRMS LEE for T&V) | Borrowed from USOS HAB module | N/A |
| Video Signal Converter (VSC) | | Borrow Existing USOS Spare | N/A |
| PDGF Mounting Assembly (Adapter Ring) | Includes 8 Thermal Bushings (No Spares) | US (SPAR); Existing NASA/CSA Contract | 6/1/96 (Authority To Proceed) |
| VSC Mounting Kit (VSC Plate) | VSC Bracket, 2 Attraction Plates, 4 screws | US (SPAR); Existing NASA/CSA Contract | 6/1/96 (Authority To Proceed) |
| PDGF External Harness (Cable Bundle), with VSC Interface | Data, Power, Video Cables, VSC Connectors, & PDGF Interface Connectors | US (SPAR) | 6/1/96 (Authority To Proceed) |
| 1553 Cable Wire (Silver & Nickel Plated) | For interface between PDGF Harness & Node/PMA 1553 Cables | US GFE (Bay Associates) | TBD |
| Video Cable (Fiber) | Interface Between S0 Truss & VSC (5 fibers for Aapprox. 100 ft.). Includes Design, Manufacturing & WETF Mockup | US GFE (Brand Rex) | TBD |
| External Connectors (Power & Video) | External Connectors (3) | US GFE (Amphenol) | TBD |
| QCDs | Internal Quick Disconnect Connectors | US GFE (TBD) | TBD |
| Power Cable Dressing & Tiedowns | External Power Cables Routing | US GFE (TBD) | TBD |
| WETF PDGF Cable Harness Mockup | Low-fidelity mockup for PDGF handling training. Includes VSC Mockup | US GFE (JSC) | TBD |
| WETF PDGF Fiber Bundle Mockup | Low-fidelity mockup for video fiber routing. Assuming EVA installation of Video Fiber | US GFE (JSC) | |
| FGB External/Internal Cable Manufacturing | RS will manufacture 1553 cables for: Interface between PDGF Harness & Node/PMA 1553 cables | RS | TBD |
| External Connectors (Data) | PDGF Harness interface & FGB Feedthrough Interface | RS | TBD |
| Internal Connectors (Data) | Internal FGB 1553 & Node/PMA 1553 cables interface | RS | TBD |
| External/Internal Connectors (Data) | FGB Feedthrough 1553 cables interface | RS | TBD |
| US H/W Modifications, T&V & Integration | Includes PDGF H/W Integration and NASA H/W Mods | US (Prime, PG 1, PG 3) | |
| - 1553 Cable/Connectors & Integration | Integration of 1553 connectors with 1553 cables | US (PG 1) | |
| - Lab-Node 1 1553 Jumper Cables | 2 jumpers. Prime/PG assessing via new SSCM. | US (PG 1, PG 3) | |
| - Video Cable Outfitting | PMA 1/Node 1 outfitting (Dressings and Tiedowns) | US (PG 1) | |
| - 1553 Bus Performance Testing | 1553 Bus Performance Testing | US (PG 1) | |
| Non-US (Joint) Integrated T&V | Power test of RACUs & SSRMS | US/RS (Prime, PG 2, SPAR, KhSC) | Dec. 96 - Mar. 97 Window of Opportunity |

## (b) - SPP PDGF Related H/W LIST (Including T&V & USOS Modifications)

| ITEM | COMMENTS | SOURCE | PROCUREMENT NEED DATE |
|---|---|---|---|
| PDGF ORU Assembly | Includes Thermal Blankets & Grapple Shaft ORU Assembly, & Connector Saver Set (Consists of 6 Harness Assemblies. Used to simulate SSRMS LEE for T&V) - Includes 8 Thermal Bushings (No Spares) | US (SPAR); Existing NASA/CSA Contract | 6/1/96 (Authority To Proceed) |
| PDGF Mounting Assembly (Adapter Ring) | | US (SPAR); Existing NASA/CSA Contract | 6/1/96 (Authority To Proceed) |
| PDGF External Harness (Cable Bundle) | Data, Power & Video Cables & PDGF Interface Connectors | US (SPAR); Existing NASA/CSA Contract | 6/1/96 (Authority To Proceed) |
| Flight Releasable Grapple Fixture (FRGF) | Required for Shuttle RMS grappling in Payload Bay | US (Existing Spare) | N/A |
| SSRMS Software Modifications | Functionality to berth SPP & control SSRMS | US GFE (JSC), Prime, SPAR | N/A |
| System Level NASA/Prime SSRSM/SPP Configuration Verification | SSRMS Functionality & Verification | US (Prime) | TBD |

## (c) - SPP/SM Space Vision System (SVS) Targets (Including T&V)

| ITEM | COMMENTS | SOURCE | PROCUREMENT NEED DATE |
|---|---|---|---|
| **SM** | | | |
| - TBD targets (4-5 minimum, 8 likely) | Work is in progress to identify quantity and need dates | US (SPAR); New procurement US | TBD |
| - Exact Location/Orientation Survey | Done by KSC personnel (1-2 days, 4 personnel) | | N/A. SM schedule & US KSC personnel availability driven |
| **SPP** | | | |
| - TBD targets (4-5 minimum, 8 likely) | Work is in progress to identify quantity and need dates | US (SPAR); New procurement US | TBD |
| - Exact Location/Orientation Survey | Done by KSC personnel (1-2 days, 4 personnel) | | N/A. SPP schedule & US KSC personnel availability driven |