Solution/Protein Crystal Growth Facility (SPCF). The SPCF has two major components, the protein Crystal Research Facility, for growing large, high-quality protein crystals for analysis on the ground, and the Solution Crystallization Observation Facility, for microscopic examination of the crystals on orbit. The two units can be operated independently. The SPCF will share rack space with the FPEF and the Image Processing Unit.

Image Processing Unit (IPU). The IPU receives experiment imagery from the experiment facilities and encodes the data either for downlink or storage on removable media. It has the capability to receive and compress four video signals simultaneously and to record the signals on four VCRs.

Minus Eighty-degree Laboratory Freezer for ISS (MELFI). This is a second unit of the MELFI described in Section 5.3.5 above.

Aquatic Animal Experiment Facility (AAEF). The AAEF is a sub-rack facility that will accommodate freshwater and saltwater organisms (such as Medaka fish) inside the JEM environment. The facility will be designed to accommodate experiments for up to 90 days, making it possible to conduct research ranging from early development and differentiation to individual responses in the microgravity environment.

6. Payload Operations

ISS Payload Operations include both the advanced planning for on-orbit research and the actual real-time operations for using on-board ISS laboratories. The advanced payload operations planning includes all the preparation activities in which the investigator's research objectives are defined and coordinated with other research payloads and the ISS system operations. Real-time operations are those activities that occur during the actual on-orbit conduct of the scientists' research protocols. These activities include conducting the experiment procedures, operating the experiment hardware, and gathering the experiment's data and samples.

The three goals of ISS Payload Operations are: 1) to give researchers some autonomy to manage and operate their research payloads; 2) to distribute operations capabilities; and 3) to provide researchers with operational flexibility.

6.1 User Autonomy

Unlike previous U.S. space vehicles, the ISS will operate continuously over several years, and will allow change-out and upgrade of payloads during that time. Planning for payload operations will allow new payloads to be added or permit the return of on-orbit payloads as part of the normal change process. Planning expertise will be geographically distributed at control centers and user sites around the world. ISS payload operations will be multidisciplinary and will include a broad range of crew-attended, unattended, automated, and telescience operations. NASA will provide Payload Operation Integration (POI) for ISS Payloads. POI is the assessment and management of interactions between multiple payloads, payload facilities, and Station systems, including interactions between hardware, software and operations. The NASA POI process involves developing integrated payload operations requirements, plans, and processes and ensures their compatibility with the flight system. This effort includes Station-wide payload operations management and integration, integrated payload planning and operations, and payload crew and ground personnel training and safety. Safety, operational effectiveness, and system-to-payload performance are the primary goals. The NASA POI process will integrate all U.S. users, regardless of the payload's location on orbit.

Researchers will have the choice of where their ground operations will be based. Whether located in a Telescience Support Center (TSC) at one of NASA's Field Centers, in the mission control center of an International Partner, or in a remote site such as a university research laboratory, researchers will be able to manage and operate their research. A TSC is a NASA facility equipped to conduct telescience operations on board ISS. A remote site is a non-NASA facility such as a Commercial Space Center, university, private industry, or non-NASA government agency. "Telescience" is defined as the acquisition of information through remote experimentation and observation. From laboratory desktop computers, Telescience will maximize the ability of researchers to communicate with the crew, to direct the "commanding" of their research hardware and software, and to manage the receipt, processing, and analysis of their research data. To support researchers in remote locations, NASA has developed the Telescience Resource Kit (TReK). TReK is a PC-based telemetry and command system which will give researchers access to their payload on board the ISS in addition to ground-based planning and information management systems (see TReK website, Appendix B).

Researchers will define their science planning requirements and provide their science expertise on payload and experiment operations. Investigators will develop the detailed operations plans for their experiments, will participate in training the crew, and will help develop the procedures the crew will use while in space. Researchers' planning inputs will also be used to develop an operational schedule for onboard activities.

6.2 Payload Ground Command and Control

ISS payload command and control is designed to give an ISS User maximum flexibility in choosing the location and method for controlling a given payload. The most simple option available is to control the payload by a payload operator who maintains personnel at the Huntsville Operations Support Center (HOSC) at the Marshall Space Flight Center. Within the HOSC is the Payload Operations and Integration Center (POIC) that that will provide 24 hour, real-time monitoring of payloads. The POIC manages the execution of on-orbit ISS payloads and payload support systems in coordination/unison with distributed IP payload control centers, TSCs and payload unique-remote facilities. Through the POIC Users have several operational options for controlling their payloads, including the use of TrEK through a TSC or directly into the POIC as well as several others. Details on these options can be found on the POIC Webpage (Appendix B).

At each optional level, payload command and control data will be routed through the POIC to the Space Station Control Center at JSC, and then onto the White Sands Complex in New Mexico for uplink to ISS. Each command is uplinked through the Tracking and Data Relay Satellite System (TDRSS) to ISS with an expected round-trip latency of <4 seconds. ISS Users that are operating at or through a TSC will have that additional link in the payload command chain, but the latency will still be <4 seconds. Downlinked payload data will come from ISS through TDRSS to the White Sands Complex, and then directly to the HOSC for distribution to the payload operations sites, either a TSC or the payload developer's home institution.

6.3 Operational Flexibility

Because the ISS vehicle is designed for extensive communications, including voice, video, telemetry, and downloads of real-time and stored data, researchers will easily be able to assess the success or shortcomings of their on-orbit research protocols. Investigators will be able to discuss problem areas with mission planners and will be better able to devise new procedures. For example, a procedure that resulted in a limited sample yield could be modified to improve future test results. ISS operations are designed to give scientists the flexibility to modify or enhance their experiment operations as long as they remain within their resource constraints. Detailed payload operations plans will be developed one week in advance, thus allowing researchers time to review previous data and revise their research approach, thereby improving the quality of data collection on later experiment runs.

7. Getting On Board: NASA Research and ISS

For potential ISS investigators located within the U.S., and for certain cases potential investigators outside the U.S., the selection, funding, and logistic support of research to be performed on board ISS is managed through the interaction between the ISS Program, and science, commercial and engineering Offices based at NASA Headquarters. The Offices manage a large range of research programs, of which research to be performed on ISS is only a subset. The Offices are as follows:

The Office of Life and Microgravity Sciences and Applications (OLMSA or Code U). OLMSA is divided into three Divisions: Life Sciences, Microgravity Research, and Space Utilization and Product Development. Life Sciences deals with the majority of life sciences and human research supported by NASA. The Microgravity Research Division (MRD) manages microgravity research involving the life and physical science. Space Utilization and Product Development is concerned with commercial projects related to either life sciences or microgravity sciences.

In addition to being responsible for solicitation, selection and funding of research within their respective disciplines, the Divisions also in certain cases set program requirement for development of the facility-class payloads that fall within their areas.

The Office of Space Science (OSS or Code S). OSS manages NASA research in the astronomical, planetary, and space sciences.

The Office of Earth Science (OES or Code Y). OES manages NASA's program in Earth observation and remote sensing.

The Office of Space Flight (OSF or Code M). OSF manages NASA's human space flight program and is responsible for the development of engineering innovations for next-generation spacecraft. Code M is involved in engineering research on the Station.

A concept of central importance to the potential ISS User is that each of these Offices has their own procedures for soliciting, selecting, and funding research to be done on ISS. To provide logistical and development support for research projects once they are funded, the Offices have implemented Research Project Offices (RPOs) at NASA Field Centers. The RPOs serve as the interface between research projects and the ISS Program, and perform other oversight and development tasks related to their disciplines.

At the present time, research funding for ISS is under distributed management between the Headquarters Offices and the ISS Payloads Office at Johnson Space Center (JSC Code OZ). The funding for investigator support and associated research costs is provided by the Headquarters Offices. The ISS Payloads Office manages the budget allocated for building the array of multi-user, facility-class and EXPRESS payloads that form the principal Space Station research infrastructure. While under this arrangement the majority of an ISS research investigator's budget resource will probably originate from the Headquarters Offices, a sub-set of additional resources may also flow from ISS Payloads. The degree of this subdivision depends on the type of project and the Headquarters Office program with which it is associated.

7.1 Life Sciences

The Life Sciences Division of OLMSA supports ISS flight experiments which are implemented through three programs: Biomedical Research and Countermeasures (BR&C), Fundamental Biology (FB), and Advanced Human Support Technology. Investigations for these programs are solicited primarily through an annual NASA Research Announcement (NRA).

In the areas of BR&C and FB, the NRA is coordinated with research announcements of the member agencies of the International Space Life Sciences Working Group (ISLSWG). Proposers responding to these announcements can utilize the capabilities for Life Sciences Research provided on ISS by all of the ISLSWG agencies. Review and selection of the proposals is coordinated by the ISLSWG agencies.

Selected proposals first enter a definition phase during which the technical feasibility is verified. Experiments which successfully complete this phase then enter a development and operations cycle and are manifested to be performed on the ISS.

Details on the review and selection process may be found by downloading the most recent Life Sciences NRA from the following internet site:

- ✓ http://peer1.idi.usra.edu/

7.2 Microgravity Sciences

NASA supports research in microgravity sciences through the Microgravity Research Program managed by the Microgravity Research Division (MRD) of OLMSA. The mission of MRD is to "Obtain new knowledge and increase the understanding of gravity dependent phenomena obscured by the effects of gravity in biological, chemical and physical systems, and where feasible, to facilitate the application of that knowledge to academic and commercially viable products and processes." The support of MRD for microgravity research is allocated across five specific disciplines: Biotechnology, Combustion Science, Fluid Physics, Fundamental Physics, and Materials Science. NRAs describing funding opportunities for each of these disciplines are released by MRD on a projected cycle of 2 years.

The latest NRAs for microgravity science are available at:

- ✓ http://peer1.idi.usra.edu/

Proposals for microgravity science flight investigations first undergo a selection process, during which they are evaluated for initial funding based on scientific and technical merits. If an experiment is selected, it then enters into a multi-phase flight definition and development cycle.

7.2.1 Microgravity Science Experiment Selection

Microgravity Science flight experiment proposals will undergo a series of three reviews.

1) Scientific peer review for selection recommendation,
2) Science peer review for scientific feasibility,
3) Science and Engineering review for definition of requirements .

Criteria related to the scientific relevance, significance, quality, and necessity of using the space flight environment are included in the scientific peer review. The relevance of the experiment to programmatic priorities, scientific merit as evaluated by the scientific peer review, technical risk as determined by the technical evaluation, funding availability and projection of future flight opportunities are also considered in the reviews. The PI must pass all 3 reviews before proceeding to flight. NASA HQ will make final selections.

7.2.2 Microgravity Sciences Experiment Definition and Development

Once a project is funded, its overall requirements for hardware development and access to NASA ground-based or flight facilities are coordinated by the Microgravity Research Program Office (MRPO) at NASA's lead center for microgravity research, Marshall Space Flight Center (MSFC). MRPO also conducts oversight of management and support tasks performed at other NASA centers for the specific microgravity science disciplines described above. A funded project that advances to flight status on ISS will generally have some aspects of its support, hardware development for example, assigned to the NASA center best suited to the project's microgravity discipline area. It is also the responsibility of the MRPO to be the bridge between an investigator and their first point of contact with the ISS program, which is the International Space Station Payloads Office at JSC.

In addition to the MRPO support role for specific microgravity research projects whether they ultimately fly on ISS or not, the MPRO monitors the development and implementation of the microgravity performance accommodations on the ISS, keeping the interests of the microgravity research community and potential microgravity investigators in mind.

7.3 Space Sciences

Research activities in the Space Sciences are funded through the Office of Space Science (OSS or Code S) at NASA Headquarters. The mission statement of the OSS is, "From origins to destiny, chart the evolution of the Universe and understand its galaxies, stars, planets, and life." The OSS supports four fundamental areas of research:

- the Search for Origins,
- the Structure and Evolution of the Universe,
- the Exploration of the Solar System, and
- the Sun-Earth Connection.

Space science research will be conducted on ISS primarily through the use of attached payloads. In addition to opportunities for EXPRESS Pallet Adapter, JEM-EF, and *Columbus* Exposed Payload Facility payloads, OSS is investigating full truss site payloads with their greater capacity for mass and volume. This type of payload is ideal for investigations such as cosmic ray research, which require a large viewing area and large mass with tolerant pointing requirements. Astrobiology research will be conducted in conjunction with Code U using their selection and funding processes.

The OSS uses NASA Announcements of Opportunity (AOs) to fund flight missions. At this time, the OSS does not have a specific AO for ISS payloads. Instead, the Missions of Opportunity (MoO) class under the Explorer Program AOs will provide the opportunity to propose ISS payloads. The MoOs are available in all Explorer AOs, including Medium-class Explorers (MIDEX), Small Explorers (SMEX), and University-class Explorers (UNEX).

Space science ISS payloads selected under the Explorers AOs will be funded and managed through the Explorers Program. The Program will be provide a mission manager for each selected payload. The primary interface between all potential and selected payloads and the SSPO is the OSS RPO located at Goddard Space Flight Center in Greenbelt, MD.

7.4 Earth Sciences

NASA supports research and development activities in the Earth Sciences through the Office of Earth Science (OES) at NASA Headquarters. The mission of OES is "to develop understanding of the total Earth system and the effects of natural and human-induced changes on the global environment". OES research is expected to encompass the areas of science and applications. Opportunities will exist for attached payloads, as well as pressurized payloads in the WORF. Due to the global coverage of the ISS orbit, ISS payloads are appropriate for most of the Earth science disciplines.

The OES uses both AOs and NASA Research Anouncements to fund research. At this time, the OES does not have a specific AO for ISS payloads. Opportunities for both attached payloads and WORF payloads will be offered under the Earth System Science Pathfinder (ESSP) and University Earth System Science (UnESS) AOs. WORF payloads may also be selected by NRAs.

Earth science ISS payloads selected under the ESSP Project and UnESS Project AOs will be funded and managed through these associated Projects. ESSP and

UnESS will provide mission managers for each selected payload. The primary interface between all potential and selected payloads and the SSPO is the OES RPO located at Goddard Space Flight Center in Greenbelt, MD.

7.5 Engineering Research and Technology

The Space Station Payloads Office funds Engineering Research and Technology (ERT) payloads that use the Station as a testbed and which develop, test and demonstrate technologies that can improve the ISS systems or payloads capabilities, lower the costs of maintenance or operations, and reduce power or crew time requirements. ISS also funds the Commercial Space Center (CSC) for Engineering that facilitates industry's use of the ISS for engineering research and technology development.

New technologies are flown as demonstration payloads so that the capabilities and reliability of a new technology can be verified before committing that technology for use on the ISS. The ERT payloads are also used to demonstrate technologies that are important to exploration programs and commercial interests. Both pressurized and un-pressurized payloads are funded through this program.

The Space Station Payloads Office has designated the Johnson Space Center's Technology Planning Office (JSC/EX2) as the manager of the ERT Program Office. The ERT payload resource allocation on the ISS is part of the payload allocation for the NASA Office of Spaceflight (Code M).

7.6 Commercial Payloads

The commercial payload development (CPD) effort, precipitated by passing of the Federal Commercial Space Act of 1998, seeks to establish a marketplace and stimulate a national economy for space products and services in low Earth orbit, where both demand and supply are dominated by the private sector. In the short term, the program will begin the transition to private investment and offset a share of the public cost for operating the Space Shuttle fleet and the ISS through commercial enterprise in open markets. Basic and applied research in science and technology, both in space and on the ground, is expected to continue in the tradition of the government-sponsored space program.

Several parties inside and outside NASA are cooperating in the planning and execution of CPD. OLMSA (Code U) and the Office of Space Flight (Code M), both at NASA Headquarters, jointly hold broad program definition, initiation, facilitation, and monitoring responsibilities for the overall CPD Program.

A joint Headquarters-ISS commercial offer process is evaluating pathfinder projects, working to remove barriers to feasible projects, and referring feasible offers to the appropriate NASA field centers for further evaluation. As promising pathfinder projects are implemented, the lessons learned will be applied to complete NASA's overall ISS commercialization policy, leading to eventual establishment of routine commercial research operations on the ISS.

OLMSA, through its Space Utilization and Product Development Division (Code UM) at NASA Headquarters, facilitates participation and investment in space-linked commercial goods and services in order to benefit U.S. industry and the economy as a whole. Funding for payload hardware to support the commercial and technology experiments planned for the ISS is included under the ISS Research Program managed bv the ISS Pavloads Office (Code OZ) at JSC. Program management for Space Utilization and Product Development is carried out by the Space Utilization and Product Development Office at Marshall Space Flioht Center in Huntsville, Alabama, and the Space Technology and Engineering Applications Program at JSC.

To accomplish orbital commercial research and to develop industry partnerships, the Space Utilization and Product Development program uses Commercial Space Centers (CSCs) which are non-profit organizations based at universities, or other non-profit centers. The CSCs provide support and expertise to encourage industry to conduct space research in areas such as biotechnology, agribusiness, and materials. A company that wants to become involved in space research can begin by establishing a partnership with a CSC that emphasizes the appropriate technical research area. A list of CSCs is provided in Appendix D.

Appendix A. Related Documents

The following documents contain supplemental information to guide the user in the application of this document. These reference documents may or may not be specifically cited within the text of the *Guide*.

Document No.	Title	Type, source
SSP 52000-PAH-PRP, Rev. A	ISS Payload Accommodations Handbook for Pressurized Payloads	Multilateral-ISS Internal
SSP 52000-PAH-ERP, Draft	ISS Payload Accommodations Handbook, EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads	Multilateral-ISS Internal
SSP 57003	Attached Payload Interface Requirements Document	NASA-ISS Internal
SSP 57021	Attached Payloads Accommodation Handbook	NASA-ISS Internal
NP-1998-02-232-HQ, Rev 1	Improving Life on Earth and in Space: The NASA Research Plan, an Overview	NASA Internal
No Number	Science and Technology Research Directions for the International Space Station	NASA Internal, available at: http://www.hq.nasa.gov/office/olmsa/
JPL 400-808, 4/99	Fundamental Physics in Space Roadmap	NASA Internal
No Number	Space Station Japanese Experiment Module Multiuser Experiment Facilities Catalog	NASDA Internal
No Number	Centrifuge	NASDA Internal
No Number	Space Station Integration & Promotion Center: The Base for Japan's International Space Station Program	NASDA Internal
JBX-98079	Introductory Guidbook for JEM Exposed Facility Potential Users	NASDA Internal
BR-137, February 1999	The International Space Station: A Guide for European Users	ESA Internal, available at: http://esapub.esrin.esa.it
No Number	International Space Station	NASDA Internal
No Number	International Space Station Fact Book, July 1999	NASA Internal
TD9702A	ISS Familiarization Manual	NASA Internal, available at: http://spaceflight.nasa.gov/station/reference/index.html
LS71001	Functional Requirements Document for the Human Research Facility	NASA Internal
AIAA 99-0312	Low Temperature Microgravity Physics Facility	AIAA Publication
AIAA 99-0314	X-ray Crystallography Facility for the International Space Station	AIAA Publication
AIAA 99-0313	EXPRESS Rack Overview	AIAA Publication

Appendix B. Related Websites

Official NASA external websites are organized below according to the sections and sub-sections of the *Guide* for which they are relevant. An official NASA-site search engine is available at:

✓ http://www.nasa.gov/search/index.html

1. Introduction

- ✓ NASA Human Space-ISS Home — http://spaceflight.nasa.gov/station/index.html

1.1 Document Purpose and Structure

1.2 ISS History and Overview

- ✓ NASA Homepage — http://www.nasa.gov
- ✓ NASA Headquarters Homepage — http://www.hq.nasa.gov/
- ✓ NASA Field Centers — http://www.nasa.gov/nasaorgs/index.html
- ✓ NASA Human Space-ISS Home — http://spaceflight.nasa.gov/station/index.html
- ✓ Spaceflight History — http://spaceflight.nasa.gov/history/
- ✓ JSC Homepage — http://www.jsc.nasa.gov/
- ✓ ISS IPs, IP Homepages — http://spaceflight.nasa.gov/station/reference/partners/index.html
- ✓ ISS Partners Sign Agreements — http://spaceflight.nasa.gov/station/ reference/partners/special/iss_aggrements/index.html
- ✓ RSA Homepage — http://www.rka.ru/english/eindex.htm
- ✓ ESA Homepage — http://www.esa.int/
- ✓ NASDA Homepage — http://www.nasda.go.jp/index_e.html
- ✓ ISS Multilateral Agreement — http://www.hq.nasa.gov/office/codei/

1.3 NASA Research Coordination and Advisory Committees

2. ISS Development

2.1 Assembly Sequence

- ✓ Phase I Shuttle-Mir — http://spaceflight.nasa.gov/history/
- ✓ ISS Assembly Website — http://spaceflight.nasa.gov/station/assembly/index.html

2.2 Build-up of Resources and Early Utilization

- ✓ Evolution of Resources — http://spaceflight.nasa.gov/station/assembly/ elements/uslab/evolut.htm

3. ISS Research Elements

- ✓ ISS Graphical Overview-PLAID Lab — http://spaceflight.nasa.gov/station/assembly/plaid/
- ✓ ISS Virtual Tour — http://spaceflight.nasa.gov/gallery/vtour/index.html

3.1 A Module Named "Destiny": The U.S. Laboratory Module

- ✓ U.S. Lab PLAID view — http://spaceflight.nasa.gov/station/assembly/plaid/lab.jpg
- ✓ U.S. Laboratory Module — http://spaceflight.nasa.gov/station/assembly/elements/uslab/

3.2 U.S. Centrifuge Accommodations Module (CAM)

- ✓ CAM PLAID view — http://spaceflight.nasa.gov/station/assembly/plaid/cen.jpg
- ✓ ISS Biological Research Project — http://spaceprojects.arc.nasa.gov/Space_Projects/ SSBRP/index.html

3.3 U.S. Integrated Truss Attachments

3.4 Japanese Experiment Module (JEM)

- ✓ NASDA ISS Home Page — http://jem.tksc.nasda.go.jp/index_e.html
- ✓ NASDA JEM Website — http://jem.tksc.nasda.go.jp/iss_jem/index_e.html

3.5 Columbus Module

- ✓ ESA Columbus Website — http://www.estec.esa.nl/spaceflight/incolab.htm

3.6 Russian Segment

- ✓ Russian Space Agency Website — http://www.rka.ru/english/eindex.htm

4. The ISS Environment

4.1 Orbital Parameters and Models of Operation

- ✓ ISS Orbit and Tracking — http://spaceflight.nasa.gov/realdata/tracking/index.html

4.2 Microgravity

- ✓ OLMSA-MG Research Div. — http://microgravity.hq.nasa.gov/
- ✓ OLMSA-Understanding Microgravity — http://mgnews.msfc.nasa.gov/db /understanding_ug/understanding_ug.html
- ✓ MSFC-What is Microgravity? — http://www1.msfc.nasa.gov/NEWMSFC/slg.html
- ✓ MSFC-MRPO — http://microgravity.nasa.gov/index.html

4.2.1 Quasi-steady Requirements

4.2.2 Vibratory Requirements

4.2.3 Microgravity Acceleration Measurement

- ✓ Microgravity measurement — http://microgravity.grc.nasa.gov/MSD/ MSD_htmls/mmap.html
- ✓ PI Microgravity Services — http://microgravity.grc.nasa.gov/MSD/MSD_htmls/PIMS.html

7. Getting On Board: NASA Research and ISS

- ✓ OLMSA-Code U Homepage http://www.hq.nasa.gov/office/olmsa/index.htm
- ✓ Office of Space Science-Code S http://spacescience.nasa.gov/
- ✓ Office of Earth Science-Code Y http://www.earth.nasa.gov/
- ✓ Office Space Flight-Code M http://spaceflight.nasa.gov/index-m.html

7.1 Life Sciences

- ✓ OLMSA Life Sci. Division http://www.hq.nasa.gov/office/olmsa/lifesci/index.htm
- ✓ Life Science Res. Opportunities http://peer1.idi.usra.edu/
- ✓ Grav. Biology RPO at Ames http://www.gravbio.nasa.gov/

7.2 Microgravity Sciences

- ✓ OLMSA MG Research Division http://microgravity.hq.nasa.gov/
- ✓ MG Science Res. Opportunities http://peer1.idi.usra.edu/
- ✓ MRPO at Marshal SFC http://microgravity.nasa.gov/index.html

7.2.1 Microgravity Science Experiment Selection

7.2.2 Microgravity Sciences Experiment Definition and Development

7.3 Space Sciences

- ✓ Office of Space Science-Code S http://spacescience.nasa.gov/

7.4 Earth Sciences

- ✓ Office of Earth Science-Code Y http://www.earth.nasa.gov/

7.5 Engineering Research and Technology

- ✓ ERT Program http://spaceflight.nasa.gov/station/science/ disciplines/ert/index.html

7.6 Commercial Payloads

- ✓ ISS Commercial Development http://commercial.hq.nasa.gov/
- ✓ OLMSA SUPD http://www.hq.nasa.gov/office/olmsa/spd/index.htm
- ✓ MRPO Space Product Develmt. http://microgravity.nasa.gov/spd.html
- ✓ OLMSA Related Sites http://www.hq.nasa.gov/office/olmsa/links/index.htm

Appendix A. Related Documents

- ✓ ESA Documents http://esapub.esrin.esa.it
- ✓ NASA Scientific and Tech. Info. http://www.sti.nasa.gov/

Appendix B. Related Websites

Appendix C. Station Assembly Flights

- ✓ ISS Assembly Website http://spaceflight.nasa.gov/station/assembly/index.html

Appendix D. Commercial Space Centers

- ✓ OLMSA SUPD http://www.hq.nasa.gov/office/olmsa/spd/index.htm

Appendix E. Acronym List

- ✓ NASA ISS Acronyms http://spaceflight.nasa.gov/station/reference/index.html

Appendix C. Station Assembly Flights

A list of ISS Assembly Flights is shown below. This is provided as a conceptual guide to the reader based on the sequence of flights in Revision E of the ISS Assembly Sequence, which was current as of December, 1999. For an up-datable more complete reference the reader should visit NASA's ISS Assembly webpage at:

- ✓ ISS Assembly Website http://spaceflight.nasa.gov/station/assembly/index.html

Flights that use the U.S. Space Shuttle have a corresponding STS number in the second column. Non-STS flights utilize Russian crewed *Soyuz* vehicles ("S" in flight name), or un-crewed *Progress* vehicles ("P" in flight name). Utilization of un-crewed European and Japanese vehicles will be added to the Sequence as these programs evolve.

Flight Name	STS No.	Delivered Elements
1A/R		FGB "Zarya"
2A	88	Node 1 (1 Stowage rack), PMA1, PMA2, 2 APFRs (on Side-walls)
2A.1	96	Spacehab Double Cargo Module; OTD, Strela Components(on ICC)
1R		Service Module (Launched on PROTON launcher)
1P		Progress-M1
2A.2	101	Spacehab Double Cargo Module; Strela Components (on ICC)
2P		Progress-M1
3A	92	Z1 truss, CMGs, Ku-band, S-band Equip; PMA3, EVAS (SLP); 2 Z1 DDCUs (Sidewall)
2R		Soyuz TM **[3 person crew capability]**
4A	97	P6, PV Array (6 battery sets) / EEATCS radiators, S-band Transponder
3P		Progress-M1
5A	98	P6, PV Array (6 battery sets) / EEATCS radiators, S-band Transponder
4P		Progress-M1
4R		Docking Compartment 1 (DC1), Strela
5A.1	102	Lab Outfitting (6 Sys racks, RSRs, RSPs, ISPR) (on MPLM); EAS, PFCS, LCA, and RU (on ICC)
5P		Progress-M
6A	100	Lab Outfitting (6 Sys racks, RSRs, RSPs, ISPR) (on MPLM); EAS, PFCS, LCA, and RU (on ICC) **[microgravity capability]**
2S		Soyuz – TM1
6P		Progress-M1
7A	104	Airlock, HP gas (2 O2, 2 N2) (on SLDP) **[Phase 2 complete]**
7A.1	105	RSRs, RSPs, ISPRs (on MPLM); OTD, APFR (on Sidewall)
UF-1	106	ISPRs, RSRs, RSPs, MELFI (on MPLM)
3S		Soyuz TMA
8A	109	S0, MT, GPS, Umbilicals, A/L Spur
UF2	110	ISPRs, 3 RSRs, RSPs (MPLM); MBS; PDGF (Sidewalls)
9A	112	S1 (3 rads), TCS, CETA (1), S-band
4S		Soyuz -TMA
11A	113	P1 (3 rads), TCS, CETA (1), UHF
9A.1	115	Science Power Platform w/4 solar arrays and ERA
5S		Soyuz TMA
12A	116	P3/4, PV Array (4 battery sets), 2 ULCAS
12A.1	118	ISPR, RSRs, RSPs (MPLM); P5 w/Radiator OSE
13A	119	S3/4, PV Array (4 battery sets), 4 PAS

Flight Name	STS No.	Delivered Elements
3R		Universal Docking Module (UDM)
5R		Docking Compartment 2 (DC2)
10A	121	Node 2 (4 DDCU racks); NTA (on Sidewall)
10A.1	122	Propulsion Module
1J/A	124	ELM PS (4 Sys, 3 ISPRs, 1 Stow); 2 SPP SA w/ truss, Conform. Shields (ULC)
1J	125	JEM PM (4 JEM Sys racks), JEM RMS
UF3	127	ISPRs, 1 JEM rack, RSPs, (on MPLM); Express Pallet w/ Payloads
UF4	128	Truss Attach Site P/L; Express Pallet w/ Payloads; ATA, SPDM (SLP)
2J/A	129	JEM EF, ELM-ES w/ Payloads and SFA; 4 PV battery sets (on SLP)
9R		Docking & Stowage Module (DSM) (FGB module type)
14A	131	2 SPP SA w/ truss, 4 SM MMOD Wings (ULC); Cupola (SLP); MT/CETA Port Rails (SLP)
UF5	132	ISPRs, RSPs (on MPLM); Express Pallet w/ Payloads
20A	134	Node 3 (2 Avionics, 2 ECLSS racks)
1E	135	Columbus Module (5 ISPRs)
8R		Research Module #1 (RM-1)
17A	136	1 Lab Sys, 4 Node 3 Sys, 2 CHeCS, RSPs, ISPRs (MPLM) - ©
18A	137	CRV #1, CRV adapter - (d)
19A	138	RSPs, 1 RSR, ISPRs, 4 Crew Qtrs. (on MPLM); S5 - (e)
15A	139	S6, PV Array (4 battery sets), Stbd MT/CETA rails
10R		Research Module #2 (RM-2)
UF7	140	Centrifuge Accommodations Module (CAM), ISPRs (TBD 3-1)
UF6	141	RSPs, ISPRs (on MPLM); 2 PV battery sets (SLP))
16A	142	Hab (6 Hab sys racks, 2 RSRs, ISPRs) - (f)

Appendix D. Commercial Space Centers

The following is a list of Commercial Space Centers (CSCs). Additional information is available on the OLMSA Space Product Development webpage at:

- ✓ http://www.hq.nasa.gov/office/olmsa/spd/index.htm

1. **Center for BioServe Space Technologies**, University of Colorado-Boulder, Department of Aerospace Engineering Sciences, Campus Box 429, Boulder, CO 80309. Established October 1, 1987. Director: Dr. Louis Stodiek, Tel: 303-492-4010, Fax: 303-492-88883, stodieck @colorado.edu, www.Colorado.EDU/engineering/BioServe/
2. **Center for Commercial Applications of Combustion in Space**, 1500 Illinois Street, Colorado School of MinesGolden, CO 80401. Established May 1, 1996. Director: Dr. Franklin D. Showengerdt. Tel: 303-384-209, Fax: 303-384-2327, fschowen@mines.edu, www.physics.mines.edu/ccacs/
3. **Center for Biophysical Sciences and Engineering (Formerly Center for Macromolecular Crystallography)**, University of Alabama-Birmingham, MCLM 262, 1530 3rd Avenue South , Birmingham, AL 35294-0005. Established October 1, 1985. Director: Dr. Lawrence DeLucas, Tel: 205-934-5329, Fax: 205-934-0480, delucas@cmc.uab.edu, www.cmc.uab.edu/
4. **Solidification Design Center**, Auburn University, 201 Ross Hall, Auburn, AL 36849. Established: January 28, 1997, Director: Dr. Tony Overfelt, Tel: 334-844-5940, Fax: 334-884-3400overfra@mail.auburn.edu
5. **Commercial Space Center for Engineering** , 223 Weisenbaker Engineering Research Center, Texas A&M University, College Station, TX 77843-3118. Established May 8, 1998, Director: Dr. David Boyle, Tel: 409-845-8768, Fax: 409-847-8857, dboyle@tamu.edu
6. **Consortium for Materials Development in Space**, University of Alabama – Huntsville, Research Institute Building/M-6517, 301 Sparkman Drive, Huntsville, AL 35899. Established October 1, 1985, Director: Dr. William Gathings , Tel: 256-890-6620, Fax: 256-890-6791, gathinw@email.uah.edu, www.smaplab.ri.uah.edu/~cmds/
7. **Center for Advanced Microgravity Materials Processing**, Northeastern University, 342 Snell Engineering Center, 260 Huntington Ave., Boston, MA 02155. Established June 16, 1997, Director: Dr. Albert Sacco, Jr., Tel: 617-373-2989, Fax: 617-373-2209, asacco@coe.neu.edu
8. **Space Vacuum Epitaxy Center**, University of Houston, Science and Research Building 1, 4800 Calhoun RoadHouston, TX 77204 –5507, Established October 1, 1986, Director: Dr. Alex Ignatiev, Tel: 713-743-3621, Fax: 713-747-7724, ignatiev@uh.edu, www.svec.uh.edu/
9. **Wisconsin Center for Space Automation and Robotics**, 2348 Engineering Hall, 1415 Engineering Drive, College of Engineering, University of Wisconsin – Madison, Madison, WI 53706-1687, Established October 1, 1986, Director: Dr. Weijia Zhou, Tel: 608-262-5526, Fax: 608-262-9458, wzhou@facstaff.wisc.edu, www.engr.wisc.edu/centers/wcsar/
10. **Medical Informatics & Technology Application Center**, Department of Surgery, VCV Hospital - West Hospital, 1200 E. Broad Street - 16th Floor, Richmond, VA 23289, Established June 1, 1997, Director: Ronald C. Merrell, M.D., Phone: 804-828-1141, Fax: 804-827-1016, ronald.merrell@vcu.edu
11. **ITD ProVisions Technology Commercial Space Center**, Bldg. 1103, Suite 118, Stennis Space Center, MS 39529, Established: October 1, 1997Director: Dr. George May, Tel: 228-688-2509, Fax: 228-688-2861gmay@IFTD.org
12. **Life Sciences Division Food Technology Commercial Technology Space Center**, 194 Meat Lab, Iowa State University, Ames, Iowa 50011-3150, Established: August 4, 1999, Director: Dr. Dennis Olson, Tel: 515-294-1055, Fax: 515-294-6328, dgolson@iastate.edu

13. **Center for Space Power**, 223 Weisenbaker Engineering Research Center, Texas A & m University, College Station, TX 77843-3118, Established October 1, 1987, Director: Dr. Frederick Best, Tel: 409-845-8768, Fax: 409-847-8857, FRB449A@acs.tamu.edu
14. **Center for Space Power and Advanced Electronics**, Auburn University, Space Power Institute, 231 Leach Center, Auburn, AL 36849-5320, Director: Dr. Henry W. Brandhorst, Jr., Tel: 334-844-5894 , Fax: 334-844-5900brandhh@mail.auburn.edu, hyperoptic.spi.auburn.edu/ccdspage.html
15. **Satellite & Hybrid Communications Networks**, University of Maryland, Systems & Research Center, V. Williams Building, Room 3117, College Park, MD 20742, Established November 1, 199, Director: Dr. John S. Baras, Tel: 205-934-5329, Fax: 205-934-0480, baras@src.umd.edu
16. **Space Communications Technology Center**, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, Established November 1, 1991, Director: Dr. William Glenn, Tel: 561-297-2343, Fax: glenn@fau.edu

Appendix E. Acronym List

Acronyms used in the *Guide* are listed below. Further Information on NASA ISS-related acronyms is available through the Internet at:

- ✓ NASA ISS Acronyms http://spaceflight.nasa.gov/station/reference/index.html

Acronym	Definition
AAA	Avionics Air Assembly
AAEF	Aquatic Animal Experiment Facility
AC	Assembly Complete
ACISS	Advisory Committee on the International Space Station
AFEX	Advanced Furnace for microgravity Experiment with X-ray radiography
AHSTF	Advanced Human Support Technology Facility
AIAA	American Institute of Aeronautics and Astronautics
AO	Announcement of Opportunity
APCF	Advanced Protein Crystallization Facility
APS	Automated Payload Switch
ARIS	Active Rack Isolation System
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
BR&C	Biomedical Research and Countermeasures
BRF	Biotechnology Research Facility
CAM	Centrifuge Accommodation Module
CB	Clean Bench
CBEF	Cell Biology Experiment Facility
CHeCS	Crew Health Care System
CIR	Combustion Integrated Rack
CPD	Commercial Payload Development
CSA	Canadian Space Agency
CSC	Commercial Space Center
EFU	Exposed Facility Unit
ELF	Electrostatic Levitation Furnace
ELM-ES	Experiment Logistics Module – Exposed Section
ELM-PS	Experiment Logistics Module – Pressurized Section
EM	Experiment Module
EMCS	Experimental Modular Cultivation System
ERT	Engineering Research and Technology
ESA	European Space Agency
ESSP	Earth System Science Pathfinder
EVA	Extravehicular Activity
ExPA	EXPRESS Pallet Adapter
EXPRESS	EXpedite the PRocessing of Experiments to the Space Station
FB	Fundamental Biology
FCF	Fluids and Combustion Facility
FIR	Fluids Integrated Rack
FPEF	Fluid Physics Experiment Facility
GBF	Gravitational Biology Facility
GHF	Gradient Heating Furnace
HHR	Habitat Holding Rack
HOSC	Huntsville Operations Support Center
HQ	Headquarters (NASA Headquarters)

Acronym	Definition
HRDL	High-Rate Data Link
HRF	Human Research Facility
HRFM	High Rate Frame Multiplexer
ICS	Interobit Communication System
IP	International Partner
IPU	Image Processing Unit
ISLSWG	International Space Life Sciences Working Group
ISPR	International Standard Payload Rack
ISS	International Space Station
ITF	Isothermal Furnace
JEM	Japanese Experiment Module
JEM-EF	Japanese Experiment Module - Exposed Facility
JEM-PM	Japanese Experiment Module – Pressurized Module
JEM-RMS	Japanese Experiment Module – Remote Manipulator System
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LSE	Laboratory Support Equipment
LTMPF	Low-Temperature Microgravity Physics Facility
LVLH	Local Vertical-Local Horizontal
MAMS	Microgravity Acceleration Measurement System
MDM	Multiplexer De-Multiplexer
MELFI	Minus Eighty-degree Laboratory Freezer for the ISS
MI	Module Insert
MIDEX	Medium-class Explorer
MIL-STD	Military Standard
MLE	Middeck Locker Equivalent
MoO	Mission of Opportunity
MPLM	Multi-Purpose Logistics Module
MRD	Microgravity Research Division
MRPO	Microgravity Research Program Office
MSFC	Marshall Space Flight Center
MSG	Microgravity Sciences Glovebox
MSRF	Materials Science Research Facility
MSRR	Materials Science Research Rack
NAC	NASA Advisory Council
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NRA	NASA Research Announcement
OES	Office of Earth Science
OLMSA	Office of Life and Microgravity Sciences and Applications
OSF	Office of Space Flight
OSS	Office of Space Science
PI	Principal Investigator
PIMS	Principal Investigator Microgravity Services
PIU	Payload Interface Unit
PM	Pressurized Module
POI	Payload Operation Integration
POIC	Payload Operations Integration Center
RMS	Root-mean-square
RPO	Research Program Office

Acronym	Definition
RSA	Russian Space Agency
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Rack
SAMS II	Space Acceleration Measurement System
SAR	Shared Accommodations Rack
SIR	Standard Interface Rack
SMEX	Small Explorer
SPCF	Solution/Protein Crystal Growth Facility
SQUID	Superconducting Quantum Interference Device
SSE	Station Support Equipment
SSPO	Space Station Program Office
SSUAS	Space Station Utilization Advisory Subcommittee
STS	Space Transportation System (Space Shuttle)
TDRSS	Tracking and Data Relay Satellite System
TReK	Telescience Resource Kit
TSC	Telescience Support Center
UNESS	UNiversity Earth System Science
UNEX	University-class Explorer
UV	Ultraviolet
WORF	Window Observational Research Facility
XCF	X-ray Crystallography Facility
XPOP	X-axis Perpendicular to Orbital Plane
XVV	X-axis toward Velocity Vector
ZSR	Zero-G Stowage Rack