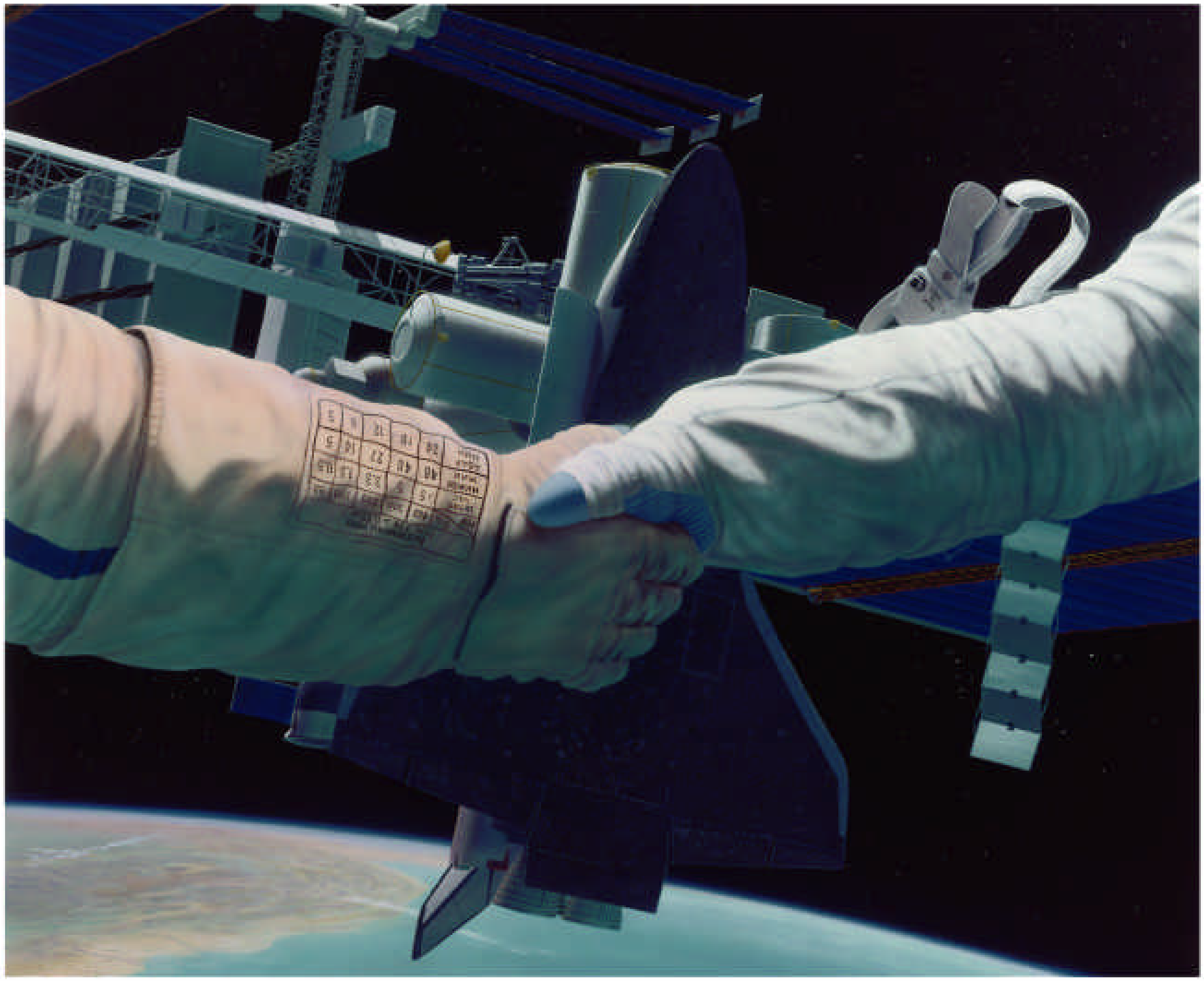

International Space Station

User's Guide

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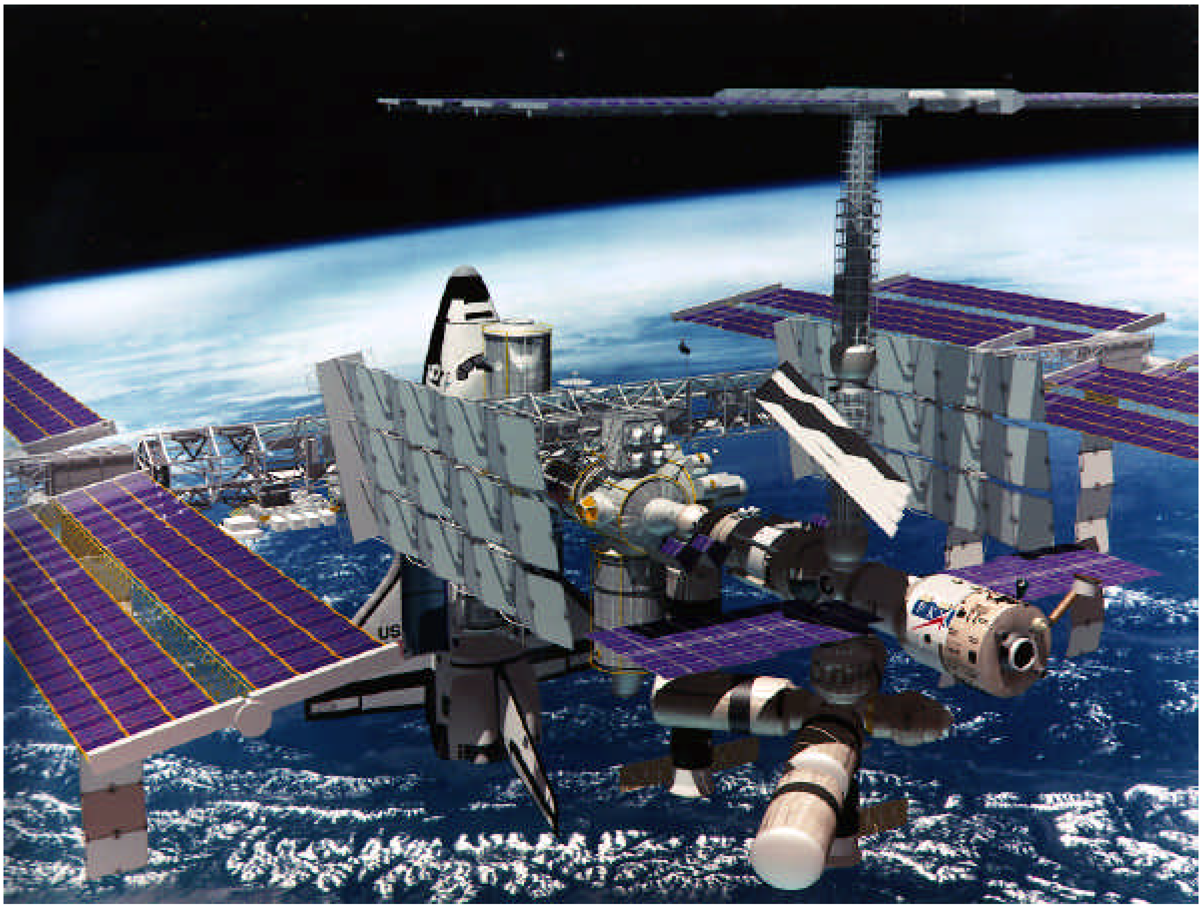

1. Introduction

Assembly of the International Space Station (ISS) began in late 1998 and will continue until completion sometime around the year 2004. During its assembly and over its nominal 10-year lifetime, the ISS will serve as an orbital platform for the United States and its International Partners to make advances in microgravity, space, life, and earth sciences, as well as in engineering research and technology and commercial product development. All of these activities will aid in understanding the basic biological, chemical, and physical processes that affect our daily lives, our home planet, our exploration of space, and our most fundamental concepts about the universe. The utilization of the ISS for creating knowledge and technology is an enterprise that not only requires the construction of a safe and viable orbiting laboratory, but also requires that ISS Users provide the best complement of research and technology payloads possible for flight on the ISS. The ISS Users, as defined in this document, comprise any and all members of the diverse community of scientific, engineering , technical and commercial organizations and individuals whose objectives may benefit from use of the ISS. The ISS Program realizes that ISS Users already associated with the program and, more importantly, Users who may potentially be interested in using ISS in the future, need an information source that is directed specifically at the working research community. The

International Space Station User's Guide was designed and developed to be this source.

1.1 Document Purpose and Structure

The *International Space Station User's Guide* is an introductory guide to the research capabilities of the ISS. It is designed to provide a top-level overview of the ISS research program, the available research hardware on ISS, and the necessary steps for getting experiments on board the Station. By reading the *User's Guide*, the external researcher should be able to determine whether the ISS might be a viable platform for their research, where in the NASA research organization they might fit, and how to go about getting into the ISS research program.

By outlining the Station operational parameters and hardware that working researchers may use to accomplish their objectives, the *Guide* is the practical accompaniment to the *NASA Research Plan Overview* and *Executive Summary*. The *Overview* and *Executive Summary* describe, in layperson terms, the rationale, likely content, and anticipated benefits of a variety of research fields for the ISS. An additional document, the *Science and Technology Research Directions for the International Space Station*, outlines the major research topics and thematic research questions that ISS will address in the area of Life and Microgravity sciences. Further descriptions of ISS systems and procedures appear in the *ISS Familiarization Manual*, a NASA training document at a technical level suitable for potential ISS researchers. The latter two documents are available to the public via the Internet, see Appendix A-Related Documents. Other documents that relate to the *Guide* are also compiled in Appendix A.

In Appendix B-Related Websites, an outline of the *Guide's* subject headings are mapped against the present structure of ISS-related websites associated with NASA and its International Partners. This map is intended to largely supplant citation of websites within the body of the *Guide*, although the *Guide* text does contain some references to sites with particularly relevant supplemental information.

1.2 ISS History and Overview

In his State of the Union Message to Congress in January 1984, President Ronald Reagan officially established the goal of developing a permanently inhabited station in orbit. Invitations were issued to Canada, Europe and Japan to join in the effort and agreements with the Canadian Space Agency (CSA) and the European Space Agency (ESA) were reached in September 1988, and with the Government of Japan in March 1989. A rapidly expanding cooperative relationship in human spaceflight between the U.S. and Russia resulted in several agreements that ultimately led to the incorporation of Russia into the International Space Station program in December of 1993. The Russian addition resulted in several design modifications that are now part of the present ISS configuration.

Today, the structure of the ISS Program as a cooperative international effort is based on a multi-lateral Intergovernmental Agreement between all of the involved governments, and on bilateral Memoranda of Understanding between NASA and the International Partner (IP) space agencies that represent these governments. The management structure spelled out in these agreements specifies that each of the IPs will make certain hardware contributions and have certain responsibilities inside a framework in which the U.S. has leading management and integration roles. Complicating the picture is the possibility for bilateral "barter" agreements, in which two partners make trades based on their respective capabilities.

Although the ISS Program has some similar aspects to large engineering testbed or "big science" projects with which a working researcher may be familiar from their own particular fields, it has other aspects that make it unique. Unlike a particle accelerator or multi-user astronomical telescope facility, the ISS is designed to meet a number of human goals in the areas of exploration and international relations that augment its goals for research *per se*. This multi-faceted aspect of ISS results in a complex program structure that is outlined as follows.

Whereas the overall management responsibility for NASA resides with the NASA Administrator and Associate Administrators at NASA Headquarters (HQ) in Washington, D.C., day-to-day management of a major NASA project such as the ISS is usually handled at one of the many NASA field centers distributed across the U.S. These so-called Lead Centers then distribute tasks to contractors or other NASA centers as needed. For ISS the lead Center is NASA Johnson Space Center (JSC) in Houston, TX. At JSC the ISS Program is managed by the Space Station Program Office (SSPO, NASA Johnson Space Center, Mail Code OA, Houston, TX, 77058).

To handle its broad range of responsibilities, the SSPO is in turn sub-divided into several offices that include the Vehicle office (Mail Code OB), which oversees vehicle construction and assembly, and Payloads (Mail Code OZ), which is in charge of development and integration of payloads.

For the ISS User who wants to pursue research on the Station, the SSPO can play an informational role initially. It does not, however, come into direct involvement until a User's project is funded, authorized for flight, and under development. Actual selection and funding of ISS research is the responsibility of science, engineering and commercialization program offices at NASA Headquarters. These program offices are organizationally separate within NASA from the SSPO. They are responsible for all of NASA research, not just investigations to be done on the ISS. It is these Headquarters programs that will in most cases be the first point of contact between a potential ISS User and the ISS program. Further information on these programs is covered below in Section 7 - Getting on Board.

1.3 NASA Research Coordination and Advisory Committees

ISS research is coordinated through NASA internal organizations as well as through external advisory councils and committees whose purpose is to aid NASA's decision-making in a variety of long term and short term areas. The councils and committees are generally drawn from academia, government and industry. The highest NASA advisory group is the **NASA Advisory Council (NAC)**. The NAC, its committees and subcommittees provide their advice and counsel directly to the NASA Administrator. Among its seven standing committees the NAC includes the **Advisory Committee on the International Space Station (ACISS)**, which answers to the NASA Office of Space Flight. There is a particularly important subcommittee called the **Space Station Utilization Advisory Subcommittee (SSUAS)**. The membership of SSUAS consists of 10 to 15 individuals drawn from academia, industry, and government. Twice each year, in the winter and summer, the full SSUAS meets with ISS Program representatives for briefings on a variety of topics. A smaller group of SSUAS members also meet with ISS Program representatives each month. The SSUAS evaluates information it receives in these briefings, makes findings and issues recommendations to ACISS and the ISS Program. These findings and recommendations have a great influence on ISS development, especially in regard to the optimization of research capability.

The internal NASA team that supports ISS research utilization is comprised of various organizations, each of which contributes in a coordinated way to meeting the needs of the research community. The research capabilities of the ISS are formally managed by incorporating the needs of the research community into the ISS technical requirements that the SSPO has direct responsibility for and the prime contractor, Boeing, is obligated to meet. To this end the SSPO maintains civil service and contractor staff whose sole purpose is to manage the science requirements and interact with NASA science and research organizations, as well as external advisory committees, to achieve research utilization of the Space Station that is as broad as possible.

2. ISS Development

2.1 Assembly Sequence

ISS development is progressing through three designated phases. ISS Phase I took place before assembly and consisted of a series of cooperative research flights between the United States and the ISS partners. Most notably, this involved a series of rendezvous flights between the Space Shuttle and the Russian space station *Mir*, cosmonaut flights on the Space Shuttle, and U.S. astronaut stays and research on *Mir*. In ISS Phase II, the knowledge gained from Phase I operations is applied to the on-orbit assembly of the ISS. ISS Phase II concludes with the successful assembly of the U.S. and Russian components of the ISS that are necessary to begin Station research. ISS Phase III development consists of the final research outfitting of the ISS, as the European, Japanese, and Canadian elements are transported to orbit and the Station becomes fully operational.

Contained within Development Phases II and III are steps in the overall ISS Assembly Sequence. The Sequence lists events in the assembly of ISS, based on the flights bringing elements, personnel and equipment to the Station. The flights may be on the

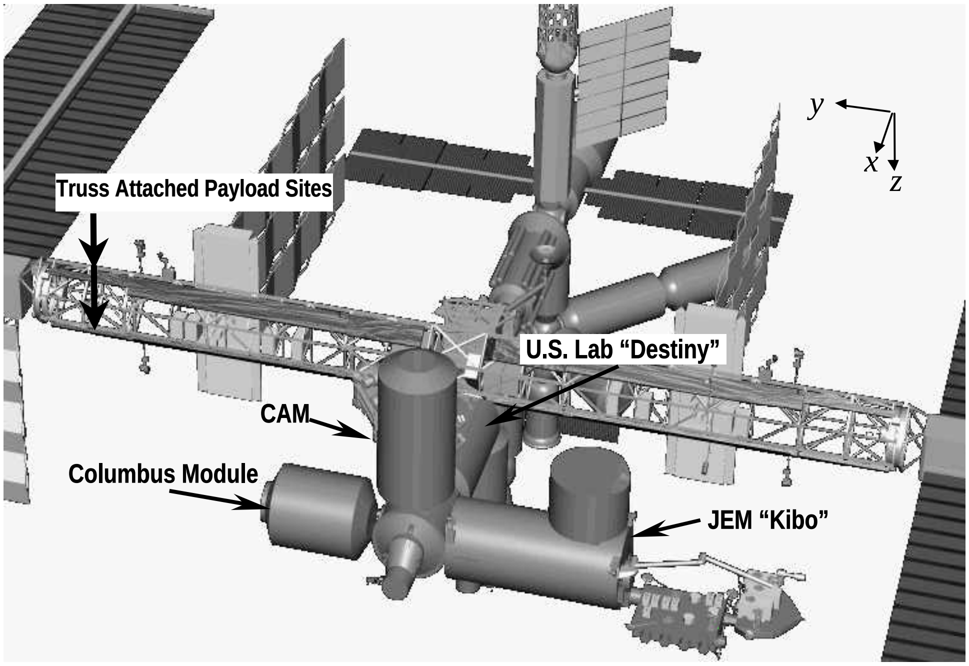

Figure 3.-1 ISS Assembly Complete configuration

U.S. Shuttle (STS), or Russian crewed (Soyuz) and un-crewed (Service Module, Progress) vehicles. The Assembly Sequence is considered a working schedule and subject to adjustment as programmatic needs arise. For this reason the *Guide* provides only a sequential list of Assembly flights, minus flight dates, as a conceptual guide to the reader in Appendix C. For the full ISS Assembly Sequence the reader is referred to the ISS Assembly website (Appendix B).

2.2 Build-up of Resources and Early Utilization

On-orbit assembly of ISS will take about five years. Because this is a lengthy time to wait to begin research activities, so-called Early Utilization of the ISS will begin at flight 5A.1, during the Assembly phase. The sequence of availability of resources for the conduct of research prior to Assembly Complete is complex and fluid making it impractical to specify the resource availability sequence as part of the *Guide*. For this reason, the *Guide* is organized around a depiction of ISS capabilities and resources as they will exist at Assembly Complete. Information on pre-Assembly Complete resources is, however, available through the SSPO for individuals that need it.

3. ISS Research Elements

The ISS is divided into *segments* that are defined in most cases along the lines of responsibility of the International Partners. Segments are in turn constructed from one or more functional *elements* that include modules, nodes, truss structures, solar arrays, and thermal radiators. Modules are pressurized cylinders that will provide most of the habitable space on board the Station. They may contain research facilities, living quarters, and any vehicle operational systems and equipment to which the astronauts may need access. Nodes connect modules to each other and offer external Station access for purposes such as docking, ExtraVehicular Activity (EVA) access, and unpressurized payload access. Trusses are erector-set-like girders that link the modules with the main solar power arrays and thermal radiators. Together, the truss elements form the Integrated Truss Structure. Solar arrays collect solar energy and convert it into electricity for the operation of the Station and its payloads. Thermal radiators radiate excess thermal energy into space.

The configuration of ISS at Assembly Complete is shown in Figure 3.-1. ISS research requiring pressurized conditions will be conducted primarily in the U.S. Laboratory *Destiny*, the European *Columbus* module, the Japanese Experiment Module (JEM) *Kibo*, and the U.S.-contributed Centrifuge Accommodation Module, or CAM. Designs and plans for additional research modules contributed by the Russian Space Agency (RSA) are not yet finalized.

Basic data such as length, diameter and mass for the ISS research modules are summarized in Table 3.-1. The interior of all of the research modules, like the ISS interior as a whole, will be a "shirt-sleeve" environment, with an oxygen-nitrogen atmosphere and

Table 3.-1. ISS Research Module Data[1]				
	U.S. Lab, *Destiny*	U.S. CAM	Columbus Module	JEM-PM
Length, exterior, m [ft]	8.8 [28.8]	8.3 [27.1]	6.5 [21.5]	11.2 [36.8]
Length, minus end cones, m [ft]	7.7 [25.2]	7.75 [25.3]	5.0 [16.4]	8.9 [29.1]
Diameter, exterior, m [ft]	4.4 [14.6]	4.4 [14.6]	4.5 [14.8]	5.0 [16.2]
Mass, on orbit AC[2], kg [lbm]	26,771 [58,896]	14,352 [31,574]	16,568 [36,449]	43,566 [95,845]
Rack locations along length	6	4	4	6
Total rack locations	24	15	16	23
Research racks, total number	13	4	10	10
Research racks, U.S. share	13	4	5	5

[1]Dimension and mass data from *International Space Station On-Orbit Assembly, Modeling, and Mass Properties Data Book, Rev. J, August 1999*

[2]Assembly complete (AC), includes full systems complement (including robotic arms, attached payload sites etc.)

temperature and humidity conditions similar to Earth-bound laboratories. Experiments within the research modules will have access to power, cooling, communication, vacuum, exhaust, gaseous nitrogen and microgravity measurement resources. Details on all of these are described below in Section 5 - Accommodations for Research.

For investigations wishing to have experiments exposed to space, various attachment sites are provided at ISS exterior locations, including the starboard side of the ISS truss (Fig. 3.-1), the JEM Exposed Facility (JEM-EF), and the end-cone of the *Columbus* module. Section 5 also provides details on the payload accommodations at these locations.

Within the U.S., European and Japanese laboratory modules, the internal space allocated for payloads is configured around a system of uniformly-sized (with some slight variations) equipment racks called International Standard Payload Racks (ISPRs). These racks, which are approximately the size of a large refrigerator, are designed to be extremely versatile with respect to the type and configuration of equipment they can accommodate. A diagram of the basic ISPR geometry and its relation to a module is shown in Figure 3.-2. Table 3.-1 lists the total number of ISPR locations for each module.

The backs of the ISPRs have a radius of curvature just slightly less than the modules to efficiently fill all available space. The resulting module cross-sectional geometry has the racks arranged in quadrants around an interior workspace with a square cross-section (Figure 3.-2). The workspace is in turn lined with racks along all four "walls" with the number of racks depending on the length of the module (Fig. 3.-2, Table 3.-1). Additional details on ISPR design are covered in Section 5.3.1. The rack system used in the Russian segment modules is presently under design.

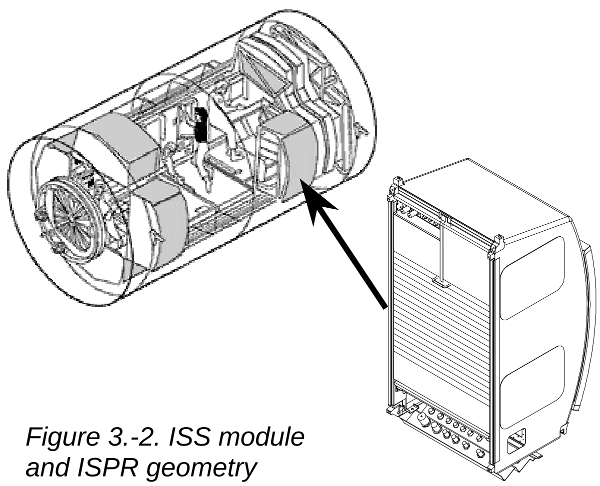

Figure 3.-2. ISS module and ISPR geometry

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

The U.S. Lab, named *Destiny*, is the module where a significant portion of the pressurized U.S. research will take place. Several exterior views are shown in Figure 3.1-1. *Destiny* will have internal interfaces to accommodate the resource requirements of 24 equipment racks. Thirteen of these are ISPR research racks and the rest are for other uses, such as controlling ISS systems. *Destiny* will be the first research module installed on the Station (see Appendix C-Station Assembly Flights) and as such will be the site of the earliest research projects. The side of *Destiny* that faces Earth for the majority of possible ISS flight

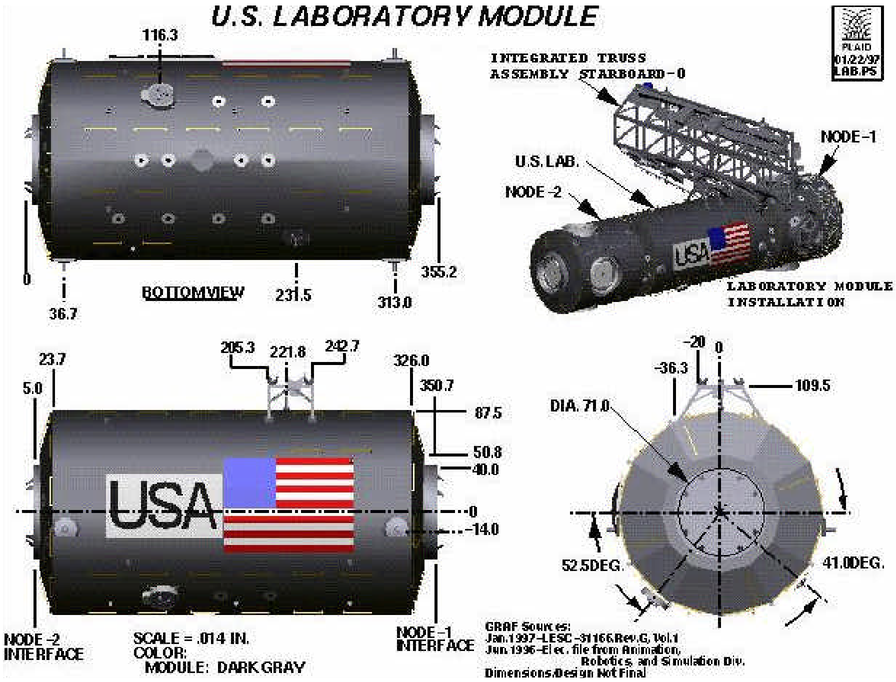

Figure 3.1-1. U.S. Laboratory module ("Destiny") views

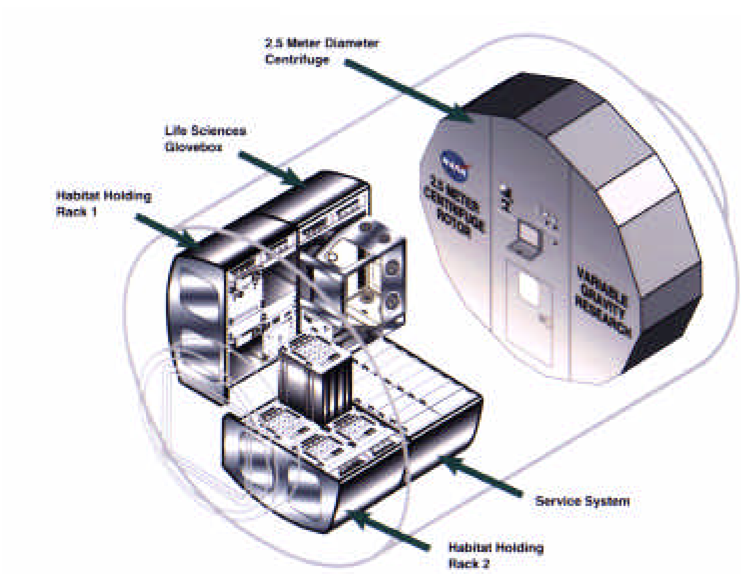

Figure 3.2-1. Centrifuge Accommodations Module (CAM)

attitudes contains a circular window of very high optical quality design. In the module interior this window will be located beneath a single rack location where the Window Observational Research Facility (WORF, see Section 5.4.7) will reside.

3.2 U.S. Centrifuge Accommodation Module (CAM)

The CAM is a laboratory dedicated to U.S. and cooperative international gravitational biology research. As shown in Figure 3.2-1, it houses a 2.5 m (8.2 ft) diameter centrifuge, which is the essential component of a larger complement of research equipment dedicated to gravitational biology. The complement will include a Life Sciences Glovebox, two Habitat Holding Racks and a Cryo-Freezer. In addition, 9 locations are provided for passive stowage racks; one for a passive service system rack for gravitational biology research, and the other 8 to be allocated for all Users' passive stowage as required on a mission-to-mission basis.

3.3 U.S. Integrated Truss Attachments

There are four dedicated sites on the starboard side of the ISS truss where external payloads can be attached. The general location of these attach points is indicated in Figure 3.-1 and a more detailed view, with the actual attach points indicated by arrows, is provided in Figure 3.3-1. There are two attach points on the nadir, or Earth-facing, side of the truss, and two on the opposite, or zenith, side of the truss. Physically the attach points consist of a system of three guide vanes and a capture latch used to secure the payload, as well as an umbilical assembly to mate utilities and connections. For illustration purposes on the two zenith attach points Figure 3.3-1 depicts a single truss-site payload of larger size next to a smaller standardized EXPRESS (EXpedite the PRocessing of Experiments to the Space Station) pallet carrying multiple payloads. The details on size, mass, power, data and other resources for both of these

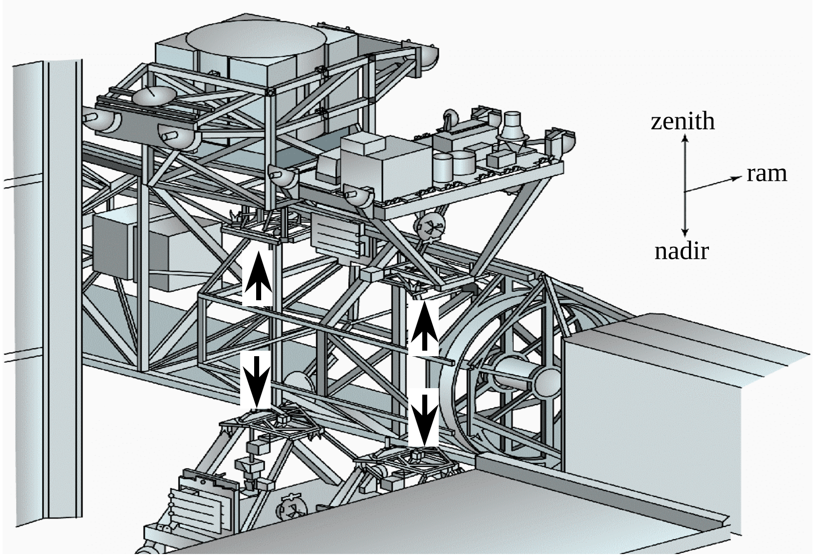

Figure 3.3-1. U.S. exposed-payload attachment sites on starboard truss.

types of attached payload accommodations are discussed below in Section 5.3.6.

3.4 Japanese Experiment Module (JEM)

The Japanese Experiment Module (JEM), also known by the name *Kibo*, is the segment of ISS developed by the National Space Development Agency (NASDA) of Japan for the purpose of supporting research and development experiments in Earth orbit. As shown in Figure 3.4-1, the JEM consists of several major systems that are assembled on orbit:

The JEM Pressurized Module (JEM-PM) is a laboratory for experimental research in areas such as space medicine, life sciences, materials processing, and biotechnologies. The JEM-PM can also transfer equipment to and from the vacuum of space through an airlock chamber without having to depressurize the entire laboratory. The JEM-PM supports a total of 10 ISPRs for research payloads, of which 5 are allocated to NASA under NASA-NASDA resource-sharing agreements. (See Section 5.1 below for details on ISS resource sharing).

The JEM Exposed Facility (JEM-EF, Fig. 3.4-1) is an un-pressurized pallet structure exposed to the environments of space to support user payloads for the purpose of experimental research in areas such as communications, space science, engineering, materials processing, and earth observation. A total of 10 payload sites are provided, and under resource-sharing provisions a total of 5 of these sites are allocated to NASA. Additional details on the structural

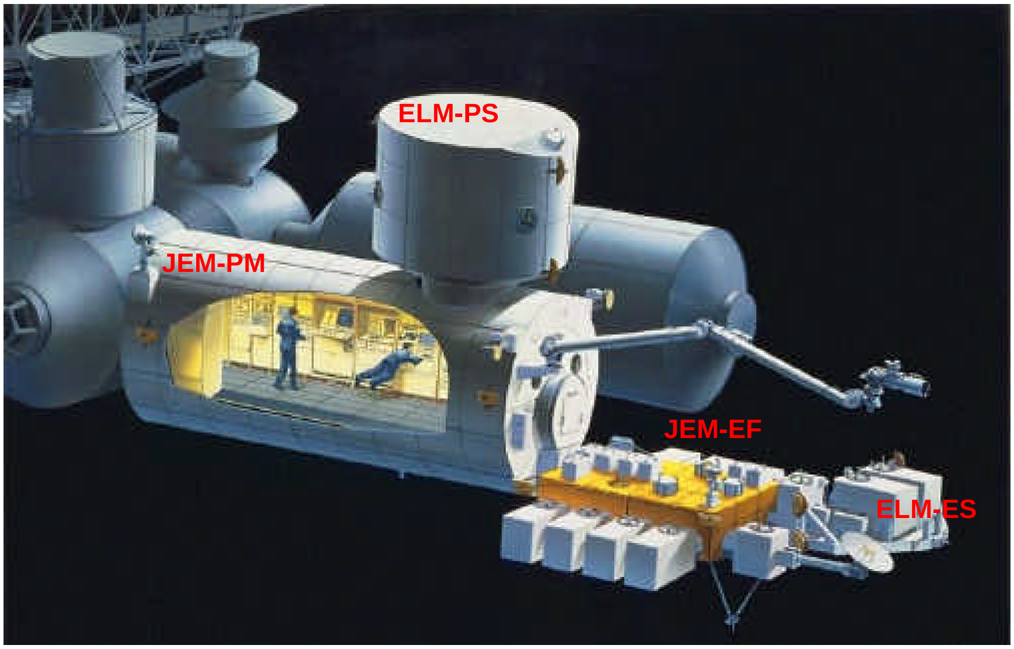

Figure 3.4-1 Japanese Experiment Module (Kibo)