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Paper Session I-A - Planning for Operations On-Board the International Space Station

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ABSTRACT

With the launch of the first element of the International Space Station (ISS) in late 1997, scientists and engineers from around the world will have greater access to the space environment for research and commercial exploration. The complexity and flexibility of the International Space Station offers opportunities as well as challenges in planning on-orbit operations. In order to make effective use of limited resources (e.g. crew time, power, and data), while maximizing the results to the scientific, commercial, military and educational communities, the ISS operations planning community must balance many constraints and criteria. The four disciplines must be aware of these constraints as well as the planning process to plan and conduct their activities on-board ISS.

INTRODUCTION

Planning for operations on-board the International Space Station (ISS) is a highly complex process designed to make effective use of limited resources within strict constraints. The planning process for ISS will involve scheduling a wide variety of objectives and procedures against these limited resources. These limited resources include, but are not limited to: power, communications coverage, crew, and microgravity conditions.

ISS operations planning also address intangibles, such as international cooperation. The nature of ISS involves operations across international boundaries. The crews, regardless of nationality, will be working in all segments of ISS. Also, each segment has its own unique capabilities and constraints. Areas such as power available and microgravity conditions will vary both in location on ISS as well as in time. Obviously, these are areas that the planners must take into consideration and will affect operations such as experiments on-board ISS.

Preliminary work to help all parties understand operations for ISS has begun with Phase 1 of the ISS Program. In the Phase 1 program, both US and Russian personnel and vehicles are working together to plan and execute both Space Shuttle-Mir joint operations, and to conduct US-sponsored experiments in the Mir environment. Planners are taking lessons learned from the Phase I missions and incorporating these into Groundrules and Constraints to guide future operations on ISS.

Unlike current Shuttle planning, which includes generating detailed activity schedules a month in advance of the flight, ISS planning delays detailed scheduling as late as possible. The objective is to minimize, if not eliminate, the multitude of replanning changes that characterize Shuttle flights. Instead, the first time a detailed ISS timeline will be generated is one week before execution. This is referred to as “Just in Time Planning.”

This paper outlines the predicted ISS planning and operations environment as well as summarizes planning processes and procedures.

NASA PLANNING APPROACH

Just In Time Planning

The International Space Station (ISS) plan development in the execution phase will provide the intermediate and short range plans for conducting Station systems and utilization operations. Within the context of a planning team composed of representatives of all International Partners, ISS planning is segmented based on the characterization of requirements as “Systems” and “Utilization”. “Systems Planning” refers to the planning that must be performed to ensure that the Station remains operational and provides a safe and supportive environment for science and commercial operations activities. (Assembly and Maintenance activities) “Utilization Planning” refers to the planning that must be performed to accomplish the goals and objectives of science and commercial operations activities. It is important to note that systems requirements generally will be planned before utilization requirements in order to provide a feasible foundation for science and commercial objectives.

The On-Orbit Operations Summary (OOS) will provide the intermediate range planning of systems and utilization operations for an entire increment. (An increment is defined as the On-orbit stay of one Station crew and may be as long as six months.) The OOS identifies the activities to be performed during each day of planned Station operations, but provides no detail as to exact time of execution. The OOS is developed based on the needs of maintaining the Station operations capability while fulfilling the objectives of individual utilization activities. Using the OOS as the starting point, the Short Term Plan (STP) will define in detail the planned systems and payload operations to occur during one week of the continuous Station operations capability. The STP is the blueprint for daily activities of all ISS participants. These two plans will be developed in an integrated manner by the international participants in the planning process.

Weekly Planning Process

Weekly planning is the process through which the OOS and STP are developed to support the onboard execution of systems and utilization activities. The weekly planning process consist of fourteen steps:

1. Determine the current state of ISS resource and operations capabilities and constraints. These capabilities and constraints are based on the current Station configuration. Systems and equipment represent the resources against which planning must be performed.

2. Identify the International Partner's specific operation guidelines and constraints for the week being planned. Based on the information, ISS planners perform a specific allocation of available resources to the International Partners (Russian Space Agency, National Space Development Agency of Japan, and European Space Agency) through the distribution of "resource envelopes." Each Partner's allocation is based on overall program agreements about how the ISS capabilities will be exploited during a specific increment. Resource envelopes also to: 1) identify the Partner's approach to ensuring their program agreements and commitments are properly reflected in the distribution of resource envelopes, and 2) ensure utilization goals and objectives of Partner sponsored payloads within each of the Station segments are properly represented.

3. Conduct the Weekly Planning Conference to ensure critical Station-wide activity requirements are coordinated across the systems and utilization planning functions of the entire Station and that utilization activity requirements are coordinated across the International Partners. The inputs during the conference consist of current Station capabilities and constraints, systems and utilization operations requirements, Partner planning guidelines and constraints, the current STP and OOS, change requests, and Partner issues and concerns. The output of the Weekly Planning Conference is the agreed set of specific system and utilization operations for the planning week.

4. Define the system operations activities for those basic activities required to operate Station. This activity set is called Basic Station. By definition, these activities do not use crew time as a resource but may use other resources such as power, thermal, and data.

5. Develop a plan of systems operations required to maintain a safe and functional Station operations capability. This plan specifies the timing and frequency of systems operations to occur during the next week of planned Station operations.

6. Determine the distribution of the available resources to each of the International Partners responsible for a Station segment. This step ensures that the utilization requirements for all payloads within an International Partner's segment are accommodated.

7. Define the resources that are unique to a particular segment. Through the evaluation of resources that are unique to a Station's segment, resource capabilities and constraints of segment systems and equipment are available in the form required for planning and scheduling.

8. Identify the resource, timing, and relationship constraints necessary to define the time dependent resource envelopes available to individual Users/User Operations Facilities (UOFs). The Users/UOFs develop the utilization requirements of one or more Users in a form that can be used to support the distribution of resource envelopes and the planning and scheduling of utilization activities.

9. Determine the timing and magnitude of resources within which individual activities of a given User or UOF must be scheduled. This step also defines the planned configurations and reconfigurations of segment unique systems required to support the utilization activities within a segment.

10. Determine the information necessary to build the products (STP) required to implement and execute utilization activities onboard the Station while ensuring that the scheduled activities for the upcoming week are consistent with resource envelopes.

11. Develop or update execution details for the system activities contained on the system operation plan. This step includes the products which define the results of systems operations planning and the inputs required to support the development, management, and control of operations across the Station. (Station-wide Product Inputs)

12. Collect the detailed plans and products necessary to support the unique and independent operations of the various Station segments. This step also provides the information necessary to ensure that scheduled segment utilization operations are consistent with resource envelopes (Segment Utilization Operations Plans). The resulting plans and products provide an integrated set of data representing all operations to be performed within a segment for both the upcoming week and for the remainder of the increment.

13. Integrate the plan of scheduled systems operations for the week and segment-specific utilization operations planning data necessary to generate the products required to support the operations across the Station. The resulting plans and products are used by the crew, automated systems, and ground controllers to implement, manage, and control onboard operations of the entire Station. The primary products resulting from the implementation of this step includes the STP, OSTP (Onboard Short Term Plan), an updated integrated systems OOS, and segment-specific execution products.

14. Perform a final check for proper integration of systems and utilization operations plans. This validation process involves reviewing plans to ensure that the plans adhere to the defined resource availability and International Partner planning guidelines and constraints.

15. Ensure that program agreements are attained and that the science goals and objectives of the respective Users are being satisfied. This is accomplished through the evaluation of the resulting intermediate and short range plans for concurrence with Partner agreements and program commitments, while taking into account the results from the previous planning cycles.

PAYLOAD OPERATION

Payload operations on-board ISS will be different from operations on the Space Shuttle. Much of the payload operations on ISS will be automated. The automated operations will be run and maintained by on-board software located in the Payload MDM (Mulitplexer/Demultiplexer). Crew hours available for payload operations will be limited to approximately 21 percent of the total crew work week during steady state operations (currently estimated at 9.25 hours per week for each crew member).

Limited communications coverage available to ISS will introduce some new operating techniques. The crew will have more personal time for operations and will do much of the problem solving themselves. Limited communications coverage means that there will not always be someone at the other end of the radio link to answer the crew's questions. Thus, the crew will need to have a good understanding of experiment being performed and have the leeway to deviate from the written procedures when necessary.

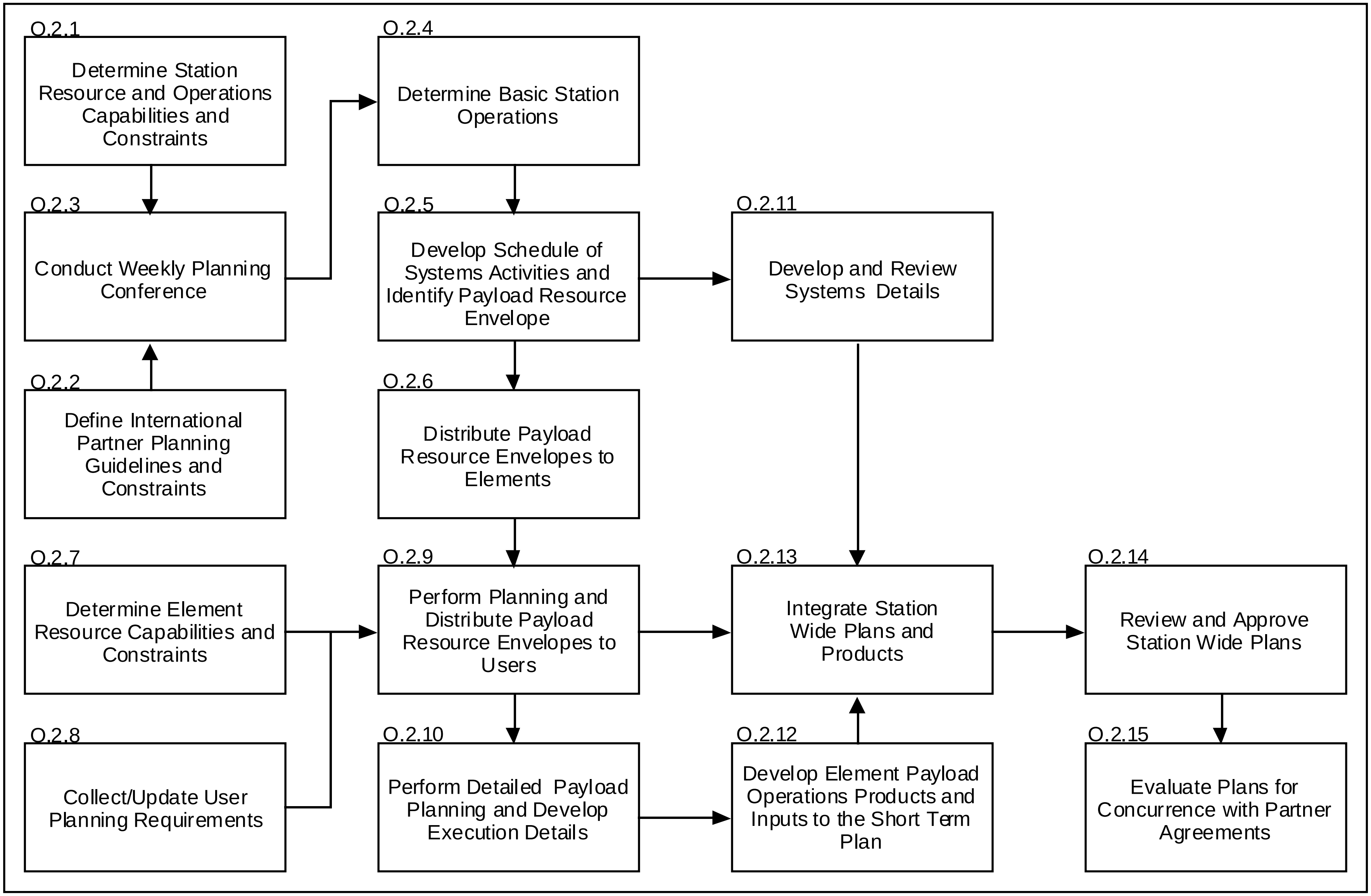

Figure O-1 Weekly Planning Flow

Research on ISS has been categorized as:

1. Life Sciences
2. Material Sciences
3. Fluid/Combustion Sciences
4. Space Sciences
5. Earth Sciences
6. Commercial/Technology

The crew will be skills trained in these areas. This is a change from current payloads training for the Space Shuttle crews which involves task training. Due to the long duration of the ISS flights, the crew will be more effective if they are trained for a type of operations rather than procedure trained for a specific procedure or task. It is felt that with the long duration missions, tasks learned in task training will be lost as time increases, however, if the crew is skills trained, they will retain the necessary skills and can develop and review procedures on-orbit just prior to performing the specific task.

Payload operations will be conducted throughout ISS requiring the crew to be trained in different operating environments. At assembly complete, internal science operations will be occurring in the US Lab, ESA's Advanced Pressurized Module, the Japanese Experiment Module (JEM), as well as in the Russian research modules. There will also be exposed research facilities located outside the JEM and along the truss structure.

Payload operations on ISS will be different from operations on the Space Shuttle and thus will require a new approach to the planning process. The extended orbital operations time offered by ISS will open a wide variety of new opportunities previously unavailable. But this also means there will be many new challenges to be met for science operations on ISS.

CONCLUSION

Operations on the International Space Station will present many challenges to the operations planning community. NASA has outlined its approach to meet these challenges and make operations on ISS as effective as possible. Good communications between the scientific community and the planning community will be required to enable operations on ISS to allow many advancements in the scientific world.