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27 October 2000

ISS Program Off-Nominal Situation Plan

International Space Station Program

October 27, 2000

BASIC

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas

INTERNATIONAL SPACE STATION PROGRAM

INTERNATIONAL SPACE STATION PROGRAM OFF NOMINAL SITUATION PLAN

PREFACE

OCTOBER 2000

This document is the International Space Station Program Off-nominal Situation Plan (IPOP).

The contents of this document are to be consistent with the tasks and products prepared by the International Space Station (ISS) Program participants as specified in SSP 50011-01, Concept of Operation and Utilization, Volume 1: Principles and SSP 50200-02, Station Program Implementation Plan, Volume 2: Program Planning and Manifesting. Official deliveries of this document are under control of the Space Station Control Board (SSCB) and any changes or revisions will be jointly agreed to and signed by the National Aeronautics and Space Administration (NASA) and the affected partners, under the provisions of Article 8 of the Memorandum of Understanding (MOU).

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1.0 INTRODUCTION

1.1 PURPOSE

The International Space Station (ISS) Program organizations review potential Off-nominal Situations (ONS) to ensure that timely decisions and plans are made to preserve the ISS mission plan and mitigate any potential safety risk or impact on research. The prevention of and recovery from ONS is taken into consideration in all phases of the development and operation of the ISS. Potential ONS are identified and assessed by all ISS program organizations, including the International Partner (IP) organizations, as part of the normal course of developing, manufacturing, and operating the ISS. Efficient use of all available Partner resources and functional capabilities is considered during the development of the ONS response to minimize cost and impact to schedules.

Redundancy built into the ISS hardware and systems, operations planning for reserve crew supplies in case of missed resupply, propellant reserve supplies, critical spares, and malfunction procedures are examples of program processes designed to overcome or mitigate the risks of ONS.

In addition, this document describes the overall ISS Program ONS processes, development schedule timeline, and documentation product flow for defining, planning, and documenting ONS and agreed to response measures in order to ensure that the appropriate flight products are developed and executed.

1.2 ONS DEFINITION

An ONS is defined as an unplanned event causing a disruption of planned operations that impact the ISS and/or crew safety or the successful completion of the ISS mission / flight plan. ONS are events that are not prevented by planned design measures or operational controls, and require an integrated multi-segment response. An ONS can range from the loss of a major ISS hardware element to the failure of an electronics component, depending on the severity of the consequence. For the purposes of this document, the ONS identified herein are subdivided into the following main categories:

- ONS causing disruption of the planned assembly sequence,
- ONS causing disruption of planned logistics flights,
- ONS causing a loss of a critical system function or capability, and
- ONS causing an event requiring an emergency response (Depress, Fire, Toxic, Release).

1.3 SCOPE

This document defines and describes the overall ISS Program plans and processes for responding to an ONS and is based on the ISS Assembly Sequence Revision (Rev) F. Flights 1A/R, 2A, 2A.1, and 2A.2A have been successfully completed and are not included. Logistics flights to maintain crew/station operations are discussed generically as well as individually. All of the ONS identified in this document are multi-segment and require the joint support and agreement of the IPs as applicable.

This document provides guidance and recommended options for responding to an ONS to be assessed during the development and execution phases of the ISS mission plan. More detailed ONS assessments, recommendations and resulting requirements for implementation will be derived from the IPOP recommendations during the increment planning (beginning two years prior to flight) and documented in the Increment Definition and Requirements Document (IDRD) and IDRD ONS Annexes. Any new hardware, software, or additional international agreements necessary to support the ONS response will be reviewed and approved utilizing the existing ISS program change process or equivalent IP change process and reflected here as necessary.

1.3.1 SCOPE OF INITIAL IPOP (BASIC VERSION)

The initial version of the IPOP to be baselined in the ISS program will be limited in content in accordance with the details outlined below in order to expedite approval and put in place a jointly agreed to ISS plan for the near term flights. Subsequent updates, being worked in parallel, will reflect the complete scope of documentation intended to be captured in the IPOP.

<u>Contents of IPOP, Basic Version</u>

- Section 1 – Introduction: Complete.
- Section 2 – Documents: Complete.
- Section 3 – ISS ONS Planning: Complete ISS ONS development process described
- Section 4 – Assembly ONS: Complete through Flight 7A. The remaining flights will be marked as TBD.
- Section 5 – Logistics ONS: Complete Soyuz, Progress, & Shuttle vehicle sub-sections as well as Soyuz, Shuttle & CRV Crew Rotation sub-sections. The rest of the Logistics vehicle sub-sections (ATV, HTV) will be marked as TBD.
- Section 6 – Subsystem Functionality ONS: Will contain an introductory paragraph describing the scope and details (e.g. format) of the type of information to be contained in this section. The rest of the section will be marked as TBD pending completion of ongoing joint subsystem functionality ONS development.
- Section 7 – Emergency Response ONS: Will contain an introductory paragraph describing the scope and details (e.g. format) of the type of information to be contained in this section. The rest of the section will be marked as TBD pending completion of ongoing Emergency Response ONS development.

1.4 REVISIONS AND UPDATES

The IPOP will be revised to reflect changes in the program plan as the ISS assembly progresses and based on the results of ISS operations. The document will be updated periodically to support major program milestones. Also, the document will be revised in response to assembly sequence changes as documented in SSP 50110, the Multi-Increment Manifet Document.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The current issue of the following documents is identified in the Program Automated Library System (PALS) (http://issa-www.jsc.nasa.gov/cgi-bin/dsql+/ORAP?-h+palshome). The documents listed in this paragraph are applicable to the extent specified herein.

SSP 50011-01 Concept of Operation and Utilization,
Volume 1: Principles

SSP 50200-01 Station Program Implementation Plan,
Volume 1: Station Program Management Plan

SSP 50200-02 Station Program Implementation Plan,
Volume 2: Program Planning and Manifesting

SSP 50200-08 Station Program Implementation Plan,
Volume 8:

SSP 50200-08 Station Program Implementation Plan,
Volume 9:

2.2 REFERENCE 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 this document.

SSP 41000 System Specification for the International Space Station

SSP 41162 Segment Specification for US On-orbit Segment

SSP 41163 Russian Segment Specification

SSP 50110 Multi-Increment Manifest Document, Revision F

SSP 50261-001 Generic Groundrules, Requirements, and Constraints
Part 1: Strategic and Tactical Planning

SSP 50505-1 Basic Provisions on Crew Actions in Case of Fire

SSP 50506-1 Basic Guidelines for Crew Activities During ISS Depressurization

TBD	Russian Segment Subsystem ONS Document

3.0 ISS ONS PLANNING

ONS prevention and response planning has been a key driver in the design and development of the ISS and is a continuing activity during the operational execution phase. Section 1 describes how ONS planning is divided into programmatic, increment, and mission level planning. Section 2 defines the categories of ONS described in this document. Section 3 outlines the ongoing processes used by the ISS program to identify, prevent, or respond to ONS.

3.1 ISS ONS PLANNING PHASES

ONS are defined and planned for at three basic levels of detail and time frames: 1) programmatic planning; 2) increment planning; and 3) mission planning. A matrix of planning levels and categories that describes the ISS program planning requirements is shown in Table 3.1-1.

Programmatic planning examines the entire assembly sequence and addresses such issues as the loss of a launch capability, a major element, logistics, or a critical system function. It is performed early in the program, and is reassessed whenever the assembly sequence is modified. The purpose is to identify hardware or planning with long lead times that may be necessary to mitigate risks from an ONS. Programmatic ONS planning is documented primarily in this document, the IPOP.

Increment planning is performed in support of increment operations and begins approximately 24 months before the start of the increment. Increment planning identifies potential ONS and response plans to ensure the successful completion of the primary objectives for the increment and each flight within the increment. The purpose of increment planning is to identify critical spares, other hardware, or operations plans to support the increment and mission objectives. Requirements identified to implement response plans are documented in the IDRD.

Mission ONS planning begins 18 months before the mission and is performed up to the execution of the mission. The purpose is to ensure the execution of the mission by developing flight products that support the real-time response measures to mitigate ONS. The flight products include flight rules, malfunction procedures, and any additional hardware or tools needed in support of the malfunction procedures. The results are captured by the flight-specific operations flight rules, malfunction procedures, and flight manifests.

TABLE 3.1-1 TIME FRAMES AND LEVELS OF PLANNING FOR ONS

Level	Programmatic Planning	Increment Planning	Mission Planning
Time Frame	More than 18 months prior to launch	Between 24 and 6 months prior to launch	Beginning 18 months prior to Launch
Documentation	IPOP	IDRD	Flight Products
Objective	Define top-level ONS and develop response measures focusing on assembly, logistics, and multi-segment system functions. Identify additional capabilities/ requirements needed to respond to ONS. Identify program resources or impacts to IP agreements.	Develop specific response measures in accordance with the IPOP, and define ONS and develop response measures for increment and mission objectives. Document operational and manifest requirements in IDRD to mitigate ONS Identify any additional program resources or impacts to IP agreements.	Develop necessary ISS procedures/flight rules with IPs to respond to applicable ONS defined in IDRD. Identify and develop response measures to additional ONS identified through flight preparation. Document in standard mission documentation.
Assembly Mission ONS Disruption of ISS assembly	Define impacts to ISS assembly and operations and identify response plan.	Develop revised flight manifests and operational work arounds; document increment/mission requirements in IDRD to enable a timely response.	Develop mission-specific ONS response plans; document via flight manifest, flight rules, and operations procedures. Perform crew training.
Logistics Mission ONS Disruption of planned logistics & crew rotation	Define impacts to ISS operations and identify response plan.	Develop revised flight sequence, schedule, and operations plan; document increment/ mission requirements in IDRD to enable a timely response.	Develop mission-specific ONS response plans; document via revised flight manifests and operations plans.
System Functionality ONS Disruption of critical functional capability	Define programmatic consequences, response strategies, and additional program planning.	Develop operational scenarios, critical equipment list, and spares strategy, manifest critical equipment and document increment/ mission requirements in IDRD to enable a timely response.	Develop mission-specific ONS response plans; document via flight manifest, flight rules, and operations procedures. Perform crew training.
Emergency Response ONS Events requiring both a near-term (emergency) response and a long-term (recovery) response such as Fire, Depressurization and Toxic Release	Define programmatic response strategies, both near-term and long-term, and identify overall scope of activities necessary to be performed to ensure survivability and recovery.	Develop operational scenarios and maintenance strategy; assess ISS & crew safety impacts and document increment/ mission requirements in IDRD to enable a timely response.	Develop mission-specific ONS response plans; document via flight manifest, flight rules, and operations procedures. Perform crew training.

3.2 IPOP ONS CATEGORY DEFINITIONS

This document defines three categories of ONS:

- Assembly mission ONS,
- Logistics mission ONS,
- System Functionality ONS, and
- Emergency Response ONS.

The ISS assembly sequence shown in Table 3.2-1 depicts the flight sequence to build the ISS. Flights generally can be categorized as primarily assembly missions or primarily logistics missions, and this distinction is reflected in this document.

Assembly mission refers to flights delivering a new major hardware element to be attached to the ISS. This includes the delivery of hardware via Russian Proton or Soyuz boosters and US Space Shuttles. In most cases, if an assembly flight is not performed, follow-on assembly missions cannot proceed.

Logistics mission refers to flights primarily delivering logistics supplies, such as crew consumables, propellant, or other equipment not adding a significant new functional capability. If a logistics mission is not performed, follow on logistics missions must continue in order to sustain the crew and on-orbit vehicle. Furthermore, if reserve supplies are utilized because of the missed flight, these supplies must be replenished on subsequent flights. If a logistics flight is missed, it will typically have little impact on assembly operations, because it should result in only a short delay until logistics supplies can be replenished.

Flights performing assembly, logistics resupply, and crew rotation are addressed specifically as assembly missions and are also covered generically as logistics missions. Assembly mission ONS are addressed in Section 4. Section 5 addresses logistics mission and crew rotation ONS.

System Functionality is the third category of ONS and is addressed in Section 6. This category includes ONS that affect the ability to perform a critical system function in support of ISS.

Emergency Response is the fourth category of ONS and is addressed in Section 7. This category includes ONS that address the overall response plan for depressurization, fire, and toxic release events.

TABLE 3.2-1 ASSEMBLY SEQUENCE REVISION F

Flight	Delivered Elements	Planning Period	Inc.
1A/R	FGB (launched on Proton launcher)	PP1	INC0
2A	Node 1 (1 Stowage rack, ZSRs); PMA1; PMA2; 2 APFRs (Sidewalls)		
2A.1	Spacehab Double Cargo Module; OTD, Strela 1 Components, SHOSS (ICC)		
2A.2A	SPACEHAB Double Cargo Module, Strela 1 Components, SHOSS (ICC)		
1R	Service Module		
1P	Progress M1		
2A.2B	Spacehab Double Cargo Module; SHOSS(ICC)		
3A	Z1 truss (CMGs, Ku-band, S-band Equipment); PMA3, 2 ETSDs (SLP); 2 Z1 DDCUs (Sidewall)		
2R	Soyuz -TM	PP2	INC1
2P	Progress M1		
4A	P6 (PV Arrays - 6 battery sets, EEATCS radiators, S-band Equipment)		
5A	Lab (Lab System racks, ZSRs); PDGF (Sidewall); ORU (Sidewall)		
3P	Progress M1		
5A.1	Lab System racks, RSRs, RSPs, ISPR (Lab Outfitting) (MPLM); EAS, ORU, LCA, RU, ESP (ICC)		INC2
4R	Docking Compartment 1 (DC1) (Strela 2)		
4P	Progress M1		
6A	RSPs, RSRs, ISPRs (MPLM); ORU (Sidewall); UHF, SSRMS (SLP)		
2S	Soyuz-TM		
7A	Airlock (Stowage Platform, CA Equip Rack, Avionics Rack, External Equip.); HP gas (2 Oxygen, 2 Nitrogen) (SLDP)		
7A.1	RSRs, RSPs, ISPRs (MPLM); SM MMOD Shields, SPP PWP Comp. , OTD, 2 SHOSS, Ext. Att. P/L (ICC); APFR (Sidewall)	PP3	INC3
5P	Progress M1		
6P	Progress M1		
UF1	RSRs, RSPs, ISPRs, MELFI (MPLM); WVS Stanchions (Sidewall)		INC4
3S	Soyuz-TMA		
7P	Progress M1		
8A	S0 (MT, GPS, Lab and Node 3 Umbilicals, A/L Spur, PWP)		
8P	Progress M1		
UF2	RSRs, RSPs, ISPRs (MPLM); MBS; PDGF (Sidewall); MDM Radiator (Sidewall)		
9P	Progress M1		
4S	Soyuz-TM	PP4	INC5
10P	Progress M1		
9A	S1 (3 TCS Radiators, CETA Cart A, S-band Equip.)		
ULF1	ISPRs (MPLM), ESP-2 w/ ORUs		INC6
11P	Progress M1		
12P	Progress M1		
11A	P1 (3 TCS Radiators, CETA Cart B, UHF)		
5S	Soyuz-TMA		INC7
9A.1	Science Power Platform (SPP) (4 solar arrays, ERA, PDGF)		
13P	Progress M1		
12A	P3/P4 (PV Arrays - 6 battery sets, 2 ULCAS)		
14P	Progress M1		
12A.1	Spacehab Single Cargo Module; ORU (ICC);P5 (PVRGF OSE)		INC8
15P	Progress M1		
6S	Soyuz-TMA		

Flight	Delivered Elements	Planning Period	Inc.
13A	S3/S4 (PV Arrays - 6 battery sets, 4 PAS)		INC8
16P	Progress M1		
17P	Progress M1		
13A.1	Spacehab Single Cargo Module; (ICC); S5 (PVRGF OSE)		
3R	Universal Docking Module (UDM)	PP5	
5R	Docking Compartment 2 (DC2)		INC9
18P	Progress M1		
UF4	S3 Attached P/L; SPDM (SLP)		
7S	Soyuz-TMA		
10A	Node 2 (DDCU racks, ZSRs); NTA (CBC)		
19P	Progress M1		INC10
20P	Progress M1		

Flight	Delivered Elements	Planning Period	Inc.
1J/A	ELM PS (4 Sys, 3 ISPRs, 1 Stow); 2 SPP SA w/truss, SM MMOD Shields (ULC); NTA, ATA (CBC)		INC11
ATV1	Prop Resupply, 2 US PL/crew		
8S	Soyuz-TMA		
1J	JEM PM (4 JEM Sys racks, JEM RMS)		
10A.1	Propulsion Module		INC12
21P	Progress M1	PP6	
UF3	RSPs, RSR, ISPRs, 1 JEM rack (MPLM); Express Pallet; ATA / P/L (CBC)		
1E	Columbus Module (ISPRs)Columbus APM Core w/3 integrated system racks, 5 ISPRs		
9S	Soyuz-TMA		INC13
22P	Progress M1		
2J/A	JEM EF; ELM-ES (EF Payload, ICS, SFA w/carrier); Cupola (SLP) JEM EF, JEM ELM-ES w/EF payloads, JEM ICS Exposed Section, JEM SFA w/carrier, 4 PV Battery sets (on SLP)		
23P	Progress M1		
HTV demo	HTV-II demonstration flight		
UF5	RSPs, RSR, RSP-2s, ISPRs (MPLM); Express Pallet; ORUs / P/L (CBC)ISPRs, 2 RSPs (on MPLM), Express Pallet w/payloads		INC14
9R	Docking & Stowage Module (DSM)		
24P	Progress M1		
14A	2 SPP SAs w/truss, 4 SM MMOD Wings (ULC); MT/CETA Port Rails (SLP); MT/CETA Stbd Rails (SLP)		
10S	Soyuz-TMA	PP7	
25P	Progress M1		
UF6	RSPs, RSR, RSP-2s, ISPR (MPLM); Express Pallet; ORUs / P/L (CBC)		
HTV1	1 JEM ELM-PS Stow, ISPRs, 4 Expendable Carriers		INC15
20A	Node 3 (2 Avionics/DDCU, Avionics/Oxygen Generation rack, 1 ARS)		
8R	Research Module #1		
26P	Progress M1		
16A	US Hab (6 Hab system racks, 2 RSRs, 6 Zero G stowage racks, ISPRs)		
27P	Progress M1		INC16
17A	1 Lab Sys rack, 4 Node 3 sys racks, 2 CHeCS racks, 2 RSPs, ISPRs (on MPLM)		
11S	Soyuz-TMA		
18A	CRV #1, CRV adapter		

Flight	Delivered Elements	Planning Period	Inc.
28P	Progress M1	TBD	TBD
19A	S5, 5 RSP, 1 RSR, ISPRs, 4 Crew Quarters (on MPLM)		
29P	Progress M1		
HTV2	1 JEM stowage rack, 5 Expendable Carriers, EF payloads, ISPRs		
15A	S6, PV Array (4 battery sets), Starboard MT/CETA rails		
10R	Research Module #2 (RM-2)		
30P	Progress M1		
UF7	Centrifuge Accommodations Module (CAM), 12 Zero G stowage racks, ISPRs		
HTV3	11 Expendable Carriers, ISPR		

3.3 ONS DEVELOPMENT PROCESS

Figure 3.3-1 illustrates the ONS planning process. Figure 3.3-2 shows the relationships between program documents, groups, panels, and functions that identify and respond to potential ONS.

As shown in Figure 3.3-1 ONS planning at the program level is initiated with the IPOP, which is managed by the Program Integration (PI) office. The IPOP is then reviewed and revised by contributors from the IPs, Program Integration, Mission Integration, Operations, EVA, Safety & Mission Assurance, and Subsystems groups. If the IPOP identifies new design requirements, capabilities, or international agreements to mitigate the ONS, these requirements and agreements will be reviewed and approved through the existing ISS processes and reflected in the IPOP.

ISS Subsystem Functionality ONS documentation will be developed using the following process.

1. Subsystem Functionality requirements will be used to form the basis for ONS development.
2. Subsystem Functionality ONS which have an impact on multiple segments of the ISS or that have a potential response from multiple segments will be documented in the IPOP.
3. RSC-E will develop ONS for the Russian Segment (RS) and NASA will develop ONS for the United States On-Orbit Segment (USOS).
4. RSC-E will validate the capability of the RS to perform responses from the RS and NASA will validate the capability of the USOS to perform the responses from the USOS.
5. All affected partners will jointly review and integrate the ONS for documentation in the IPOP
6. In general, once the responses are validated and documented, a decision on which response option is selected will be made when the ONS occurs.

The increment and mission objectives and the ONS responses identified in the IPOP are used to assess and develop the content of the IDRD ONS Annexes, which is a product of the Mission Integration group and the IPs. The ONS Annex documents the Increment level ONS response plans which are then used to develop specific IDRD requirements for implementation.

The following criteria will be used for development of the Increment ONS.

1. All increment and mission objectives will be considered for ONS.
2. The USOS team will develop ONS for the USOS tasks and the RS team will develop ONS for the RS tasks.

3. The IDRD will contain ONS that occur on one segment and impact another segment.

4. The IDRD will contain ONS that occur on one segment and have a potential response employing a capability from another segment for a specific increment.

5. ONS responses will be consistent with the IPOP.

ONS planning at the mission execution level is documented and implemented for development of flight rules and procedures by the Operations group.

Figure 3.3-2 illustrates some of the basic relationships between activities and documents that impact the ONS planning process.

3.3.1 ONS EVALUATION CRITERIA

The evaluation criteria are the list of planning activities that must be performed when developing a response/workaround scenario for an ONS.

- Operational workarounds—define operational concepts to recover from ONS and/or operational concepts to mitigate risks due to the ONS.
- New/modified H/W or S/W–-identify new hardware/software or modifications to existing hardware/software to support ONS recovery operations.
- ISS vehicle performance impacts—identify impacts to the nominal vehicle performance for consideration in defining operational workarounds and impacts to the traffic model.
- ISS traffic model impacts—define the impacts to the traffic model including all logistics aspects and identify new flights as required.
- Training requirements—define special training requirements associated with the operational workarounds and new/modified hardware.
- Organizational responsibilities—define International Partner responsibilities for implementing the proposed workaround scenario.
- Schedule—define a proposed schedule for implementing the workaround scenario.
- Safety impacts—identify any impacts to ISS/crew safety or the successful completion of the planned mission as a result of the ONS, specifically catastrophic/critical hazards.

Products	**OPR**	**OND**
IPOP	Program Integration	I-20 (SIR/ SAR)
IDRD ONS Annex (s)	Mission Integration & Operations	L-12
IDRD Require-ments	Mission Integration & Operations	L-6
Procedures. Flight Rules, etc.	Operations	L-6 ->

FIGURE 3.31 ONS PLANNING PROCESS

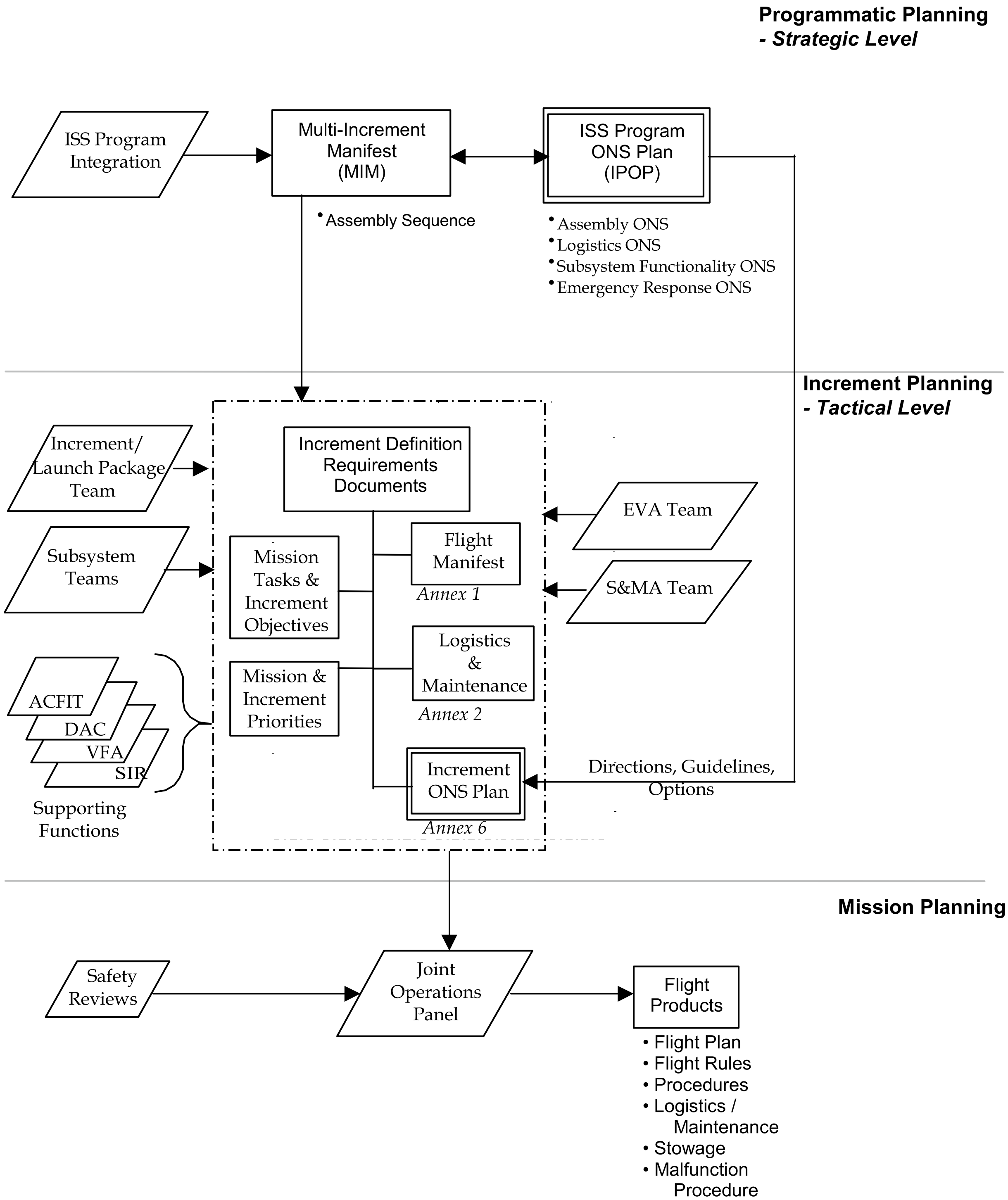

FIGURE 3.3-2 ONS DOCUMENTATION TREE & DEVELOPMENT/COORDINATION PROCESS

4.0 ASSEMBLY MISSION OFF-NOMINAL SITUATIONS

This chapter identifies the program response to an assembly ONS that precludes the execution of a subsequent assembly mission. Each assembly mission is addressed assuming the mission is delayed or attempted, but due to an ONS, hardware is lost and needs to be replaced, or damaged and needs extensive refurbishment. Because of the intricate nature of the assembly sequence, and the dependency of one flight on the next, it is assumed that assembly flights will be delayed concurrently because of late element processing. Flights delivering both assembly hardware and a significant amount of logistics are also considered assembly missions. The remaining logistics flights are addressed in Section 5. For each flight, the following is provided:

- Background information describing the significance of the flight to follow-on missions,
- A table identifying each ONS, causes, consequences, and program responses, and
- A revised assembly sequence for the affected flights when appropriate.

The following naming convention is used for Assembly ONS descriptions.

- Pre-Launch ONS: A pre-launch ONS is defined as any ONS event the occurs before launch of the item.
- Launch ONS: A launch ONS is defined as any ONS event that makes the spacecraft unable to rendezvous and dock with the ISS.
- Assembly ONS: An assembly ONS is defined as any ONS event that prevents mating of the item to the ISS or planned removal of the item from the ISS.

Flights 1A/R, 2A, 2A.1, and 2A.2A have been successfully completed and are not addressed.

4.1 1R—SERVICE MODULE

Background: The SM is launched unmanned on a Proton rocket as the fourth ISS assembly mission. Once on orbit, the FGB/Node 1 will rendezvous and dock with the SM. The SM provides the primary attitude control, re-boost, and life support functions once attached to the ISS.

The SM Assembly Mission has been completed. ONS have been considered and are documented in Table 4.1-1 for reference. Actual ONS that occurred during the SM assembly mission are described in Section 4.1.1.

TABLE 4.1-1 ASSEMBLY ONS—FLIGHT 1R

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-1R-1	Delay of less than 12 months	Pre-flight ONS	• Delay in assembly process but no significant changes to the assembly sequence.	• An additional shuttle flight might be considered to perform any necessary repairs and reboost the ISS, but the sequence of assembly flights and plans for sending crew to the ISS remain unchanged.
A-1R-2	SM insertion into unplanned orbit	Launch ONS	• Inability to utilize the SM.	• Perform an emergency reboost using the SM reboost thruster to raise the SM to the assembly orbit and for rendezvous with FGB+Node1. This would require a Progress M1 to compensate for the propellant resources used. • Alternatively, dock a Progress M1 to the SM and use the Progress to boost the SM to the proper orbit.
A-1R-3	Failed automatic docking	FGB Kurs-A failure (Set 1 & Set 2)	• Inability to dock SM with FGB + Node 1 due to inability to perform automatic rendezvous of SM with FGB + Node 1 to within ~200 m	• For all 3 causes, a Soyuz (Flight 1R.1) with two crewmembers aboard will launch and dock with the SM. 1. If automatic rendezvous of FGB+Node 1 to SM +Soyuz to ~200m is assured then proceed to step (D), otherwise proceed to step (A). A) Launch Progress-M1 to refuel FGB. B) If feasible, attempt ballistic precision rendezvous of FGB+Node 1 to SM+Soyuz (FGB active) to ensure required conditions for manual docking in TORU mode. If successful proceed to step D), otherwise proceed to step C). C) Change 2A.2b mission to launch Shuttle to dock with FGB+Node 1 (>5 km from SM). Shuttle performs rendezvous to within ~200 m of SM and then releases 1. D) 1R.1 crew will manually dock the SM to the FGB using remote operator mode (TORU). 2. 1R.1 crew will manually dock the SM to the FGB using remote operator mode (TORU). 3. 1R.1 crew will make necessary repairs and deploy the arrays. *Requirements for these scenarios are documented in the IDRD for Planning Period 1 named as the 1R.1 contingency mission.*

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-1R-4	Loss of SM; Delay of more than 12 months.	Ground ONS Launch ONS Docking ONS	• Inability to assemble the Russian Segment (RS) by the nominal deadline. - Delay in assembly process. - Requires use of ICM to ensure survival of ISS.	• Launch additional shuttle flights as necessary to provide reboost. • The ICM will be launched aboard a shuttle and docked to the ISS in place of the SM to provide temporary attitude control and reboost capability. About 9.5 months will elapse from the time the ICM is called into service until it is launched. • Assembly of the USOS segment will continue through Flight 6A. • Following Flight 6A, the US Propulsion Module will be delivered, providing a permanent attitude control and reboost capability. • Permanent crew will not be placed on the ISS until after a SM is provided, or other suitable life support systems are added. *Requirements for this scenario are documented in the IDRD for Planning Period 1 named as the 2A.3 contingency mission.*

4.1.1 1R ACTUAL ONS

During the SM assembly mission:

- One solar panel of the SM solar array did not deploy as planned. The solar array will be deployed using EVA on a subsequent flight. A more detailed response is described in the IDRD.
- One contingency docking target next to the SM transfer compartment did not deploy as planned. This docking target was deployed using an EVA during assembly flight 2A.2B.

4.2 2A.2B—SPACEHAB DOUBLE CARGO MODULE

Background: The 2A.2B assembly flight delivers some SM outfitting hardware and logistics resupply items to the ISS. This mission has been successfully completed.

The 2A.2B Assembly Mission has been completed. ONS have been considered and are documented in Table 4.2-1 for reference. Actual ONS that occurred during the SM assembly mission are described in Section 4.2.1.

TABLE 4.2-1 ASSEMBLY ONS—FLIGHT 2A.2B

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-2A. 2B-1	Delay of 2A.2B cargo	Pre-launch ONS Launch ONS Assembly ONS	• Delay unloading of 1P • May delay initial ISS crew • Delay in 2P	• Depending on duration of delay, launch schedule may be altered so 1P is followed by 2R with initial crew. 2R Soyuz docks to FGB nadir, and the crew unloads 1P. • Launch dates for other planned Russian and US vehicles may be impacted. • Depending on the duration of the delay, content of "dry" cargo for 2P and 3P may be adjusted by 800kg each to compensate for 2A.2B, with a reduction in amount of fuel delivered. Reserve propellant will be used and replenished on subsequent flights.
A-2A. 2B-2	Loss of 2A.2B cargo	Pre-launch ONS Launch ONS Assembly ONS	• Delay in initial ISS manning. • May require an additional Progress vehicle to deliver 2A.2B hardware	• See response above • Tasks to be performed by 2A.2B crew will be performed on later flights. • Content of "dry" cargo for 2P and 3P may be adjusted by 800kg each to compensate for 2A.2B, with a reduction in the amount of fuel delivered. Reserve propellant will be used and replenished on subsequent flights.

4.2.1 2A.2B ACTUAL ONS

No significant ONS occurred during flight 2A.2B. During this mission, an SM emergency target was deployed using EVA to mitigate an ONS from Flight 1R.

4.3 3A—Z1 TRUSS, PMA-3

Background: Flight 3A delivers the Z1 Truss and PMA-3. The Z1 truss contains the Control Moment Gyros (CMG), Ku-band and S-band antennas, and DC to DC Converter Units (DDCU). The Z1 truss is mounted on the zenith radial port of Node 1 and provides the interface for the Flight 4A, P6 Truss element. PMA-3 is mounted to the nadir radial port of Node 1 and provides the docking interface for the Shuttle on Flight 4A. Both items are critical to continuing the assembly sequence.

TABLE 4.3-1 ASSEMBLY ONS—FLIGHT 3A

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-3A-1	Delay of 3A cargo - Z1 Truss - DDCU - PMA-3 - CMGs	Pre-launch ONS Launch ONS Assembly ONS	• Delay in the assembly sequence for the USOS hardware. Z1 and PMA-3 are both required before Flight 4A.	• Delay USOS assembly. • In the case of ONS during assembly and activation, it may be necessary to return the cargo elements to Earth and refly them once the problems have been remedied. • A decision to man the ISS will be made after consideration of the power balance, propellant balance, and the duration of the 3A delay. • Possible to split 3A reflight into sub-flights so that lagging hardware is flown later in lieu of either MPLM or Hab (USOS and RS EPS spares, supply, etc. could continue)
A-3A-2	Loss of Z1 Truss	Launch ONS Assembly ONS	• Inability to continue USOS assembly • Continue to utilize Propulsive Attitude Control • Continue reliance on existing communications systems (E-COMM, RSA Systems)	• 3A cargo replacement: - **Z1 Truss Structure:** Refurbish and certify qualification unit, which will require 8 to 14 months. - **CMGs:** Manufacture new CMGs, which will require a minimum of 24 months. - **Ku-Band, S-Band Hardware:** Use spares and backfill. • The ISS crew operations will be performed during the assembly delay. Crew duration may be limited due to increased propellant requirements driven by need to fly X-POP attitude for sufficient power.
A-3A-3	Loss of PMA-3	Launch ONS Assembly ONS	• Inability to continue nominal USOS assembly operation	• 3A cargo replacement: - **PMA-3:** Build replacement PMA, which will require 18 to 24 months • If the ONS results only in the loss of PMA-3, and is not due to the Node 1 interface with PMA-3, then PMA-2 could be relocated to the nadir radial port on Node 1. This allows the USOS assembly process to continue sooner than it would by waiting for the procurement and flight of a new PMA. Operationally, it requires ISS Increment 1 crew to relocate the PMA-2 on Node 1 before Flight 4A, and relocate it from Node 1 to the US Lab following Flight 5A.
A-3A-4	Loss of DDCU	Launch ONS Assembly ONS	• Inability to provide power to RS	• Use other flight units from down-stream element and backfill.

4.4 4A—P6 TRUSS

Background: Flight 4A delivers the P6 Truss element containing a Photovoltaic (PV) Module and the Early Active Thermal Control System (EATCS). P6 is installed on Z1 and provides the power and active thermal cooling resources for the USOS until the second PV Module is activated on Flight 12A.1.

TABLE 4.41 ASSEMBLY ONS—FLIGHT 4A

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-4A-1	Delay of 4A cargo	Pre-launch ONS Launch ONS Assembly ONS	• Inability to continue USOS assembly • Delay of ISS crew supplies and SM spares	• Delay USOS assembly operations. • In the case of ONS during assembly and activation, it may be necessary to return the cargo elements to Earth and refly them once the problems have been remedied. • ISS crew operations can continue during the assembly delay. Crew duration may be limited, based on the duration of the delay, the power balance, crew supplies, and the propellant balance. May require acceleration of the next scheduled Progress to sustain on-orbit crew operations.
A-4A-2	Loss of 4A cargo	Launch ONS Assembly ONS	• Inability to continue USOS assembly • Power transfer from RS segment to US segment must continue • Insufficient power to run SM Electron continuously, which generates oxygen	• 4A cargo replacement: - **P6 PV Module:** Prepare S6 to temporarily replace P6, which will require approximately 13 to 17 months. - USOS assembly must be delayed until replacement for P6 is ready since the US Lab requires power from P6 and the US Lab is in the critical path for continued assembly. - Manufacturing a replacement for the P6 element would require greater than 24 months. If it is decided not to replace the lost P6 array, there will be a long-term reduction in power to users (~20 kW at assembly complete). - **P6 Long Spacer w/EEATCS:** Will require greater than 24 months for replacement. - **S-Band Hardware:** Fly second string and backfill. - **Batteries:** Procure replacement, ECD … • The ISS crew operations can continue during the assembly delay, but crew stay duration may be limited due to increased crew supplies and propellant requirements driven by need to fly X-POP attitude to increase power generation. - Requires additional Solid Fuel Oxygen Generators (SFOG) to be manifested on next available flight to support crew operations.

4.5 5A—US LABORATORY

Background: Flight 5A delivers the US Lab Module, which provides environmental control and new command and control capabilities for the USOS. In addition, the CMGs delivered on Flight 3A are activated. CMG activation requires the new command and control capabilities delivered with the US Lab. The CMGs provide non-propulsive attitude control for the ISS, reducing the demand for propellant.

TABLE 4.5-1 ASSEMBLY ONS—FLIGHT 5A

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-5A-1	Delay of 5A cargo	Pre-launch ONS Launch ONS Assembly ONS	• Delay in activation of CMGs. • Delay in the USOS assembly operation.	▪ Delay USOS assembly operations. ▪ In the case of ONS during assembly and activation, it may be necessary to return the cargo elements to Earth and refly them once the problems have been remedied. ▪ Any delay in the activation of the CMGs is a significant impact to propellant usage. Any significant delay will result in increased propellant requirements. Analysis will be performed to determine the required rescheduling and cargo content of Progress and Shuttle flights to maintain adequate propellant margins. ▪ Options to reduce the propellant requirements are: - Adjust P6 solar array orientation and vehicle attitude to minimize drag and/or raise the ISS altitude.
A-5A-2	Failure to install PMA-2 on US Lab	Assembly ONS	• Inability to continue assembly of the American Segment unless PMA-3 is relocated to Lab-forward.	• If the ONS results in the loss of PMA-2, and is not due to the US Lab interface with PMA-2, then PMA-3 will be relocated to the Lab-forward port, allowing the continuation of assembly operations. • If ONS is due to the US Lab interface, an additional flight docked to PMA-3 will be necessary to affect repairs.

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-5A-3	Loss of US Lab	Launch ONS Assembly ONS	• Inability to continue USOS assembly. • Inability to activate US CMGs, resulting in increased propellant consumption.	• 5A cargo replacement: - **US Lab:** Modify flight test article to be replacement Lab, which will require 24 to 36 months, or manufacture a replacement lab, which will require 30 to 42 months. - **Lab System Racks:** Manufacture replacement racks, which will require 18 to 24 months. • Any delay in the activation of the CMGs is a significant impact to propellant usage. Any significant delay will result in an increase in propellant requirements. Analysis will be performed to determine the required rescheduling and cargo content of Progress and Shuttle flights to maintain adequate propellant margins. • To reduce propellant usage, some combination of the following options may be necessary: - Adjust P6 solar array orientation and vehicle attitude to minimize drag and/or raise the ISS altitude • Assembly on the RS segment can proceed with Flight 4R delivering the Docking Compartment 1 (DC-1) depending on propellant and power balance. • The ISS crew operations can continue during the assembly delay as long as reserve on-orbit supplies are available.

4.6 5A.1—MPLM WITH US LABORATORY OUTFITTING, SSRMS INSTALLATION PREPARATION

Background: Flight 5A.1 delivers additional system and stowage racks for the US Lab in an MPLM, the Lab Cradle Assembly (LCA), and a Power and Data Grapple Fixture (PDGF) rigid umbilical to support SSRMS installation on Flight 6A. Among the system racks installed in the US Lab is the Mobile Servicing System (MSS) workstation. This workstation is also required for SSRMS installation on Flight 6A. The first crew rotation is also performed on Flight 5A.1.

TABLE 4.6-1 ASSEMBLY ONS—FLIGHT 5A.1

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-5A.1-1	Delay of 5A.1 cargo - MPLM - US Lab Cradle - PDGF	Pre-launch ONS Launch ONS Assembly ONS	• Delay of logistics supplies impacts both Crew Operations and Crew Rotation.	• The 6A mission, without the SSRMS, can be flown prior to 5A.1 to perform the crew rotation and support logistics operations. Additional changes to the 6A manifest to support the critical logistics needs and crew rotation will be required. • In the case of ONS during assembly and activation, it may be necessary to return the cargo elements to Earth and refly them once the problems have been remedied. Assembly on the RS can proceed with Flight 4R delivering the Docking Compartment 1 (DC-1).
A-5A.1-2	Failure to Unberth MPLM		• Node 1 nadir port is unavailable for subsequent mission(s). • Inability to continue USOS assembly. Cannot perform 6A nominal mission.	• Develop MPLM repair and retrieval mission. • Assembly on the RS can proceed with Flight 4R delivering the Docking Compartment 1 (DC-1).

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-5A.1-3	Inability to berth MPLM	Launch ONS Assembly ONS	• Inability to continue USOS assembly. • Lack of lab system and stowage racks. - Without MSS workstation rack, SSRMS cannot be installed on Flight 6A. - Without SSRMS, USOS assembly cannot continue. • Impacts disposal of old ECLS equipment, resupply of ISS with ECLS replacement parts/ consumables, and disposal of crew metabolic waste.	• Lab system racks replacement: - **MSS workstation:** Will require at least 24 months - **Lab core system racks:** 18 to 24 months. - Loss of multiple FCE stowed in MPLM. Replacement will require a minimum of 12 months. • Replan flight schedule of MPLM fleet - In event of loss of MPLM, replacement requires TBD months. • The 6A mission, without the SSRMS, can be flown prior to a 5A.1 re-flight to perform the crew rotation and support logistics operations. Additional changes to the 6A manifest to support the critical logistics needs and crew rotation may be required. • Assembly on the RS can proceed with Flight 4R delivering the Docking Compartment 1 (DC-1). • The ISS crew operations can continue during the assembly delay as long as on-orbit reserves are available.
A-5A.1-4	Loss of Lab Cradle assembly, PDGF	Launch ONS Assembly ONS	• Inability to continue USOS assembly. Without the Lab Cradle assembly or the PDGF, the SSRMS cannot be installed on Flight 6A. Without SSRMS, USOS assembly cannot continue.	• Lab cradle assembly and PDGF replacement: - **Lab Cradle Assembly:** Will require greater than 24 months. - **PDGF and umbilicals:** Will require greater than 24 months. • Delivery of replacement hardware can be performed no earlier than 24 months. The 6A mission, without the SSRMS, can be flown prior to 5A.1 to perform the crew rotation and support logistics operations. Additional changes to the 6A manifest to support the critical logistics needs and crew rotation will be required. • Assembly on the RS can proceed with Flight 4R delivering the Docking Compartment 1 (DC-1). • The ISS crew operations can continue during the assembly delay as long as on-orbit reserves are available.

4.7 4R—DOCKING COMPARTMENT 1, STRELA

Background: The Docking Compartment 1 (DC1) is launched on a Soyuz rocket and performs an automated rendezvous and docking at the SM nadir port. The DC-1 provides Russian-based EVA capability in addition to the US provided Airlock. Also, the DC-1 provides an additional docking port for the Soyuz and Progress vehicles. Flight 4R also delivers the second Strela robot arm and an Orlan-M EVA suit.

TABLE 4.7-1 ASSEMBLY ONS—FLIGHT 4R

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-4R-1	Delay of 4R cargo	Pre-launch ONS	• Disrupts nominal assembly and maintenance EVAs on the RS	• Requires replan of RS EVAs. If DC is delayed past 7A, RS EVAs will be performed using the Joint Airlock
A-4R-2	Failed jettison of Docking Compartment Cargo Vehicle Module (CVM)	Assembly ONS (Failure of Pyros)	• Additional docking port for Progress/ Soyuz unavailable - Temporary reduction in available room to store cargo during Soyuz changeovers	• Requires undocking of Progress from SM aft port prior to bringing up the next scheduled Soyuz which then docks to SM aft port. After the Soyuz located on FGB nadir port is undocked, the Soyuz on the SM aft port is transferred to the FGB Nadir port. - Assess option to redock Progress to SM aft port after Soyuz rotation is completed to minimize time with reduced cargo stowage capability.
A-4R-3	Inability to deliver 4R cargo - DC1 - Strela Arm - Orlan-M EVA Suit	Launch ONS Docking ONS	• Disrupts planned assembly and maintenance EVA operations on the RS, but does not preclude the ability to continue assembly or perform EVA maintenance. • Additional docking port for Progress/ Soyuz unavailable - Temporary reduction in available room to store cargo during Soyuz changeovers	• Assembly operations can be continued. • EVAs for the RS will be based out of the Joint Airlock or Shuttle Orbiter. • Requires undocking of Progress from SM aft port prior to bringing up the next scheduled Soyuz which then docks to SM aft port. After the Soyuz located on FGB nadir port is undocked, the Soyuz on the SM aft port is transferred to the FGB Nadir port. - Assess option to redock Progress to SM aft port after Soyuz rotation is completed to minimize time with reduced cargo stowage capability • Replacement Orlan-M EVA Suit and Strela Arm will be delivered on a subsequent flight after manufacture. Manufacturing new hardware will require a minimum of TBD. • Decision of manufacturing a replacement DC1 or waiting for DC2 will be made if ONS occurs.

4.8 6A—MPLM WITH US LABORATORY OUTFITTING, SSRMS

Background: Flight 6A delivers additional stowage and utilization racks for the US Lab in an MPLM, and the SSRMS. US Lab outfitting includes logistics resupply, critical spares, and experiment equipment. Installation and activation of the SSRMS is critical to subsequent assembly tasks.

TABLE 4.8-1 ASSEMBLY ONS—FLIGHT 6A

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-6A-1	Delay of 6A cargo - MPLM - SSRMS - UHF antenna	Pre-launch ONS Launch ONS	• Inability to continue with assembly of USOS. SSRMS is required for subsequent assembly missions.	• Delay assembly of USOS. Logistics supplies may need to be replenished by subsequent Progress or Shuttle flights. • The ISS crew operations can continue during the assembly delay as long as on-orbit reserves are available.
A-6A-2	Inability to berth MPLM	Launch ONS Assembly ONS	• The loss of logistics supplies affects crew operations. • Impacts disposal of old ECLS equipment, resupply of ISS with ECLS replacement parts/consumables, and disposal of crew metabolic waste.	• 6A cargo replacement: - **MPLM:** Use next available MPLM. An MPLM is scheduled for 7A.1, 5 months after 6A, and may be accelerated. A replacement MPLM will require greater than 24 months to manufacture. • Logistics supplies may need to be replenished by additional Progress or Shuttle flights. • The ISS crew operations can continue during the assembly delay as long as on-orbit reserves are available.
A-6A-3	Loss of UHF antenna	Launch ONS Assembly ONS	• The loss of the UHF antenna would impact ISS-based EVAs with EMUs from the Joint Airlock	• Accelerate launch of second UHF antenna scheduled for launch on 11A. - Manufacture replacement antenna and system hardware, which will require TBD months. • USOS assembly EVAs with EMU will be based out of the Shuttle airlock, rather than the ISS airlock. (TBD) • ISS-based EVAs can be performed from the Airlock or Docking Compartment using Orlan suits. (TBD)
A-6A-4	Loss of SSRMS	Launch ONS Assembly ONS	• Without SSRMS, future USOS assembly operations cannot be performed. For example, Joint Airlock installation on Flight 7A and S0 Truss installation on Flight 8A cannot be performed.	• 6A cargo replacement: - **- SSRMS:** Manufacture replacement, which will require about 33 months.Repeat launch of the Orbiter with SSRMS can be performed after about 33 months. USOS assembly would be delayed. • Need to assess alternate berthing procedures • The ISS crew operations can continue during the assembly delay as long as on-orbit supplies are available.

4.9 7A—JOINT AIRLOCK, HIGH-PRESSURE GAS ASSEMBLY

Background: Flight 7A delivers the Joint Airlock and the High-Pressure Gas Assembly (HPGA). The Airlock provides nominal ISS based EVA capability for ISS maintenance, and operational flexibility for accomplishing follow-on assembly EVA tasks. The HPGA provides make-up nitrogen and oxygen for life-support and experiment operations.

TABLE 4.9-1 ASSEMBLY ONS—FLIGHT 7A

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
A-7A-1	Delay of 7A cargo - Airlock - High Pressure Gas Assembly	Pre-launch ONS Launch ONS	• Disrupts planned assembly and maintenance EVA operations.	• Assembly and maintenance operations are slowed, but may be continued while the airlock is prepared for flight. • USOS assembly EVAs will be based out of the Shuttle airlock, rather than the ISS airlock. • ISS-based EVAs can be performed from the Docking Compartment using Orlan suits.
A-7A-2	Inability to berth Airlock to Node 1 using SSRMS	CBM ONS Robotics system ONS (SSRMS, VSC, etc.)	• Disrupts planned assembly and maintenance EVA opreations. • Impact logistics planning for Nitrogen/Oxygen resupply	• Return 7A cargo to the ground and refly (TBD). • Recertify Airlock & Nitrogen/Oxygen tanks. - A/L certified by design for 2 launches/ landings. • Minimum Shuttle turnaround time is 3 months.
A-7A-3	Loss of Nitrogen/ Oxygen tanks	Launch ONS Assembly ONS	• Impacts logistics planning for Nitrogen/Oxygen resupply • Limits ISS EVA, payloads, System/ Structural leakage makeup, & Crew healthcare activities	• 7A cargo replacement: • **Nitrogen/Oxygen tank sets:** Manufacturing a replacement will require greater than 24 months. - Increase Nitrogen/Oxygen resupply during Shuttle and Progress flights. - Program has two spare tanks. If tanks are lost but Airlock is installed, configure one spare tank for oxygen, one for nitrogen, and launch at first opportunity.
A-7A-4	Loss of airlock	Launch ONS Assembly ONS	• Disrupts planned assembly and maintenance EVA operations. • Nitrogen/Oxygen tanks cannot be installed, which will impact logistics for Nitrogen/Oxygen resupply	• 7A cargo replacement: - **Airlock**: Manufacture replacement, which will require about 36 months. - **HPGA:** Manufacture replacement; which will require a minimum of 8 months. • Assembly operations will be delayed and proceed at a slower pace, but can be continued while a replacement airlock is being prepared. • Assembly EVAs will be based out of the Shuttle airlock, rather than the ISS airlock. • Additional Shuttle flights may be needed to perform assembly and maintenance EVAs currently schedule for ISS-based crew. • ISS-based EVAs can be performed from the Docking Compartment utilizing Orlan suits.

4.10 7A.1—MPLM WITH LAB UTILIZATION AND STOWAGE RACKS, SM MMOD SHIELDS, SPP PWP COMP, EXTERNAL EXPERIMENTS, APFR (TBD)

4.11 UF-1—MPLM WITH LOGISTICS AND OUTFITTING (TBD)

4.12 8A—S0 TRUSS, MOBILE TRANSPORTER, GPS (TBD)

4.13 UF-2—MPLM WITH LOGISTICS AND OUTFITTING, MBS, PDGF, MDM RADIATOR (TBD)

4.14 9A—S1 TRUSS, CETA CART A, S-BAND EQUIPMENT (TBD)

4.15 ULF1—MPLM WITH LAB UTILIZATION RACKS (TBD)

4.16 11A—P1 TRUSS, CETA CART B, UHF (TBD)

4.17 9A.1—SCIENCE POWER PLATFORM WITH 4 SOLAR ARRAYS, ERA (TBD)

4.18 12A—P3/P4 TRUSS AND PV ARRAY (TBD)

4.19 12A.1—P5 TRUSS (TBD)

4.20 13A—S3/S4 TRUSS (TBD)

4.21 13A.1—S5 TRUSS (TBD)

4.22 3R—UNIVERSAL DOCKING MODULE (TBD)

4.23 5R—DOCKING COMPARTMENT 2 (TBD)

4.24 UF-4—TRUSS ATTACH SITE P/L, EXTERNAL EXPERIMENTS, SPDM (TBD)

4.25 10A—NODE 2 (TBD)

4.26 1 J/A—JEM ELM-PS, 2 SPP SA, SM MMOD SHIELDS (TBD)

4.27 1J—JEM PM, JEM RMS (TBD)

4.28 10A.1—PROPULSION MODULE (TBD)

4.29 UF-3—MPLM WITH LOGISTICS AND OUTFITTING, JEM ICS (TBD)

4.30 1E—COLUMBUS ORBITAL FACILITY (TBD)

4.31 2J/A—JEM EF, JEM ELM-ES W/EF PAYLOADS, ICS, SFA, 4 PV BATTERY SETS, CUPOLA (TBD)

4.32 UF-5—MPLM WITH LOGISTICS AND OUTFITTING (TBD)

4.33 9R—DOCKING AND STOWAGE MODULE (TBD)

4.34 14A—2 SPP SA, SM MMOD SHIELDS, MT/CETA RAILS (TBD)

4.35 UF-6—MPLM WITH STOWAGE AND UTILIZATION RACKS (TBD)

4.36 20A—NODE 3 (TBD)

4.37 8R – RESEARCH MODULE #1 (TBD)

4.38 16A—US HABITATION MODULE (TBD)

4.39 17A—MPLM WITH LAB AND NODE 3 OUTFITTING, SYSTEMS RACKS, AND CHECS RACKS (TBD)

4.40 18A—CREW RETURN VEHICLE #1 (TBD)

4.41 19A—S5 TRUSS, MPLM WITH NODE 2 CREW QUARTERS OUTFITTING (TBD)

4.42 15A—S6 TRUSS, PV ARRAY, STARBOARD MT/CETA RAILS (TBD)

4.43 10R—RESEARCH MODULE #2 (TBD)

4.44 UF-7—CENTRIFUGE ACCOMMODATIONS MODULE (TBD)

5.0 LOGISTICS OFF-NOMINAL SITUATIONS

Section 5 discusses ONS involving the logistics operations for the ISS. Section 5.1 discusses ONS for resupply flights and Section 5.2 discusses ONS for crew rotation and emergency crew return.

Logistics in the case of the ISS refers to the transport of materiel necessary to support and maintain the operations of the ISS and its crew. Logistics includes the following three categories.

1. Resupply of:
   - Crew supplies, including food, water, air, clothing, medical supplies, etc.
   - Propellant
   - Spares

2. Removal of material from the ISS, including:
   - Solid trash
   - Liquid waste
   - Scientific material
   - Broken spares and other equipment to be removed from the ISS.

3. Rotation of:
   - Crew
   - Vehicles that provide emergency crew return capability

Due to the limited amount of storage on orbit, large amounts of material cannot be maintained, or stockpiled, on the ISS. Thus, regular flights to resupply the ISS, to return materials, and to dispose of unwanted material are necessary. Also, crew and emergency crew-return vehicles are allowed to stay on-orbit for a limited time and must be changed regularly. Logistics flights to maintain and supply the operation of the ISS and its crew comprise a large number of flights during assembly and after assembly is complete. Logistics supplies are delivered via Progress, HTV, ATV, Soyuz and Shuttle vehicles. Many of the Shuttle assembly flights also carry logistics supplies in addition to their assembly cargo.

The implications of ONS in logistics flights differ somewhat from those in assembly flights. In many cases, assembly of the ISS can simply be delayed if ONS occur on assembly flights. However, providing logistics to the ISS cannot be significantly delayed. If logistics flights experience difficulties, the crew's ability to stay on-orbit is jeopardized and the survivability of the ISS is threatened. Thus, means of mitigating logistics ONS in a timely manner are critical. Furthermore, ONS on assembly flights could significantly increase the need for logistics flights. For example, a delay in the delivery of the US Lab Module delays the activation of the Control Moment Gyros for attitude control. This, in turn, results in a longer duration of propulsive attitude control in an unfavorable configuration and an increased demand for propellant. Thus, the logistics system for the ISS must be prepared to mitigate ONS caused by difficulties in the assembly process.

Because logistics flights are time-critical and the consequences of exhausting supplies are severe, several measures are designed to prepare for and respond to a logistics ONS. These measures include the following.

- Reserve crew supplies: To help mitigate the effects of a disruption in the resupply schedule, a reserve of 45 days' worth of food and other supplies are maintained on the ISS. If a logistics vehicle does not make it to the ISS on schedule and the normal supplies are exhausted, the crew uses these reserve supplies.
- Reserve Propellant: The ISS maintains a propellant margin sufficient to boost the ISS to an altitude that allows 360 days of orbital decay to an altitude of no less than 278 km.
- On-orbit spares: Critical spares are maintained on-orbit so that the crew can make timely repairs if necessary.
- Redundant logistics vehicle types: The ISS program maintains redundant logistics vehicle types to help mitigate potential ONS that could result in the reduced availability of one type of vehicle. For example, Shuttles carrying MPLMs could be used more extensively in the case of the reduced availability of Progress vehicles, and vice versa.

In the event of an ONS it may also become necessary to reduce logistics demands. There are several methods for reducing logistics demands, although each has consequences. For example:

- Crew reduction: The crew size could be reduced to decrease the demand for crew supplies and life support supplies. However, with fewer crewmembers, assembly and research operations would be delayed.

- More frequent reboost: Reboosting the ISS more frequently could reduce propellant demands. However, the more frequent reboosts may disrupt microgravity experiments.

Reducing logistics demands, which may be temporarily necessary to ensure the survival of the ISS, would impact operation of the ISS and effect research capability.

5.1 LOGISTICS RESUPPLY

Four different logistics vehicle types are available to resupply the ISS after assembly complete. Logistics during the assembly phase is provided primarily by Progress vehicles, with support from the Shuttle. In the late phases of assembly, the ATV and HTV will become available to provide additional logistics capability.

Table 5.1-1 gives a summary comparison of the similarities and differences among capabilities provided by the various logistics vehicles. Although the vehicles provide redundant logistics capabilities, the vehicles are not directly interchangeable. The following sections describe each logistics vehicle and the ONS for that vehicle.

5.1.1 GUIDELINES/DEFINITIONS

The “Delay of a Logistics Vehicle” ONS is defined as a near-term delay of the logistics flight launch with the duration of the delay not to exceed the time which can be supported by the existing on-orbit reserves.

The "Loss of a Logistics Vehicle" ONS is defined as a situation which results in the destruction of the vehicle and contents prior to its mating to the ISS.

The "Reduction of Quantity of Logistics Vehicles Per Year" ONS is defined as a situation which results in a reduction to the planned launch rate or a delay in the planned launch which is longer in duration than time which on-orbit reserves can sustain nominal operations.

TABLE 5.1-1 LOGISTICS VEHICLE DELIVERY CAPABILITY

	Progress M	Progress M1	Shuttle Pressurized (MPLM)	Shuttle Unpressurized (ULCs)	HTV Mixed	ATV
Propellant (maximum)	1100 kg for ISS use.	1950 kg for ISS use	3400 – 4000 kg	3400 – 4000 kg	None	4860 kg for ISS use (4000 reboost, 860 resupply)
Cargo, overall (maximum)	2350 kg	2230 kg	8605 kg (includes rack structure)	9449 kg	6000 kg	7385 kg
Cargo, pressurized (maximum)	1700 kg dry cargo 6.6 m^3	1700 kg dry cargo 6.6 m^3	8600 kg (includes rack structure)	0	6000 kg 20 m^3 pressurized (16 m^3 in 8 ISPRs, 4 m^3 in aisle) 15 m^3 unpressurized	5500 kg dry cargo (up to 7.5t reported by ESA) - TBD
Cargo, unpressurized (maximum)	0	0	8605 kg (with no pressurized cargo)	9449 kg	1500 kg	0
Water (maximum)	420 kg	300 kg	200 – 400 kg	200 – 400 kg	300 kg (TBD)	840 kg
Gas (maximum)	50 kg	40 kg	30 kg	30 kg	TBD	100 kg
Reboost Control	Yes	Yes	Yes (Until 2J/A)	Yes (Until 2J/A)	No	Yes
Down Mass: Recoverable	None	None	12022 kg overall max 9071 kg press. max	12866 kg max	None	None
Down Mass: Non-recoverable	1000 kg typical 1600 kg max 6.6m^3 max	1000 kg typical 1600 kg max 6.6m^3 max	0	0	6000 kg overall max: 6000 kg max pressurized, 1500 max unpressurized, 300 kg max waste fluid 20 m^3 pressurized 15 m^3 unpressurized	5500 kg maximum dry cargo 840 kg maximum waste fluid 20.6 m^3 max pressurized volume
Maximum Number of Flights per year	7-12 flights total for M and M1	7-12 flights total for M and M1	5-7 flights for Shuttle	5-7 flights for Shuttle	2 flights	2 flights
Minimum Number of days between flights	30 days	30 days	60 – 90 days (depends on MPLM)	60 – 90 days (depends on MPLM)	180 days	180 days
Maximum On-orbit docked duration	180 days	180 days	7 – 8 days	7 – 8 days	180 days (TBR)	180 days

5.1.2 PROGRESS

The Progress is the primary vehicle for logistics during the assembly sequence. Progress vehicles are unmanned logistics vehicles that are launched on a Soyuz booster and dock to the ISS automatically. The Progress vehicles deliver food, other crew supplies, nitrogen, oxygen, and propellant to the ISS. Each Progress vehicle is scheduled to launch before the reserve supplies are needed. Progress vehicles also serve as a stowage location for trash on the ISS, and can remain on the ISS for up to 6 months. The on-orbit Progress undocks and carries away the ISS trash approximately 1 day before the planned docking of the next Progress. The vehicle and its contents are then destroyed upon reentry into the Earth atmosphere.

TABLE 5.1.2-1 LOGISTICS ONS—PROGRESS

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-P-1	Delay of 2P	Pre-launch ONS	• Reduced crew supplies (i.e. oxygen, LIOH, water, food, etc.) on-orbit to support crew operations. • Reduced propellant supply margin on orbit to support ISS reboost & attitude control. • Increased risk to ISS crew due to prolonged operations of 0-fault tolerant SM systems (e.g. Life Support).	• Reserve crew supplies will be used as required until the Progress is launched and replenished on subsequent logistics flights. • If crew supplies are not replenished prior to using all reserve crew supplies, or a 0-fault tolerant SM life support function fails, the crew will return via the Soyuz • Propellant reserves will be used as required and then replenished using subsequent Progress vehicles. • Assembly flights 4A, and 5A can continue as scheduled.
L-P-2	Loss of 2P - Logistics H/W - SM outfitting H/W (required to be installed to provide SM Life Support system 1-fault tolerance)	Launch ONS Docking ONS	• Reduced crew supplies (i.e. oxygen, LIOH, water, food, etc.) on-orbit to support crew operations • Reduced propellant supply margin on orbit to support ISS reboost & attitude control. • Increased risk to ISS crew due to prolonged operations of 0-fault tolerant SM systems (e.g. Life Support).	• Reserve crew supplies will be used as required and replenished on subsequent logistics flights. • If crew supplies are not replenished prior to using all reserve crew supplies, or a 0-fault tolerant SM life support function fails, the crew will return via the Soyuz • Reserve propellant will be used as required and then replenished using subsequent Progress vehicles. • Replacement SM outfitting hardware will be delivered on subsequent logistics flights. • Assembly flights 4A, and 5A can continue as scheduled.

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-P-3	Delay of Progress flight	Pre-launch ONS	• Reduced crew supplies (i.e. oxygen, LIOH, water, food, etc.) on-orbit to support crew operations • Reduced propellant supply margin on orbit to support ISS reboost & attitude control.	• Utilize reserve crew supplies and propellant until Progress flight can be launched. • Accelerate the next logistics flight for launch 30 days after the original launch date of the delayed Progress, in case delayed flight is not able to launch on time. • Launch the accelerated backup flight if original Progress will not be ready in time. • Launch delayed Progress as soon as it is ready. • Replenish reserve crew supplies and propellant on subsequent logistics flights. • If neither Progress nor backup logistics flight is launched on time, return ISS crew in Soyuz or CRV. • Modify nominal ISS operations plan (e.g., flight attitude, altitude, etc.) to reduce propellant requirements to extend on-orbit life as required.
L-P-4	Loss of Progress flight	Pre-launch ONS Launch ONS Docking ONS	• Reduced crew supplies (i.e. oxygen, LIOH, water, food, etc.) on-orbit to support crew operations • Reduced propellant supply margin on orbit to support ISS reboost & attitude control. • Supplies not replenished.	• Utilize crew reserve supplies and propellant while the next logistics flight is prepared for an accelerated launch. • Launch the accelerated backup flight with replenishment crew supplies and/or propellant. • Accelerate future logistics flights and assess adding an additional logistics flight to the schedule to replenish reserve crew supplies and/or propellant. • Remanifest cargo on other vehicles. • Return crew in Soyuz or CRV if resupply is not delivered in time. • Modify nominal ISS operations plan (e.g., attitude, altitude, etc.) to reduce propellant requirements.

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS

L-P-5	Reduction in quantity of Progress Vehicles per year	Any failure which results in reduction in quantity of Progress Vehicles per year (e.g., Launch ONS, funding, Manufacturing ONS)	• Reduced capability to launch sufficient number of Progress vehicles, resulting in reduced capability to support logistics operations and supply reboost and propulsive attitude control.	• **Crew supplies**:
				- The crew will use the available on-orbit supplies, including reserve supplies if necessary.
				- The next scheduled logistics flight will be accelerated.
				- If necessary, supplies will be delivered on the next available flight (Shuttle, ATV, or HTV).
				- Assess potential for additional logistics flight.
				- Reduce crew size to decrease demand for crew supplies.
				- If additional supplies cannot be delivered before the reserve supplies are exhausted, the crew will return.
				• **Propellant:** Response varies on the basis of capabilities aboard ISS at the time of failure.
				- <u>Prior to US Propulsion Capability</u>
				  - Restrict operations to minimize propellant usage to a level sustainable by the Shuttle (until flight 10A.1 – potentially delays Shuttle-based assembly).
				    - Consider option to feather solar arrays(which may require removing the crew)
				    - Consider option to reboost more frequently.
				    - Reduce science.
				  - Utilize reserve propellant
				  - Rely on Shuttle to augment reboost until flight 2 J/A (due to structural load constraints).
				  - Augment propulsion capability with the ICM if there is a long term Progress loss.
				- <u>Post US Propulsion Capability</u>
				  - Perform propulsion functions using the US Propulsion Elements.
				  - Resupply propellant on Shuttle logistics flights
				  - Utilize reserve propellant
				  - Reduce operations demands to a level sustainable by the Shuttle.
				  - Support operations with ATV launch vehicles, as they become available.

5.1.3 HTV (TBD)

5.1.4 SPACE SHUTTLE

The Space Shuttle is the US logistics vehicle. It is capable of providing water, gas, dry cargo, and propellant. Cargo can be carried unpressurized in the cargo bay on cargo pallets, or pressurized inside an MPLM or SPACEHAB Logistics Double Cargo Module. Shuttles provide propellant to the US Propulsion Module, and they provide attitude control and reboost capability to the ISS in the early phases of the assembly sequence.

TABLE 5.1.4-1 LOGISTICS ONS—SHUTTLE LOGISTICS FLIGHT

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-STS-1	Delay of Shuttle logistics flight	Pre-launch ONS	• Supplies not replenished. • May need to return ISS crew.	• If necessary, utilize reserve supplies until Shuttle flight can be launched. • Accelerate the next alternate logistics vehicle flight for launch 30 days after the original launch date of the delayed Shuttle, in case delayed flight is not able to launch on time. • Launch the accelerated backup logistics vehicle flight if original Shuttle will not be ready on time. • Launch delayed Shuttle as soon as it is ready. • Replenish reserve supplies once the delayed Shuttle is launched. • Remanifest cargo on alternate vehicles. • If neither Shuttle nor backup flight is launched before reserve supplies are depleted, return crew in Soyuz or CRV.
L-STS-2	Inability to dock Shuttle logistics flight to ISS	Pre-launch ONS Launch ONS	• Supplies not replenished • May need to return ISS crew.	• If necessary, utilize reserve supplies while the next logistics flight is prepared for launch. • Remanifest cargo on alternate vehicles. • Launch backup logistics flight vehicle with replacement supplies. • STS reflight of mission is possible in approximately 4 months. If a new cargo bay complement is required, reflight may take 6 to 18 months depending on the chages required. • Accelerate future logistics flights and add an additional logistics supplies flight to the schedule to replenish reserve supplies. • Return crew in Soyuz or CRV if resupply is not delivered before reserve supplies are depleted. • Adjust flight attitude, altitude, and solar arrays to extend on-orbit life if necessary.
L-STS-3	All Shuttle flights delayed greater than 180 days	Any failure resulting in inability to launch shuttle fleet.	• Inability to continue ISS Shuttle-based assembly operations. • Reduced capability to support ISS logistics operations.	• Reduce operations demands to a level sustainable by Progress and Soyuz vehicles. • Support operations with HTV and ATV launch vehicles when they become available. • May include reduction in the number of crew or return of all crew.

5.1.5 ATV (TBD)

5.2 CREW ROTATION AND EMERGENCY CREW RETURN CAPABILITY

The following sections describe the ISS crew rotation and off-nominal crew return vehicles and address their associated ONS scenarios. Two vehicles are capable of supporting crew rotation for the ISS: the Soyuz-TM and the US Space Shuttle. Two vehicles are capable of providing emergency crew-return capability: the Soyuz-TM and the CRV.

5.2.1 SOYUZ-TM

The Soyuz spacecraft is available for crew rotation, and during much of ISS assembly, it is the primary vehicle for emergency crew return. Physically, Soyuz vehicles have much in common with Progress vehicles, but the Soyuz is used for transporting crew and has a recoverable crew module. Like the Progress, Soyuz are launched using a Soyuz booster. The Soyuz spacecraft can transport three crewmembers to and from the ISS, and it can remain docked to the ISS for up to 198 days to act as an emergency-crew-return vehicle.

While a crew is on the ISS, there must always be at least one Soyuz-TM docked at the ISS (before the CRV becomes available). Thus, when Soyuz-TM vehicles are rotated, the replacement vehicle must arrive at the ISS before the previous vehicle can leave the ISS. If a Soyuz-TM vehicle must change its docking location, the entire crew rides in the Soyuz-TM during the re-docking maneuver, so that no crewmember is left on the ISS without a means of escape. To accommodate two Soyuz-TMs and have an additional docking location in case of an ONS with one of the docking ports, three Soyuz-TM compatible docking locations are maintained on the ISS during most of the manned ISS assembly process.

TABLE 5.2.1-1 LOGISTICS ONS—SOYUZ-TM

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-SZ-1	Delay of 2R	Pre-launch ONS	• Delay permanent manning of ISS • Delay of RS assembly	• Proceed with assembly of USOS and begin permanent manning at a later point.
L-SZ-2	Inability to dock 2R to ISS	Launch ONS Docking ONS	• Delay permanent manning of ISS • Delay of RS assembly	• Proceed with assembly of USOS and begin permanent manning at a later point. • Replacement Soyuz can be launched no earlier than 1 month. Subsequent Soyuz flights would be delayed approximately one month.
L-SZ-3	Delay of Soyuz flight that does not exceed service life of on-orbit Soyuz.	Pre-launch ONS	• Potential delay of crew rotation.	• Make decision whether or not to extend on-orbit stay of Soyuz. • If it is a crew rotation flight, assess potential to rotate crew on next Shuttle flight. • Prepare backup Soyuz for flight if it is possible to reach ISS before current on-orbit Soyuz or crew must return. • Return crew from ISS in current on-orbit Soyuz if the crew or vehicle allowable on-orbit time limit is reached.
L-SZ-4	Delay of Soyuz flight that exceeds service life of on-orbit Soyuz.	Pre-launch ONS	• Potential delay of crew rotation.	• Make decision whether or not to extend on-orbit stay of Soyuz beyond the design service life. • If the decision is to return Soyuz, crew will return leaving ISS temporarily unmanned. • If the next crew rotation was planned for Shuttle, accelerate crew rotation to Soyuz to minimize period when ISS is unmanned.

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-SZ-5	Inability to dock Soyuz to ISS	Launch ONS Docking ONS	• Potential delay of crew rotation.	• Make decision whether or not to exceed service life of on-orbit Soyuz. • Prepare backup Soyuz for flight if it is possible to reach ISS before the service life of current on-station Soyuz is exceeded. • Return crew from ISS in current on-station Soyuz if the crew on-orbit time limit or the vehicle service life is reached. • Accelerate crew return to ISS.
L-SZ-6	Inability of on-orbit Soyuz to return the crew	Any failure resulting in the inability of on-orbit Soyuz to return the crew	• Cannot meet crew emergency return requirement	• Plan ISS crew rescue mission on Shuttle. • Assess removal of inoperable Soyuz.
L-SZ-7	Soyuz vehicle unavailable	Any failure resulting in unavailability of Soyuz-TM vehicle	• Inability to launch Soyuz-TM vehicles, resulting in reduced ability to support crew operations.	• Response varies on the basis of capabilities aboard ISS at the time of failure. - Prior to CRV: Crew must return when the life limit of the on-orbit Soyuz is reached. Shuttle flights could continue for ISS assembly, maintenance, and utilization. - Post-CRV availability: CRV provides crew escape function. Number of crew members on ISS is determined by crew capacity of the CRV. All-crew rotation is performed using the Shuttle.

5.2.2 SPACE SHUTTLE

The Space Shuttle can deliver and return up to (TBD) ISS crew, but the tradeoff is generally a reduction in Shuttle crew.

TABLE 5.2.2-1 LOGISTICS ONS—SHUTTLE CREW ROTATION FLIGHT

ONS NUMBER	NAME	CAUSES	CONSEQUENCES	RESPONSE/TASKS
L-STS-4	Delay of Shuttle crew rotation flight	Pre-launch ONS	• Shuttle does not arrive on time. • ISS crew may be required to abandon ISS.	• Prepare backup Shuttle or Soyuz for flight if it is possible to reach ISS before current on-station crew must return. • Return crew from ISS in Soyuz or CRV if the crew's allowable on-orbit time limit is reached.
L-STS-5	Inability to dock Shuttle crew rotation flight to ISS	Pre-launch ONS Launch ONS Docking ONS	• Shuttle does not arrive on time. • ISS crew may be required to abandon ISS.	• Prepare backup Shuttle or Soyuz for flight if it is possible to reach ISS before current on-station crew must return. • Return crew from ISS in Soyuz or CRV if the crew allowable on-orbit time limit is reached.

5.2.3 CRV (TBD)

6.0 SYSTEM FUNCTIONALITY OFF-NOMINAL SITUATIONS

This section contains ONS involving the inability to execute required funtions for the ISS construction or operation due to failure of individual onboard subsystems.

The information in this section is the baseline data for analyis and detailed development of measures to counteract ONS by the Increment Management Team and the developers of the onboard systems. It is also intended for use in developing instructions for the crew and real-time operations team. Decisions on ONS remedies will be made by the Increment Management Team and/or Flight Operations Team according to the baseline ISS program process.

The information in this section includes:

- A general description of ONS;
- Information on possible failure sources that initiated the given ONS;
- Means for detecting these ONS;
- Measures to prevent the given ONS integrated into the system structure or its control;
- Measures to counteract the ONS in question (method of counteraction, general counteraction sequence) using Russian segment capabilities;
- Measures to counteract the ONS in question (method of counteraction, general counteraction sequence) using USOS capabilities;
- Information on the suitability of the various counteraction measures during the different ISS operating stages.

Each ONS can be counteracted by measures of a different level:

- Intrasystem measures (as a result of redundancy within the system, automatically);
- Intersystem measures (as a result of the additional capabilities of other onboard systems);
- Integrated measures by resources of ISS as a whole;
- Program measures (as a result of a flight program change).

Intrasystem ONS, i.e., ONS that can be counteracted automatically within the framework of the system itself, are documented in the System and Segment Specifications (SSP 41000, SSP 41162, and SSP 41163).

This section examines ONS that require specific operations to be performed using additional ISS resources in order to counteract them. These resources include crew and MCC capabilities (regardless of whether they are being counteracted on the program or intersystem level).

The information in this document will be added to or updated as the ISS assembly progresses designed and based on the results of ISS operation.

6.1 FUNCTIONAL ONS (TBD)

6.2 SUBSYSTEM ONS (TBD)

7.0 EMERGENCY RESPONSE OFF-NOMINAL SITUATIONS

This section identifies the overall ISS Program response to the potentially catastrophic Depressurization, Fire and Toxic Release ONS.

The ISS Program has developed an overall strategy to deal with the consequences of these ONS and provide risk mitigation in the event they occur on-orbit. The strategy includes, but is not limited to, preventive design measures, automatic detection and response means, repair methods, and operational interfaces.

Crew and ISS safety impacts and preventive design measures are addressed in ISS Hazard Reports and assessed by the ISS Safety Review Panel, which assures the necessary operational controls are put in place to ensure Crew and ISS Survival in the event of these ONS.

NOTE: For the initial IPOP, Basic version, the introduction paragraph and a basic listing of the tasks needed to be performed for Depressurization and Fire ONS will be included. The team is developing the detailed section for the ONS and these will be included in IPOP, Revision A

7.1 RESPONSE MEASURES FOR DEPRESSURIZATION ONS (TBD)

The tasks that need to be planned and excetued to ensure ISS Porgram readiness to respond to a depressurizaiton on ISS are as follows:

1) Automatic response of ISS systems to depressurization
   ISS requirements are developed and implemented in system architecture design to ensure automatic response measures are executed in the event of a despressurization. The automatic response measures are documented in SSP 50506, Basic Guidelines for Crew Activities During ISS Depressurization. Specific requirements are documented in SSP 41000, ISS System Specification and are flowed down to all the Segment Specifications (SSP 41162, USOS Spec, SSP 41163, RS506.

3) MCC-Houston and MCC-Moscow response in the event of a depressurization is documented in SSP 50506.

4) Undocking of manned rescue vehicles from ISS in the event of depressurization (Soyuz, Shuttle, CRV).

5) Undocking of unmanned transport vehicles from ISS in the event of a depressurization (Progress, ATV, HTV).

6) Requirements for functionality of ISS systems after a depressurization occurs.
   Design requirements necessary to ensure survivability and operability of critical ISS systems in a depressed volume for up to 180 days are documented in SSP 41000, ISS System Specificaiton and flowed down to all the Segment Specifications (e.g. SSP 41162, USOS spec, SSP 41163, RS Spec, etc.)

7) Leak detection and repair methods

8) Measures to ensure ISS functionality in the event it is not possible to restore the pressure integrity of a depressurized and isolated volume. This assumes a need to provide critical ISS survival functions for up to ~180 days (nominal propellant reserve limit post-AC) is documented in SSP 50505, Basic Provisions on Crew Actions in Case of Fire.

7.2 RESPONSE MEASURES FOR FIRE ONS (TBD)

The tasks that need to be planned and executes to ensure ISS Program readiness to respons to a fire related event on ISS are as follows.

1) Automatic response of ISS systems to a fire event (e.g. turn off air circulation and power to the affected volume, etc.)

2) Crew response in the event of a fire event on ISS is documented in SSP 50505.

3) MCC-Houston and MCC-Moscow response in the event of a depressurization is documented in SSP 50505.

4) Provision of ISS modules with fire protection equipment (fire annunciation equipment, individual protection gear, fire extinguishers, atmosphere purification equipment, equipment for monitoring the atmosphere for toxic substances).

5) Provision of ISS Soyuz vehicles with fire annunciation and suppression equipment.

6) Compatibility of using various fire suppression equipment in different segments.

7) Response measures to ensure ISS functionality in the event that a fire cannot be extinguished in a module or in the event a damaged module can no longer be used nominally.

8) Development of allowable ISS toxic substance concentrations that determine the further actions of the crew.

9) Undocking from the ISS of unmanned transport vehicles damaged by fire.

7.3 RESPONSE MEASURES FOR TOXIC RELEASE ONS (TBD)

APPENDIX A:

ACRONYMS AND DEFINITIONS

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ACRONYMS AND DEFINITIONS

ACFIT Assembly Critical Failures Implementation Team

ATV Automated Transfer Vehicle

CAM Centrifuge Accommodations Module
CBM Common Berthing Mechanism
CETA Crew and Equipment Translation Assembly
CHeCS Crew Health Care Systems
CMG Control Moment Gyro
COF Columbus Operating Facility (ESA Laboratory Module)
CRV Crew Return Vehicle

DAC Design Analysis Cycle
DC Docking Compartment (i.e. DC-1 and DC-2)
DDCU Direct Current to Direct Current Converter Unit

EATCS Early Active Thermal Control System
EF Exposed Facility
EFPL Exposed Facility Payload
ELM-ES Experiment Logistics Module-Exposed Section
ELM-PS Experiment Logistics Module Pressurized Section
ERA European Robotic Arm
ESA European Space Agency
EVA Extra-Vehicular Activity

FGB Functional Cargo Block [sic] (Functionalui Germaticheskii Block)

GPS Global Positioning System

H-IIA NASDA Logistics Vehicles
HTV H-IIA Transfer Vehicle

ICM Interim Control Module
ICS Inter-satellite Communications System
IDRD Increment Definition and Requirements Document
IPOP ISS Program Off-Nominal Situation Plan
IP International Partner
ISS International Space Station

JEM Japanese Experiment Module

LCA Lab Cradle Assembly

MBS Mobile Base System
MMOD micro-meteor and orbital debris
MOD Mission Operations Directorate
MPLM Multi-Purpose Logistics Module, also Mini-Pressurized Logistics Module

MPM Multi-Purpose Module
MSS Mobile Servicing System
MT Mobile Transporter

NASA National Aeronautics and Space Administration
NASDA National Space Development Agency of Japan

ONS Off-Nominal Situation, Off-Nominal Situations
Orlan Russian EVA suit
ORU Orbital Replacement Unit

PCS Portable Computer System
PDGF Power and Data Grapple Fixture
PM Pressurized Module
PMA Pressurized Mating Adapter
Progress Russian cargo vehicle
PV Photovoltaic

RACU Russian-American Converter Unit
RM Research Module (i.e. RM-1, RM-2)
RMS Remote Manipulator System
RS Russian Segment
RSA Russian Space Agency, English acronym for

SA Solar Array
SFA Small Fine Arm
SIR Stage Integration Review
SM Service Module
SPDM Special Purpose Dexterous Manipulator
SPP Science Power Platform
SSP Space Station Program, or Space Shuttle Program
SSRMS Space Station Remote Manipulator System
Strela Russian cargo crane

UDM Universal Docking Module
UF Utilization Flight
UHF ultra high-frequency
Unity Node-1
US Lab United States Laboratory
USOS United States On-orbit Segment

VFA Vehicle Failure Assessment

Zarya FGB name, Russian word for "Sunrise"