

# REQUIREMENTS, RESOURCE PLANNING AND MANAGEMENT FOR DECREWING/RECREWING SCENARIOS OF THE INTERNATIONAL SPACE STATION

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## ABSTRACT

Following the failure of 44 Progress (44P) on launch in August 2011, and the subsequent grounding of all Russian Soyuz rocket based launches, the International Space Station (ISS) ground teams engaged in an effort to determine how long the ISS could remain crewed, what would be required to safely configure the ISS for decrewing, and what would be required to recrew the ISS upon resumption of Soyuz rocket launches if decrewing became necessary. This White Paper was written to capture the processes and lessons learned from real-time time events and to provide a reference and training document for ISS Program teams in the event decrewing of the ISS is needed.

Through coordination meetings and assessments, teams identified six decrewing priorities for ground and crew operations. These priorities were integrated along with preflight priorities through the Increment re-planning process. Additionally, the teams reviewed, updated, and implemented changes to the governing documentation for the configuration of the ISS for a contingency decrewing event. Steps were taken to identify critical items for disposal prior to decrewing, as well as identifying the required items to be strategically staged or flown with the astronauts and cosmonauts who would eventually recrew the ISS.

After the successful launches and dockings of both 45P and 28 Soyuz (28S), the decrewing team transitioned to finalizing and publishing the documentation for standardizing the decrewing flight rules. With the continued launching of crews and cargo to the ISS, utilization and science is again a high priority; both Increment pairs 29 and 30, and Increment 31 and 32 reaching the milestone of at least 35 hours per week average utilization.

## 1. INTRODUCTION

This White Paper provides a summary of the thought processes from an International Space Station Program (ISSP) Increment Integration Operations (OC3) perspective, actions taken during the meetings, and

associated discussions for the August - November 2011 Decrewing Scenario. In the event of future decrewing/recrewing scenarios, it is hoped the material in this White Paper will be useful. Topics covered include:

- A summary of assumptions made to bound the scope of work for the Decrew Planning Joint Operations Panel (JOP) and Vehicle Manifest and Consumables Splinter,
- The questions and actions that were given to provide direction to Vehicle Manifest and Consumables Splinter members for decrewing and recrewing,
- Crew time and task priority discussions,
- Conclusions, Recommendations, and Lessons Learned from the Decrew review process and improvements to existing practices.

## 2. BACKGROUND

On August 24, 2011, the Soyuz-U rocket carrying 44 Progress (44P) malfunctioned on ascent and failed to make it to orbit. Due to the catastrophic loss of the vehicle, the launching of subsequent Soyuz-U rockets was suspended until the cause of the failure could be determined. The Soyuz-U rocket is similar to the Soyuz-FG rocket that carries the crewed Soyuz (S) spacecraft, therefore the launching of astronauts and cosmonauts to the International Space Station (ISS) was also suspended until confidence was regained in the rocket and its components.

The two Soyuz spacecraft attached to the ISS (26S and 27S) were unaffected by the failure and the onboard crew was in no danger from the early termination of the 44P flight. However, due to the Soyuz vehicles' limited on-orbit lifetime, plus the requirement for a landing during daylight in Kazakhstan meant the Soyuz crews' stays could not be extended to maintain crew presence on ISS. The launch date of the next crew, on 28S, became dependent upon the Russian Commission investigation results, subsequent corrective actions, and a successful launch of a Soyuz-U rocket (45P).

During meetings with the ISSP Manager, the decision was made that even with a successful launch and docking of 45P, the threat of decrewing the ISS could not be ignored until the successful docking of 28S due to continued uncertainty with the Soyuz rocket. With full confidence in the Russian Commission's ability to determine the cause of the 44P failure, and their subsequent mitigation plans, it was concluded that decrewing preparations should continue until the successful docking of 28S or the undocking of 27S resulting in an uncrewed ISS.

The major milestones of launch, dock, and undock/landing for the Soyuz and Progress vehicles were reviewed to maximize 6-crew operations and crew time capabilities. 26S undocked and landed successfully on September 16, 2011, starting Increment 29 one week later than initially baselined. New dates for 42P, 45P, 27S, and 28S were selected. The undocking of 42P slid from October 25 to October 29 pushing 45P docking from October 28 to November 2. The undocking of 27S could only be extended to November 22, due to the Soyuz's in-space constraints; 28S slipped past the Progress vehicle traffic from September 24 to November 16, 2011 resulting in approximately four and one-half usable crew-days to perform direct handover during the 6-crew timeframe. In Fig.1 and Fig. 2, the vehicle traffic and crew size is depicted as both the baselined Flight Program and the as flown Flight Program following the 44P accident to resumption of 6-crew operations in Increment 30 with the docking of 29S on December 23, 2011.

The ISSP baselined a decrewing document, SSP 50715, ISS Decrewing and Recrewing Plan in 2008. This document had been updated through the assembly of the ISS and as ISS systems evolved and were upgraded. Flight Rule (FR) B2-152 Crew Contingency Return provides the operational teams a starting checklist for configuration of the ISS in the event of a planned decrewing event and was developed from SSP 50715.

### 2.1. Decrewing Assessments

An Increment 29/30 Decrew Planning JOP was established to assess the requirements for decrewing, sustained uncrewed operations, and subsequent recrewing of the ISS. The Decrew Planning JOP delegated to ten sub-splinters which were chaired and supported by Mission Operations Directorate (MOD), Mission Evaluation Room (MER), Safety, and International Space Station Program (OC3) personnel.

- Vehicle/Systems Configuration & Unmanned Operations Concepts,
- Emergency Response (standing Generic Joint Operations Panel [GJOP] Splinter),
- Recrew Planning,
- Atmosphere Management and Consumables,
- System Degradation/Trending,

- Software Uplinks,
- Regen Environment Control and Life Support System (ECLSS) Configuration,
- Operations Local Area Network (OpsLAN) Configuration,
- Onboard Imagery Configuration,
- Vehicle Manifest/Consumables.

Each JOP splinter held regular meetings and provided status briefings to the Decrew Planning JOP. As the Splinters completed their outlined objectives, they folded back into the parent Decrew Planning JOP and those topics were discussed with the forum's larger community. This White Paper focuses on the Vehicle Manifest/Consumables splinter and integration of the priorities as those were the main aspects of decrewing that the ISSP representatives participated in.

The Decrew Planning JOP set five priorities in coordination with the ISS Mission Management Team (IMMT) Chair and ISSP Manager for the sub-splinters to follow. A sixth priority was inserted during a subsequent JOP to capture tasks that were identified as Increment 29 requirements, but did not fall within the original generic decrewing priority set.

### 2.2. Unmanned Priorities as presented to the Oct 11, 2011 Space Station Program Control Board (SSPCB)

1. Maintain vehicle safety and insight through return to crewed operations.
2. Maximize critical system redundancy.
  - Includes possible addition of maintenance tasks for degraded systems and workarounds to increase redundancy for uncrewed ops (e.g. use of jumpers).
3. Prevent loss of critical hardware. (*This priority was added to include maintenance tasks required to support non-redundant systems and utilization.*)
4. Prevent loss of science.
  - Includes consideration for delaying start of new utilization that would be lost if terminated due to decrewing.
5. Optimize vehicle configuration for an efficient (crew time) return to nominal ops.
6. Continue utilization (*during crewed and decrewed phases*).
  - Includes new utilization assuming no risk for losing science.

During the Decrew Planning JOPs, the team revised FR B2-152 Crew Contingency Return, and incorporated the Unmanned Priorities listed above. A dual path to edit the FR was followed. First, the team created an Increment 29 specific rule to be approved through the Real-Time FR change process. A subsequent edit and review would update the rule to a generic rule following

the nominal change and approval process. This second update would incorporate the Increment 29 changes, potential lessons learned, and provide for a review of the FR by the larger reviewing community.

As members of the Decrew Planning JOP, an Increment Manager (IM) and an Increment Engineer (IE) offered Programmatic insight and direction as the Splinters reported on their status and requested activities. The IM and IE provided assistance to the JOP community by answering questions to task and crew time priorities. The IM and IE supporting the JOPs and Splinter meetings were not members of the Increments 28, 29, or 30 teams which enabled the console teams to focus on real-time operations. The IM and IE provided regular communication back to the console Increment Team.

As the duration of potential decrewing would be unknown, the teams analyzed for short durations – a decrewing of the ISS at 27S undock and then a recrewing by a Soyuz within a few days to a few weeks; analysis for medium and long duration decrewing was performed with the timeframes of longer than multiple weeks to a potential of one to multiple years.

### **3. VEHICLE MANIFEST AND CONSUMABLES SPLINTER**

The Vehicle Manifest and Consumables Splinter, chaired by an OC3 IM, had two main goals:

1. Review trash that would be on ISS at the time of decrewing, and develop mitigation plans if any trash posed risks to a decrewed ISS,
2. Identify any hardware or consumables that would need to be manifested on the vehicle that recrewed ISS.

The JOP first met on September 2, 2011. Ground rules and assumptions were set to establish goals for all participants to work towards. The Vehicle Manifest and Consumables Splinter aimed to dispose of available trash items off of the ISS prior to decrewing as part of nominal operations independent of Decrewing Operations, and to project/identify all “nasty” trash items (potential chemical/biological hazards, toxic, and/or odorous items) that would need to be removed from ISS prior to (or with) the decrewing of the ISS. Identified items were to have the appropriate paperwork submitted to the Trash/Waste Integration Group (TWIG) without designation for a disposal vehicle. The TWIG/Manifest team used this information to estimate, plan, prioritize, and coordinate disposal.

#### **3.1 Vehicle Manifest and Consumables Splinter Direction**

- Decrewing would occur with the undocking of 27S. A successful docking of 45P could not be guaranteed, so assessments were made with the assumption that 43P was the last successful

resupply, having arrived on June 23, 2011. Even with the successful docking of 45P, the proximity of its arrival and 27S departure was too close to count on its delivered cargo for decrewing or recrewing assessments.

- The time of a decrewed ISS could be short or long term.
- Should decrewing occur, the next crew in the rotation would be the crew that recrewed the ISS. Any change to that plan would result in a separate analysis and assessment.
- Changes to manifests for 42P disposal, 45P launch, and 26S and 27S return were to be worked through the nominal real-time processes with the appropriate Increment teams. At the time of the 44P incident, the manifests and disposal lists were already being worked.
- A short term decrewing may not require changes in manifesting posture.
- Maximize disposal on 42P (the next nominally departing disposal vehicle) to minimize waste to dispose of on 27S or store on ISS. Highest priority for disposal consideration was for the aforementioned “nasty” trash.
- Identify disposal items of risk to the crew/station that were to be generated between 42P undocking and 27S undocking.

#### **3.2 Waste Disposal and Consumables Planning**

In accordance with the priorities and assumptions, the members were to review their onboard hardware for potentially toxic items, odor sources, and/or health hazards (mediums for bacterial and/or fungal growth) and to provide them to the Splinter Chair. These items identified were to be prioritized for disposal following the nominal Additional Items disposal process. “Nasty” items not available for disposal on the Progress vehicle (generated during the four weeks between 42P undocking and 27S undocking) were to be identified for disposal in the 27S Habitable Module (BO). Once decrewing was declared, the coordination would begin for either disposal in the BO or for containment in a safety approved manner. The disposal of United States On-orbit Segment (USOS) items in the BO is not part of the nominal National Aeronautics and Space Administration (NASA) contracted disposal allocation, and negotiations for the highest priority trash items would have to occur. The TWIG reviewed the Waste Manifest Requests (WMRs) and assigned all decrew-related items to a specific decrew list; once the decision to proceed with decrewing the ISS was made, these items would be coordinated with the appropriate Russian specialists.

The Integrated ISS Consumables Team performed an analysis of the nominally reported consumables for both short term and long term decrewing events. The team

followed two approaches. First, the team assessed the available ISS consumables and determined if they would be expended or expired prior to recrew. Second, the team defined how long each consumable would last, either due to expiration date or consumption/expenditure. This second assessment would drive resupply needs required prior to recrew the ISS or to fly with the re-inhabiting crewmembers.

1. Consumables used throughout the decrew phase or prior to recrew,
  - i. Propellant (*required to maintain vehicle altitude, attitude, velocity, and perform Debris Avoidance Maneuvers [DAMs]*),
  - ii. Nitrogen (*lost through tank and ISS stack leakage rates*),
  - iii. Oxygen (*lost through tank and ISS stack leakage rates*),
2. Consumables not used during decrew phase, however may expire prior to recrew,
  - i. Water,
  - ii. Water (liquid) Container (E/D/B's),
  - iii. Recycle Filter Tank Assembly (RFTA)/Recycle Tank,
  - iv. Food,
  - v. Crew Provisions,
  - vi. Waste Hardware (Solid Waste Container [KTOs], Filter Inserts, Toilet Inserts).

In all categories it was determined that, due to previous resupply delivered on Automated Transfer Vehicle (ATV)-2 and Utilization Logistics Flight (ULF)-7, sufficient consumables were available to cover a short term decrewing event and did not require any manifest items. Should a long term decrewing occur, strategies would be implemented to extend usage rates and capabilities or to plan on resupply/manifesting prior to, during, or shortly after recrew.

- For propellant, changes in altitude and attitude would be addressed to extend current capabilities. Additionally, the members of the Decrew Planning JOP worked with their Russian counterparts to ensure that either the Russian Progress or European Space Agency (ESA) ATV resupply vehicles could be automatically/remotely docked to the ISS to provide additional propellant quantities. Steps to ensure this capability were to be built into the decrewing procedures and configurations.
- Usage of Nitrogen (N<sub>2</sub>) and Oxygen (O<sub>2</sub>) during the decrew timeframe would be through leakage from the USOS Airlock tanks and leakage of the ISS atmosphere would be through seals, all at known specification rates. The ISS atmosphere is typically 80% N<sub>2</sub> and 20% O<sub>2</sub>; at the time of the decrewing analysis,

the usable onboard inventory of N<sub>2</sub> was approximately 390 pounds-mass (lbm), and 663 lbm of O<sub>2</sub>, resulting in N<sub>2</sub> being the limiting atmospheric consumable. The Atmospheric Splinter determined that the best course of action, to maximize capability, was immediately prior to decrewing to repress the ISS to 14.8 pounds per square inch (psi) (765.4 millimeters of Mercury [mmHg]) and allow nominal stack leakage to occur down to 14.0 psi (724.0 mmHg) prior to repressing again. The upper and lower limits were chosen based on FR B17-2 Total Pressure Management. Unlike propellant, gas delivered by a resupply vehicle cannot be managed from the ground and requires crew interaction for represses. Current gas resupply capability is through the ATV and Progress tanks which provide their atmospheric contents into the cabin. Resupply to the external USOS tanks is still in development following the retirement of the shuttle.

- For Food, Waste Hardware, and most Crew Provisions, the analyzed cases, the cargo delivered by prior vehicles provided sufficient consumables for approximately one-year of an uncrewed ISS.

Following the review of the ISS Consumables Team analyses and presentation to the Decrew Planning JOP, the members of the Vehicle Manifest and Consumables Splinter determined that any additional manifest and consumables issues would be worked through the Decrew Planning JOP.

### 3.3 Recrew Manifest and Crew Arrival Preparation

Through discussions at the Decrew Planning JOPs and Recrew Splinter JOPs, the Vehicle Manifest and Consumables Splinter tracked items that would be required to travel with the crew to the ISS, or fly separately and be required within a short period of time following their arrival. The list of items that teams were to identify as manifest candidates were to reflect the expiration dates of the identified recrew-required hardware.

With sufficient time available to prepare for the possible decrewing, the plan was made to configure the ISS in a manner that safed hardware and systems as best as possible. The uncrewed configuration was documented in the Increment 29 version of B2-152 Crew Contingency Return and was broken down by systems and International Partner (IP) module.

As part of the decrewing preparation steps, a list of equipment for the crew to gather and stage in support of the re-ingress operations was compiled. Some of the items on the gather list duplicate items on the recrew manifest list as their limited life certifications are valid

only for a short decrewed timeframe. The gathered equipment list included:

- Compound Specific Analyzer – Combustion Products (CSA-CP), Carbon Dioxide Monitor (CDM), Compound Specific Analyzer for Oxygen (CSA-O<sub>2</sub>) and related support equipment to perform calibrations,
- Personal Protective Equipment (PPE) (dust mask and goggles),
- Grab Sample Containers (GSC),
- Bose noise cancelling headset for use during sleeping in Russian Segment (RS),
- Earplugs,
- USOS Clothing sufficient for a few days until access to the clothing pantry was available,
- Hatch contingency tool kit,
- Maglite and Light-Emitting Diode (LED) headlamp,
- G1 camcorder and support equipment.

Upon recrewng, the crew would require water for consumption that could be confirmed potable in the RS, as the USOS would be both isolated and the water delivery system in a non-dispensary and potentially uncertified configuration. The RS water supply in Service Module (SM) Rodnik tanks is certified potable for approximately three years after being filled with water and would be available for crew use immediately. Water stored in Contingency Water Containers-Iodine (CWC-I's) would require running the water through Activated Carbon/Ion Exchange (ACTEX) filters to remove the Iodine prior to consumption, resulting in the recommendation to not store CWC-Is in the RS during decrewing.

The cargo items identified to fly with the crew were items required for the crew to use during ingress operations to ensure crew health and safety. The cargo included items needed for both a nominal ingress and ingress where insight (through telemetry) to the atmospheres of the isolated RS and USOS would not be available. The items included:

- PPE of goggles and dust/surgical masks provided by NASA and Russian provided oxygen masks (ИПК),
- CSA-CP, CSA-O<sub>2</sub>, and CDM for real-time air quality monitoring and GSCs for archive sample analysis,
- A memory stick with procedures, timelines, and necessary files for the crew to execute ingress and reactivation in the event the onboard computer network is not readily available,
- Russian Water Dispenser,
- Russian Atmosphere Cleaning Filter Unit (АФOT),

- Crew specific items required during independent flight and prior to access to USOS or prepositioned in the RS.

#### **4. INTEGRATION OF DECREW PRIORITIES AND INCREMBT PRIORITIES**

The Current Stage Requirements Document (CSRD) is the ISS Program's prioritized list of tasks to be performed during a stage. Typically, there is not enough crew time in a stage to perform all of the tasks in a CSRD, so lower-priority tasks are "rolled" from one stage to the next. Low priority tasks may include repairs and maintenance that can be postponed because adequate redundancy exists, including the crew's ability to take immediate action in case of another failure.

At the time of the 44P incident, during Increment 28, the Increment 29 CSRD for Stage 29-3 was in the nominal review process, in Chit 9888 Requirements Increment 29: Stage 29-3 CSRD. A placeholder task was added to the CSRD to absorb tasks identified by the Decrew Planning JOP.

The JOP compiled the lists of tasks associated with decrewing and prioritized them according to the approved Unmanned Priority List. The tasks identified by the JOP fell into two categories: tasks already in the Increment 29/30 CSRD but at a lower priority than the set Decrewing "placeholder" priority or new tasks identified during the JOP Decrew assessments and not currently in the CSRD whose completion would put the ISS in a better posture for decrewing.

Examples of previously identified, low priority tasks included JSL Edge Router and the Lab Smoke Detector #2 Remove and Replace (R&R) maintenance tasks. Examples of newly identified enhancements included Permanent Multipurpose Module (PMM) Intermodular Ventilation (IMV) jumper and a Remote Power Control Module (RPCM) R&R to provide auxiliary power to EXPedite the PROcessing of Experiments (EXPRESS) Rack 2 and thereby improve redundancy for Ku-Band communication.

To appropriately capture the priorities in preparation for decrewing following 45P docking, another CSRD was written (Chit 9955) to cover the Increment 29-3 stage from 45P docking to 28S docking. In case of an unsuccessful docking of 28S, this CSRD also covered the requisite 27S undocking tasks. This CSRD integrated the Decrew Priorities with the nominal Increment 29-3 stage priorities. The Decrew priorities in the CSRD referred to the already defined tasks in the Decrew FR B2-152 and also called out tasks that were identified during the Decrew JOP but considered to be a one-time only task and still required prioritization during the 45P to 28S docking timeframe. In the CSRD, the Decrew priorities were called out specifically to differentiate these priorities and the nominal.

1. Maintain the health and safety of crew onboard the ISS (Nominal CSRD priority),
2. Maintain the health and safety of vehicle (Decrew Priority #1),
3. Emergency Onboard Training (OBTs) required to keep crew safe and trained for emergency (Nominal CSRD priority, crew time reduced during this stage),
4. Prepare for arrival of 28S and its crew (Nominal CSRD priority for 3-crew stage),
5. Perform tasks to protect for critical systems redundancy for a decrewed ISS (Decrew Priority #2),
6. Perform preventative or corrective maintenance tasks to prevent loss of critical hardware for a decrewed ISS (Decrew Priority #3),
7. Perform critical utilization operations to prevent non-recoverable loss of science (Decrew Priority #4),
8. Perform ISS medical operations (nominal CSRD priority),
9. Utilization during decrew (Decrew Priority #6),
10. Priorities 10 and subsequent were the remainder of the IDR/CSRD priorities identified for the Increment 29-3 stage.

*Note: Unmanned Priority #5 was not baselined as part of the CSRD; however during a subsequent priority assessment, the tasks associated with efficient recrew would be prioritized between CSRD tasks 8 and 9.*

Decrew preparation tasks that would need to be undone if decrewing was waived off were planned for the final week prior to 27S departure. If the 28S crew arrived at ISS before 27S departure, a one-week handover would be performed. If the 28S crew did not arrive, then one week of final preparations for decrewing would be performed.

Upon docking of 28S, the Increment team began executing from the Stage 29-6 CSRD priorities list (Chit 9976). The stage length was only five days, resulting in a significantly reduced priority list:

1. Maintain the health and safety of crew onboard the ISS,
2. Dock 28S to the ISS,
3. Complete preparations and undock 27S from ISS,
4. Perform critical utilization operations necessary to prevent non-recoverable loss of science,
5. Perform minimum handover of ten hours per arriving crew member,
6. Perform decrewing back-out operations required during 6-crew timeframe,

7. Perform ISS medical operations necessary to complete non-deferrable medical operations,
8. Perform one high priority Public Affairs Office (PAO) event (not including docking, undocking, Crew Command Handover, and RS Symbolic activities),
9. Perform additional crew handover of four hours per arriving crewmember substituting functional handover when possible,
10. Perform utilization per Increment Definition and Requirements Document (IDRD) Annex 5,
11. Perform non-deferrable ISS maintenance.

Tasks added after priority 11 were added via the nominal Pen & Ink process and scheduled based on crew time availability.

## **5. RECOMMENDATIONS AND LESSONS LEARNED**

During the Decrew Planning period, due to the number of meetings that were required to attend, the support of an IM and an IE not assigned to an Increment was used to assist the already busy real-time Increment Management Center (IMC) team. The chairing of the Vehicle Manifest and Consumables Splinter by the office IM provided the experience and point-of-view that an IM has without the added burden on the real-time team. In activating a team similar to an extended Team 4, the IMC team was able to continue with the day-to-day operations. The successful utilization of the office personnel was due to communication between the IMs and IEs supporting console and IMs and IEs supporting the JOPs and Splinter meetings. The communication ensured the Increment team's interests were appropriately represented, and that the priorities and interests of the console team were conveyed.

After the increment, during the crew time reconciliation/Post Increment Evaluation Report (PIER) timeframe, it was coordinated that activities completed solely for decrewing were categorized as Contingency Maintenance. Tasks that were pulled earlier or completed in advance of the potential decrewing but were scheduled to occur in the Increment 29/30 timeframe were categorized as they nominally would. This method of tracking the maintenance crew time activities enabled the team to easily differentiate between the nominal activities and what was performed specifically for the decrewing case.

By the arrival of 28S and its crew to the ISS on November 16, 2011, several tasks had been completed that were deemed required for an uncrewed ISS. The backing out of these tasks was a high priority during Stage 29-6 and early Stage 30-3 timeframes. Additionally, direct handover between the departing 27S and newly arrived 28S crews was a high priority task. To facilitate and maximize handover and ease the transition to on-board life, the 27S crew made videos for

downlink that provided key information for the 28S crew to watch/study while waiting for their launch. Utilizing functional handover between the experienced and newly arrived crew was performed during the reconfiguration of the ISS back to a non-decrewing/nominal configuration. Handover videos such as these can make shortened overlaps of Soyuz crews more efficient.

As part of the certification and proficiency plans for IMs and IEs, reviewing of SSP 50715, B2-152 Crew Contingency Return, and this White Paper should be required so that in the event of a future decrewing, the teams can be primed to make quick and informed decisions.

## 6. CONCLUSIONS

With the successful launch and docking of both 45P and 28S, the teams working the decrewing processes and

JOPs stood down from further work on the Increment 29 decrewing. The increment specific changes to Flight Rule B2-152 Crew Contingency Return were reviewed and rolled into a Generic rule following the nominal FR change and review processes. SSP 50715 was reviewed for content following the decrewing discussions, and determined that as a high level document; no additional changes were required based on the events following the 44P incident. As of September 2012, the generic update to Flight Rule B2-152 is still in pre-coordination steps, and final approval is expected in early 2013.

The Increments 29 and 30 crew and ground teams were able to reconfigure the ISS back to a nominal following the execution of several decrewing preparations. Additionally, the Increment 29/30 team was able to meet many of the ISSP Objectives, including being the first to average 35 hours/week of USOS Utilization over the increment pair.

	August 2011	September 2011	October 2011	November 2011	December 2011	January 2012
Inc # [#of crew] [#of days]	Increment 28 (6)	Increment 29 (3) [15]	Inc 29 (6) [54]	Increment 30 (3) [15]	Increment 30 (6) [105]	
MRM2	26S (undock Sept 8)	28S (dock Sept 24)				
MRM1	27S (undock Nov 16)				29S (dock Dec 1)	
DC1	42P (undock Oct 25)			45P (dock Oct 28)		
SM Aft	<small>43P (undock Aug 23)</small>	44P (dock Sept 26)				

Figure 1. Baselined Flight Program / Port Utilization Plan

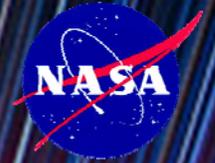
	August 2011	September 2011	October 2011	November 2011	December 2011	January 2012
Inc # [#of crew] [#of days]	Increment 28 (6)	Increment 29 (3) [61]		Inc 29 (6) [5]	Increment 30 (3) [31]	Increment 30 (6) [129]
MRM2	26S (undock Sept 16)				28S (dock Nov 16)	
MRM1	27S (undock Nov 22)				29S (dock Dec 23)	
DC1	42P (undock Oct 29)			45P (dock Nov 2)		
SM Aft	<small>43P (undock Aug 23)</small>	44P failure on launch August 26, 2011. SM Aft port remains open until ATV3 docking on March 28, 2012				

Figure 2. As-Flown Flight Program / Port Utilization Plan



Export control classification in Footer needed??

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# Requirements, Resource Planning and Management for Decrewing/Recrewing Scenarios of the International Space Station

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# Topics Covered



(or should I actually put the slide header names here?)

**UPDATE?**



- August 2011 Decrewing Background and History
- Increment Support
- Priority Integration
- Recommendations and Lessons Learned



# What happened?



- At the end of Expedition 28, on August 24, 2011 the a propulsion unit of the Soyuz-U rocket carrying 44 Progress (44P) failed. The rocket and cargo was lost. No crew or ground personnel were injured.
- Subsequent Russian launches using the Soyuz rocket (-U and -FG series) were suspended pending analysis and Russian Commission results.
- The two Soyuzes attached to ISS for the Expedition 28 crew were unaffected by the failure of 44P.



Expedition 28 Crew



Launch of 43P - June 21, 2011



# Planned and Executed Flight Programs



## Baselined Flight Program / Port Utilization Plan

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SM Aft	43P (undock Aug 23)	44P (dock Sept 25)				

## As Flown Post-44P Incident Flight Program / Port Utilization Plan

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MRM1	27S (undock Nov 22)			29S (dock Dec 23)		
DC1	42P (undock Oct 29)		45P (dock Nov 2)			
SM Aft	43P (undock Aug 23)	44P failure on launch August 26, 2011. SM Aft port remains open until ATV3 docking on March 28, 2012				



# Increment Team Support



26S departs the ISS on September 16, 2011. Expedition 29 begins with only 3 crewmembers onboard for 61 days (four times longer than originally planned).

- Joint Operations Panel established with Splinter teams to assess decrewing, sustained uncrewed operations, and subsequent recrewings of the ISS
- Splinters were chaired by various teams from across the ISSP
- Existing ISS Program and Flight Rule documentation was used by the Splinters in developing crew and ground actions.



# Vehicle Manifest & Consumables Splinter



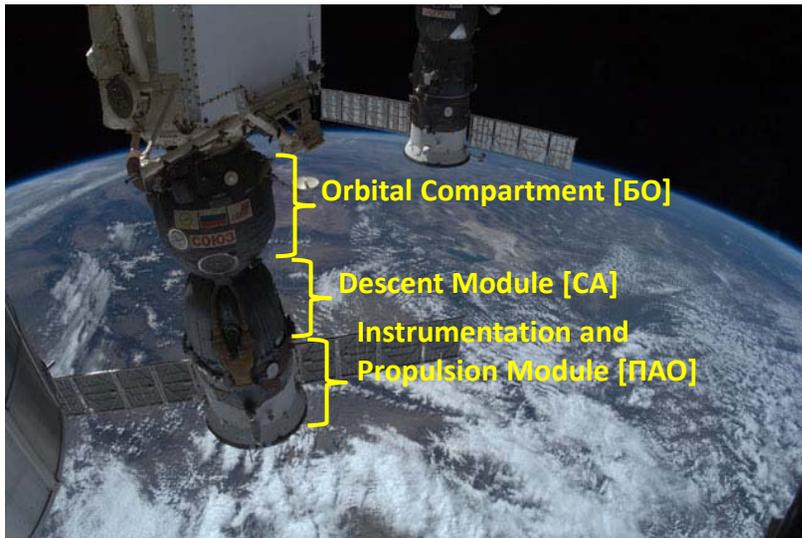
- ISSP Representatives chaired the Vehicle Manifest and Consumables splinter.
- Splinter's two main goals were:
  1. Review trash projected to be on the ISS at the time of decrewing, and develop mitigation plans if any trash posed risks to a decrewed ISS,
  2. Identify any hardware or consumables that would need to be manifested on the vehicle that recrewed ISS.



Expedition 29 Flight Engineer Furukawa amongst storage in the PMM



# Waste Disposal Planning



29S docked to the Rassvet Mini-Research Module 1 (MRM1) in foreground, 47P in background.



42P departing the ISS on October 29, 2011. 42P was the last disposal vehicle prior to the deorbiting decision to be made based on 28S arrival, scheduled for November 16, 2011.

- Manifest Splinter Team identified high priority items that needed to be disposed of on 42P.
- Items generated between 42P departure and deorbiting would require coordination for “long term” stowage on ISS or for disposal in the BO of 27S.



# Consumables Planning

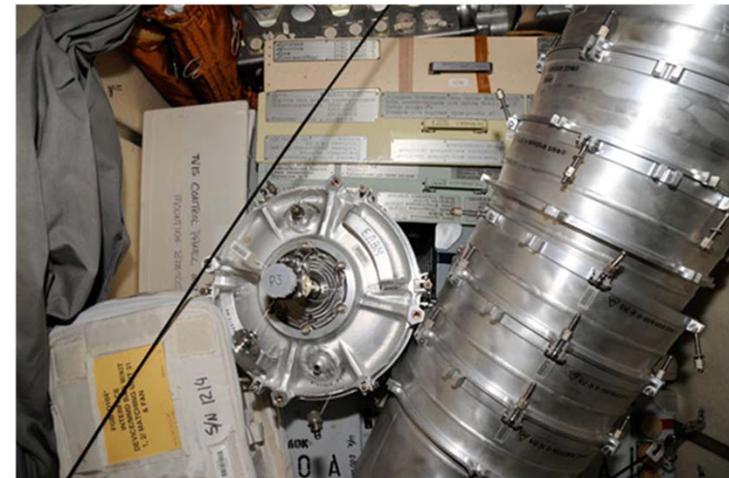


Analysis of ISS consumables was performed for both Short and Long Term deorbiting and for two categories of consumables:

1. Consumables used throughout the deorbit phase or prior to reorbiting,
  - Propellant (*required to maintain vehicle altitude, attitude, velocity, and perform Debris Avoidance Maneuvers*),
  - Nitrogen (*lost through tank and ISS stack leakage rates*),
  - Oxygen (*lost through tank and ISS stack leakage rates*)
2. Consumables not used during deorbit phase, however may expire prior to reorbit,
  - Water,
  - Water (liquid) Containers (EDBs and CWCs),
  - Recycle Filter Tank Assemblies and Advanced Recycle Filter Tank Assemblies,
  - Food,
  - Crew Provisions,
  - Waste Hardware (Solid Waste Containers, Filter Inserts, Toilet Inserts).



CWC Water Storage bags



Stack of EDBs in Russian Segment



# Decrew / Recrew Configuration



Expedition 29 Commander Mike Fossum in the LAB installing the Secondary Power Distribution Assembly Jumper. The SPDA jumper would provide a redundant power path should it be needed during a decrewed ISS phase.

- Hardware required for recrewing the ISS would be flown with the new crew, on a vehicle arriving close to their recrew time, available through appropriate stowage locations.
  - Manifest updates would be addressed as required and based on decrewing duration.
- The different modules and systems were configured keeping to the established Uncrewed Priorities to enable for a recrew, continued science during a decrewed phase, and maintaining sufficient redundancies.



# Prioritization of Tasks



- Decrewing requirements were identified by the JOP teams, and through the nominal process, integrated to the standard Increment Requirements documents.
- Through the execution of the priorities, Expedition 29 was able to both prepare for a potential decrewing, while maintaining crew and vehicle health, and completing utilization tasks.



Fossum installing the Advanced Recycle Filter Tank Assembly on Oct 10, 2011. The priority for checkout of the ARFTA was elevated following the 44P accident.



# Return to Full Crew Complement



28S successfully docked to the ISS on November 16, 2011. The six crewmembers had 4.5 crewdays together prior to 27S undocking on November 22, 2011.



29S arrived on Dec 23, 2011, bringing the ISS to its nominal 6-crew complement again. 28S undocked on April 27, 2012.

- Following the successful launching and docking of both 45P and 28S, the ISS teams stood down from further decrewing activities.
- The 6-crew stage after 28S arrival lasted 4.5 days, followed by one month of 3-crew operations prior to 29S arrival in December.
- The crews were able to meet the high priority ISSP objectives, including performing an average of more than 35 hrs per week utilization over both Increments.