International Space Station Environmental Control and Life Support System Status for the Prior Year: 2010 - 2011

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The International Space Station (ISS) Environmental Control and Life Support (ECLS) system includes regenerative and non-regenerative technologies that provide the basic life support functions to support the crew, while maintaining a safe and habitable shirtsleeve environment. This paper provides a summary of the U.S. ECLS system activities over the prior year, covering the period of time between March 2010 and February 2011. The ISS continued permanent crew operations including the continuation of six crew members being on ISS. Work continues on the last of the Phase 3 pressurized elements, the commercial cargo resupply vehicles, and work to try and extend ISS service life from 2015 to no later than 2028.

I. Introduction

THE ISS is a global partnership of 15 nations representing six space agencies, including the United States National Aeronautics and Space Administration (NASA), Russian Space Agency (Roscosmos), European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), Canadian Space Agency (CSA), and Italian Space Agency (ASI). The participating countries are Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Russia, Spain, Sweden, Switzerland, the United States, and the United Kingdom. The ISS operates at an altitude of approximately 310 to 350 km (170 to 190 nautical miles) and an inclination of 51.6^o to the equator.

The International Space Station Program is divided into three phases. Phase 1, completed in 1998, consisted of the joint Shuttle-Mir missions to prepare for the ISS build phases. Phase 2, the initial ISS construction phase, began assembly in November 1998, established permanent crew operations in November 2000, and culminated with the Joint Airlock delivery in July 2001. Phase 3 started with the increase of the ISS crew size from three crew members to six crew members on May 27, 2009. It will be completed after the delivery of the last of the permanent pressurized elements. A total of 109 flights have been completed to ISS, including 35 Shuttle flights. Figure 1 shows photos of key events from the prior year.

The ISS ECLS system provides the basic life support functions to support the crew, while maintaining a safe and habitable shirtsleeve environment. The ECLS hardware providing this functionality is organized into seven subsystems: Atmosphere Revitalization (AR), Temperature and Humidity Control (THC), Fire Detection and Suppression (FDS), Atmosphere Control and Supply (ACS), Water Recovery and Management (WRM), Waste Management (WM), and Vacuum System (VS). The current principle ECLS hardware distribution across ISS elements is shown in Figure 2 and 3. The ECLS functions by subsystem are listed below:

Atmosphere Revitalization:
- Control and disposal of carbon dioxide (CO_2)
- Control of airborne trace contaminants

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Figure 1 – Pictures of Key Events from the Prior Year

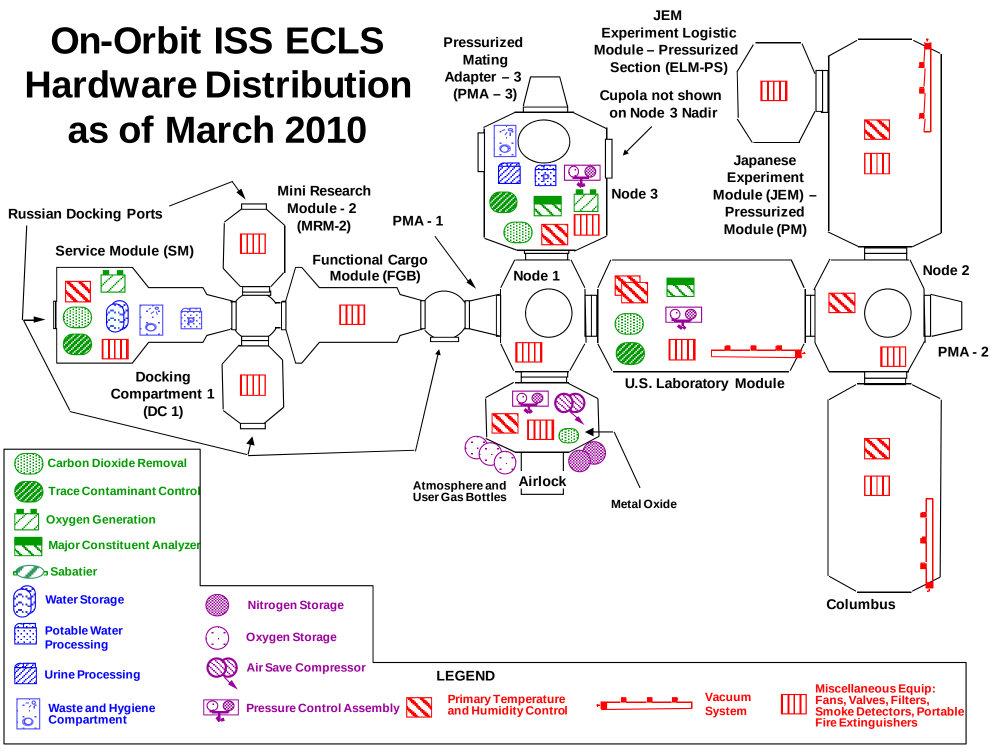

Figure 2 – ISS ECLS Hardware Distribution at the Start of This Time Period Covered by This Paper

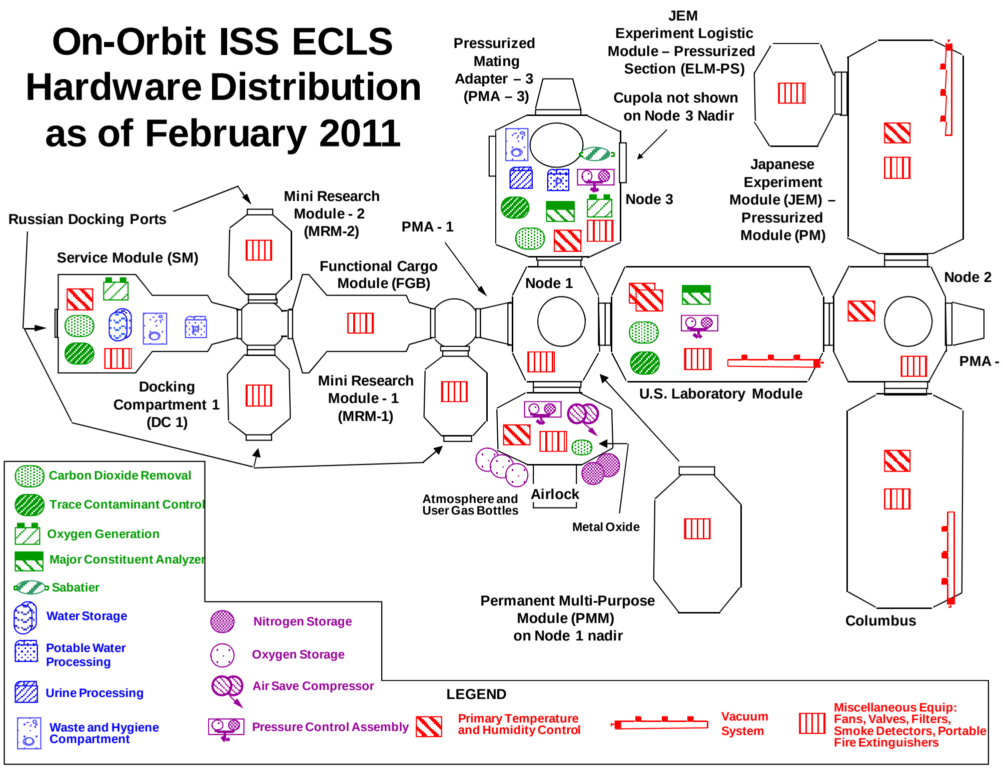

Figure 3 – ISS ECLS Hardware Distribution at the End of This Time Period Covered by This Paper

- Oxygen (O_2) supply via generation
- Atmosphere monitoring of major constituents, including CO_2, O_2, nitrogen (N_2), hydrogen (H_2), methane (CH_4), and water vapor (H_2O)

Temperature and Humidity Control:
- Cabin air temperature and humidity control
- Equipment air-cooling
- Inter- and intra-module ventilation for crew comfort and station level control of CO_2, O_2, and trace contaminants
- Airborne particulate and microbial control

Fire Detection and Suppression:
- Smoke detection
- Fire extinguishment

Atmosphere Control and Supply:
- Total pressure and O_2 partial pressure control during normal one-atmosphere operations and Extra Vehicular Activity (EVA) preparation in the Joint Airlock at 70 kPa (10.2 psia)
- Total pressure monitoring and loss of pressure (dp/dt) monitoring
- Stored gaseous N_2 and O_2 supply and replenishment
- Over/under pressure relief to maintain structural integrity
- Pressure equalization between modules

Water Recovery and Management:
- Potable and hygiene water supply
- Wastewater and urine water collection, recovery, and disposal

Waste Management:
- Urine/fecal collection, fecal storage and disposal, and urine transport to the Water Recovery and Management hardware

Vacuum System:
- Vacuum venting (1.2×10^{-3} torr-liters/sec at 10^{-3} torr) and maintenance (1.0×10^{-6} torr) for payload support.

The basic ISS ECLS design and architecture has been previously described and updated in papers previously written and presented at the International Conference on Environmental Systems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15]. This paper will focus on the ISS ECLS current status and updates between March 2010 until the end of February 2011, with activities that included the continuing permanent crew presence and the delivery of some of the final pressurized elements.

II. ISS ON-ORBIT OPERATIONS

Table 1 lists the ISS flight summary with special focus on key ECLS activities, Table 2 summarizes the Progress Resupply and Soyuz Taxis Flights to ISS, and Table 3 summaries the non-Russian Resupply Vehicles. There were fourteen flights to ISS from March 2010 until the end of February 2011. Of the fourteen flights nine were Russian flights. The nine Russian flights included four Soyuz flights, and five Progress flights. Two of the five non-Russian flights to ISS were the delivery of the third and fourth non-Russian resupply vehicles to ISS (i.e., the European Space Agency (ESA) Automated Transfer Vehicle (ATV) – 2 and the Japan Aerospace Exploration Agency (JAXA) H-II Transfer Vehicle (HTV) – 2. Of the three U.S. flights, one of them delivered a new pressurized module for the Russian Segment. A more detailed discussion of the key ECLS related occurrences on each flight for the year divided by Increments is provided below.

Table 1 - ISS Flight Summary

Incr.	Launch Date	Flight	Key Elements	Key Events (ECLSS related)
0	*20-Nov-98*	*1A/R*	*FGB (Zarya)*	*Unmanned launch*
	4-Dec-98	2A	Node 1 (Unity), PMA 1 and 2	First entry into ISS
	27-May-99	2A.1	SpaceHab	Logistics/maintenance flight
	19-May-00	2A.2a	SpaceHab	Logistics/maintenance flight
	12-July-00	*1R*	*Service Module (Zvezda)*	*Unmanned launch*
	8-Sept-00	2A.2b	SpaceHab	Logistic/maintenance flight; Entry into Service Module (SM); and A/C installation in the SM
	11-Oct-00	3A	Z1 truss, PMA 3	Z1 truss, PMA3 installation; Z1 dome pressurization
1	*31-Oct-00*	*2R*	*Soyuz TM*	*Permanent crew ops - Expedition 1(ISS Commander – Williams (Bill) Sheperd; Soyuz Commander – Yuri Gidzenko; and Flight Engineer- Sergei Kritkalev); Vozdukh, Elektron, 2nd A/C installation & activation*
	30-Nov-00	4A	P6 truss - solar arrays, radiators	U.S. power activation
	7-Feb-01	5A	Laboratory Module (Destiny)	U.S. Lab activation - AR rack installation and activation
2	8-Mar-01	5A.1	MPLM (Leonardo)	Expedition 2 replacement crew (ISS Commander – Yury Usachev; Flight Engineer – James Voss; Flight Engineer – Susan Helms); first payload rack; logistic transfer
	19-Apr-01	6A	MPLM (Raffaello), Space Station Robotic Manipulator System (SSRMS)	Logistics transfer, additional payload racks
	12-July-01	7A	Joint Airlock (Quest), High Pressure Gas Assemblies (2 O2 and 2 N2)	The last EVA was performed out of the Joint Airlock; USOS ACS activation and checkout
3	10-Aug-01	7A.1	MPLM (Leonardo)	Expedition 3 replacement crew (ISS Commander – Frank Culbertson; Soyuz Commander – Vladimir Dezhurov; and Flight Engineer – Mikhail Tyurin), logistic transfer, additional payload racks
	14-Sept-01	*4R*	*Docking Compartment 1 (Pirs)*	*EVA capability out of the Russian Segment; additional Soyuz/Progress Docking port*
4	5-Dec-01	UF1	MPLM (Raffaello)	Expedition 4 replacement crew (ISS Commander – Yury Onufrienko; Flight Engineer – Daniel Bursch; and Flight Engineer – Carl Walz), Logistic transfer
	8-Apr-02	8A	S0 Truss, Mobile Transporter (MT)	
5	5-June-02	UF2	MPLM (Leonardo); MBS	Expedition 5 replacement crew (ISS Commander – Valery Korzun; Flight Engineer – Peggy Whitson; and Flight Engineer Sergei Treschev) Logistics transfer, additional payload racks
	7-Oct-02	9A	S1 Truss	
6	24-Nov-02	11A	P1 Truss	Expedition 6 replacement crew (ISS Commander – Kenneth Bowersox; Flight Engineer – Donald Pettit; and Flight Engineer – Nikolai Budarin)
7	*26-Apr-03*	*6S*	*Soyuz TMA*	*Expedition 7 replacement crew (ISS Commander- Yuri Malenchenko; and Flight Engineer – Ed Lu)*

Note: Italics represent Russian flights. Progress and Soyuz Taxi flights not included.

Table 1 - ISS Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key Events (ECLSS related)
8	*18-Oct-03*	*7S*	*Soyuz TMA*	*Expedition 8 replacement crew (ISS Commander- Michael Foale; Flight Engineer – Alexander Kaleri); and Visiting Flight Engineer – Pedro Duque [ESA]*
9	*19-Apr-04*	*8S*	*Soyuz TMA*	*Expedition 9 replacement crew (ISS Commander- Gennady Padalka; Flight Engineer – Mike Fincke); and Visiting Flight Engineer – Andre' Kuipers [ESA]*
10	*14-Oct-04*	*9S*	*Soyuz TMA*	*Expedition 10 replacement crew (ISS Commander- Leroy Chiao; Flight Engineer – Salizhan Sharipov); and Visiting Flight Engineer – Yuri Shargin*
11	*15-Apr-05*	*10S*	*Soyuz TMA*	*Expedition 11 replacement crew (ISS Commander- Sergei Krikalev; Flight Engineer – John Phillips); and Visiting Flight Engineer – Roberto Vittori [ESA]*
	26-July-05	LF1	MPLM (Raffaello); ESP- 2	Logistics transfer, an additional payload rack, and a control momentum gyro (CMG)
12	*30-Sept-05*	*11S*	*Soyuz TMA*	*Expedition 12 replacement crew (ISS Commander- William McArthur; Flight Engineer –Valery Tokarev); and ISS Visitor – Gregory Olsen*
13	*29-Mar-06*	*12S*	*Soyuz TMA*	*Expedition 13 replacement crew (ISS Commander- Pavel Vinogradov; Flight Engineer –Jeffery Williams); and Brazilian Space Agency Astronaut - Marcos C. Pontes*
	4-July-06	ULF1.1	MPLM (Leonardo)	Expedition 13 third crewmember (Flight Engineer- Thomas Reiter (ESA)) Delivery of OGS Rack
	9-Sept-06	12A	P3/P4 Truss- solar arrays, radiator	
14	*18-Sept-06*	*13S*	*Soyuz TMA*	*Expedition 14 replacement crew (ISS Commander- Michael Lopez-Alegria; Flight Engineer –Mikhail Tyurin); and ISS Visitor – Anousheh Ansari*
	9-Dec-06	12A.1	P5 Truss; SpaceHab; ICC	Expedition 14 replacement crew (Flight Engineer- Sunita Williams replacing Thomas Reiter (ESA))
15	*7-Apr-07*	*14S*	*Soyuz TMA*	*Expedition 15 replacement crew (ISS Commander- Fyodor Yurchikhin; Flight Engineer - Oleg Kotov); and ISS Visitor – Charles Simonyi*
	9-June-07	13A	S3/S4 Truss- solar arrays, radiator	Expedition 15 replacement crew (Flight Engineer- Clay Anderson replacing Sunita Williams)
	8-Aug-07	13A.1	S5 Truss; SpaceHab; ESP-3	
16	*10-Oct-07*	*15S*	*Soyuz TMA*	*Expedition 16 replacement crew (ISS Commander- Peggy Whitson; Flight Engineer – Yuri Malenchenko); and ISS Visitor – Muszaphar Shukor Al Masri*
	23-Oct-07	10A	Node 2 (Harmony)	Expedition 16 replacement crew (Flight Engineer- Dan Tani replacing Clay Anderson)
	7-Feb-08	1E	Columbus Module; ICC-Lite	Expedition 16 replacement crew (Flight Engineer- Leo Eyharts (ESA) replacing Dan Tani)

Note: Italics represent Russian flights. Progress and Soyuz Taxi flights not included.

Table 1 - ISS Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key Events (ECLSS related)
	11-Mar-08	1J/A	Japanese Experiment Logistics Module-Pressurized Section (ELM-PS) and part of "Kibo"; Canadian Special Purpose Dexterous Manipulator (SPDM) "Dextre"	Expedition 16 replacement crew (Flight Engineer- Garrett Reisman replacing Leo Eyharts (ESA))
17	*8-Apr-08*	*16S*	*Soyuz TMA*	*Expedition 17 replacement crew (ISS Commander- Sergei Volkov; Flight Engineer – Oleg Valeriavich Kononenko); and ISS Visitor – So-yeon Yi*
	31-May-08	1J	Japanese Experiment Module – Pressurized Module (JEM-PM) a part of "Kibo"; and the Japanese Remote Manipulator System (RMS)	Expedition 17 replacement crew (Flight Engineer- Greg Chamitoff replacing Garrett Reisman
18	*12-Oct-08*	*17S*	*Soyuz TMA*	*Expedition 18 replacement crew (ISS Commander- Michael Fincke; Flight Engineer – Yuri Lonchakov); and ISS Visitor – Richard Garriott*
	14-Nov-08	ULF2	MPLM (Leonardo)	Expedition 18 replacement crew (Flight Engineer- Sandra Magnus replacing Greg Chamitoff) Delivery of WRS Rack 1&2, WHC, and other 6 crew hardware.
	15-Mar-09	15A	S6 Truss - solar arrays, radiator	Expedition 18 replacement crew (Flight Engineer- Koichi Wakata (JAXA) replacing Sandra Magnus)
19	*26-Mar-09*	*18S*	*Soyuz TMA*	*Expedition 19/20 replacement crew (ISS Commander - Gennady Ivanovich Padalka, Flight Engineer - Dr. Michael Barratt); and ISS Visitor Charles Simonyi (on his second ISS visit)*
20	*27-May-09*	*19S*	*Soyuz TMA*	*ISS starts 6 crew members operations on ISS with Expedition 20 (Future Expedition 21 Commander –Frank DeWinne (ESA), Flight Engineer – Roman Romanenko, and Flight Engineer – Bob Thirsk (CSA))*
	15-July-09	2J/A	Japanese Exposed Facility a part of "Kibo"	Expedition 20 replacement crew (Flight Engineer- Tim Kopra replacing Koichi Wakata (JAXA))
	28-Aug-09	17A	MPLM (Leonardo)	Expedition 20 replacement crew (Flight Engineer- Nicole Stott replacing Tom Kopra) Delivery of the Node 3 AR Rack.
21	*30-Sept-09*	*20S*	*Soyuz TMA*	*Expedition 21 replacement crew (Future Expedition 22 Commander - Jeffery Williams and Flight Engineer – Maxime Suraev); and ISS Visitor Guy Laliberté*
	10-Nov-09	*5R*	*MRM 2 [Mini Research Module 2] (Poisk)*	*Will replace DC 1 for EVA capability out of the Russian Segment; fourth Soyuz/Progress Docking port on SM Zenith; and it allows scientific research*
	16-Nov-09	ULF3	Two Express Logistic Carriers with unpressurized cargo	Delivery of the 3rd Airlock Oxygen Tank and the 5th Airlock ECLS gas tank
22	*20-Dec-09*	*21S*	*Soyuz TMA*	*Expedition 22 replacement crew (Future Expedition 23 Commander – Oleg Kotov, Flight Engineer – Soichi Noguchi (JAXA), and Flight Engineer – Timothy J. Creamer)*

Note: Italics represent Russian flights. Progress and Soyuz Taxi flights not included.

Table 1 - ISS Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key Events (ECLSS related)
	8-Feb-10	20A	Node 3 (Tranquility) and Cupola	Final home for the OGS Rack, WRS Rack 1 & 2, WHC, and Node 3 AR Rack.
23	*2-Apr-10*	*22S*	*Soyuz TMA*	*Expedition 23 replacement crew (Future Expedition 24 Commander – Alexander Skvortsov, Flight Engineer – Tracy Caldwell-Dyson, and Flight Engineer – Mikhail Kornienko*
	5-Apr-10	19A	MPLM (Leonardo) and LMC	Logistics transfer, additional payload racks, and the Commercial Sabatier
	14-May-10	ULF4	MRM 1 (Mini Research Module 1) [Rassvet (Dawn)] and ICC with unpressurized cargo	
24	*15-June-10*	*23S*	*Soyuz TMA*	*Expedition 24 replacement crew (Future Expedition 25 Commander – Doug Wheelock, Flight Engineer - Shannon Walker and Flight Engineer - Fyodor Yurchikhin*
25	*7-Oct-10*	*24S*	*Soyuz TMA-M*	*Expedition 25 replacement crew (Future Expedition 26 Commander - Scott Kelly, Flight Engineer - Alexander Kaleri, and Flight Engineer - Oleg Skripochka*
26	*15-Dec-10*	*25S*	*Soyuz TMA-M*	*Expedition 26 replacement crew (Future Expedition 27 Commander – Dmitry Kondratyev, Flight Engineer - Catherine Coleman, and Flight Engineer - Paolo Nespoli (ESA))*
	24-Feb-11	ULF5	PMM (Permanent Multipurpose Module) [The former MPLM Leonardo] and Express Logistic Carriers with unpressurized cargo	Modified MPLM for Additional On-Orbit Stowage

Note: Italics represent Russian flights. Progress and Soyuz Taxi flights not included.

Acronyms:
FGB - Functional Cargo Block
A/C - Air Conditioner
AR - Atmosphere Revitalization
EVA – Extra Vehicular Activity
MPLM – Multi-Purpose Logistic Module
USOS – United States On-Orbit Segment
Incr - Increment
Z - Zenith
S – Starboard
P – Port
MBS – Mobile Base System
U.S. – United States
ICC – Integrated Cargo Carrier
ESP - External Stowage Platform
ACS – Atmosphere Control and Storage
PMA – Pressurized Mating Adapter
WRS – Water Recovery System
WHC – Waste and Hygiene Compartment
OGS – Oxygen Generation System

Increment 22:

Increment 22 crew members were ending their stay on ISS at the start of the time period that is described in this paper. On March 1st the crew noticed as they were preparing to complete the Node 1 to Node 3 vestibule fine leak check, that they had not replaced the Node 3 starboard positive pressure relief valve (PPRV) with the Node 3 manual pressure equalization valve (MPEV). Due to this oversight it was decided by the ground team to defer the valve swap and the fine leak check task until the next day. That same day, the crew also reported that the Waste and Hygiene Compartment (WHC) had a "Pretreat Bad Quality" light illuminated on the Russian provided toilet, commonly called by its Russian acronym ACY, control panel. The crew investigated this problem and found a kinked hose between the dose pump and the pump separator along with air bubbles in the flush water tank. The crew straightened the hose as best as they could, but they had trouble removing the bubbles that were trapped in flush water tank. To resolve this problem, it was decided to replace the flush water tank with a new tank that contained bubble free water. These maintenance tasks reestablished the WHC back to nominal operation.

The next day, the crew performed a couple of ECLS tasks and leak checks. The first thing that the crew did was to remove the Node 3 starboard PPRV and replace it with an MPEV. The second task that they did was to attach the Node 3 nitrogen line to the Total Organic Carbon Analyzer (TOCA) water quality monitor. After these tasks were completed, the crew removed the Intermodule Ventilation (IMV) ducts, closed the Node 1 and Node 3 hatches, depressurized the Node 1 to Node 3 vestibule, and attached a pressure gauge to the Node 1 hatch to monitor the Node 1 to Node 3 vestibule leakage. While these tasks were performed, the ground monitored for leakage from the newly installed TOCA nitrogen line. On March 3rd after completion of the successful leak checks, the Node 1 to Node 3 hardware was reconfigured to support nominal operations and the TOCA was declared ready to support nominal operations at its new location. After the crew ingressed Node 3, they repressurized Pressurized Mating Adapter (PMA) – 3 so that they could perform a leak check of PMA – 3 prior to ingressing PMA – 3. After a successful PMA – 3 leak check, the crew ingressed PMA -3 and stowed ~ 17 crew transfer bags (CTBs) in PMA - 3. They then reconfigured the Node 3 to PMA – 3 interface so that PMA – 3 could be depressurized.

On March 8th the WHC had another failure. The crew reported to the ground that the WHC was not functioning and the "Check Separator" light was illuminated on the AYC control panel. The crew tried some simple troubleshooting steps, but had no success restoring WHC functionality. The ground controllers had the crew stand down while they came up with some new procedures to troubleshoot the problem. The next day, the crew was directed to remove and replace (R&R) the WHC pump separator and to fix the orientation of the pump separator cooling duct. Unfortunately this did not correct the problem, so on March 10th the crew demated, inspected, and remated the six connectors between the pump separator and the separator control unit along with replacing the urine hose. Since no problems were found with the connectors, the crew was directed to R&R the pump separator control unit. After the R&R was completed, the crew found that the check separator failure light illuminated again after two restart attempts. So the ground directed the crew to R&R the ACY control panel and then performs testing of the WHC, which determined the R&R had not resolved the problem. After standing down for another day, the ACY engineers figured out that the control logic of the ACY had drained the pump separator after each start up attempt following the pump separator R&R. Therefore, every time the WHC was restarted after the R&R, the control logic illuminated on the ACY control panel light was due to a failed leak check caused by having too little fluid in the WHC pump separator at start up. When the crew inhibited the pump separator internal fluid quantity sensors the pump separator was refilled and the WHC successfully proceeded through a nominal startup.

While part of the crew was dealing with the WHC problem, some of the other crew members installed the Japanese Experiment Module (JEM) – Pressurized Module (PM) Scientific Airlock vacuum pump on March 8th to allow gas recovery of the air in the Scientific Airlock when the crew needed to transfer materials from the JEM – PM to the JEM – Exposed Facility (EF) and vice versus. Two days after the installation of the vacuum pump, the ground started to notice that the Node 3 Carbon Dioxide Removal Assembly (CDRA) was experiencing an erratic bed temperature sensor in the front CDRA bed. Also on that same day, the crew took photographs of the pre-treated urine (PTU) - tee valve so that the ground could determine what part was needed to fly on the next Space Shuttle flight to recover the valve that had failed after the WRS Racks had been transferred to Node 3.

On March 18th Increment 22 came to an end when the Soyuz TMA-16/20S undocked from Mini-Research Module (MRM) 2 and landed later that day in the steppes of Kazakhstan with Maxime Suraev and Jeffery Williams onboard.

<u>Increment 23:</u>

Increment 23 started with the undocking of the Soyuz and the ISS crew size being temporarily being reduced to three crew members. Five days after the Soyuz departed ISS the crew and the ground received a Water Processor Assembly (WPA) low temperature fault. After reviewing the data overnight the ground commanded the WPA back into process mode, since it was a signature similar to an earlier fault. However, as the WPA heaters were heating up during startup, the crew received another low temperature fault that shut down the WPA. To rule out a leak in the system, the ground closed the WPA catalytic reactor outlet valve to determine if the WPA low temperature fault was due to leakage of water. The data indicated a leak, but the data was inconclusive for isolating the leak location so the ground decided to shutdown the WPA and remove power. After the power was removed the crew inspected the standoff between Water Recovery System Rack (WRS) Rack 1 & 2 and inside both Racks for evidence of a water leak. The crew did not find any free water during the visual inspection. On March 26th, the ground commanded the WPA isolation valve 1126-1 closed and monitored WPA pressures overnight. This action resulted in being able to isolate the leak location to the WPA catalytic reactor. March 30th the crew inspected the WPA catalytic reactor and found water underneath the catalytic reactor thermal cover. With the location of the leak determined, the crew re-assembled the WPA catalytic reactor and re-installed it into the WPA so that WPA waste water tank could be drained. This was necessary since the WPA waste water tank was full and draining it would allow the crew to use the tank to store additional waste water prior to delivery of the replacement catalytic reactor Orbital Replacement Unit (ORU) on the next Space Shuttle flight.

On that same day that the ground had attempted to restart the WPA, the crew began to perform the in-flight maintenance task to repair the Node 3 CDRA by installing the jumper wires in the CDRA bed #2 to recover from the erratic B temperature sensor that could, if left alone, shutdown CDRA. On March 25th, the crew finished the CDRA in-flight maintenance task and reinstalled the bed in the rack. After the maintenance task was finished, the ground successfully powered up CDRA to verify that the CDRA was operational after the temperature sensor was bypassed.

On March 31st the ground directed the crew to drain the WPA waste water tank prior to the launch of the next Soyuz and Space Shuttle flights. While the crew was draining the tank, they received a Node 3 Hub Control Zone (HCZ) Multiplexer/Demultiplexer (MDM) – 2 Ada exception, which caused the MDM to go to a diagnostic mode. The ground had to reconfigure to the backup MDM in order to re-establish communication with the equipment in Node 3. The next day the ground was able to determine that the Ada exception was due to the WPA waste water tank indicated less than zero after the tank had been off loaded.

22S:

On April 2nd Soyuz 22S launched from Baikonur and docked to MRM 2 two days later. This flight returned the station crew size to six again. The same day the Soyuz launched the ground informed the ISS crew to update their procedure to not draining the WPA water tank below an indicated zero quantity to prevent another HCZ MDM Ada software exception.

19A:

On April 5th the Space Shuttle Flight 19A launched from Kennedy Space Center (KSC) and docked to ISS on April 7th. The day the Space Shuttle launched to ISS, the ISS crew installed the old Oxygen Generation System (OGS) Water Delivery System (WDS) to allow stored potable water to be supplied to the potable water bus while the WPA was off-line. After installation of the WDS, the crew started to flush the potable water bus by drawing water out of the bus at the Potable Water Dispenser (PWD) in the United States (U.S.) Laboratory Module. Unfortunately, only a small amount of water came from the bus. The ground discussed the problem and discovered that the flex hose that they had the crew use had a check valve in the middle of it and that the flex hose was installed opposite of the intended water flow. That next day the crew continued to get ready for the Space Shuttle by pressurizing PMA – 2, installing the modified IMV ducting in Node 2 to minimize CO2 levels on the Space Shuttle while docked to ISS, and configuring the Airlock oxygen system to allow the Space Shuttle to supply the oxygen for extravehicular activity (EVA) preparations in the Airlock. On April 7th the Space Shuttle docked to ISS and the crew reversed the flex hose that contained the check valve, which allowed the crew to finally get stored potable water delivered to the PWD.

During the docked operation the joint crew performed three EVAs, transferred five racks to ISS (i.e., the Crew Quarter [CQ] Rack, the Window Observation Research Facility [WORF] Rack, the Minus Eighty-degree Laboratory Freezer for ISS – 3 [MELFI – 3] Rack, the Express Rack – 7 [ER – 7], and the Muscle Atrophy Research and Exercise System [MARES]), R&R'ed the WPA catalytic reactor, repaired the Pre-Treat Urine (PTU) tee valve by replacing a failed retaining ring, filled 7 Contingency Water Containers (CWCs) with silver biocide water, and filled 8 CWC – Iodine (CWC – I) with iodine water. After the R&R of the WPA catalytic reactor and the successful reactivation of the WPA to deliver potable water to the potable water bus, the crew disassembled and stowed the OGS WDS. The Space Shuttle undocked on April 17th and landed at KSC on April 20th.

Two days after the Space Shuttle undocked, the ISS crew started the regeneration of the EVA METOX canisters. Unfortunately the crew did not feel well during the METOX regeneration which was assumed to be caused by elevated CO2 levels. To compensate for this concern the ground increased the CDRA fan speed, which dropped the ppCO2 levels a little more than 1 mmHg (0.02 psia). The next day the crew re-installed PTU tee valve hose and had the pre-treated urine delivered from the WHC to the Urine Processor Assembly (UPA). Starting on April 24th and continuing the next two days the crew relocated the treadmill – 2 (T-2) Rack from Node 2 to Node 3. After the T-2 Rack movement from Node 2 to Node 3, the crew installed the newly delivered CQ Rack into Node 2 overhead rack bay.

37P:

Progress 37P launched from Baikonur on April 28th and docked to ISS at Docking Compartment (DC) 1 on May 1st. The day the Progress launched the OGS was re-activated at 100% capability and the ground monitored the

Table 2 - Progress Resupply and Soyuz Taxis Flight Summary

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
0	6-Aug-00	1P	Progress M1 (Progress 251)	Delivery of SM Elektron; Elektron support hardware; Solid Oxygen Cartridges and support hardware; DSD pressure alarm system; Vozdukh rotary equipment, control panels and support hardware; water supply system hardware for Elektron; Rodnik accessory hardware; SRV-K catalytic oxidizer; Air Conditioning system assembly kit; and some ventilation system hardware
1	16-Nov-00	2P	Progress M1 (Progress 253)	Delivery of FGB dust filter; RS Depressurization Airflow Sensors; Solid Oxygen Cartridges; spare BMP fan; spare Elektron parts; spare SM Gas Analyzer parts; spare Vozdukh parts; spare SRV-K parts; spare water supply hardware for the Elektron; Rodnik accessory hardware; spare FGB fans; second SM Air Conditioning unit; and SM Air Conditioning support hardware
	26-Feb-01	3P	Progress M (Progress 244)	Delivery of spare FGB smoke detectors and dust filters; Vozdukh spare parts; SM Gas Analyzer spare parts; SM Gas Analyzer Calibration Gas Assembly; N2 Purge Assembly; spare Solid Oxygen system parts; spare SRV-K parts; Toxic Spill masks; spare ventilation system fans and hardware; and spare SM Air Conditioning system parts
2	28-Apr-01	2S	Soyuz TM (Soyuz 206)	Soyuz Commander - Talgat Musabayev; Soyuz Flight Engineer – Yury Baturin; ISS Visitor – Dennis Tito
	20-May-01	4P	Progress M1 (Progress 255)	Delivery of spare FGB ventilation system fans and dust filters; 6 SM LiOH cartridges, spare SM LiOH fan; KKT payload vacuum access hardware; acoustic reduction hardware for the Vozdukh; spare Elektron water supply hardware; spare SRV-K hardware; SM ventilation system fans and dust filters; and SKV 1 compressor and condensate collection device
3	21-Aug-01	5P	Progress M (Progress 245)	Delivery of spare FGB dust filters; spare SM smoke detectors; spare Gas Analyzers for the Elektron; spare BMP parts; spare Vozdukh parts; spare SRV-K parts; spare Rodnik parts; SKV-1 power supply; and spare ventilation system fans
	21-Oct-01	3S	Soyuz TM (Soyuz 207)	Soyuz Commander – Victor M. Afanasyez; Soyuz Flight Engineer – Konstantin M. Kozeev; and Soyuz Flight Engineer – Claudie Haignere' (CNES) Plus delivery of DDI pressure sensor parts; repair kit for POTOK-150MK air decontamination equipment; spare ventilation system fans and parts
	26-Nov-01	6P	Progress M1 (Progress 256)	Delivery of spare FGB ventilation system fans; spare gas masks; spare FGB dust filters; spare SM smoke detector controller and power supply; spare BMP parts; new pressure manometer; spare water supply hardware to support the Elektron; spare SRV-K parts; soft Rodnik tanks; SKV parts; and SM dust filters
4	21-Mar-02	7P	Progress M1 (Progress 257)	Delivery of spare FGB smoke detectors; spare FGB dust filter fans and filters; Vozdukh cable; SRV-K spare parts; spare water supply hardware for Elektron; spare SM dust filters; and spare ventilation system fans
	25-Apr-02	4S	Soyuz TM (Soyuz 208)	Soyuz Commander – Yuri Gidzenko; Soyuz Flight Engineer – Roberto Vittori (ESA); and ISS Visitor – Mark Shuttleworth

Table 2 - Progress Resupply and Soyuz Taxis Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
5	26-June-02	8P	Progress M (Progress 246)	Delivery of spare FGB ventilation system fans; spare DC1 smoke detectors; spare BMP filter; spare SM Gas Analyzer CO2 filters; Vozdukh CO2 sensor filter; spare water supply hardware for Elektron; Elektron pressure monitoring equipment; new design SM LiOH; spare SRV-K hardware; and Rodnik accessory hardware
	25-Sept-02	9P	Progress M1 (Progress 258)	Delivery of Vozdukh switch guard and spare part; spare Elektron Liquid unit, cables, and test panel; experimental Elektron air/water separator; spare SRV-K hardware; spare SM smoke detectors; and FGB dust filters
	30-Oct-02	5S	Soyuz TMA (Soyuz 211)	Soyuz Commander – Sergei Zalyotin; Soyuz Flight Engineer – Yuri Lonchakov; and Soyuz Flight Engineer – Frank De Winne (ESA)
6	2-Feb-03	10P	Progress M (Progress 247)	Delivery of new BMP filter; spare SM Gas Analyzer parts; spare Vozdukh parts; spare water supply hardware for Elektron; spare SRV-K hardware; spare fire extinguishers; spare ventilation system fan; new frames for SM dust filters; spare SKV condensate pump; spare FGB smoke detectors; and spare FGB dust filter fans and filters
7	8-June-03	11P	Progress M1 (Progress 259)	Delivery of SM Gas Analyzer spare parts; spare Elektron Liquid Unit; SRV-K spare parts; Rodnik accessory hardware; one Rodnik tank mounted in the cargo compartment; spare FGB fire extinguishers; spare FGB dust filters; and *two CDRA Air Selector Valves*
	30-Aug-03	12P	Progress M (Progress 248)	Delivery of two new SM LiOH canisters; new pressure manometer; spare BMP part; SM Gas Analyzer spare parts; spare Vozdukh parts; Elektron Nitrogen Purge Unit; SRV-K spare parts; Rodnik accessory hardware; spare gas masks; spare SM smoke detectors; spare DC1 smoke detectors; SKV-2 spare parts; air circulation equipment; FGB smoke detector cleaning unit; *US Hepa filters*
8	29-Jan-04	13P	Progress M1 (Progress 260)	Delivery of GANK gas analyzer; spare Elektron Liquid Unit; Vozdukh spare parts; SRV-K spare parts; SM ventilation system parts; FGB dust filters; FGB smoke detectors; and *CDRA air selector valve sock filters*
9	25-May-04	14P	Progress M (Progress 249)	Delivery of two new SM LiOH canisters, Elektron Nitrogen Purge Unit; and SRV-K spare parts
	11-Aug-04	15P	Progress M1 (Progress 350)	Delivery of one new SM LiOH canisters, SM Gas Analyzer spare parts; Elektron Cables; and SRV-K spare parts; SM Smoke Detectors; DC1 Smoke Detectors; Dust Filters; Replacement Condensate Lines; and *U.S. MCA Mass Spectrometer ORU and Flight Support Equipment*
10	24-Dec-04	16P	Progress M1 (Progress 351)	Delivery of one H2 in O2 Gas Analyzer; Rodnik support HW; SRV-K spare parts; and FGB Dust Filters
	28-Feb-05	17P	Progress M (Progress 352)	Delivery of newly designed Solid Oxygen Cartridges; newly designed Solid Oxygen Generator; spare Vozdukh parts; Elektron Nitrogen Purge Unit; container with electrolyte for Elektron; SRV-K spare parts; spare SM Dust Filters; a SM Crew Quarter Fan and Acoustic kit; and FGB smoke detectors

Table 2 - Progress Resupply and Soyuz Taxis Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
11	16-June-05	18P	Progress M (Progress 353)	Delivery of newly designed Solid Oxygen Cartridges; spare Vozdukh parts; spare Elektron parts; Elektron Nitrogen Purge Unit; container with electrolyte for Elektron; SRV-K spare parts; spare SM dust filters; spare FGB dust filters; spare FGB gas masks; and *U.S. MPEV ISA replacement o-rings*
	8-Sept-05	19P	Progress M (Progress 354)	Delivery of newly designed Solid Oxygen Cartridges; spare Vozdukh parts; spare Elektron Liquid Unit; spare BMP part; SM Gas Analyzer spare parts; SRV-K spare parts; spare SM smoke detectors; spare ventilation fans and vibration isolation mounts; SKV spare parts; and SM dust filters
12	21-Dec-05	20P	Progress M (Progress 355)	Delivery of newly designed Solid Oxygen Cartridges; spare Vozdukh parts; spare Elektron Liquid Unit; Elektron Nitrogen Purge Unit; spare Elektron parts; SRV-K spare parts; Rodnik accessory hardware; spare gas masks; FGB dust filters, *U.S. TCCS Sorbent Bed Assembly (SBA)*
13	24-Apr-06	21P	Progress M (Progress 356)	Delivery of a spare Elektron data interface box; a new Elektron H2 vent kit; spare SRV-K parts; spare portable fire extinguishers; and spare smoke detectors
	24-June-06	22P	Progress M (Progress 357)	Delivery of 3 Russian LiOH cans; SM gas analyzer spare parts; spare Vozdukh parts; spare Russian water system and SRV-K parts; a spare ventilation fan; spare FGB smoke detectors; and replacement air duct
14	26-Oct-06	23P	Progress M (Progress 358)	Delivery of 3 Russian LiOH cans; the new solid oxygen generator and control panel; Elektron spare parts; spare Russian water system and SRV-K parts; spare SM smoke detectors; and *U.S. replacement IMV Valve*
	18-Jan-07	24P	Progress M (Progress 359)	Delivery of 2 new -3 solid oxygen generators; new -3 solid oxygen cartridges; SM gas analyzer spare parts; spare Vozduhk parts; spare Liquid Unit; spare Elektron parts; spare SRV-K parts; and spare FGB dust filters
15	12-May-07	25P	Progress M (Progress 360)	Delivery of 4 Russian LiOH cans; SM gas analyzer spare parts; spare Vozdukh parts; spare Russian water system and SRV-K parts; FGB smoke detectors and smoke detector cleaning kit; and *U.S. Clean Room Gloves*
	2-Aug-07	26P	Progress M (Progress 361)	Delivery of 3 Russian LiOH cans; Vozdukh spare parts; spare Russian water system and SRV-K parts; SM smoke detectors; FGB Dust Filters; *3 U.S. Hepa Filters; and U.S. Clean Room Gloves*
16	23-Dec-07	27P	Progress M (Progress 362)	Delivery of Vozdukh spare parts; spare Elektron parts; spare Russian water system and SRV-K parts; DC1 smoke detectors; 2 spare ventilation fans; 1 SM Fire Extinguisher; *6 U.S. Hepa Filters*
	5-Feb-08	28P	Progress M (Progress 363)	Delivery of 2 Russian LiOH cans; SM gas analyzer spare parts; spare Elektron parts; spare Russian water system and SRV-K parts; Russian 0.2 micron water filters; set of new condensate lines; FGB dust filters; and *U.S. Regen ECLS Modification Kit hose*

Table 2 - Progress Resupply and Soyuz Taxis Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
17	14-May-08	29P	Progress M (Progress 364)	Delivery of spare pressure sensors; spare BMP fan; water microbial filter; spare water system parts; spare ventilation fan; Freon 218 resupply tanks; spare FGB gas masks; spare FGB smoke detectors; smoke detector cleaning unit; and *U.S. Regen ECLS Modification Kit hoses, wires, brackets, closeout cover, and purge adapter*
	10-Sept-08	30P	Progress M (Progress 365)	Delivery of Elektron power supply EMI filter; spare SRV-K and water system parts; and *U.S. Waste and Hygiene ASU parts*
18	26-Nov-08	31P	Progress M (Progress 401)	Delivery of accessories kit to replace Vozdukh bed; spare SRV-K and water system parts; replacement SM Gas Masks; replacement SM Smoke Detectors; replacement FGB dust filters; FGB air decontamination unit; Soyuz replacement fan; and *U.S. Waste and Hygiene ASU parts*
	10-Feb-09	32P	Progress M (Progress 366)	Delivery of spare Gas Analyzer hardware; spare Vozdukh CO2 analyzer; spare Elecktron Gas Analyzer; spare water system parts; and *U.S. Waste and Hygiene ASU parts*
19	7-May-09	33P	Progress M (Progress 402)	Delivery of portable air pressurization tank; spare SRV-K and water system parts; spare SM ASU parts; spare air/water separator parts; spare SM dust filters; spare SM fire extinguishers and gas masks; fire system data processing hardware; and *U.S. Waste and Hygiene ASU parts*
20	24-July-09	34P	Progress M (Progress 367)	Delivery of 3 Russian LiOH cans; spare SRV-K and water system spare parts; spare SM ASU parts; spare SM dust filters; spare condensate lines; spare FGB dust filters; *spare OGA H2 Sensor ORU; and U.S. Waste and Hygiene ASU parts*
21	14-Oct-09	35P	Progress M (Progress 403)	Delivery of 2 Elektron Liquid Unit Kits; SRV-K and water system spare parts; SM ASU spare parts; spare SM dust filters; 1 spare DC 1 fire extinguisher; *and U.S. Waste and Hygiene ASU parts*
22	3-Feb-10	36P	Progress M (Progress 404)	Delivery of SRV-K and water system spare parts; SM ASU spare parts; spare SM dust filters; spare FGB dust filters; *and U.S. Waste and Hygiene ASU parts*
23	28-Apr-10	37P	Progress M (Progress 405)	Delivery of a Russian LiOH can; SM gas analyzer spare parts; spare Elektron valve; SRV-K and water system spare parts; spare SM ASU parts; spare FGB fan; spare MRM1 fire extinguisher and gas mask; *and U.S. Waste and Hygiene ASU parts*
24	30-June-10	38P	Progress M (Progress 406)	Delivery of spare Vozdukh air save pump; SRV-K spare parts; spare SM ASU parts; 3 new gas masks including 1 for MRM 2; a spare fan and dust filters; a spare set of condensate lines; a rigid air duct for MRM 1; *and U.S. Waste and Hygiene ASU parts*
	10-Sept-10	39P	Progress M (Progress 407)	Delivery of spare Vozdukh air save pump; SRV-K and water system spare parts; spare SM ASU parts; 4 new gas masks; SM fan damping equipment and dust filters; a spare heat exchanger and replacement hardware; FGB dust filters; *OGA differential pressure sensor replacement kit; and OGA hydrogen sensor ORU*

Table 2 - Progress Resupply and Soyuz Taxis Flight Summary (cont'd)

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
25	26-Oct-10	40P	Progress M (Progress 408)	Delivery of SRV-K and water system spare parts; spare SM ASU parts; 7 spare smoke detectors; spare dust filters; ATV fire extinguisher; *UPA RFCA; WRS high flow transfer pump replacement parts; and U.S. Waste and Hygiene ASU parts*
26	27-Jan-11	41P	Progress M (Progress 409)	Delivery of Freon analyzer; SM gas analyzer; SRV-K and water system spare parts; spare SM ASU parts; a spare fan and dust filters; spare FGB and DC 1 smoke detectors; DC 1 IMV duct; 2 spare MRM 1 fans and ducting; *and U.S. Waste and Hygiene ASU parts*

Table 3 – Non-Russian Resupply Vehicle Flight Summary

Incr.	Launch Date	Flight	Key Elements	Key ECLS Hardware Delivery
16	8-Mar-08	ATV 1	ATV (Jules Verne)	Demonstration flight for ESA's unmanned logistic resupply vehicle
20	10-Sept-09	HTV 1	HTV 1	Demonstration flight for JAXA's unmanned logistic resupply vehicle and scavenged the HTV 1 smoke detector prior to HTV 1 departure *Delivery of spare U.S. WHC ASU components, Hepa filters, and IMV cap o-rings*
26	22-Jan-11	HTV 2	HTV 2 [Kounotori (White Stork)]	Second flight for JAXA's unmanned logistic resupply vehicle *Delivery of the Amine Swingbed CO2 Removal Assembly payload, teflon bags for O2 maintenance, some new fire hole decals, spare MCA connector savers, spare OGS H2 sensors, spare WPA particulate filter ORU, spare WPA pump separator ORU, spare CDRA blower/precooler ORU, spare CDRA two stage pump ORU, spare TCCS blower assembly ORU, two spare WPA hoses, spare UPA RFTAs, and four CWC-Is filled with water*
	16-Feb-11	ATV 2	ATV (Johannes Kepler)	Second flight for ESA's unmanned logistic resupply vehicle *Delivery of spare U.S. WPA Multifiltration Beds, spare UPA RFTAs, some UPA FCA cables, three MRK Fans with 6 screens, a medium ammonia respirator kit, a large ammonia respirator kit, a spare CDRA Absolute Pressure Transducer, and a spare CO2 solenoid valve*

pump delta pressure. Nine days after the Progress docked to ISS the crew removed and replaced (R&R'ed) the expired WHC flush water Activated Carbon / Ion Exchange (ACTEX) to be able to remove the iodine from the flush water prior to being used in the ACY. The next day the crew inadvertently connected the U.S. Lab condensate tank to the waste bus while the WPA waste tank was still connected. Due to this configuration the WPA waste tank transferred its contents to the U.S. Lab condensate tank. This caused two problems. The first problem was that the WPA waste tank filled the condensate tank above its limited life 60% quantity level. The second problem was that urine distillate and condensate water mixed in the condensate tank. This was a problem since there was no way to transfer the water back into the WPA waste tank and the Russian's would not process it in their SRV-K. The ground decided to have the crew drain the condensate tank into some unused EDVs until they could decide what to do with the water mixture.

ULF-4:

On May 14th the Space Shuttle Flight ULF-4 launched from Kennedy Space Center (KSC) and docked to ISS on May 16th. During the docked operation, the joint crew performed three EVAs, delivered and installed the MRM 1 on the FGB nadir docking port, R&R'ed the Oxygen Generation Assembly (OGA) Water Orbital Replacement Unit (ORU) due to the high delta pressure in the recirculation loop, R&R'ed one of the two Node 3 CDRA beds, transferred 10.5 lbm (4.8 kg) of GN2 and 44 lbm (20 kg) GO2 from the Space Shuttle to the Joint Airlock tanks, filled 5 Contingency Water Containers (CWCs) with silver biocide water, filled 3 Payload Water Reservoirs (PWRs), and filled 18 CWC – Iodine (CWC – I) with iodine water. On May 20th the crew ingressed MRM 1 and noticed some metal shavings floating inside the new module. It was decided by the ground to have the crew close the hatch for 24 hours and turn on the ventilation system so that its filter could remove the debris from the air. Three days after the R&R of the OGA Water ORU, the OGS shutdown due to a low pump delta pressure reading on May 22nd. Due to the availability of sufficient oxygen stores onboard and the busy near term timeline, it was decided to postpone the investigation of the OGA pump pressure problem until after the start of the next Increment. The Space Shuttle flight came to an end when it undocked on May 24th and landed at KSC on May 26th.

On June 1st Increment 23 came to an end when the Soyuz TMA-17/21S undocked from the Service Module and landed later that day in the steppes of Kazakhstan with Oleg Kotov, Soichi Noguchi and Timothy Creamer onboard.

Increment 24:

Increment 24 started after the undocking of the Soyuz 21S and the ISS crew size being temporarily being reduced to three crew members. Two days after the Soyuz left ISS, the crew saw a WHC Bad Pre-Treat Indication light after three uses following an automatic flush water fill. This fault had been seen before so the ground team instructed the crew to activate the dose pump six more times to move any potential air bubbles out of the system. Since the procedure was not successful, the ground had the crew check the pre-treat lines for bends or kinks. The crew verified the lines were not bent or kinked and were given a go ahead to use the WHC eight more times assuming that if a bubble had gotten into the flush water tank that it would eventually pass through the system. The next day the crew reported that the WHC light had gone out solving the problem. That same day the crew also started to troubleshoot the OGA pump ORU pressure sensor, which had failed low during the last Space Shuttle mission to ISS. The OGA pump ORU pressure sensor troubleshooting steps confirmed that the problem was not within the OGS controller. On June 9th the crew R&R'ed the OGS pump ORU with an onboard spare and connected only the electrical and data lines to the new ORU to check out the new pressure sensor. With a successful checkout of the new pressure sensor, the crew finished installing the new pump ORU so the OGS could be restarted the next day. Also, that same day the crew connected the Vacuum Exhaust Subsystem (VES)/Vacuum Resource Subsystem (VRS) jumper hose to the U.S. Laboratory Module port rack 4 location to determine if the jumper had a leak when it was last used to leak test the U.S. Laboratory Module starboard rack 2 location. The next day the ground tried to activate the OGS after the successful R&R, but unfortunately the new pump did not come up to speed. The next day VES/VRS jumper leak test was successful completed and the results showed that the leak at the starboard rack 2 location was not due to the jumper. On June 11th the ground tried unsuccessfully to activate the OGS three times. With no joy, the ground asked the crew to check all of the connections to the new pump ORU. With no obvious problems observed by the crew with any of the connectors, the ground stood down to come up with additional troubleshooting steps. This stage of the Increment concluded on the day that the Soyuz was finishing up its launch preparation and the ground commanding the CDRA off to check out the performance of the Vozdukh CO2 removal capability. Also, the crew and ground started the leak check of the VRS at the starboard rack 2 location in the U.S. Laboratory Module.

23S:

On June 15th Soyuz 23S launched from Baikonur and docked to Service Module (SM) aft docking port two days later. This flight returned the station crew size up to six. This launch was note worth since it was the 100th launch in support of ISS dating back to the FGB launch in November 1998.

The day that the Soyuz 23S launched the crew and ground finished the VRS leak test at the starboard rack 2 location. The data indicated that the leakage at that location was ~ 2.7×10^{-4} psia (14 milliTorr), which was slightly above the specified leak rate of 1.7×10^{-4} psia (8.8 milliTorr) for this location. The ground told the crew to stand down on any more leak testing of the VRS while they assessed the possible impacts on the microgravity science glovebox (MSG) rack that was planned to be moved from the Columbus module to that location in the near future. The next day the crew was instructed to remove the new OGS pump ORU and re-install the old pump ORU as well as re-activate the CDRA after completion of the Vozdukh performance test. The day after the successful docking of the new Soyuz spacecraft the ground was able to successfully reactive the OGS with the OGA pump ORU pressure sensor inhibited. On June 28th the 23S Soyuz was relocated from SM aft to MRM 1 nadir.

38P:

Progress 38P launched from Baikonur on June 30th and docked to ISS at SM aft docking port on July 4th after an aborted docking attempt on July 2nd. The same day the that Progress launched the ground observed via review of downlinked photos that the low pressure line that supplies oxygen to the respiratory support pack (RSP) was damaged. The observed damage showed that the oxygen flex hose outer braids had been birdcaged. So far there was no indication of leakage in the oxygen system so the ground decided to assess the hardware and decide what the potential remediation step should be taken to correct the problem.

The day after the Progress docked to ISS, the ground had to shut down the OGS due to a high voltage reading on two of the cells in the cell stack. The next day the crew reported that the WHC was making unusual noises and the control panel lights went out. While troubleshooting the problem the crew noticed a foreign material downstream of the urine funnel. After replacing the urine hose the crew tried to re-activate the WHC, but unfortunately WHC power tripped off due to excess current draw. On July 7th and 8th the crew successfully performed the R&R of the rear CDRA bed in the Node 3 CDRA. Unfortunately, due to insufficient time, the crew was unable to mate the fluid, power, and data connectors to the CDRA. As the crew was finishing the CDRA bed task they also continued to troubleshoot the WHC problem. The crew first demated the connector to the ASU pump/separator and repowered the control panel. With a successful start up of the WHC control panel, the ground instructed the crew to R&R the ASU pump/separator. This corrected the problem and allowed the WHC to become operational again.

The next week the crew finished the Node 3 CDRA fluid, power, and data connections on July 12th so that the rack was ready to move from Node 3 to the U.S. Laboratory in the near future. That same day the OGA Dome ORU failed due to high voltage on two cells in the cell stack. That same day, the ground started to load the new version of the Command and Control System (CCS) release 9 (R9), Node Control System (NCS) release 4 (R4), and the Payload MDM to R9 and completed the task on July 14th. Two days later the crew started the R&R of the OGA Dome ORU by preparing the new Dome ORU by pressurizing it with nitrogen and replacing the Hydrogen Sensor ORU and purging it with oxygen. On July 20th the crew attempted to flush the low pH water from the OGA water circulation loop, but unfortunately the remote power controller module (RPCM) powering the OGS tripped. After analysis by the ground, it was determined that the RPCM trip was really due to the OGS controller losing its heartbeat causing a loss of communication to the upstream MDM, which caused upstream MDM to open the RPCM switch to the OGS. The next day the OGA low pH water was flushed from the circulation loop. On July 22nd the crew completed the replacement of the Dome ORU and the following day the ground was able to successfully reactivate the OGS. On July 24th the ground started to discuss the possibility of changing out the WPA multifiltration beds due to an upward trend in the total organic carbon (TOC) for the WPA product water even though it was still below the maximum permissible limit for consumption.

On July 26th Russian Stage EVA #25 was performed out of DC 1. The primary purpose of the EVA was to replace the ATV video camera, route and mate the external MRM1-to-FGB KURS cables to the FGB, route and mate ethernet cables to the SM, and jettison the old camera. The day of the EVA, the crew removed and replaced the WHC pretreat tank. After the replacement was completed it was noticed by the crew that the pretreat tank was slowly leaking, so the ground asked the crew to disconnect and reconnect the tank to the WHC plumbing to see if that would stop the leak. That action was successful in stopping the small leak from the pretreat tank. That day the ground also commanded the WPA pump to a slower speed to provide more residence time in the WPA catalytic reactor and reduce the TOC levels in the potable water until the WPA multifiltration beds could be removed and replaced. July closed out with two ECLS events. The first event occurred on July 27th when the WRS water transfer pump failed while transferring stored water from a CWC-I to the WPA potable water tank. Since, there were no spare parts for the WRS transfer pump on-orbit, the crew was asked to stand down. The other ECLS event occurred on July 29th when the crew was able to change out the WPA multifiltration beds.

August 1st ISS experienced a major non-ECLS problem when one of the two external thermal control system (ETCS) pumps failed. Even though this failed hardware is not ECLS hardware it had a sufficient impact on what could and could not be operated on ISS. The first EVA, U.S. Stage EVA 15, was performed on August 7th to recover from the failed ETCS pump failure. The EVA did not complete all planned tasks due to a leaky NH3 quick disconnect (QD) when it was disconnected. The crew had to reconnect the QD due to the EVA suit time limitation not allowing sufficient time for QD troubleshooting. One ECLS problem did occur when the crew was getting ready for the EVA when the crew reported an intermittent whining noise from the prebreath hose assembly (PHA) QD. Besides the noise there were no other issues with the PHA QD providing sufficient oxygen to the prebreathing crew members. The next EVA to recover the failed ETCS pump during U.S. Stage EVA 16 occurred on August 16th. This time the crew was able to remove the failed pump without any QDs leaking NH3 and stow it on the Payload ORU Accommodations (POA) on the Mobile Transporter (MT). The problem was resolved during the third EVA on August 16th when the crew installed the spare ETCS pump.

September started with the crew getting time to sample the residue for ground analysis that was found in the WHC interface to the urine monitoring system (UMS) back on July 5th to understand what had caused the formation of the residue. Six days later the crew swapped the Node 3 and U.S. Laboratory Air Revitalization (AR) racks so that the original U.S. Laboratory AR rack could be returned to its original location in the Laboratory module. After successfully swapping the two racks, they were started up for check out.

Unfortunately the U.S. Laboratory CDRA failed to start due to all three temperature sensors in the front CO2 absorption bed read off scale high. Troubleshooting determined that the connector to the heater controller was disconnected. After the crew re-mated the connector, the CDRA processed through a partial start up. The partial CDRA start up was determined to be caused by an air leak to vacuum through the CDRA absorption bed. To work around this problem, the ground commanded the CDRA to single bed mode to successfully check out the rest of the CDRA. The remainder of the AR rack was successfully checked out except for the Major Constituent Analyzer (MCA) since it was still missing ORU #1. The CDRA continued to operate in single bed mode until the next morning when a time tagged command was not sent at the correct time and the faulty bed leaked cabin air to space vacuum for about 2 minutes. After the ground recognized the problem, they were able to restart the U.S. Laboratory Module CDRA in single bed mode again. On September 9th it was decided to try the new automated CDRA single bed mode software instead of the ground sending time tagged commands to operate CDRA in single bed mode. The software successfully automated CDRA operation in single bed mode that will help in the future to reduce the ground controller work load, should single bed CDRA operation be needed in the future.

The Node 3 CDRA would not start due to the CDRA air selector valve (ASV) 106 not transitioning to the correct position. The next day the ground was able to successfully move CDRA ASV 106 and achieve CDRA nominal two bed mode operation. It operated for a day before CDRA ASV 103 failed to move to the correct commanded position.

39P:

Progress 39P launched from Baikonur on September 10th and docked to ISS at the SM aft docking port on September 12th. The time between the launch docking of the Progress, the Node 3 CDRA ASVs continued to periodically not transition to the correct position causing the CDRA to shutdown until the ground were able to restart it. The day after the docking of the Progress, the crew was able to successfully isolate the U.S. Laboratory Module CDRA air leak to a hydroflow connector that was located in the front bed vacuum circuit and were able to fully recover CDRA. While working in the U.S. Laboratory Module AR rack the crew also installed the new MCA ORU #1. The same day the crew and ground were able to fully recover the U.S. Laboratory module CDRA, the ground was able to recover the Node 3 CDRA that had failed due to the air save pump not coming on. The next day after recovering the Node 3 CDRA, the crew and ground shutdown the Node 3 CDRA to save its remaining life for the upcoming Sabatier operations. This same day the U.S. Laboratory Module MCA ORU #1 experienced a Loss of Communication (LOC) with the INSYS MDM. The ground was able to recover the MCA by power cycling the MCA. Also that same day that the MCA ORU #1 had a LOC with the INSYS MDM, the Node 3 Pressure Control Assembly (PCA) positive pressure relief annunciated a failure and transitioned to a safe state. Since the Node 3 PCA failure was similar to a previous failure of the Joint Airlock PCA, the ground was able to successfully recover the PCA by power cycling the next day.

September 16th through the 19th the U.S. Laboratory Module MCA had five more LOC events. The first of the five events also had a spike in the ion pump current and a shift in the partial pressure readings. Due to problems with the MCA, the ground placed the MCA into life extension mode after each LOC until they were sure that they understood the failure signature. During the first of the five MCA LOC events, the crew also took a pH reading of the OGS water recirculation loop. The pH of the OGS recirculation loop was 5.9 – 6.0, which was lower than expected. On September 21st the ground transitioned the MCA from life extending mode to operating mode based on the last MCA LOC event. Unfortunately, when the MCA was brought back to operating mode, it came up on Filament 2. After additional troubleshooting it was determined that Filament 1 was failed, but the MCA was still considered operational with its remaining Filament. Finally, on September 22nd the crew finished out the Increment by moving CQ 3 from the JEM – PM to its final home of the deck location in Node 2.

On September 24th Increment 24 came to an end when the Soyuz TMA-18/22S undocked from the MRM - 2 and landed later that day in the steppes of Kazakhstan with Alexander Skvortsov, Tracy Caldwell-Dyson, and Mikhail Kornienko onboard.

Increment 25:

Increment 25 started with the undocking of the Soyuz and the ISS crew size being temporarily reduced to three crew members. A couple of days later the crew started the installation of the new WPA tee hose to allow a CWC - I to be connected to the WPA water delivery ORU. This modification allows distribution of water stored in a CWC-I to be pumped to all users via the potable water distribution system should the WPA not be processing an adequate amount of water for all of the users. The new hardware also incorporated a sample port adapter. This task ended up taking three days to complete due to the tight packaging within the WRS Rack 1. On the last day of the WPA tee hose installation the ground commanded the MCA on in the U.S. Laboratory Module for a one week health check due to the failure of filament 1.

On October 6th the crew started the installation of the Sabatier hoses. The next day the crew removed the protective panels that were in the OGS Rack to protect the OGS Rack hardware from the small items that had been stowed in the rack space planned for later Sabatier installation.

24S:

On October 7th Soyuz 24S launched from Baikonur and docked to MRM 2 two days later. This flight returned the station crew size to six again. This Soyuz was the first of the new breed of Soyuz vehicles, looking unchanged from the outside but having the old computer and analog parts replaced by digital avionics. It did experience a minor life support problem prelaunch that was not related to the avionics upgrades. Due to the problem, the crew experienced an oxygen (O2) regulator intermittent high O2 flow into the cabin when they opened up the downstream isolation valve. After opening and closing the downstream isolation valve two times the regulator apparently fixed itself allowing the launch to proceed with no other problems.

The first major ECLS task post docking occurred on October 12th when the crew started the Sabatier installation procedure by installing the Sabatier mounting brackets in the OGS Rack. The next day, the crew completed the Sabatier installation. That same day the Sabatier installation was finished the crew installed a new urine hose into the WHC. After the installation of the new urine hose, the crew noticed that the A2 connector had gunk in it similar to what was found previously in the Urine Monitoring System (UMS) line three months ago. On the same day the Node 3 MCA failed off due to a ion pump high current spike.

Five days after the installation of the Sabatier into the OGS Rack it was powered up to make sure that the Sabatier controller was able to communicate with the Station computers. The next day the Node 3 CDRA was powered on to support the Sabatier activation and checkout. Unfortunately, the CDRA ASV 103 failed to change position in the required transition time causing the activation of the Sabatier to be postponed to the next day. On October 20th the ground was able to perform the operational functionality checks and required overrides, leak checks of vent and supply lines, purging of the Sabatier carbon dioxide (CO2) accumulator, and filling the Sabatier CO2 accumulator. During the filling of the Sabatier CO2 accumulator the Sabatier went to stop due to a low fill rate. It was decided to lower the fill rate in the Sabatier controller, to turn on a second CDRA heater to increase the CO2 fill rate, and continue to fill the accumulator. After the accumulator had been filled by the next day, the Sabatier ran for about four minutes before it failed off due to high OGS hydrogen (H2) delivery pressure. After the software limit for H2 delivery pressure was adjusted, the Sabatier was able to successfully complete the planned five hour check out. Upon the completion of the check out, the ground commanded the OGS to 100% production rate for a short time to evaluate the pressure in the shared OGS and Sabatier vent line.

During the Sabatier operations the Node 3 CDRA had shut down six times, including the onetime mentioned above. Of these six shut downs all of them were understood as to why they had occurred. Two of the shutdowns were triggered by higher than normal pressure in the CO2 vent line, when Sabatier stopped receiving CO2. Three of the shutdowns were caused by the CDRA ASVs being in an indeterminate state. The last shutdown was caused by failure of the CDRA pump motor controller to command the pump on at the correct time.

40P:

Progress 40P launched from Baikonur on October 26th and docked to ISS at DC 1 on October 30th. The day the Progress launched the crew took water samples downstream of the WPA multifiltration bed #2 and from the OGS recirculation loop for ground water quality analysis to support investigation of some system issues.

The first two weeks of November had several ECLS tasks that the crew had to perform. On November 1st the crew started troubleshooting the Joint Airlock Pre-Breathe Hose Assembly (PHA) QD whining noise that had been reported during U.S. Stage EVA 15 prebreathe activities. Based on the troubleshooting the crew reported that the noise seemed to be coming from behind the panel, so the remainder of the planned activities was suspended to allow the ground to derive new troubleshooting steps. The next day the crew continued the ECLS tasks by repairing the WRS high flow transfer pump when the Commander replaced the damaged roller and roller bolt. On November 3rd the crew started to clean out the Node 1 aft port IMV fan. While performing that task, the crew reported that one of the flexible IMV ducts had collapsed. The crew straightened the collapsed IMV duct and finished by cleaning out the small amount of observed debris. The next day the crew installed the new PMA 1/Node 1 bulkhead IMV cone screen and checked the IMV flowrate from the Russian Segment IMV to Node 3. The IMV flowrate between the Russian Segment and the U.S. On-Orbit Segment was verified to have returned to normal range. That same day the crew cleaned the JEM – PM forward IMV to restore the IMV between JEM – PM and Node 2 to its expected flowrate. Four days later the crew observed a WHC "Pretreat Bad Quality" light. Upon inspection of the WHC the crew found a kinked urine hose. Since the hose was near end of life, the ground made the decision to replace the hose. After the urine hose was replaced, the WHC returned to normal operation.

On November 15th Russian Stage EVA #26 was performed out of DC 1. The primary purpose of the EVA was to retrieve some payloads, install the DC-1 gap spanner, retrieve the MRM 1 zenith TV camera, and take some samples of the multi-layer insulation (MLI) near the SM Elektron vent and from DC 1. That same day the crew received a WPA Process Water Fault. The fault was thought to be due to a suspected bubble that had come from a CWC – I after transferring its contents into the WPA Water Storage Tank using the newly installed WPA tee hose. Based on this assumption the ground had the crew flush the water from the tank to the rack interface panel (RIP) into an empty CWC – I. This action restored WPA functionality.

On November 17th the crew started to remove the Node 3 CDRA from the Node 3 AR Rack in preparation of removing the rear CRDA bed and CDRA ASV 103 for return on the next Space Shuttle flight. Unfortunately, they were only able to partially to remove the CDRA from the AR rack. After the ground discussed the problem for two days they had the crew completely remove the CDRA launch restraint bolts from the Node 3 AR Rack. This allowed the crew to completely remove the CDRA from the rack so that the rear CDRA bed and CDRA ASV 103 could be successfully removed for refurbishment on the ground. It also allowed the crew to install a filter in front of the Node 3 AR rack avionics air assembly (AAA) to prevent dust buildup inside the Node 3 AR rack AAA.

On November 25th the Increment 25 came to an end when the Soyuz TMA-19/23S undocked from MRM 1 and landed later that day in the steppes of Kazakhstan with Fyodor Yurchikhin, Doug Wheelock, and Shannon Walker onboard. That same day the Node 3 Nitrogen Introduction Assembly introduction and vent valves opened unexpectedly releasing a small quantity of nitrogen into the cabin. The grounded commanded the valves back to their proper configuration fully recovering the hardware. This was the first instance of this failure in Node 3, but it has been seen multiple times in Node 2.

Increment 26:

Increment 26 started with the undocking of the Soyuz and the ISS crew size being temporarily being reduced to three crew members. Six days later the crew cleaned the U.S. Laboratory Module forward IMV to restore the IMV flow to Node 2 to its expected flowrate. On December 9th the ground uplinked version 6.0 of the UPA software to the UPA electronically erasable programmable memory (EEPROM), which incorporates Distillation Assembly (DA) serial number (s/n) 002 motor calibration overrides, updates the conductivity sensor calibration, adds DA overfill and pressure monitoring software, and added waste storage tank assembly (WSTA) leak to the triggers for the UPA H20 Storage Tank Qty High caution and warning message. Just prior to the launch of the next Soyuz the crew spent part of their time gathering hardware to flush the low pH water out of the OGA recirculation loop.

25S:

On December 15th Soyuz 25S launched from Baikonur and docked to MRM 1 two days later. This flight returned the station crew size to six again. Five days later the crew cleaned the debris from the Node 1 starboard IMV fan and they also installed the newly developed IMV fan screens to collect the dust and debris in a spot that easier for the crew to access and clean.

January continued with ISS ECLS problems and problems with other systems that impacted ISS ECLS. On January 4th Node 3-1 (N3-1) MDM had a low level analog (LLA) card that toggling between failed and not failed. This problem affected the Node 3 AR and OGS rack AAA speed sensor readings. Three days later the ground uploaded release 3 (R3) for Node 3 System 1 (N3 SYS 1) software load for the N3-1 and N3-2 MDMs. After the upload the ground decided to power cycle N3-1 MDM, but unfortunately that did not fix the LAA card toggling problem. After the N3-1 and N3-2 were operational and the Node 3 ITCS were configured to single loop mode the software indicated a false NH3 leak from the ETCS to the ITCS due to shifting water from one accumulator to another. The ground was able to tell the crew that it was a false alarm and started working on reversing the automated software reconfiguration. Unfortunately, the ground could not recover the Node 1 port forward IMV valve so on January 10th the crew had to manually cycle the IMV valve so that the ground could recover the automated control of the IMV valve. That same day the WHC pump separator failed and the crew had to R&R it to recover the WHC operations. On January 13th the Node 1 sample delivery subsystem (SDS) valve that selects the Joint Airlock or Node 3 for sampling did not indicate that the valve has moved to sample Node 3. Since the failure was a position indicator and not a valve functionality, it was decided to leave the problem for future troubleshooting.

The day before the HTV launch the Russian's completed Russian Stage EVA #27 from DC - 1. The primary purpose of the EVA was to installing a radio data transmission system for the SVPI Napor experiment (a system for high-speed information transmission) on the SM; taking photographs of the SM plasma pulse injector monoblock; placing a protective cover on, then deactivating & removing the another monoblock from a portable workstation on the SM; placing a protective cover on the EXPOSE-R monoblock, then deactivating & removing the monoblock from the portable workstation; and installing/connecting a TV camera at the MRM 1 passive docking side.

HTV 2:

HTV 2 launched from the Japanese launch site at Tanegahima Space Center on January 22nd. Five days later the HTV was captured by the Station robotic arm and berthed to Node 2 nadir. The next day the crew completed the vestibule outfitting and ingressed into the HTV.

February continued to be busy for the ISS crew and ground with a few ECLS tasks and problems. On February 8th the crew took another sample of the OGS water recirculation loop. The pH was between 4.52 and 4.57. The ground had decided to try and remediate the loop once the pH dropped to 4.4 to prevent the formation of any precipitates in the loop. That same day the WPA Mostly Liquid Separator (MLS) faulted off due to an overcurrent and underspeed condition. On February 9th the ground was able to successfully command the WPA MLS back on allowing the WPA to continue processing waste water into potable water. On February 14th the ground continued to monitor the U.S. Laboratory Module starboard Common Cabin Air Assembly (CCAA) water separator ORU degradation. The decision by the ground was to replace it just prior to or during the next Space Shuttle flight. That same day the crew modified the WRS 2 left door to try and save crew time when they have to work on the UPA recycle filter tank assembly (RFTA).

On February 16th Russian Stage EVA #28 was performed out of DC 1. The primary purpose of the EVA was to install and connect the Molniya-GAMMA monoblock portable multipurpose work platform on the SM; installation, connection & deployment of the new RK-21-8 SVCh-Radiometriya experiment system on the SM; removal of two Komplast panels from the FGB; and removal of the Yakor foot restraint from its location on the SM. That same day the ground noticed a small nitrogen leak across the Low Temperature Loop (LTL) and the Moderate Temperature Loop (MTL) Nitrogen Isolation Valve (NIV) into their accumulators. Since the leak was small it was decided to just monitor the leak and not do anything for the time being.

ATV 2:

ATV 2 launched from Europe's launch site in Kourou, French Guiana on February 17th. The ATV carried to ISS 100 kg (220 lbm) oxygen, some propellant for transfer to ISS and for reboost & attitude control, and dry cargo. That same day the WPA failed off again due to a transient fault within the WPA MLS. Due to the WPA shutting down, the upstream Urine Processor Assembly (UPA) also shutdown. Due to the UPA being shutdown, the WHC Pump Separator flooded, which caused an error on the ACY Panel to be indicated. The crew was able to recover the WHC pump separator by flushing the excess liquid from the Separator into the WHC EDVs. While the crew was doing that, the ground was able to recover the UPA and the WPA after the WPA catalytic reactor was heated back up to temperature. The next day after the launch of ATV 2, HTV 2 was moved from Node 2 nadir berthing port to the

Node 2 zenith berthing port using the ISS robotic arm. This was necessary for ISS to get ready and allow access of the Space Shuttle payload bay after it has docked to PMA -2.

The day before the ATV docked to ISS, the crew R&R'ed the U.S. Laboratory starboard CCAA water separator ORU to prepare the water separator for return on the next Space Shuttle mission. While performing the R&R approximately 1.4 kg (3 lbm) of condensate leaked into the cabin that triggered the WPA leak algorithm and caused the WPA and the waste water bus to shutdown. On February 24th the ATV docked to SM aft docking port.

ULF5:

The time period covered by this paper ended with the start of the ULF5 Space Shuttle Flight to ISS. The mission began on February 24th when the Space Shuttle launched from KSC and docked to ISS on February 26th. The day the Space Shuttle docked the crew sets up the lines to transfer O2 and N2 from the Space Shuttle to the Joint Airlock O2 and N2 external tanks. In between those two days the ISS crew ingressed into ATV 2 to start removing some of the cargo inside ATV 2. As the Space Shuttle mission continued the joint crew successfully performed the first EVA on February 26th. Two days later the ISS crew started to prepare for the long planned R&R of the SM Vozdukh bed assembly and the R&R of the newly delivered CDRA bed into the Node 3 CDRA. That same day the U.S. Laboratory CDRA bed 2 primary internal heater shorted forcing CDRA operation on its secondary heater.

III. Near Term Shuttle Flights

The Space Shuttle Program (SSP) was able to successfully launch two Space Shuttle flights during the time period covered by this paper with minor schedule problems. The last three Space Shuttle flights were delayed due to concern about the external tanks (ETs). The launch windows for the Space Shuttle flights were mainly driven by high beta angles because of the thermal and power generation concerns, the flight vehicle traffic to and from ISS, and the time required for process the next Space Shuttle. The current Space Shuttle Program direction is to fly the last Shuttle flights before the end of the 2011 fiscal year. The paper covering the next year's ISS ECLS 2011 – 2012 status will discuss the last three Space Shuttle flights to ISS based on the current Space Shuttle Program plans and the final Congressional budget for fiscal year 2011.

IV. ISS Element Integration Status

Most of the pressurized elements and all of the Truss Segments have been delivered to ISS. Even though the Space Shuttle is nearing the end of its life, ISS still has plans to add some additional pressurized modules to the Station, as can be seen in Figure 4. In fact, next year's paper will discuss the delivery of the last of the Russian pressurized elements [i.e., the Multi-Purpose Laboratory Module (MLM)], and the Permanent Multi-Purpose Module (PMM), which was occurring after the time period of this paper. The MLM will provide the Russian Segment with additional docking ports and additional areas to conduct research. As for the PMM it will provide additional stowage space on ISS.

V. Shuttle Transition and Retirement Status

To prepare for Shuttle Transition and Retirement (STaR) the ISS ECLS team is currently working four major tasks. The first task being worked on is a system to be able to resupply oxygen and nitrogen to ISS after the Space Shuttle retires, which is called the Nitrogen/Oxygen Recharge System (NORS). The NORS has completed its Project's Preliminary Design Review (PDR) and will soon be ready for the Project's Critical Design Review (CDR). The second task is an Advance Recycle Filter Tank Assembly (ARFTA). This equipment is designed to minimize UPA resupply up mass while taking advantage of cheaper brine disposal methods. The third change is the addition of the Cabin Air Separator for EVA Oxygen (CASEO) to scavenge oxygen out of the cabin air and transferring it to the Joint Airlock Oxygen Tanks. The CASEO has completed its Preliminary Design Review (PDR) and will soon be ready for the Project's Critical Design Review (CDR). The final STaR is the delivery of additional spares to support the end of life of ISS. This will become a critical and difficult task due to post Shuttle retirement resulting in most of the ISS ECLS ORUs not being returned to the ground for failure analysis or refurbishment as well as the projected life extension of ISS from 2015 to post 2020 needing additional spares.

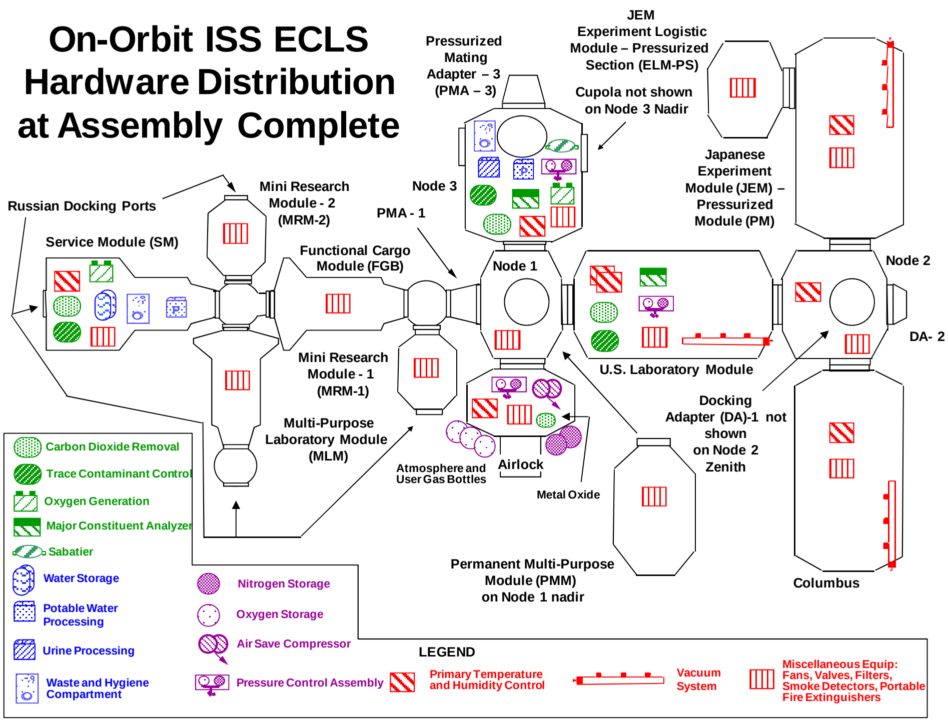

Figure 4 – ISS ECLS Hardware Distribution at Assembly Complete

VI. Commercial Service Contracts

ISS is currently working with three different commercial service providers. Out of these three commercial providers, ISS has established a contract with a vendor to provide a Sabatier. The Sabatier will provide water to ISS by reacting the waste carbon dioxide from CDRA and the waste hydrogen from the OGA when the Node 3 CDRA and OGA are operational. The Sabatier has been integrated into the Node 3 OGS Rack and has been successfully checked out. The other two commercial companies operated under Space Act Agreements (SAAs) with NASA's Commercial Crew and Cargo Program Office (C3PO) to demonstrate resupply cargo to ISS. For these SAAs the ISS ECLS team has been involved in managing the on-orbit docked interface requirements for the commercial cargo vehicles and verifying that the two vendors are meeting these requirements. One of the two vendors, i.e., SpaceX, has successfully completed one of their demonstrations when they were able to launch their capsule and recover it off the coast of California. Next year they plan to launch their first demonstration flight that will berth with ISS. The other vendor, i.e. Orbital Science Corporation, is planning to launch its demonstration flight that will be similar in scope to the SpaceX demonstration flights. These flights will be discussed in next year's paper. The ISS Program Office cargo contract for both companies will start after successful flight demonstrations. ISS is also supporting the next phase for the commercial crew transportation to ISS that is being managed by the new Commercial Crew Program Office (CCPO). Currently they are working on the requirements generation for this new service.

VII. Conclusion

This paper has outlined the ISS ECLS activities from March 2010 through the end of February 2011. The assembly of ISS has continued with the addition of the stowage module and a new Russian Module. ISS has continued with a permanent crew size of six. It continues to be a challenge to provide the functionality necessary to support the six crew members on ISS with all of the problems that have occurred with the new regenerative ECLS racks, WHC, and CDRA. Next year's paper will discuss the delivery of the final pressurized elements and the final Space Shuttle flights. It will also discuss the status of the new commercial cargo delivery vehicles that will be used to deliver cargo to ISS after the Space Shuttle is retired. It will also discuss the final changes to ISS ECLS hardware due to the Shuttle Transition and Retirement.

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