International Space Station: Access and Operations

Program Review

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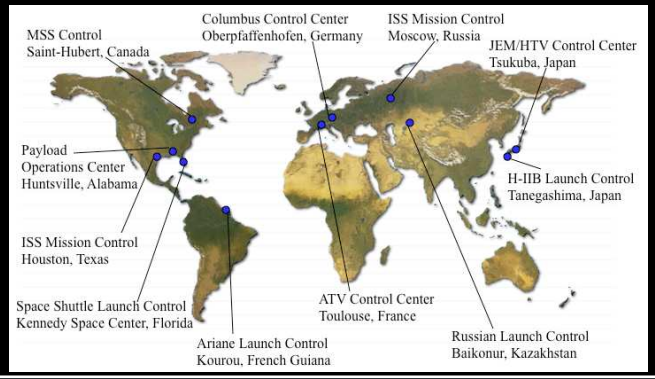
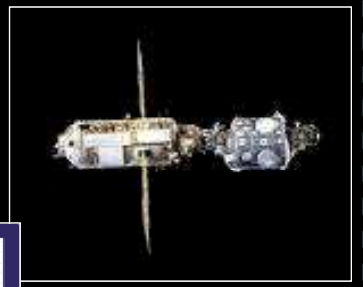
International Space Station

- International space-based research and technology development endeavor in partnership with 5 space agencies
  - US, Russia, Europe, Japan and Canada
- In orbit since November 1998 with the launch of the first ISS element *FGB* from Kazakhstan
- Permanently crewed since November 2000
- Ground control, training, operations and launch facilities in 8 countries





ISS: FY 2011 and FY 2012 Plans

- **Complete research outfitting, deliver hardware and pre-position critical system spares**
  - Two ExPrESS Logistics Carriers (ELCs) and Alpha Magnetic Spectrometer (AMS)
  - **Maximize utilization of 6 crew to increase ISS research time availability and ramp up for full research operations**
  - **Demonstrate Commercial Cargo transport systems**
  - SpaceX Demo 2 (ISS flyby) – July 2011 (NET) (Under Review)
  - SpaceX Demo 3 (berthing to ISS) – January 2012 (NET) (Under Review)
  - OSC Demo – December 2011
- **Continue stable crew/cargo flight plan while moving toward domestic transportation capabilities for US responsibilities**
  - Four Soyuz crew exchanges per year (6 Russian/6 non-Russian crew) and 4-5 Progress resupply flights per year
  - JAXA H-II Transfer Vehicle (HTV) and ESA Automated Transfer Vehicle (ATV) flights
  - Begin SpaceX and OSC Commercial Resupply Services (CRS) flights

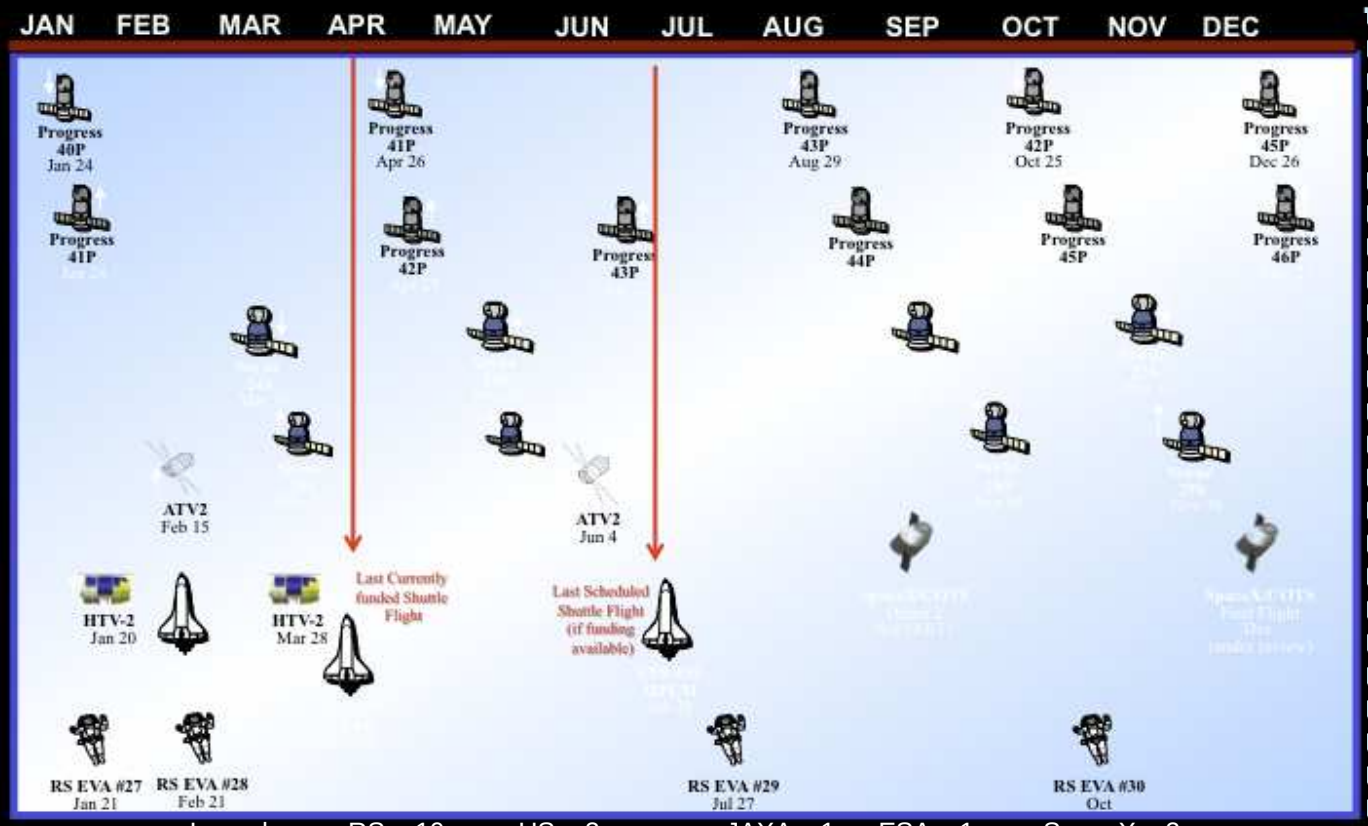
JAXA HTV

Space Shuttle

Russian Progress

ESA ATV

ISS: CY 2011 Visiting Vehicle Plans*



Launches: RS = 10 US = 3 JAXA = 1 ESA = 1 SpaceX = 2

* As of January 2011

ISS Vehicle Traffic

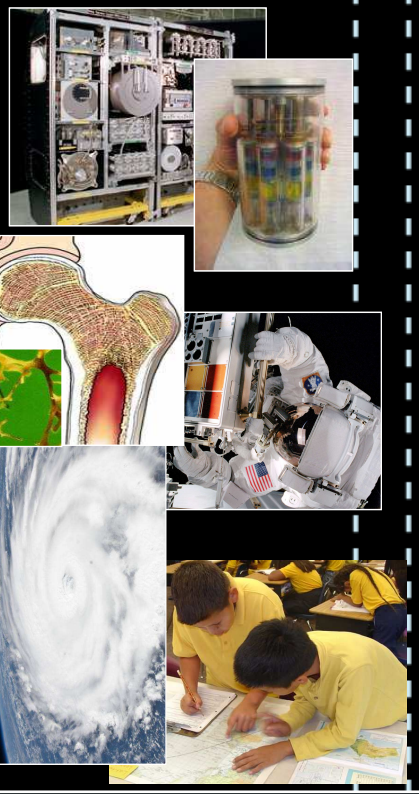
- Between now and 2020, as many as 100 spacecraft will visit the ISS
- Crew exchanges 2 times a year
    - Soyuz through approximately 2016
    - Commercial crew beginning approximately in 2016
- As many as 8 cargo flights per year including Progress, ATV, HTV, SpaceX Dragon and Orbital Cygnus vehicles
    - Delivering well over 100MT of cargo through 2020
- Commercial cargo services expected to begin within the next year through the Commercial Resupply Services contract

ISS: Cargo Transportation Services
Commercial Resupply Services (CRS) Contracts

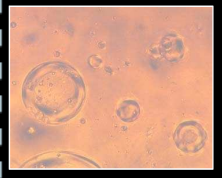
- SpaceX
  - Four missions currently in flow
  - Both cargo and external integration activities have begun and are going well
  - In 2011 SpaceX will demonstrate its ability to manage multiple missions
- Orbital
  - Three missions currently in flow
  - OSC has been relying on NASA assets at Stennis Space Center (engine testing) and Wallops Flight Facility (launch vehicle processing and integration)
  - Liquid fueling facility development delays are impacting the overall start of the launch pad certification activities and subsequent use of the pad for the launch vehicle cold flow and hot fire tests and the demonstration mission
- Mission dates will be finalized as contractors demonstrate mission and production progress. Charts on following pages show current providers “not earlier than” dates
- Both providers are making progress on their missions and have key milestones in FY 2011

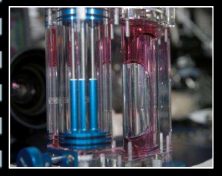
ISS: Research and Technology Demonstration Progress

- More than 1,200 experiments to date supporting >1,600 scientists and 59 counties world-wide
- ECLSS systems have achieved 70-80% water and air recycling on ISS; on the way to 85% to reduce logistics requirements to support humans in space
- Human research documenting how humans adapt to and recover from long-durations in space as an analog for human exploration missions beyond LEO and improving human health on Earth
- Materials testbeds have shortened development time for satellite hardware components by as much as 50% and have important applications to future spacecraft design
- Passes over 95% of the population centers on Earth every day documenting global change and geographic events
- >30 million students have participated in human space flight though communications downlinks and interactive experiments with the ISS astronauts



ISS Research: Examples of Earth-based Applications





- Biotechnology research has shown that *Salmonella* bacteria become more virulent in microgravity. AstroGenetix has funded follow-on studies on ISS and is pursuing approval of a vaccine as an Investigational New Drug with the FDA. Applying a similar development approach to methicillin-resistant *Staph aureus* (MRSA)
- Tiny biomedical balloon microcapsules with improved cancer treatment delivery properties developed on the ISS have been patented and clinical trials of the drug delivery method are beginning
- A Japanese scientist crystallized the HQL-79 protein on the ISS as part of a candidate treatment for Duchenne's muscular dystrophy
- Capillary flow experiments on the ISS have produced the first space-validated models describing fluid behavior in space important for design of future exploration vehicles. Three patents have been filed
- Technology developed the for ISS greenhouse plant growth experiments led to a new technology widely used on Earth for killing airborne pathogens

ISS Research: Examples of Research Planned for 2011 and 2010

- AMS-02 with an international team from 16 countries, seeking to understand the origin and structure of the universe
- Investigating how surfactants affect the physical chemistry properties and emulsion stability of droplet interfaces
- Performing synchronized observations of the aurora borealis from the ISS
- National Institutes of Health evaluating the effect of microgravity on immune response cells
- Demonstrating dexterous robot technology
- Studying capillary flow liquid management systems for future exploration spacecraft
- Investigating mechanisms of immune system activation challenges during space flight
- Quantifying biomechanics of treadmill exercise during long duration spaceflight and developing exercise prescriptions to improve crew health
- Determining if vacuum regenerated amine system can remove carbon using a smaller more efficient vacuum regeneration system

ISS Research: National Laboratory Update

- Memoranda of Understanding with five federal agencies and nine Space Act Agreements (SAAs) with companies and universities
- NIH issued 3-yr rolling Funding Opportunity Announcement for ISS-based investigations March 2009 to include two-phase awards up to $2.5M per grant over 5 years
  - 1st three NIH grants awarded August 2010 to study bones and the immune system
  - Second set of NIH proposals received September 2010 ; currently under review
- National Science Foundation to use ISS as a platform for deploying CubeSats to study the upper atmosphere
- Continued progress at Astrogenetix on vaccine development project
- Making progress on implementing a non-profit organization (NPO) to stimulate, develop and manage the U.S. national uses of the ISS National Lab
  - Cooperative Agreement Notice (CAN) for soliciting proposals for an ISS NGO posted on February 14, 2011; Notices of intent due February 28, 2011; award planned for late spring

ISS: International Docking Standard

- **The International Docking System Standard (IDSS) Interface Definition Document (IDD) is the result of a working group established in 2009 by the ISS partners**
- **The IDD defines the interface characteristics and requirements of the IDSS, which is intended for uses ranging from crewed to autonomous space vehicles, and from Low Earth Orbit to deep-space exploration missions. It defines the docking system interface definitions supporting the following missions:**
  - ISS
  - Lunar mission
  - Crew rescue
  - International cooperative demonstration
- **IDSS working group is nearing the finalization of the standard**
  - Should be complete by April 2011

NASA Low Impact Docking System conceptual computer aided design (CAD) model (retracted configuration)

ISS: Robotic Demonstration Testbeds

- SPDM, aka Dextre completed checkout and activation
  - Canadian 11-ft tall, two-armed robot will support ISS logistics (reducing EVA requirements) and utilization
  - Orbital Replacement Unit (ORU) relocation demo completed December 22, 2010; External Pallet relocation and cargo transfer demo completed February 8, 2011
- Robonaut 2
  - Humanoid robot developed in partnership with General Motors (GM) will demonstrate robot tasks internally on ISS
- Spacecraft Servicing Demonstration Project
  - Recently released GSFC Satellite Servicing Study
    - International Workshop on On-Orbit Satellite Servicing conducted March 2010
    - Notional Mission Studies completed to identify requisite capabilities and technology gaps
  - Robotic Refueling Mission technology demonstration
    - Being prepared for launch on STS-135 (planned June 2011)
    - Will use Dextre to demonstrate capability for on-orbit servicing of legacy spacecraft

Summary

- **ISS program fully operational and completely assembled, serves as the largest space-based scientific and technical cooperative program in history**
  - ISS is important to the pursuit of research applied to both national needs and NASA science & exploration missions, as well as to provide a stable market for commercial cargo transportation providers
  - SOMD will enter into an agreement with a not-for-profit organization to manage the ISS National Laboratory; “No less than 50 percent of planned U.S. utilization resources on ISS could be available for non-NASA use” based upon the NASA Authorization Act of 2010
    - NASA Headquarters and field center research project office oversight of existing biological and physical research grants will be phased out as current grants are completed
    - In future, NPO will co-select/manage new peer-reviewed grants, including any renewals
  - The ISS will continue to serve as a critical science platform in Earth’s orbit until at least 2020, or beyond
  - Cargo and crew transportation continue to be the largest program risks