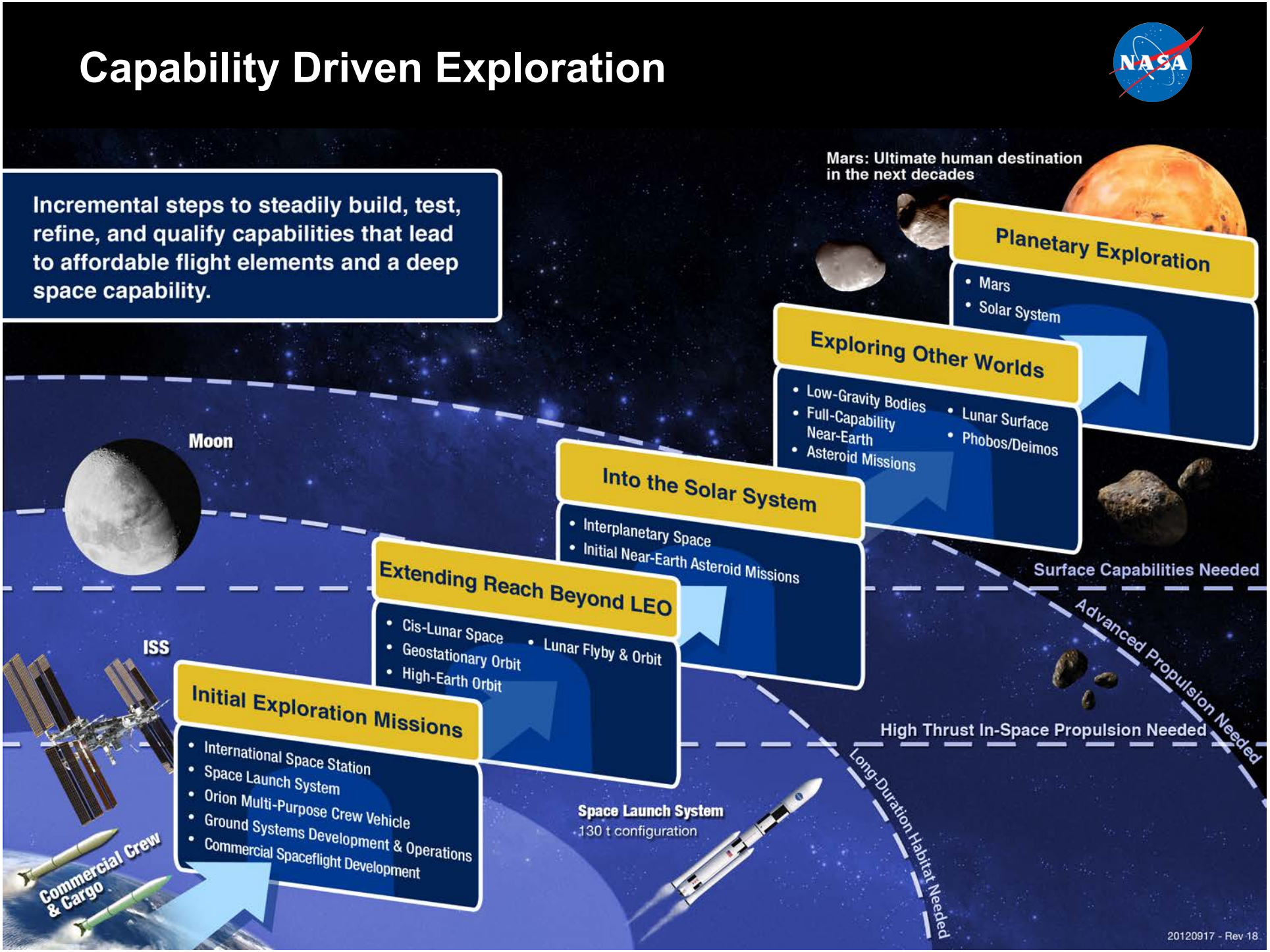
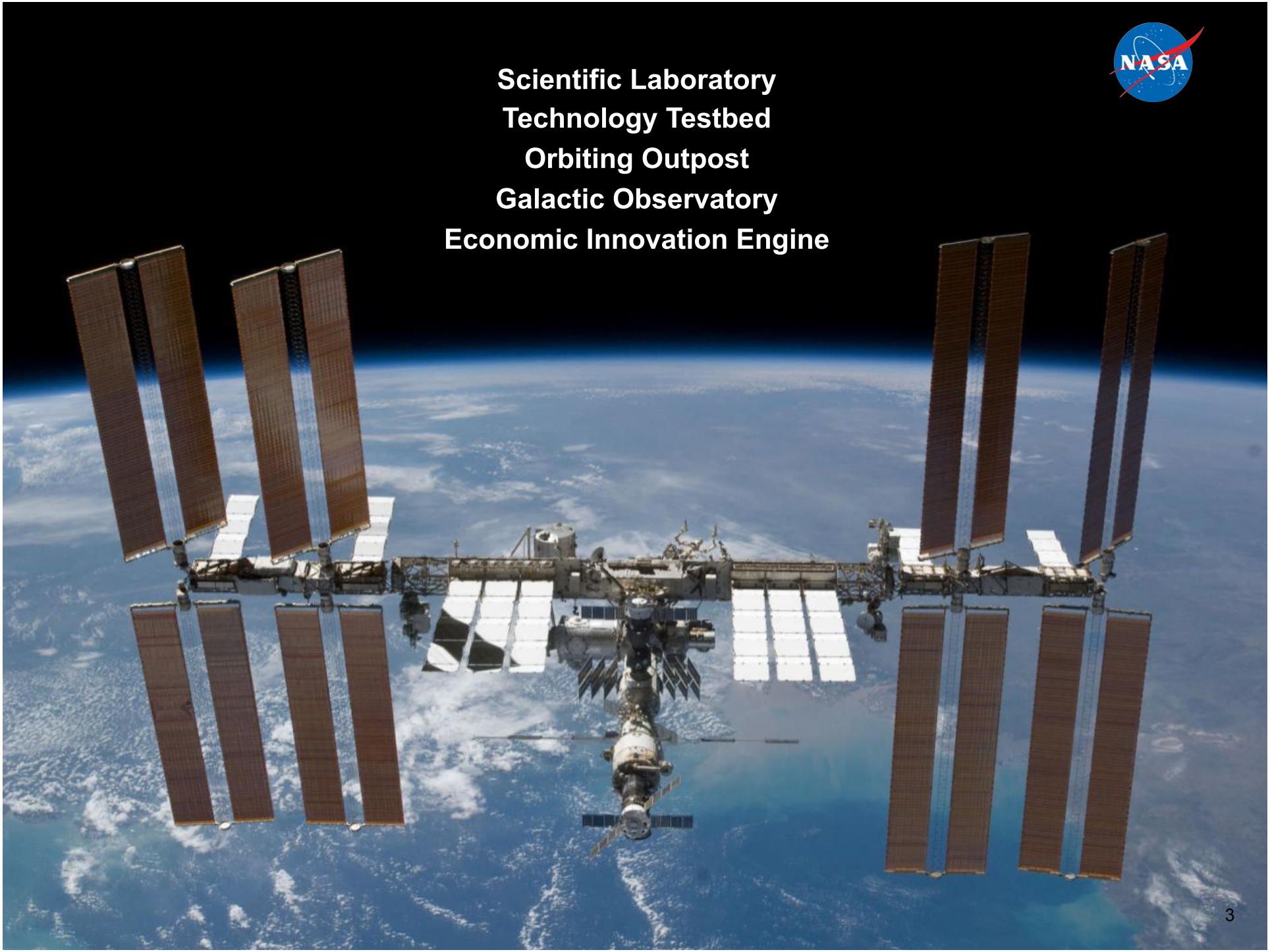
NAC HEO Committee Meeting: Open Session

William Gerstenmaier | November 15, 2012

Capability Driven Exploration




Scientific Laboratory
Technology Testbed
Orbiting Outpost
Galactic Observatory
Economic Innovation Engine

ISS Utilization for Exploration

- ISS activities to support future human exploration missions will build upon current activities and leverage the incremental development of exploration capabilities.
- Exploration preparation activities on the ISS fall into four main categories (details on following pages):
  - Exploration technology demonstrations
  - Demonstrating maturity and readiness of critical exploration systems
  - Human health management for long duration space travel
  - Operations simulations and techniques for missions beyond LEO
- A significant amount of exploration related research is planned in the near-term
  - Increment 31-32 (Summer 2012) - 52% (32 of ~71 payloads)
  - Increment 33-34 (Winter 2013) - 49% (37 of ~75 payloads)
  - Increment 35-36 (Summer 2013) - 56% (40 of ~71 payloads)
  - Increment 37-38 (Winter 2014) - 51% (37 of ~73 payloads)

October 5, 2012: NASA and its international partners have announced an agreement to send two crew members to the International Space Station on a one-year mission designed to collect valuable scientific data needed to send humans to new destinations in the solar system.

ISS Technology Demonstrations & Critical Exploration System Development

Technology Demonstrations

- Technology demonstrations are on-board or manifested on ISS, with plans in place to prepare additional technology demonstrations for future flights.
  - ISS partners are discussing ways to ensure that priority technology demonstrations are able to be flown to ISS.
  - Examples of technology demonstration activities onboard or planned for launch include demonstrating:
    - Use of RFID tags, smart enclosures, and portal readers for improved inventory management;
    - Autonomous vehicle fault management, power automation, disruption tolerant network (DTN) communications, and use of software controlled radios;
    - Demonstrating use of on-board and surface robots/assets for mission-enhancing IVA, EVA, and surface routine, emergency, ISRU, and scientific operations.

Systems Development

- To meet beyond LEO exploration requirements, the state of the art of critical systems sustaining the ISS crew must be advanced. Examples include:
  - ISS environmental control and life support system (ECLSS); initial focus for this effort
    - Advanced carbon dioxide removal systems, Advanced oxygen generation systems, Advanced atmospheric monitoring systems, New trace contaminant control systems
  - Robotics, Comm and Nav, Power Generation, Thermal Control

ISS Activities to Support Human Health Management for Long-Duration Space Travel & Operations Techniques and Simulations

Human Health Management for Long-Duration Space Travel

- NASA and its international partners are conducting over 160 studies and activities onboard the ISS to address Top human health and performance risk:
  - Immune system studies
  - Nutrition studies
  - Integrated cardiovascular system studies
  - Functional task studies
  - Vitamin studies
  - Exercise effectiveness studies
  - Crew performance studies
  - Ocular health studies
  - Medical operations and health management studies

Operational Techniques and Simulations

- ISSP plans to conduct a one year increment on-board ISS
  - This is to validate our current state of physical performance countermeasures; those which address:
    - Bone density and strength
    - Muscle mass and strength
    - Aerobic capacity and overall fitness.
- Other planned activities to demonstrate exploration operations concepts and techniques include:
  - Demonstrating just-in-time medical and other training
  - Evaluating a crew's ability to schedule their own activities
  - Increased crew autonomous procedure execution

Current ISS Related Policy, Guidance and Performance (1 of 2)

- **National Space Policy (2010)**
  - (Obama, April 2010, KSC) Extend the life of the ISS, using it for its intended purpose: research and technology/capability testbed
  - (June 2010 National Space Policy) Continue operation of ISS to 2020 or beyond, expand efforts for scientific and technology, commercial, diplomatic, and educational purposes; support future human space exploration objectives. Seek commercial partnerships for transport of crew and cargo.

- **NASA Authorization Act (2010)**
  - Sustain capability for long-duration presence in low-Earth orbit through continuation of ISS
  - Build upon partnership agreements and experience
  - Use ISS as a testbed for technology or capability

- **NASA Strategic Plan (2011)**
  1. Expand and sustain human activities across the solar system
     - *1.1 Sustain operation and full utilization of the ISS and expand efforts to utilize it for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration*
     - *1.2 Develop opportunities for commercial community*
  2. Expand scientific understanding of the Earth and universe
  3. Create innovative new space technologies
  4. Share NASA with the public, educators and student

Current ISS Related Policy, Guidance and Performance (2 of 2)

- **NASA 180-day Response to House Report (2012)**
  - The ISS is a cornerstone of human exploration
  - The ISS is an enabling testbed for NASA's evolving capabilities
  - The ISS can play a key role in exploration

- **NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space – feedback on NASA's Technology Roadmaps**
  - "The International Space Station (ISS) is a unique research and test facility that is critical
  - for the development of space technologies. It provides a platform for testing in microgravity and the harsh environment of space for long durations."

- **Agency Annual Performance Goals are as follows**
  - 6 onboard crew capability
  - Commercial cargo flights
  - Provide ISS resources utilization
  - Utilization activities
  - Crew time

How Do We Know We Are At Full Utilization?

- **Real estate bottom line**
  - Racks 71% occupied
  - EXRESS 60% occupied, expect 80% by the end of 2014
  - External Sites 35% occupied, expect 75% by end of 2014
  - Best external sites (best viewing with good Nadir or Zentith views) are mostly claimed through 2020
- **Crew time bottom line**
  - Scheduled time oversubscribed (>100%)
  - Crew as human subjects oversubscribed (multi-year queue carefully managed by HRP, a big issue for our partners, limits CASIS research)
  - NASA and CASIS users are soon going to compete for this limited resource unless we are able to expand availability
- **Upmass/downmass bottom line**
  - Mass not limiting--No backlog on the ground today, projected mass capacity is good
  - Our on-orbit freezers are nearly full (>100%), dependent on regular SpaceX return
  - User demand for powered launch and return cannot be met (>100%) due to Biotech and Biology interest

Proposed Starting Point for ISS Future Vision As Input To The Next NASA Strategic Plan

- **NASA will maximize ISS use over its life, and promote and enable commercial, academic, and other government uses**
- **NASA will utilize the ISS to enable human spaceflight exploration beyond LEO and prioritize its use**
  - Technology development, Research, Operational Experience, and Human Health and Performance
- **NASA will leverage the ISS partnership to form the basis for collaboration with international partners on exploration activities**
- **The ISS will provide the market and resources to expand the commercial spaceflight industry**
  - Cargo and Crew
  - Capabilities and services
  - Technology development

The ISS has a limited life. Its capabilities and partnerships should be leveraged to their fullest to realize its full potential

ISS Program Forward Work

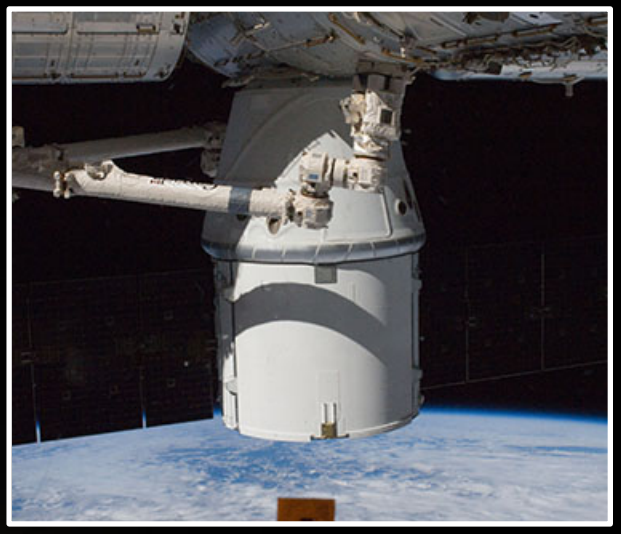
Tactical

- Is the agency aligned effectively to fully benefit from the ISS?
  - Science & technology development across HEO, SMD and OCT
  - Need agency strategic investment strategy & plan
- Is the agency positioned to fully promote the role and benefits of ISS?
  - Need agency communication strategy
- How do we fully capitalize on the commercial opportunities?
  - Capabilities or services beyond cargo and crew

Strategic

- Do we extend the ISS planning horizon to NET 2028?
  - Many tactical decisions are influenced by a hard cutoff date
  - Research/technology development needs leveraging ISS beyond 2020
  - Is there a commercial opportunity for ISS
  - How and when does the partnership exit from the program
  - Do the IGA's continue to live on beyond the actual life of the platform
  - How do we work with the next administration
  - How is the partnership leveraged for exploration

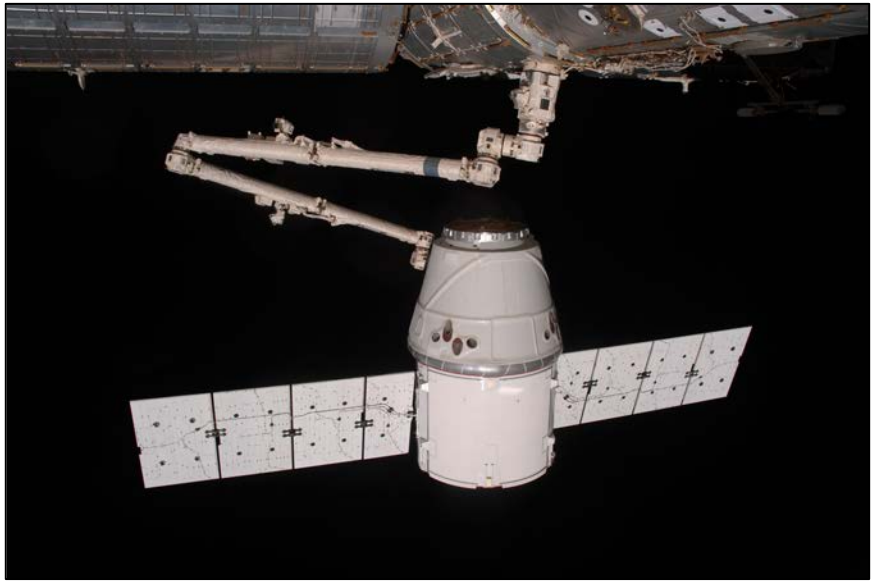
Rather than a hard cutoff date, what criteria can help NASA identify the most appropriate time to phase out the agency's active, full-time participation?



The SpaceX Falcon 9 rocket and Dragon capsule lifting off from Cape Canaveral. SpaceX CRS-1 is the first of twelve contracted commercial resupply missions to the International Space Station.

Commercial Crew

Commercial Cargo



Commercial Spaceflight Accomplishments

- Commercial Cargo
  - After 70 months, 40 milestones, and a $396M investment from NASA, SpaceX developed and brought into operations:
    - A new U.S. intermediate class commercial launch vehicle (Falcon 9),
    - A spacecraft (Dragon), and
    - A launch pad (LC-40)
  - SpaceX has already begun regular cargo resupply missions to the ISS
  - Orbital Sciences is making steady progress with a test flight planned in the next few months.
- Commercial Crew
  - CCDev1 successfully completed
  - The majority of CCDev2 milestones completed
  - CCiCAP is underway
  - NASA safety and performance requirements baselined
  - Industry is making significant progress on multiple crew transportation system designs
  - NASA certification efforts planned to begin early next year

Space Life and Physical Sciences Research and Applications Division 2012 Highlights

- Completed research demonstrating that exercise prescriptions using the ISS Advanced Resistive Exercise Device, together with appropriate nutrition, is an effective countermeasure against bone and muscle loss in space.
- Delivered an updated radiation risk assessment tool to manage the risk to crew members for future space missions. The tool supports mission planning and spacecraft shielding design.
- Implemented high fidelity biomedical imaging using the recently delivered Ultrasound 2 device to support research and monitor crewmembers to understand the connection between decrements in visual acuity and increased intracranial pressure in long duration space flight.
- The Radiation Assessment Device (RAD) instrument on board Curiosity collected valuable radiation data during the spacecraft transit to Mars, and continues to collect data on the Martian surface.

Space Life and Physical Sciences Research and Applications Division 2012 Highlights - *continued*

- Combustion research on ISS advanced the understanding of “cool flames,” a combustion process that occurs at temperatures below normal combustion. This phenomenon is a key to homogeneous charge compression ignition, an advanced clean-burning diesel technology.
- Results from ISS experiments on magnetorheological fluids, published with authors including Barratt, De Winne, Finke, Magnus, Wakata, and Whitson, demonstrated how pulsating magnetic fields can be harnessed in the creation of unique materials and electromechanical devices
- Work has begun to reestablish an animal research capability on the ISS. Validation experiment design is underway and concept of operations is being refined for a first launch planned for SpaceX-4.
- CASIS announced selections from its initial research solicitation in protein crystal growth, an area identified by a team of science advisors as having strong economic potential. Projects are being evaluated for flight in FY 2013 and 2014.

SLS

Ground Systems Development

Orion

Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry from deep space return velocities.

ESD Accomplishments (FY 12)

Space Launch Systems:

- SLS completed a major system design review in July 2012, only ten months after program start.
- This review also clears the way for manufacturing and testing of key hardware elements, including production of a large adaptor mechanism that will fly with the Orion Multi-Purpose Crew Vehicle (MPCV) test flight EFT-1 in 2014 and future flights of Orion on SLS.
- Continued rigorous testing of the J-2X engine at the Stennis Space Center in Mississippi, reaching full power milestones in only a fraction of the time of previous high-performance rocket engines development timelines.

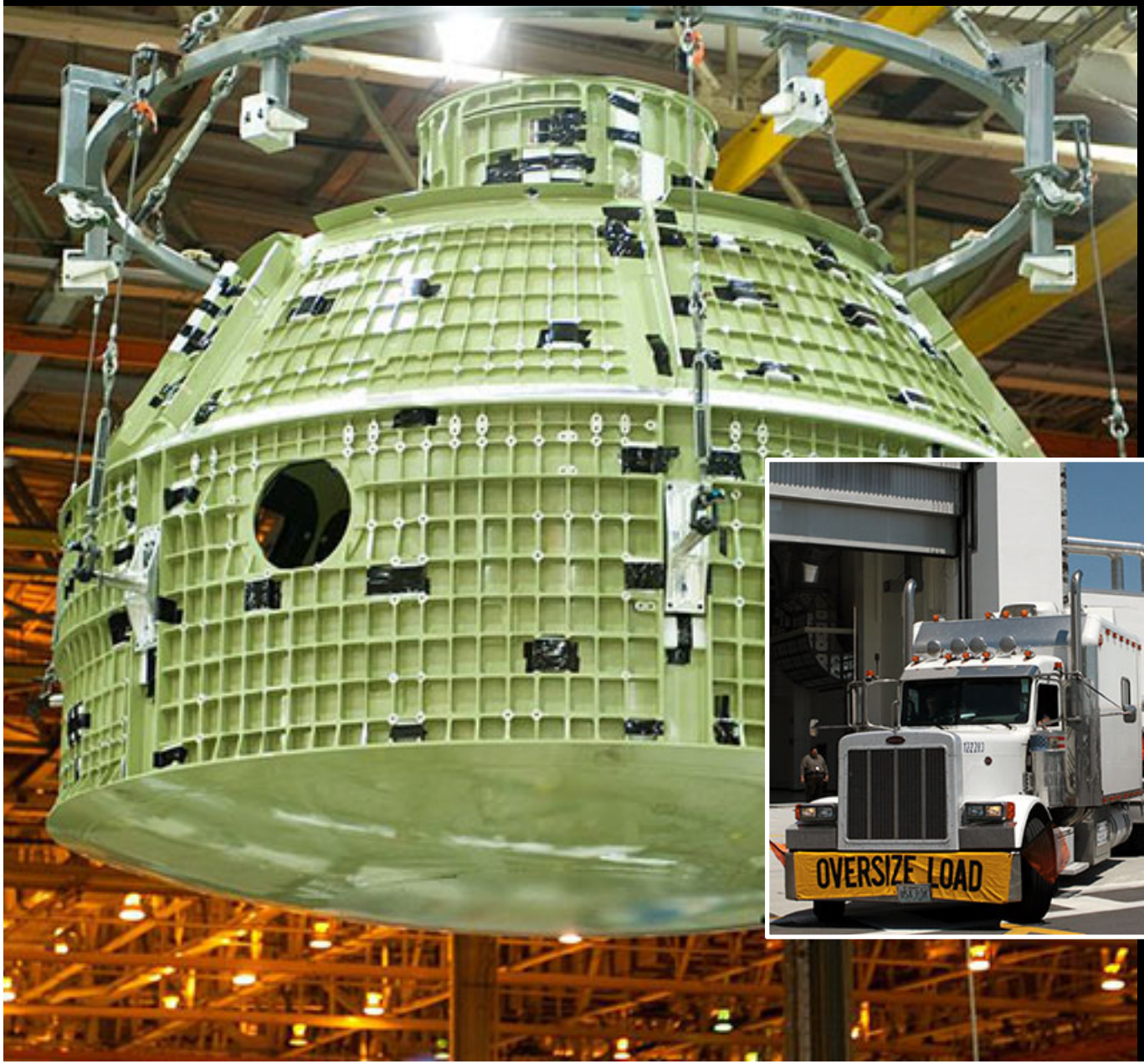
Orion MPCV:

- Delivered first flight test crew module structure of Orion MPCV for EFT-1 Test flight to Kennedy Space Center (KSC) for assembly and integration.
- Orion MPCV program completed
  - Significant acoustic and vibration testing in the Lockheed Martin Denver facilities
  - Water impact tests at Langley Research Center
  - Parachute tests in various configurations at the Yuma Proving Grounds

Ground Systems Development

- Continued extensive progress toward enhancing the launch infrastructure at KSC to support the EM-1 launch, the first planned flight for the integrated SLS and Orion MPCV in 2017.
- Awarded the mobile launcher structure and facility support system design contract was awarded, ensuring the ML is structurally sound and is outfitted to support SLS and Orion MPCV requirements enroute to and on the launch pad.
- Completed refurbishment of LC 39B systems, including Pad B instrumentation and Ground Support Equipment development
- Finalized Firing Room 1 command and control hardware installation, implementing initial voice, video, and data infrastructure.

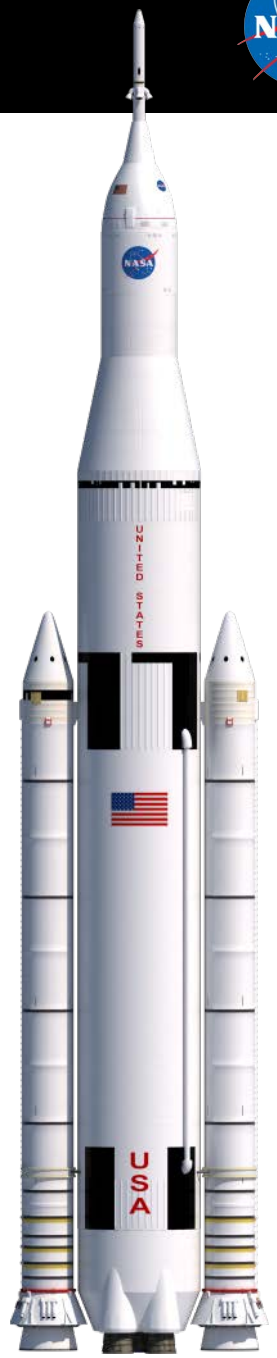
Orion EFT-1 Updates



Orion EFT-1 in route to NASA's Kennedy Space Center

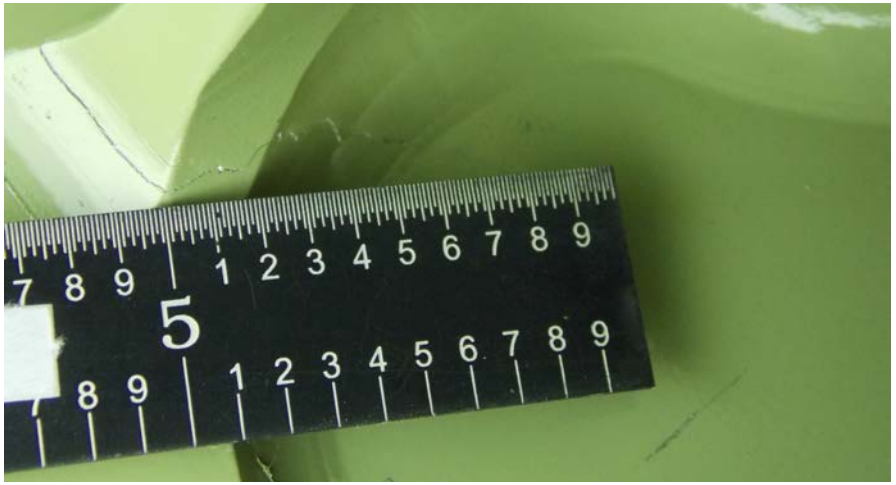
Exploration Flight Tests: Entering a New Era of Human Spaceflight

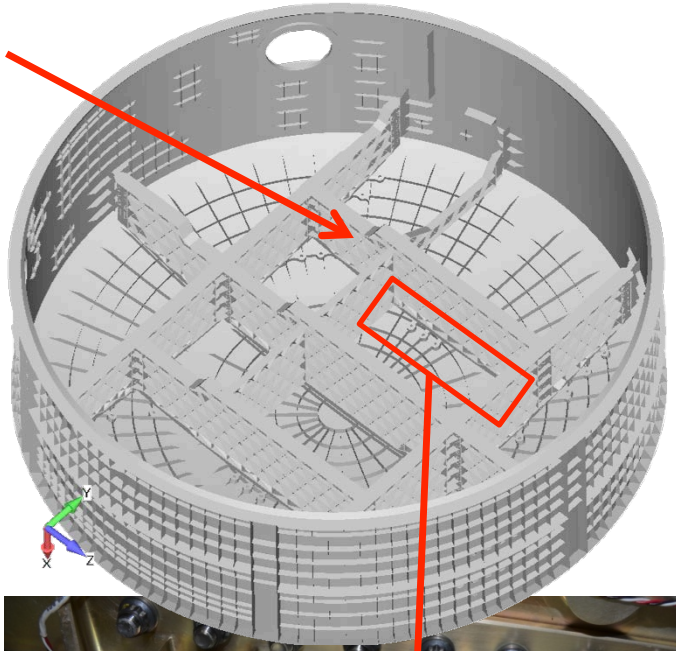
- The SLS and MPCV programs are actively working toward the goal of sending humans to explore deep space, with flight tests starting in 2014
- The Un-crewed Exploration Flight Test-1 (EFT-1) in 2014 and Exploration Mission 1 (EM-1) in 2017 will validate innovative approaches to space systems development to ensure the systems are safe for human travel, reduce cost, and demonstrate spacecraft post-landing recovery procedures
- The crewed Exploration Mission 2 (EM-2) will validate human risk mitigation techniques developed for the integrated SLS-MPCV system
- Current flight test plans take the integrated SLS-MPCV system to lunar fly-by and high lunar orbit. Current assessments are evaluating alternate destinations to address long-term exploration and science-based objectives.



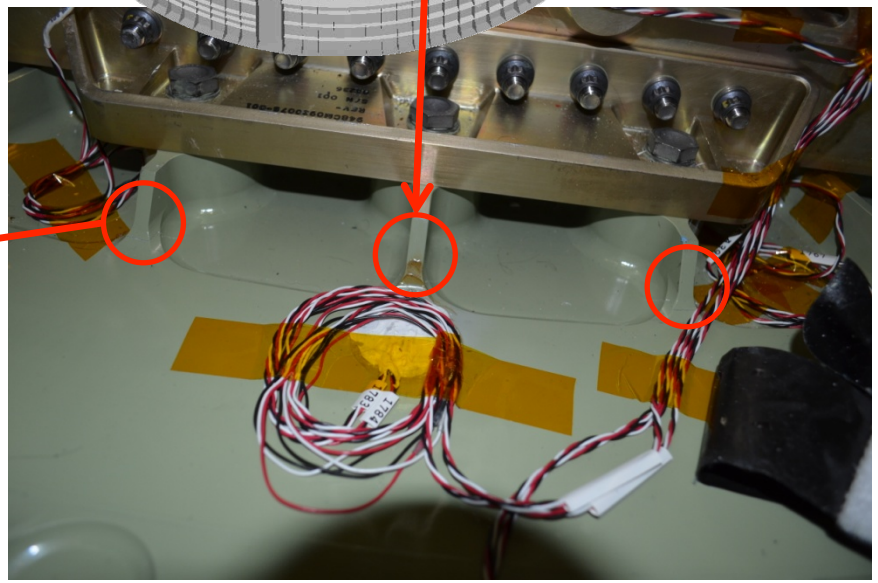
Cracked Occurrence During Proof Testing

Backbone panel 4

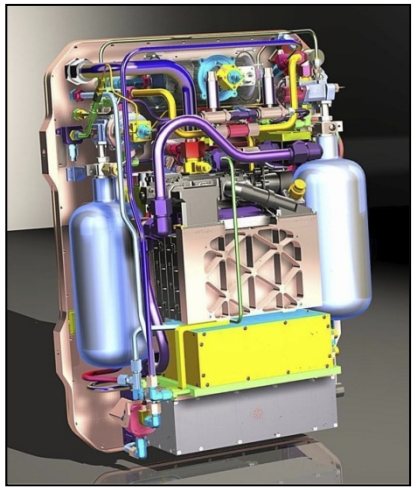




3 cracks at radius of rib run-out on far side of backbone panel 4



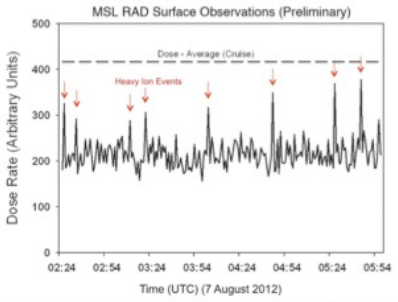
AES FY12 Accomplishments



EVA: Assembled prototype Portable Life Support System for advanced space suit.

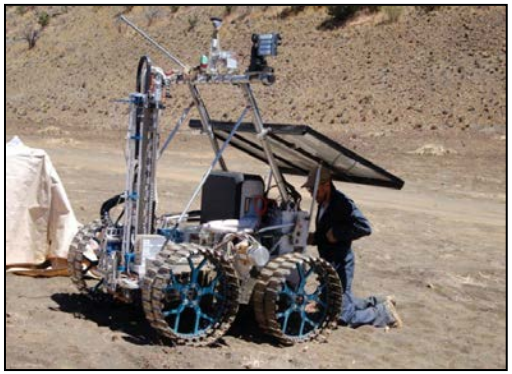
Life Support: Tested ISS-based air revitalization systems to improve reliability.

Morpheus Vertical Test Bed: Completed 20 tethered flight tests of Morpheus lander.



Radiation Assessment Detector: Acquired radiation data during MSL's interplanetary cruise and on surface of Mars

Goldstone Radar: Imaged 12 near-Earth asteroids to determine their orbits, size, shape, and spin rate.



RESOLVE: Conducted field test in Hawaii of lunar ice prospecting experiment in partnership with Canadian Space Agency.

Curiosity rover gets instructions daily from NASA via a network of antennae.

SCaN Accomplishments

- Decided and began Phased Implementation for the unified network.
- Maintained above 99% proficiency in all three networks.
- Flawlessly supported Curiosity Entry Descent & Landing and surface operations
- Launched SCaN Testbed; it is now in check-out aboard the International Space Station.
- Secured necessary Space Network (SN) funding for FY 2013 and FY 2014.
- Completed the Phase 1 technical baseline for requirements, architecture, and ConOps.
- Met all Tracking and Data Relay Satellite (TDRS)-K/L milestones.
  - (K launch Jan. 2013, L launch Feb. 2014)
- TDRS-L KDP-D successfully completed.
- Secured TDRS-M funding. Seeking a number of options to launch TDRS-M.
- Initiated the Deep Space Network Aperture Enhancement Project.
- Successfully passed SN Ground Segment Sustainment (SGSS) PDR (KDP-C in signature cycle).
- Completed optical module flight unit for LADEE flight.
- Initiated Laser Communication Relay Demonstration in partnership with Office of Chief Technologist.
- Defended successfully spectrum against LightSquared and prevailed at World Radiocommunication Conference, WRC-12 on all NASA issues.
- Engaged actively at the Plans and Policy Steering Group in support of the President's Broadband Initiative on Spectrum.
- Continue to provide leadership at Positioning, Navigation and Timing Executive Committee.
- Matured TDRS arraying to be inserted into operation after SGSS implementation.

Launch Services Program -- FY 2012 Highlights

4 Successful Launches

October 28, 2011

November 26, 2011

June 13, 2012

August 30, 2012

Launch Services Program – FY12 Programmatic Highlights

- **NLS II Contract "On-Ramp" Activities:**
  - May 14, 2012 added the Space Exploration Technologies (SpaceX) Falcon 9 v1.1 launch vehicle
  - June 26, 2012 added the Orbital Sciences Corporation Antares 120 and 130 model launch vehicles

- **NLS II Launch Service Task Order (LSTO) Awards:**
  - April 5, 2012 awarded LSTOs for two intermediate-class National Oceanic & Atmospheric Administration (NOAA) missions (i.e., Geostationary Operational Environmental Satellite (GOES) R and S) awarded to United Launch Services (ULS), LLC
    - Spacecraft will launch in October 2015 and February 2017, respectively, aboard Atlas V 541 rockets from Space Launch Complex (SLC)-41 at Cape Canaveral Air Force Station (CCAFS), FL
  - July 16, 2012, awarded LSTOs for two medium-class NASA Science Mission Directorate (SMD) missions (i.e., Soil Moisture Active-Passive (SMAP) & Orbiting Carbon Observatory-2 (OCO-2)) along with a NOAA mission (i.e., Joint Polar Satellite System (JPSS-1)) to ULS
    - Spacecraft will launch in October 2014, July 2014 and November 2016, respectively, aboard Delta II rockets from SLC- 2 at Vandenberg Air Force Base (VAFB), CA
  - July 16, 2012 awarded LSTO for one medium-class NOAA mission (i.e., Jason-3) to SpaceX
    - Spacecraft will launch in December 2014 aboard a Falcon 9 v1.0 rocket from SLC-4 at VAFB, CA

- **New Entrant Launch Vehicle Certification:**
  - October 12, 2011 signed New Entrant Launch Vehicle Certification Strategy with the United States Air Force, and the National Reconnaissance Office
  - July 16, 2012 began Category 2 certification of the Falcon 9 v1.0 with award of Jason-3 LSTO

Launch Services Program – FY13 Plan

- **Successfully launch the following missions this fiscal year (i.e., FY2013):**

NET January 25, 2013
Atlas V 401 CCAFS, FL

NET February 11, 2013
Atlas V 401, VAFB, CA

NET February 27, 2013
Pegasus XL, VAFB, CA

- **Conduct the LSTO selection process for the following missions:**
  - Medium-class launch service for the SMD/Earth Science Division *Ice, Cloud, and land Elevation Satellite-2* (ICESat-2) mission
  - Intermediate-class launch service for the SMD/Planetary Science Division *Origins Spectral Interpretation Resource Identification Security-Regolith Explorer* (OSIRIS-REx) mission

Taurus XL T9 Mission "Glory"
Launch Vehicle Failure Investigation Status

- **4 Mar 2011: Launch Failure, Glory (T9) mission failed to reach orbit**
  - Telemetry indicated that the Taurus XL fairing did not separate from the launch vehicle.
    - This was the second failure of the Taurus XL for a similar reason – 1st failure was OCO in Feb 2009
- **16 Sep 2011: Orbital T9 Accident Investigation Board (AIB) report submitted to NASA**
  - Orbital T9 AIB unable to identify root cause for failure. (No root cause was found for OCO failure either in 2009.)
- **16 Dec 2011: NASA T9 Mishap Investigation Board (MIB) report delivered NASA HQ**
- **20 Jan 2012: NASA T9 MIB internal briefing to NASA Flight Planning Board (FPB)**
  - NASA T9 MIB also unable to identify a root cause for the failure. (T8 OCO MIB also unable to identify root cause.)
- **2 Feb 2012: NASA terminated the Taurus XL launch service task order for the OCO-2 mission**
  - New commercial launch service was put in place for OCO-2 on 16 July 2012 with ILC of July 2014
- **13 Apr 2012: NASA T9 MIB Report completed endorsement process per NPR 8621.1B**
  - MIB members have been released
- **On-going Actions:**
  - Publicly releasable summary (similar to the OCO failure summary) is in final coordination – expect release prior to end of CY2012 that documents the findings from the endorsed T9 MIB report
  - Launch Services Program (LSP) and Orbital have been continuing the investigation, responding to T9 MIB technical recommendations and developing a Corrective Action Plan that is applicable across the Orbital launch vehicle fleet
    - Some great work has been done by LSP and by Orbital; however, the work is not done and the details are currently proprietary
  - Special FPB is being planned to make Agency aware of updated findings and mitigation activities that will apply not only to Taurus XL, but also Pegasus, Minotaur and Antares launch vehicles

For more information about the HEO directorate visit:

www.nasa.gov/directorates/heo

For the latest news about human exploration visit:

www.nasa.gov/exploration