Innovation and Technology

NASA Space Operations Mission Directorate

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Presentation to the NAC Technology and Innovation Committee Meeting – 4/22/2010

Innovation in SOMD

SOMD Innovation Opportunities in three main areas

1. Mission Focused Innovation – Needed to conduct the primary mission
2. New or enhancement capabilities that allow for a more robust solution or lower long term operation costs
    a. Acquisition – Can the government be more commercial like or enable future commercial markets through our acquisition approaches?
3. Participatory Public engagement and Innovative methods to reach the public

Mission Focused Innovation

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Mission Focused

Example – The completion and operation of the International Space Station

The International Space Station Vision - A human outpost in space bringing nations together for the benefit of life on Earth … and beyond.

dimensions:
240 ft. long, 291 ft. wide, 45 ft. high, 25,640 cubic feet of living space.

Weight at completion:
420,500 kg.

science capabilities:
laboratories from four international space agencies – U.S., Russia, Europe, and Japan.

orbital inclination/path:
51.6 degrees, covering 90% of the world's population.

altitude:
approximately 220 miles above the Earth.

speed:
17,500 miles per hour, orbiting the Earth 16 times a day.

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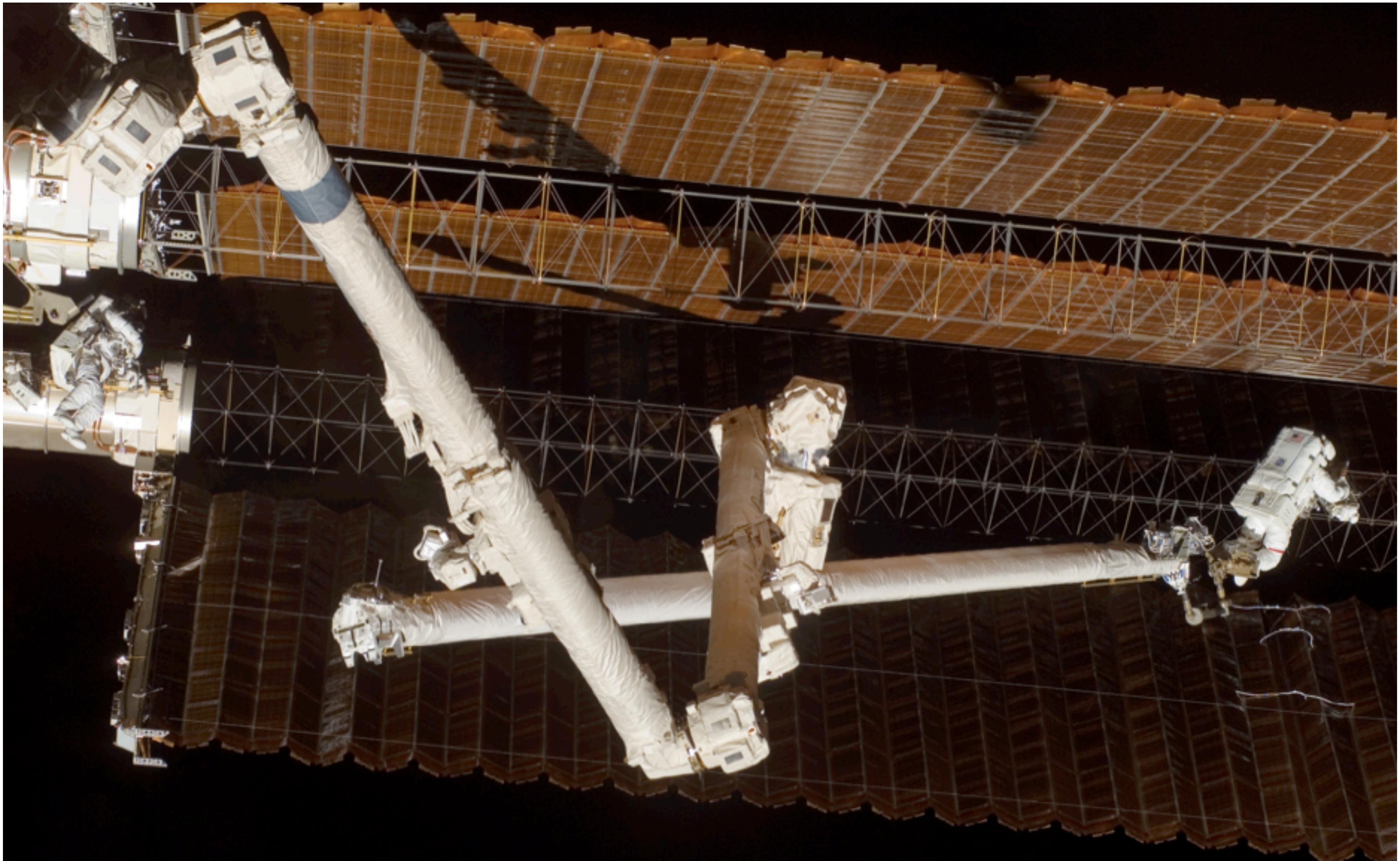

Mission Focused

As we execute the mission we have opportunities to be innovative

Mission also Includes ISS as a U.S. National Lab

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U.S. National Lab onboard the ISS

Why was the International Space Station designated a U.S. National Laboratory?

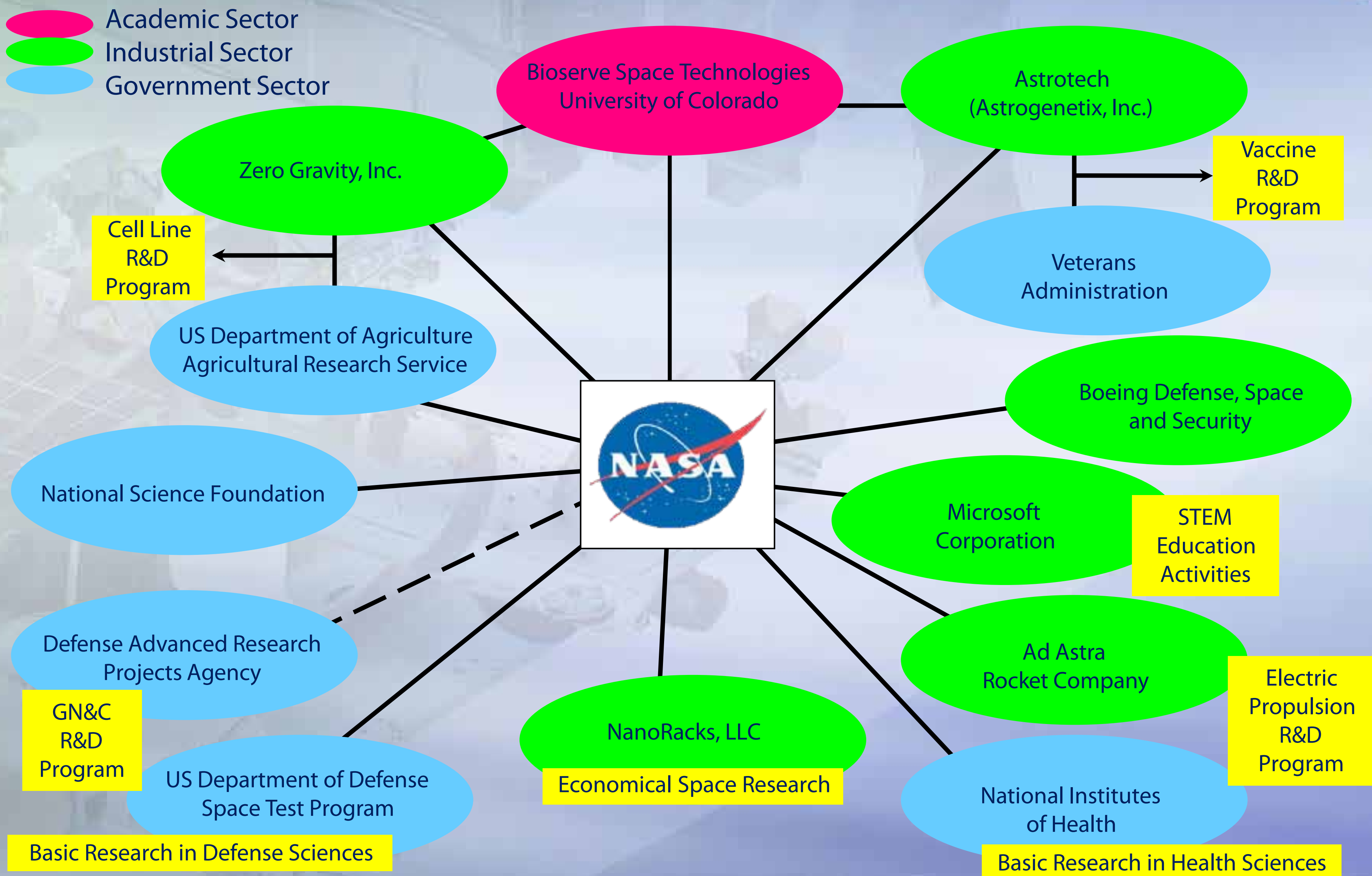
Once ISS assembly is complete and 6 crew (already has 6 person crew) are present on board, the ISS payload science capability is not fully utilized by NASA's planned science program

In order to maximize the return on investment of the ISS, Congress wanted to open up the orbiting laboratory to non-NASA users

NASA Authorization Act of 2005, Section 507, National Laboratory Designation, Public Law 109-155, enacted Dec 30, 2005.

- Opportunity for other government agencies to use ISS to meet their agency objectives
- Opportunity for commercial interests to use ISS in the interests of economic development in space

Current National Lab Partnerships



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Current National Lab Partnerships

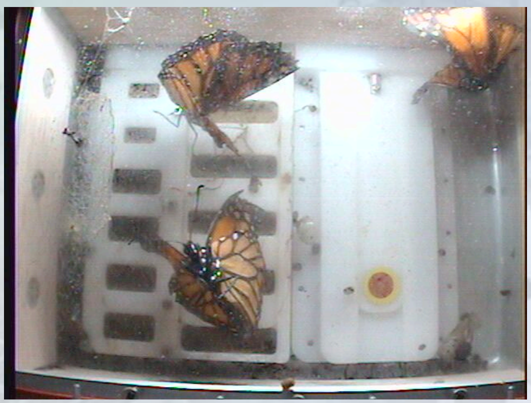
Began signing formal agreements in September '07

- National Institutes of Health (MOU, 9/12/07)
  - Issued 3-year rolling Funding Opportunity Announcement (FOA) Mar. '09 for peer-reviewed grants up to $450K each, with 9/27 institutes participating
- Bioserve Space Technologies, University of Colorado (SAA, 5/9/08)
  - Veteran of > 40 flight experiments since 1991 with two Commercial Generic Bio-processing Apparatus (CGBAs) currently on-board ISS.
- Spacehab, Inc. (SAA, 5/27/08) now dba Astrotech/Astrogenetix
  - Successful vaccine development program for bacterial pathogens; completed for salmonella and pending FDA Investigational New Drug (IND) classification; staphylococcus underway.
- Zero Gravity, Inc. (SAA, 5/27/08)
  - CRADA w/USDA for plant & animal cell line development; limited funding from Maryland State Technology Economic Development Corp (TEDCO)
- U.S. Department of Agriculture, Ag Research Service (MOU, 7/23/08)
  - Completed initial plant & animal genesis flight experiments on STS-118/126; six priority research themes identified in Feb. '09 workshop of ARS national program leaders
- Ad Astra Rocket Company (SAA, 12/5/08)
  - Electric propulsion test bed based for VASIMR (Variable Specific Impulse Magnetoplasma Rocket) technology.
- NANORACKS LLC (SAA, 9/21/09)
  - Utilize the ISS by launching hardware that enables multiple small payloads to be operated within an Expedite the Processing of Experiments to Space Stations (ExPRESS) Rack (ER) locker on a commercial basis.
- National Science Foundation
- Microsoft

Pending MOUs with USGS, NOAA, DARPA and other Commercial Firms

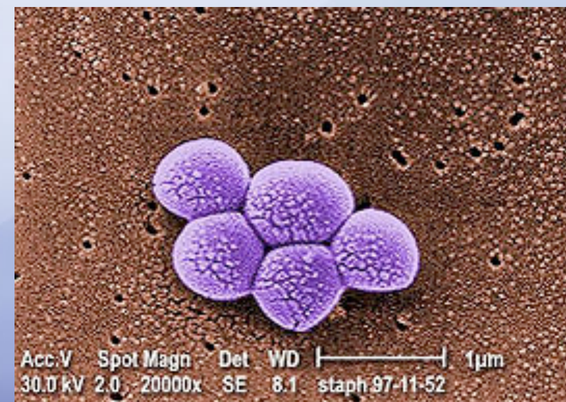
Examples from Partnerships

BioServe Space Technologies
and OrionsQuest
STEM education

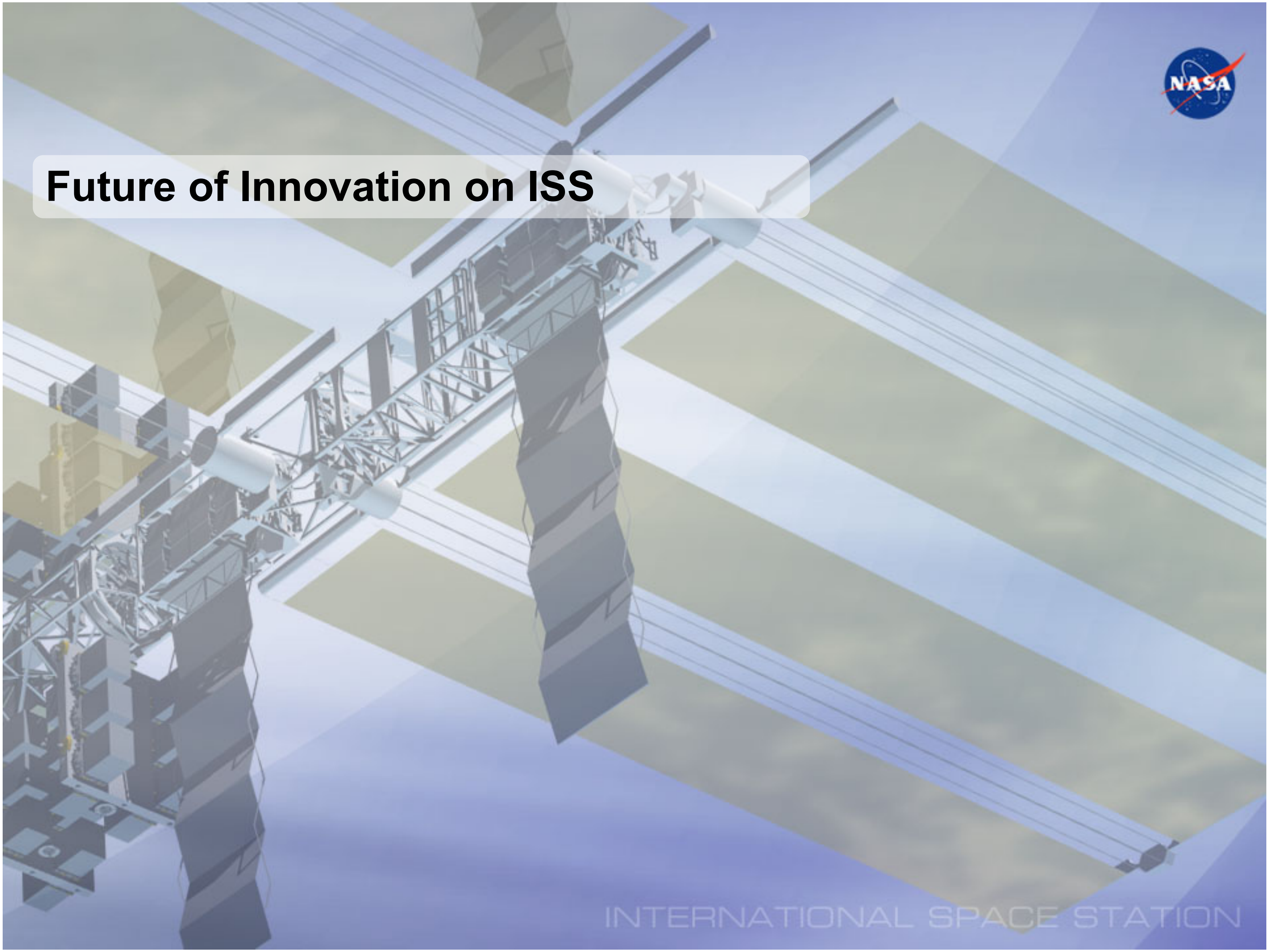


Zero Gravity, Inc
Plant Cultivars
for Biofuel Feedstock

Astrogenetix, Inc
Vaccines & Therapeutics
for Bacterial Pathogens



Future of Innovation on ISS



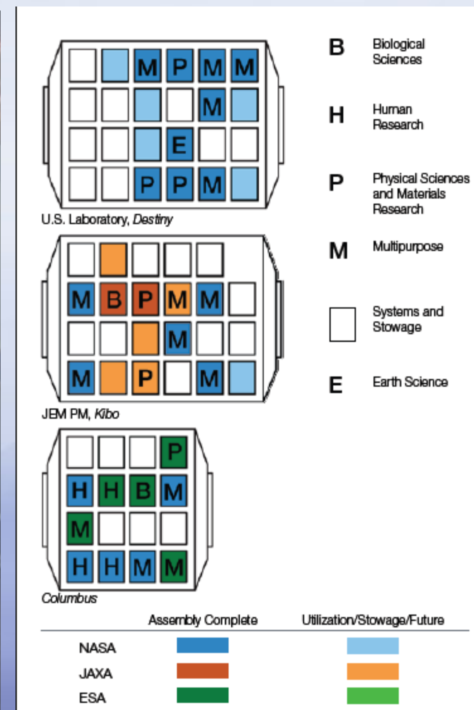
President's Budget for FY11

- Funding to extend Space Station Operations beyond 2016
  - Additional Funding for ISS Utilization and National Lab
- Further emphasis on:
  - Work with partners around the World
  - Maximize return on investment
- Deploy New Research Facilities
  - Scientific Research
  - Test Technologies
- Make Space Station Research Capabilities available to Educators and new Researchers

FY11 Presidential Budget specifically directs NASA to “revitalize utilization”

Overview of Opportunities on ISS

Internal Pressurized Rack Sites	Station-Wide	U.S. Share
U.S. Laboratory	13 ISPRs	13 ISPRs
Japanese Experiment Module	11 ISPRs	5 ISPRs
European Columbus Orbital Facility	10 ISPRs	5 ISPRs
Total	34 ISPRs	23 ISPRs
External Un-pressurized Attachment Sites		
U.S. Truss	8 sites	8 sites
Japanese Exposed Facility	10 sites	5 sites
European Columbus Orbital Facility	4 sites	0 sites
Total	22 sites	13 sites



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ISS Payload Accommodations

International Standard Payload Rack (ISPR) Sites

Power
- 3, 6, or 12 KW, 114.5-126 VDC

Data
- Lo Rate: 1 Mbps
- High Rate: 100 Mbps
- Ethernet: 10 Mbps
- Video: NTSC

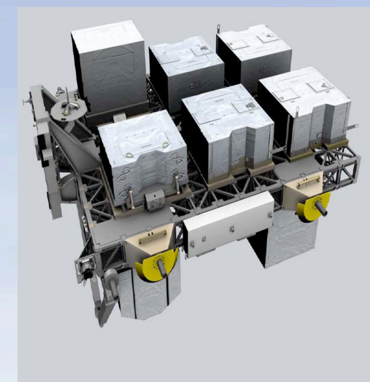
Gases
- Nitrogen
  - Flow =0.1 kg/minute (min.)
  - 517-827 kPa nominal, 1379 kPa (max.)
- Argon, Carbon Dioxide, Helium
  - 517-768 kPa nominal
  - 1379 kPa maximum

Cooling Loops
- Moderate Temperature: 16.1 C - 18.3 C
  - Flow rate=0-45.36 kg/hr
- Low Temperature: 3.3 C - 5.6 C
  - Flow rate=233 kg/hr

Vacuum
- Venting: 10^{-3} torr in less than 2 hours
- Vacuum Resource: 10-3 torr

http://www.nasa.gov/externalflash/lab_racks/labs.html

ISS External Payload Sites



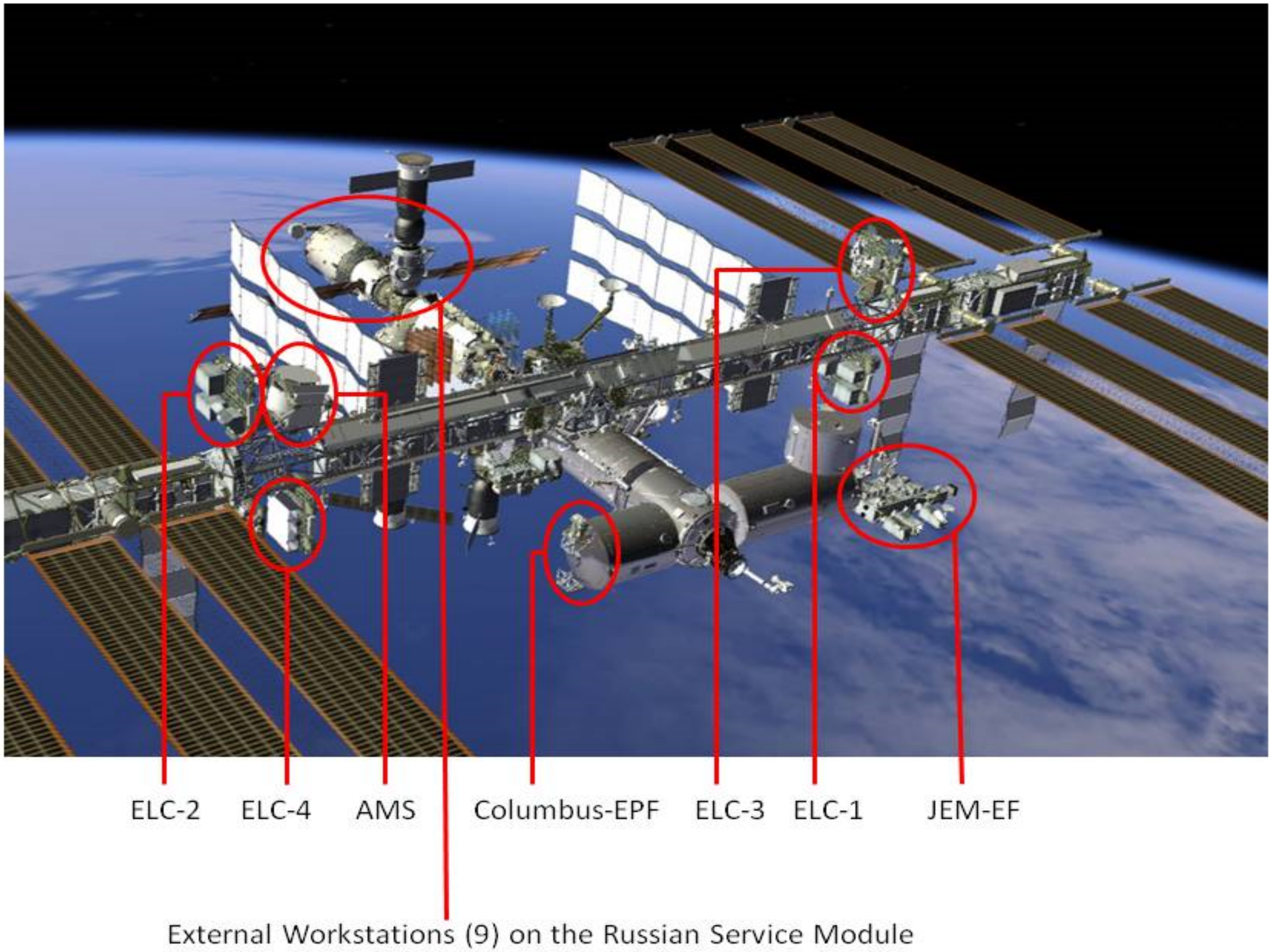
Express Logistics Carrier (Truss)
- Mass: 9,800 lbs
- Volume: 30 m^3
- Power: 3 kW max
  113-126 VDC
- Data: Low Rate: 1 Mbps
  High Rate: 95 Mbps

EXPRESS Adapter Site
- Mass: 500 lbs
- Volume: 1 m^3
- Power: 750W max, 113-126 VDC
  500 W max, 28 VDC
- Data: Low Rate: 1 Mbps
  Medium Rate: 2 Mbps (shared)

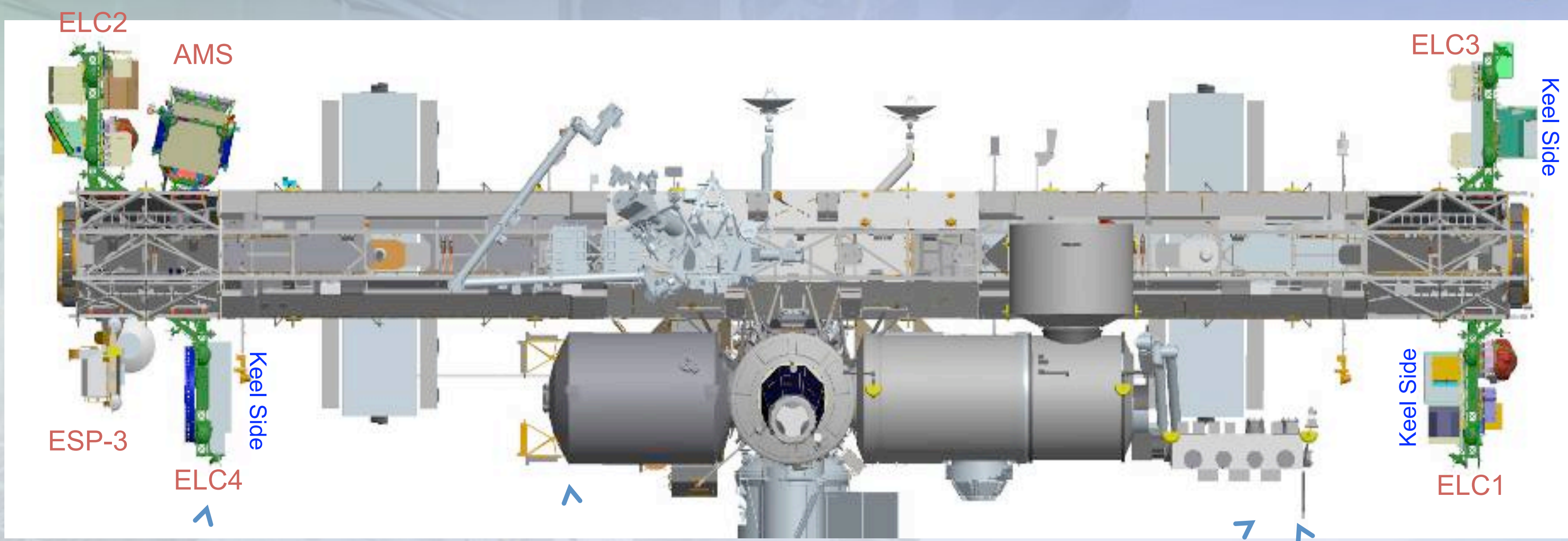
JEM Exposed Facility (EF) Site
- Mass: 1,150 lbs Standard Site; 5,500 lbs
- Volume: 1.5 m^3
- Power: 3 kW max, 113-126 VDC
- Data: Low Rate: 1 Mbps
  High Rate: 43 Mbps (shared)
  Ethernet: 10 Mbps

COF Exposed Payload Facility (EPF) Site
- Mass: 500 lbs
- Volume: 1 m^3
- Power: 2.5 kW max, 120 VDC (shared)
- Data: Low Rate: 1 Mbps
  Medium Rate: 2 Mbps
  Ethernet: 10 Mbps

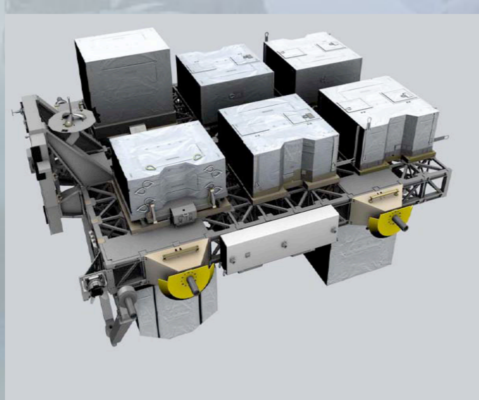
ISS External Payload Sites



ISS External Platforms

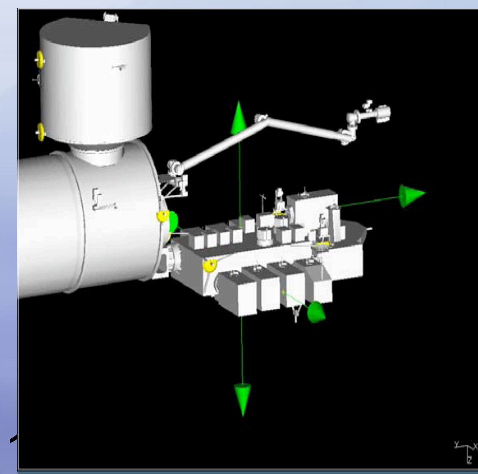


External Logistics Carrier



Columbus External Payload Facility

Kibo
External Facility



Innovation through New or Enhanced Functionality and Testbeds

ISS as a Testbed

- Extension to at least 2020
  - Evaluating certification to 2028
- Expansion of functions and capabilities
  - International Docking standard
  - Enhanced computing and communication systems
  - Increase in utilization accommodations
  - Enhanced stowage
- Call for technology development proposals
- Robotics testbed
- Evaluating role in exploration

ISS as a Testbed

- Deployed permanent bus on orbit
  - ISS is now 90% complete
  - 22 external payloads sites
  - 34 internal payload sites
- Crewed platform in space
  - Continuously manned for 10 years
  - Research efforts began with the first crew
  - Six crew operations established in 2009
- Commercial Resupply Services
  - On contract for quarterly visits
- Costs
  - Class D hardware (non-critical application)
  - Mission success criteria less stringent
- **10 plus year planning horizon now**

ISS as a Testbed

- Research Development Test & Evaluation (RDT&E) Initiative
  - Ideas from those closest to the issues, challenges and technology are solicited
  - Problem Solving and Creativity in the Agency is tapped
  - Centers are asked to bring forward their best ideas for research on the International Space Station

Current Schedule

Feb 1	Initial Call released to field installations.
Mar 31	Round One proposal submissions due.
April 30	Round one evaluations and team recommendations complete; status and recommendations briefed to
Sponsoring	Authorities; approval for development of formal proposals.
May 1	Call for proposals issued to proposers selected in round one.
June 30	Round two proposal submissions due.
August 13	Round two proposal evaluations and team recommendations complete.
August 30	Selection briefing and decisions.
October 1	Start of implementation (pending FY11 appropriations)

ISS as an Acquisition Test Bed

- ISS Is serving as a platform for Research, Commercial, and Engineering Test Bed activities but there is more we can use it for
- Problem? Does NASA lack innovation in acquisition?

NASA NEEDS INNOVATION IN ACQUISITION

- Claims?
  - Contractors claim that if NASA would just tell us what they want the hardware to do and what the interfaces are, they can build it …..
    - Faster
    - Cheaper
    - Just as reliable
    - Without any more risk

OK….. But are they ready to take the risk?

Money on the line?

- Why not use ISS requirements as a way to test some of the concepts?
- The Industrial Base that supplies NASA is shrinking? Why?

Flight Hardware on a Service Contract

Water Production Services on the ISS

What does it mean?

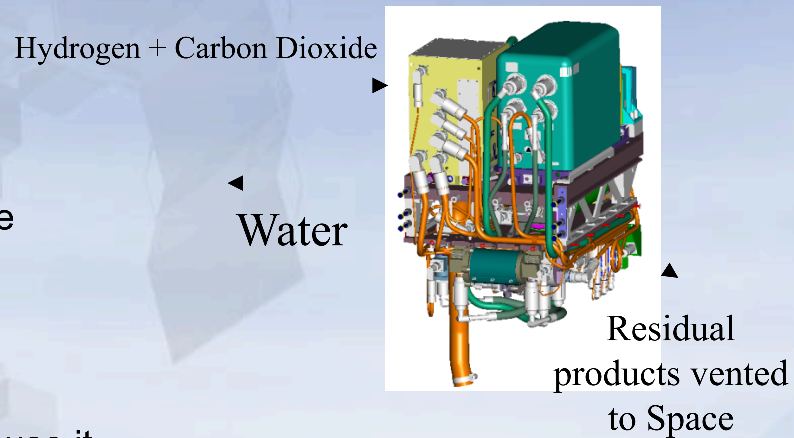
- NASA pays for a service instead of a piece of hardware
- Don’t own the hardware once it is built

What does it look like?

- Looks like a utility contract at your house
- You pay for the availability of the service (whether you use it or not, like your land phone line) or the amount used (water, sewer, power)
- Have to define limits on resources used to enable the service
  - In this case: upmass, crew time, and system interfaces

Why would you do it?

- Minimizes NASA risk because we only pay for the service when it is available
  - Fixed price for the service defines NASA maximum commitment and puts the contractor’s “skin in the game” throughout the entire life cycle
- Minimizes NASA involvement in design and development
  - If the contractor only gets paid when and if it works, they are more motivated than anyone else to build a high quality/high reliability system
- Demonstrate another type of contract that moves closer to commercialization of space



$4H_2 + CO_2 \leftrightarrow 2H_2O + CH_4$

Technology and Innovation in SOMD Beyond ISS

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Transformation Tasks & Demos

Transformation Tasks

Schedule – 3 Months

Staffing – No More than 3

Funding – Less than 300K

No Paperwork – Hands on Tasks with Hardware or real test results on operational systems

Access to Decision Makers

Demonstrations

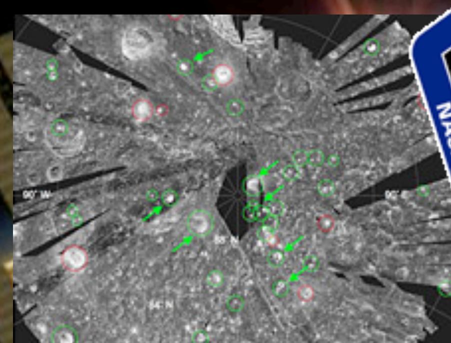
Access to Flight Systems or Development of Systems for Flight

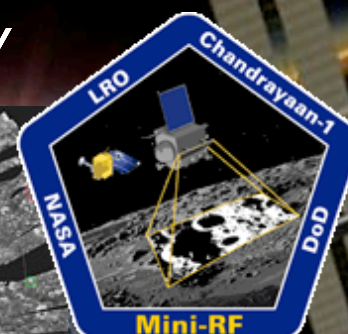
Missions of Opportunity

Flexibility on Process

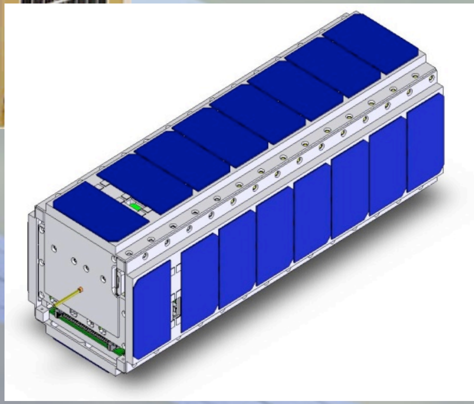
Lean Management

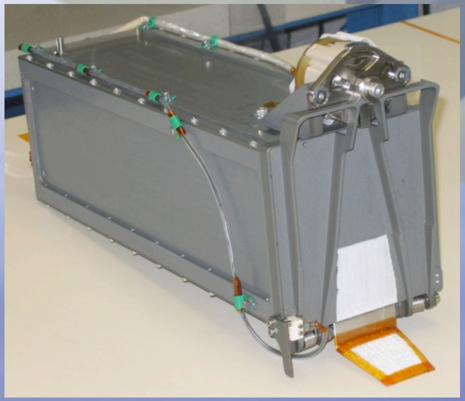
Potential for Leave behind asset or capability





CubeSat Launch Initiative





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CubeSat Launch Initiative

– OBJECTIVE: Provide CubeSat launch services on ELV and CRS Launches

2006 Strategic Plan:

– Strengthen NASA and the Nation's future workforce—NASA will identify and develop the critical skills and capabilities needed to ensure achievement of NASA's vision
  – Attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers, and faculty.
– Promote and develop innovative technology partnerships among NASA, U.S. industry, and other sectors for the benefit of Agency programs and projects
  – IPP would like to use SmallSats as a means to advance the development of technologies from SBIR, Seedfund, and for a stepping stone from other programs such as the FAST
– Develop a balanced overall program of science, exploration, operations, and aeronautics
  – SMD/ESMD/SOMD could use CubeSats for low-cost technology development or pathfinders, EPO efforts, and/or PI training

http://www.nasa.gov/directorates/somd/home/CubeSats_initiative.html

Participatory Public Engagement and Innovative Methods for Communication

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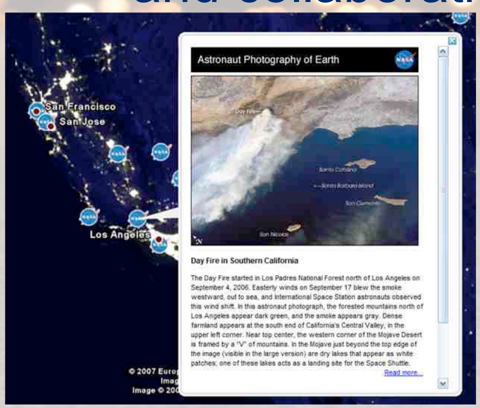
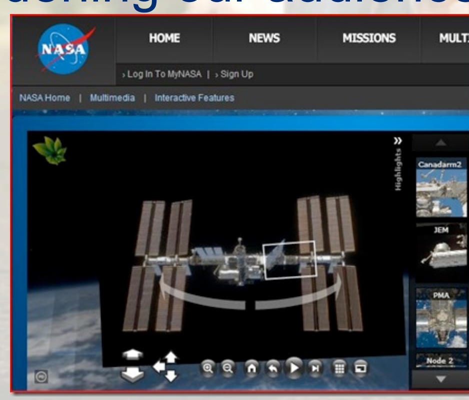
Innovative Communication Methods

- Access to Space Opportunities for the general public
  - Web and social media tools and traveling educational exhibits.

- Building Research Partnerships with the Public
  - Striving to make data accessible to everyone via innovative and collaborative tools, thus broadening our audience.



Google Earth



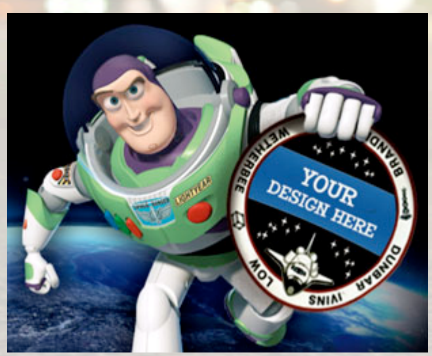
Microsoft Photosynth

Image Tweeted from Space

Participatory Public Engagement and Education

- Access to Space Opportunities for Students
  - Developing opportunities where students can conduct research that ties in with NASA's missions, and student experiments and hardware can be launched

- Innovative Competitions and Challenges



Education Onboard the ISS National Lab

Overview of Zero-Robotics Pilot

Pilot Program Underway with MIT

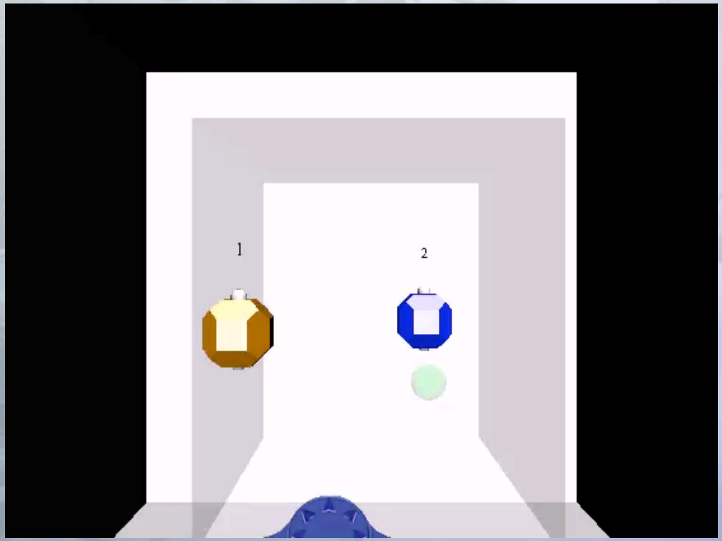
- Open ISS to High Schools and Undergraduates
  - Modeled after FIRST Robotics, starting with programming of algorithms and culminating with reconfigurable hardware
  - Coordinate with FIRST Robotics program
  - Promote interest in STEM by allowing students to “touch” space.

- Ideas consist of three possible phases:
  - **1) High school students program SPHERES and compete for opportunity to test on ISS**
  - 2) Pre-position modular hardware on ISS. High school students upload S/W and assembly plans for building and operating competing robots
  - 3) Collegiate competition allowing college students to do the same but with more access to the various software modules

Overview of Zero-Robotics Pilot

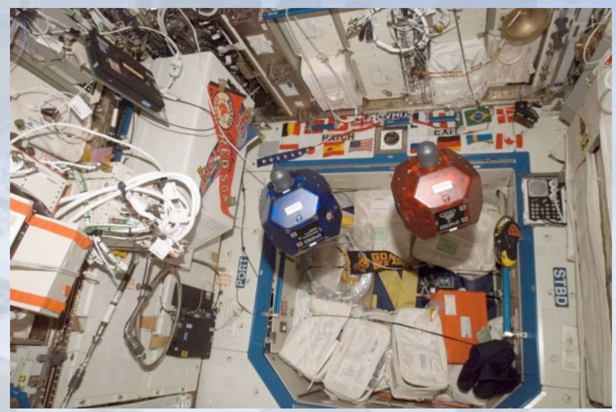
- Objective: “Learn by Doing”
  - Familiarization, simulation, procedures, programming, MIT visit coordination, FAQs
- Two teams participated from Idaho
  - Team 1: Bonners Ferry High School
  - Team 2: Coeur d’Alene School District
- First round Kicked off in Sept 2009. Completed 12/12/2009
- Steps 2-4: simulation, ground hardware testing, ISS testing
  - No proposals were requested
  - Started with C coding tutorial and an introductory game
  - “Competitions” in simulation and ground testing, but neither team eliminated
- Timeline:
  - Simulation files delivered to MIT — Mid Oct ‘09
  - Hardware files delivered to MIT — Early Nov ’09 (Webcast of testing)
  - Files sent to NASA for ISS — Early Dec ‘09
  - Feedback from pilot program — Late Dec ’09
  - Discussion of expansion based on Results of Pilot — Spring 2010

Zero-Robotics Pilot Results



Follow on Partnership with DARPA for SPHERES

- InSPIRE (ISS SPHERES Integrated Research Experiments) program



  - Project includes a Grand Challenge competition where high school students design software to control the on orbit SPHERES hardware.
  - Pathfinder ZERO Robotics competition ran in December 2009 with 2 schools successfully executing SPHERES control software on board ISS
  - Development of additional relative navigation expansion hardware for the SPHERE Platform

Overview of Kids in Micro-g

- "Kids in Micro-*g*" is a student experiment design challenge to give students a hands-on opportunity to design an experiment or simple demonstration that could be performed both in the classroom and aboard the International Space Station (ISS).

- The winning experiments will have observably different results when the experiments are performed in the "1-gravity" or "1-g" environment of the classroom, compared to when the experiments are performed by Astronauts in the "Micro-g" environment (one-millionth of 1-g) environment of the ISS.
- 130 experiment proposals were received. Selection was completed on April 2, 2010
- No Direct NASA Funding

www.nasa.gov/mission_pages/station/science/nlab/experimentchallenge.html

Overview of HUNCH

– High Schools United with NASA to Create Hardware (HUNCH):

– Middle and high school students build flight and training hardware for use on ISS

– Additional students edit ISS videos for NASA use, design experiments for ISS, and design ISS related web pages.

– HUNCH is now in 8 states in at least 31 schools.

– HUNCH funding provided by NASA

– An additional expansion of HUNCH to the United States Military Academy, for engagement of schools in New York state is underway with minimal NASA support.

http://www.nasa.gov/vision/space/preparingtravel/hunch.html www.nasa.gov