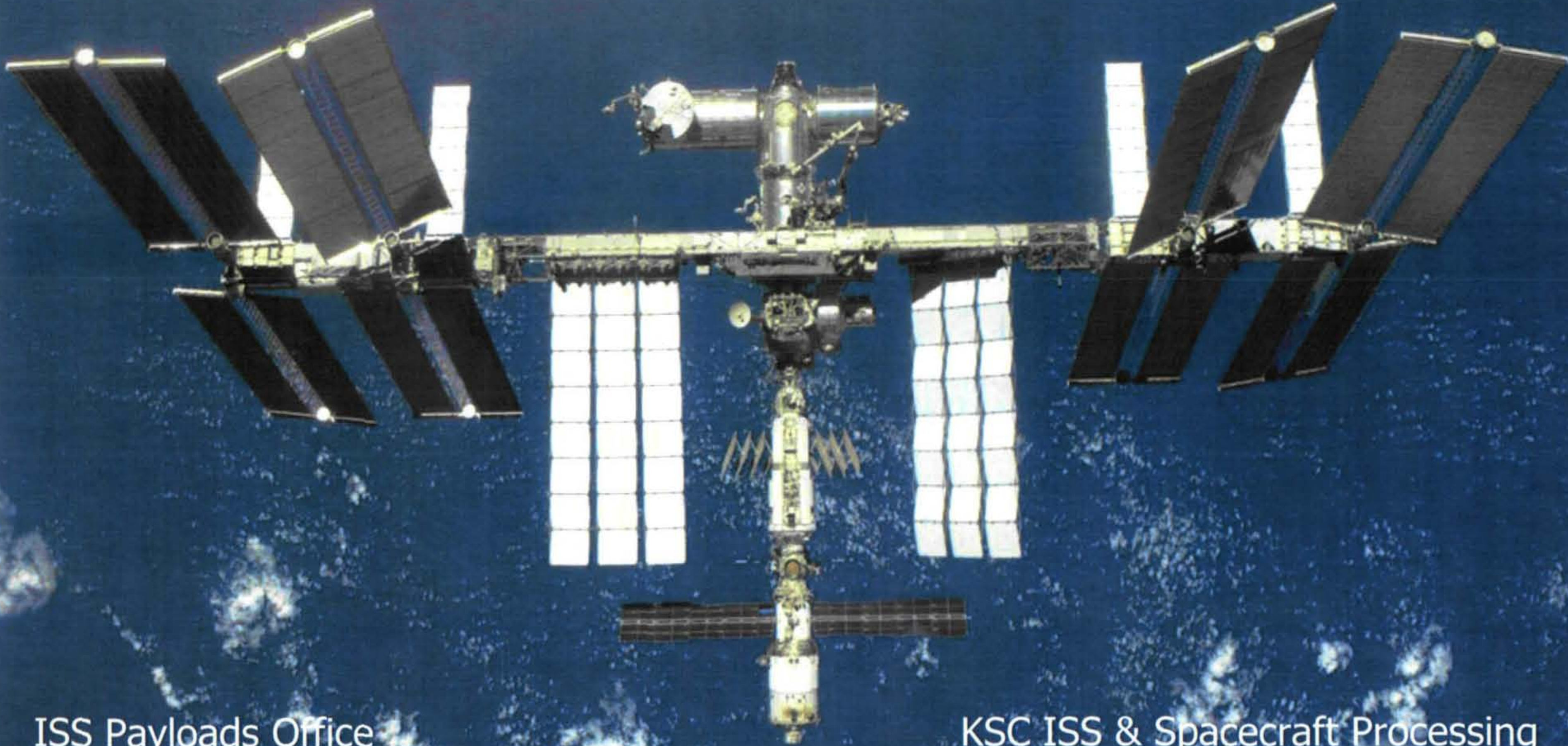
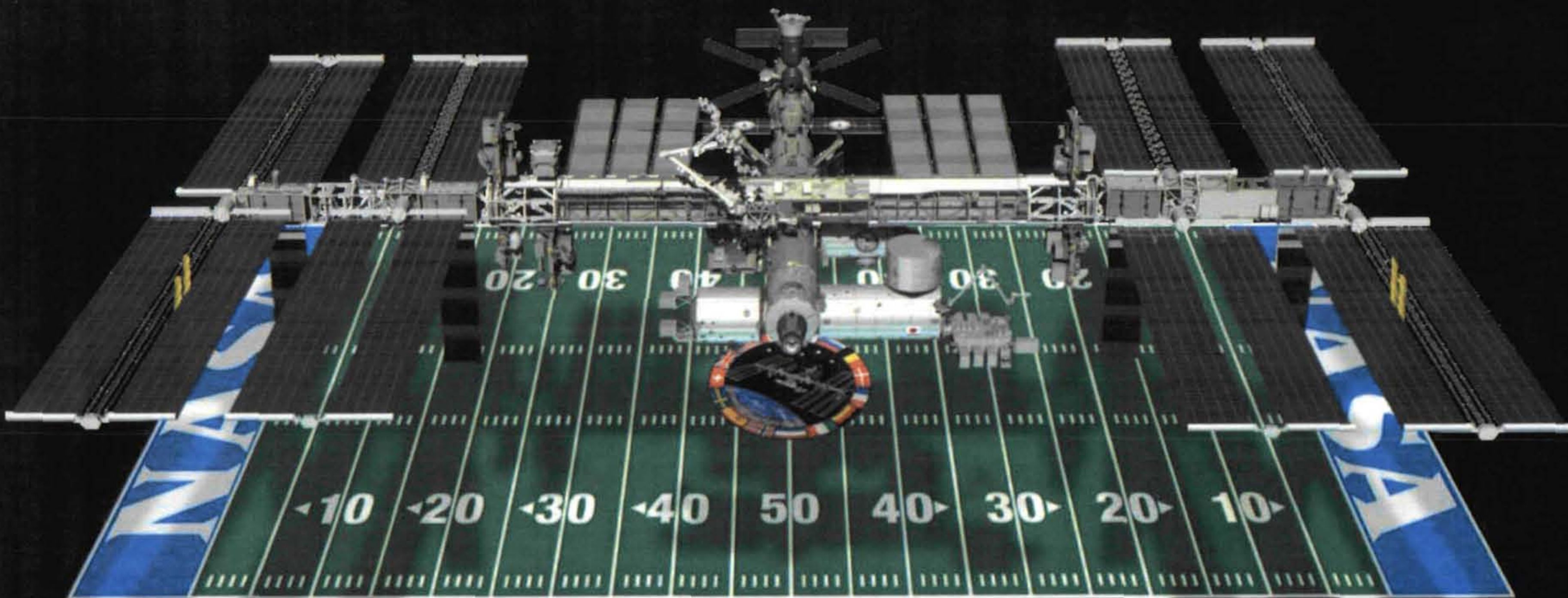
International Space Station



ISS Payloads Office
3 August 2010

KSC ISS & Spacecraft Processing
15 October 2010

International Space Station Facts



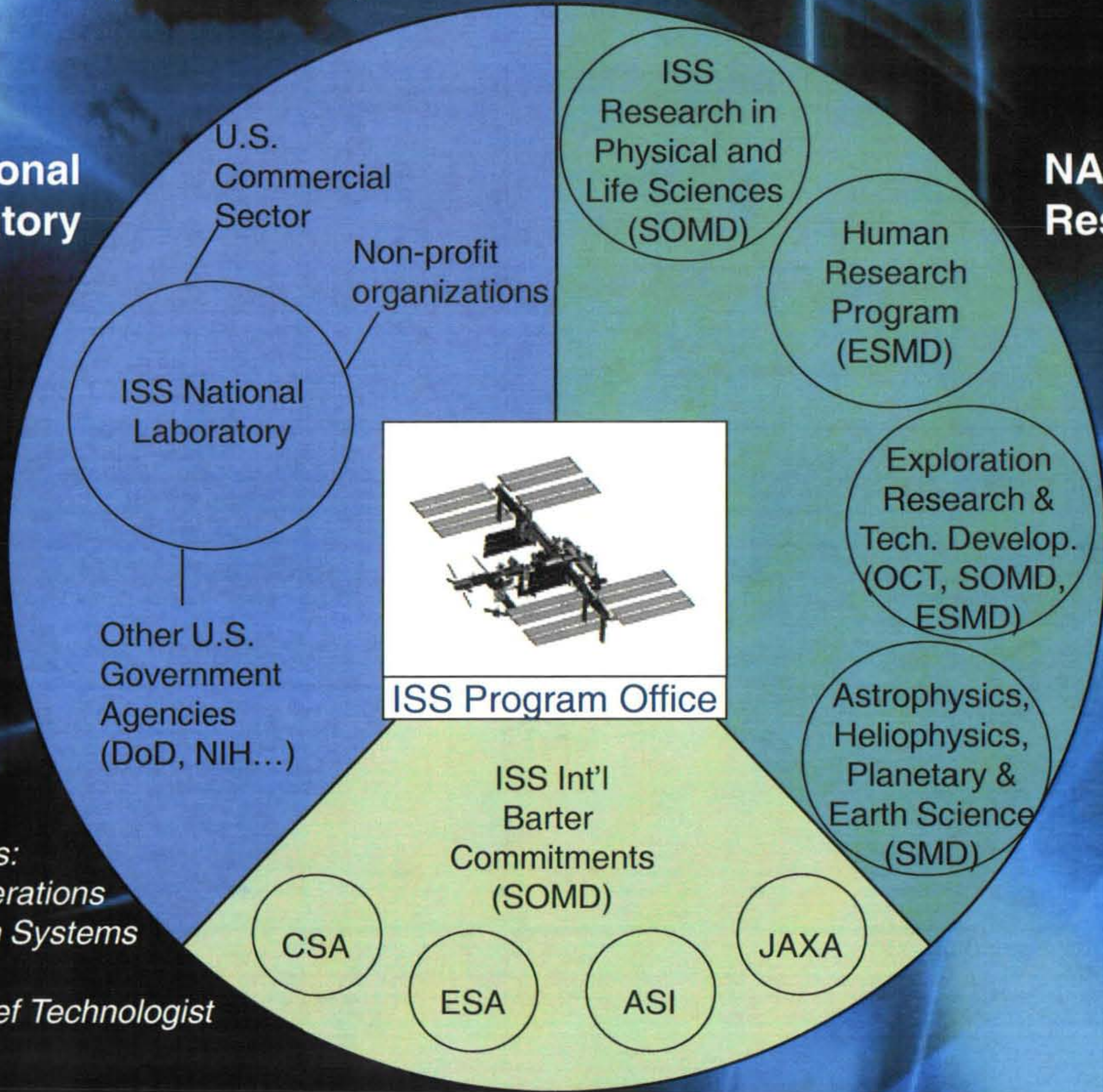
Spacecraft Wingspan: 361 ft (110 m)
Spacecraft Mass: 799,046 lb (362,441 kg)
Spacecraft Volume: ~25,000 ft^3 (708 m^3)
Velocity: 17,500 mph (28,200 kph), 16 orbits per day
Altitude: ~220 miles above Earth
Power: 80 kW continuous

Science Capability: Laboratories built by US, Europe, Japan, and Russia
Extended through *at least 2020*

A Premier Research Platform

- **ISS Research includes every scientific initiative which utilizes the capabilities of the ISS as a multi-discipline research platform.**
  - Multipurpose Facilities (multipurpose racks, freezers, and gloveboxes)
  - Biological Research (incubators, growth chambers, centrifuges)
  - Human Physiology Research (neuroscience, cardiovascular, musculoskeletal and exercise equipment, radiation sensors)
  - Physical Science and Materials Research (fluid physics, crystal growth, external test beds)
  - Earth and Space Science (Radiation, Thermal, Solar, Geophysics)
  - http://www.nasa.gov/pdf/393789main_iss_utilization_brochure.pdf

Sponsorship of Payloads on ISS



NASA Mission Directorates Manage Agreements:
SOMD – Space Operations
ESMD – Exploration Systems
SMD – Science
OCT – Office of Chief Technologist

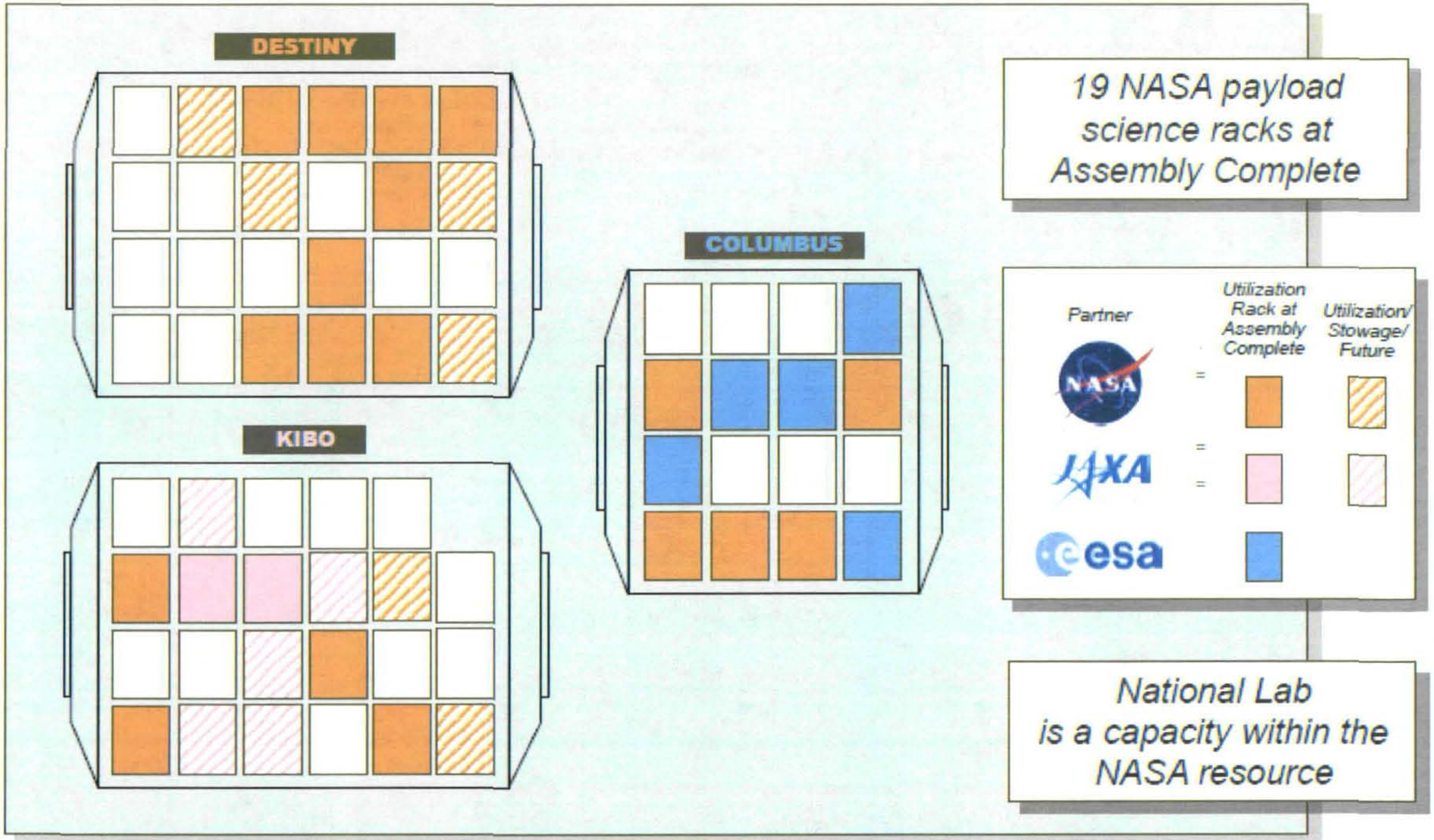
ISS Program Office Plans, Integrates and Operates

ISS National Lab

- **At this time the NASA-funded ISS Research program is projected to utilize only 50% of the U.S. internal payload accommodations.**
- **The remaining 50% is available for ISS National Lab investigations or an expanded number of NASA-supported investigations.**
  - National Lab uses of ISS are different from NASA uses in two significant ways
    - The research objectives are defined by the mission of another government agency or private firm
    - Normally, the funding for National Lab users comes from other government agencies or private firms and not from NASA

What internal space is available for research?

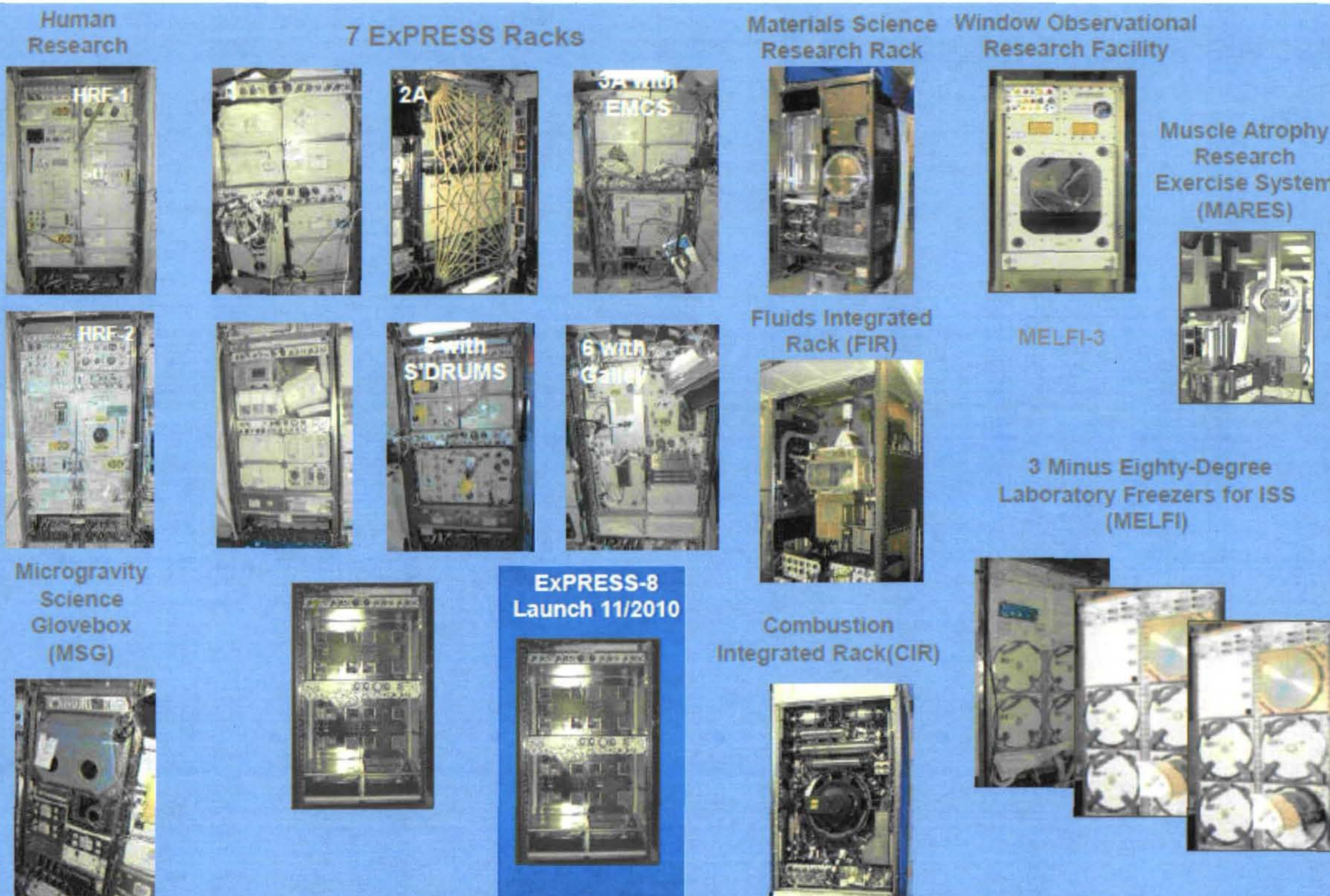
Science Rack Topology



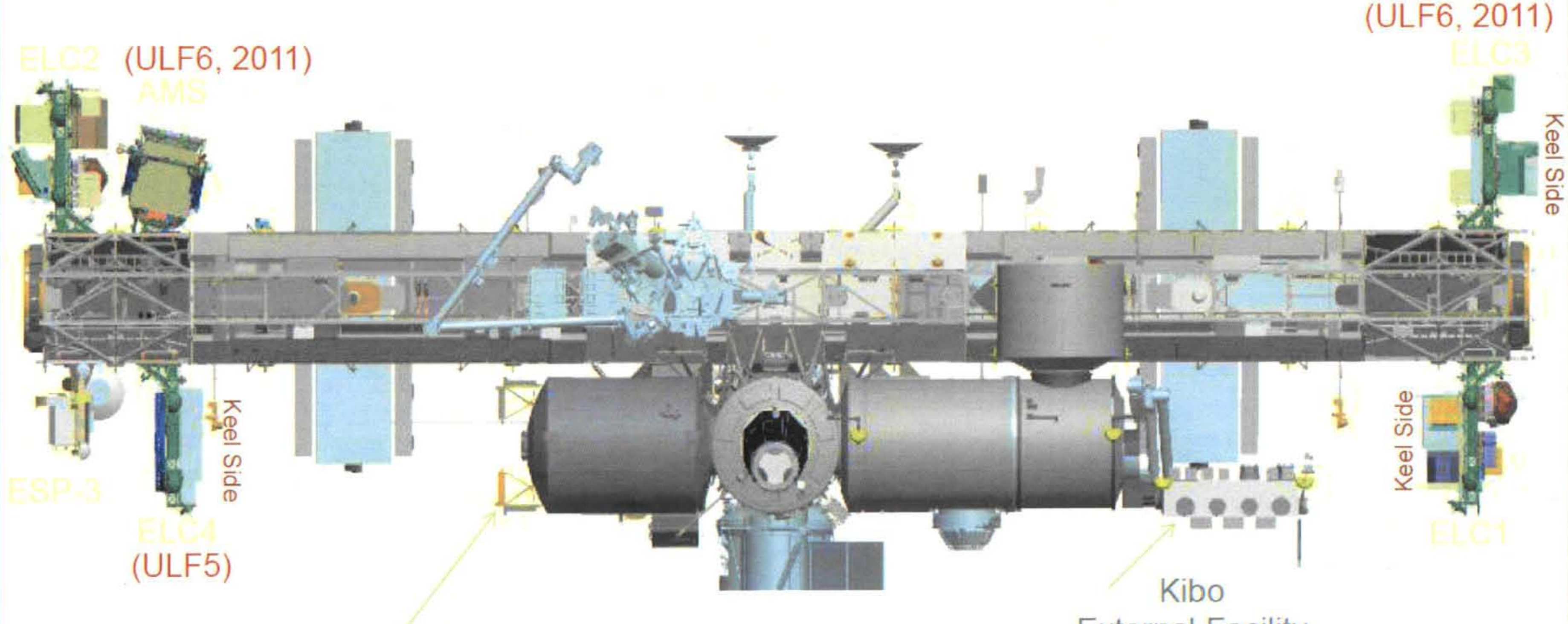
19 NASA payload science racks at Assembly Complete

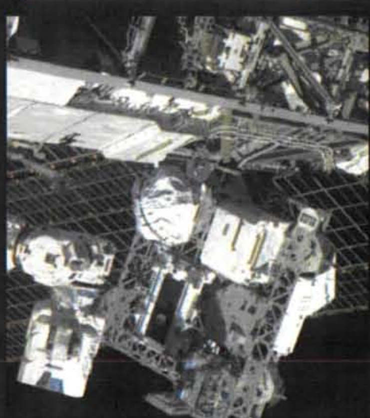
National Lab is a capacity within the NASA resource

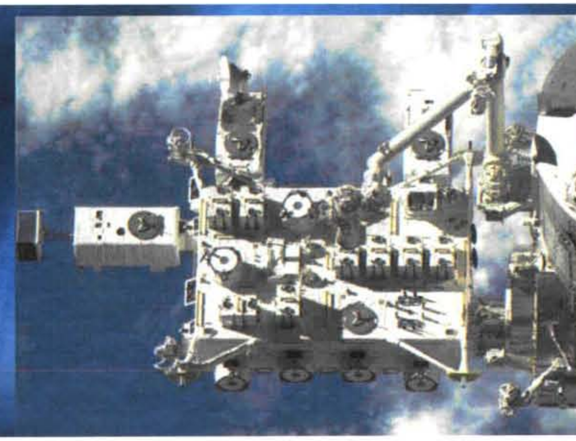
NASA Science Laboratory "Rack" Facilities



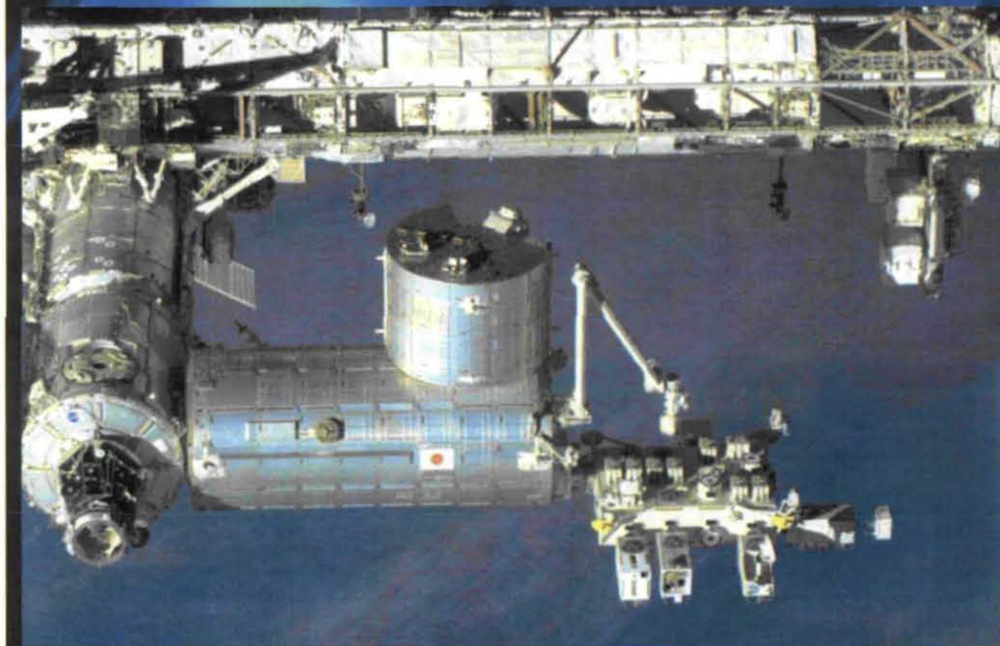
ISS External Research Facilities

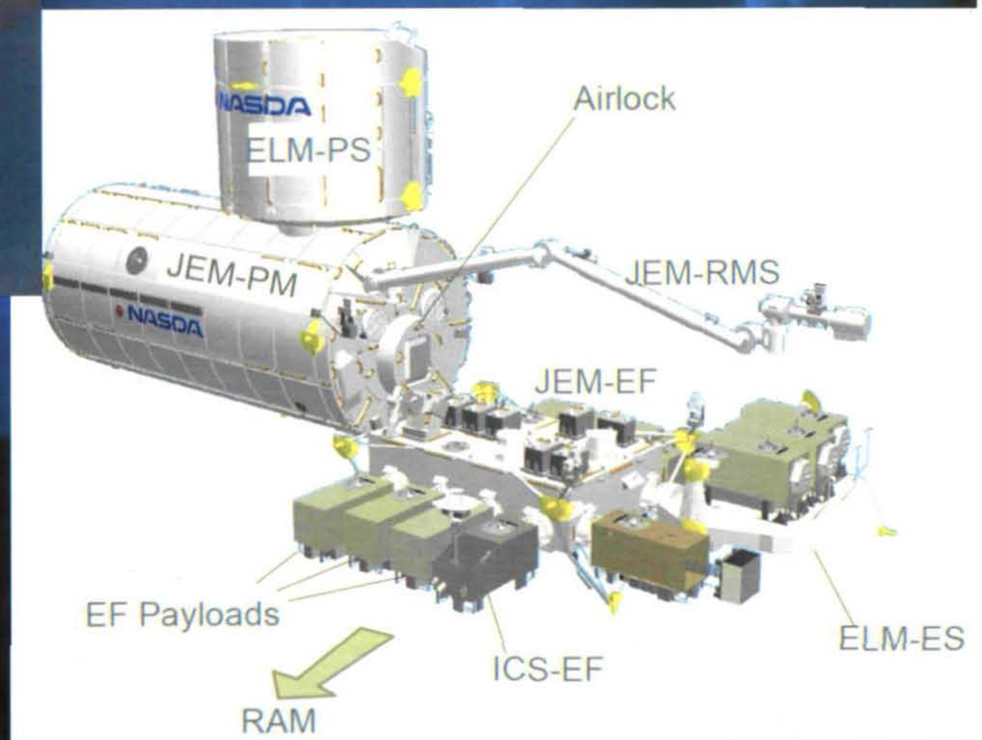






Japanese Experiment Module - Kibo



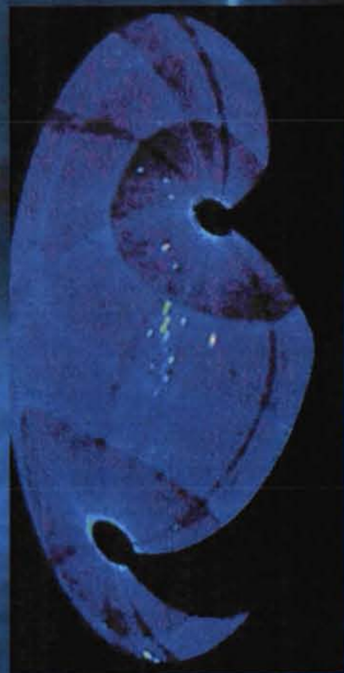


Highlights of JAXA ISS Investigations

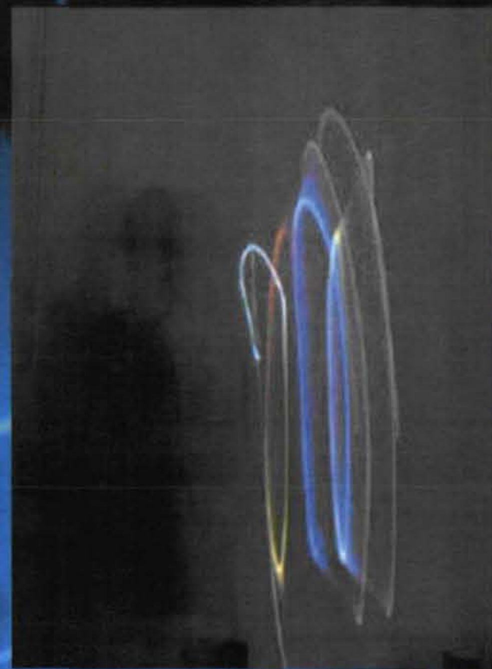
- **Monitor of All-sky X-ray Image (MAXI)** is a highly sensitive X-ray slit camera for the monitoring of more than 1000 X-ray sources in space over an energy band range of 0.5 to 30 keV. On September 25, 2010 an X-ray nova emerged in the constellation of Ophiuchus and was discovered by MAXI's X-ray cameras. The discovery was immediately disseminated to all researchers registered on the MAXI mailing list. The nova was named "MAXI J1659-152". Masaru Matsuoka, Ph.D., Japan Aerospace Exploration Agency, Tsukuba, Japan

- **Biomedical Analyses of Human Hair Exposed to a Long-term Space Flight (Hair)** examines the effect of long-duration space flight on gene expression and trace element metabolism in the human body to maintain the health of future long-duration space explorers. Chiaki Mukai, M.D., Ph.D., Japan Aerospace Exploration Agency, Tsukuba, Japan

- **Japan Aerospace Exploration Agency Education Payload Observation 6 (JAXA EPO 6)** activities demonstrate educational events and artistic activities on board the ISS to enlighten the general public about microgravity research and human space flight. Naoko Matsuo, Japan Aerospace Exploration Agency, Tsukuba, Japan



The "First Light" all-sky X-ray image obtained with the Gas Slit Camera (GSC) of MAXI over one ISS orbit. Image courtesy of Japan Aerospace Exploration Agency (JAXA).



An example of the type of Spiral Top action that will be recorded onboard the ISS. Image courtesy of JAXA.

Highlights of JAXA ISS Investigations

- **Hydrotropism and Auxin-Inducible Gene expression in Roots Grown Under Microgravity Conditions (HydroTropi)** determines whether hydrotropic response is used for the control of cucumber, *Cucumis sativus* root growth orientation in microgravity. Determining this process is important for future long-duration space exploration missions when food has to be produced for consumption in microgravity. Hideyuki Takahashi, Ph.D., Tohoku University, Sendai, Japan

- **Chaos, Turbulence and its Transition Process in Marangoni Convection (Marangoni)** analyzes the behavior of a surface-tension-driven flow in microgravity. Marangoni contributes to high quality crystal growth such as oxide materials for optical application. The results will provide the knowledge for cooling personal computer devices and energy transport with a higher efficiency in future human space activities. Hiroshi Kawamura, Ph.D., Faculty of Science and Technology, Tokyo University of Science, Chiba, Japan

- **Investigation of Mechanism of Faceted Cellular Array Growth - 2 (Facet-2)** investigates the phenomena at the solid-liquid interface for crystallization, especially for facet-like crystallization, which are considered to be strongly influenced by the temperature and concentration distributions in the liquid phase. Y. Inatomi, Japan Aerospace Exploration Agency, Tsukuba, Japan

NASA Image: ISS020E048792 - Canadian Space Agency astronaut Robert Thirsk, Expedition 20/21 flight engineer, holds Fluid Physics Experiment Facility/Marangoni Surface (FPEF MS) Core hardware in the Kibo laboratory of the International Space Station.

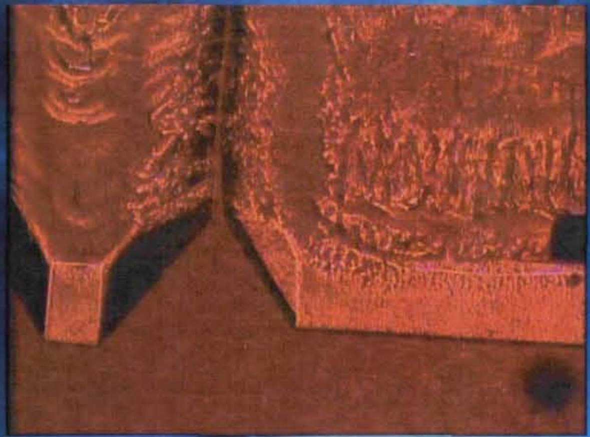
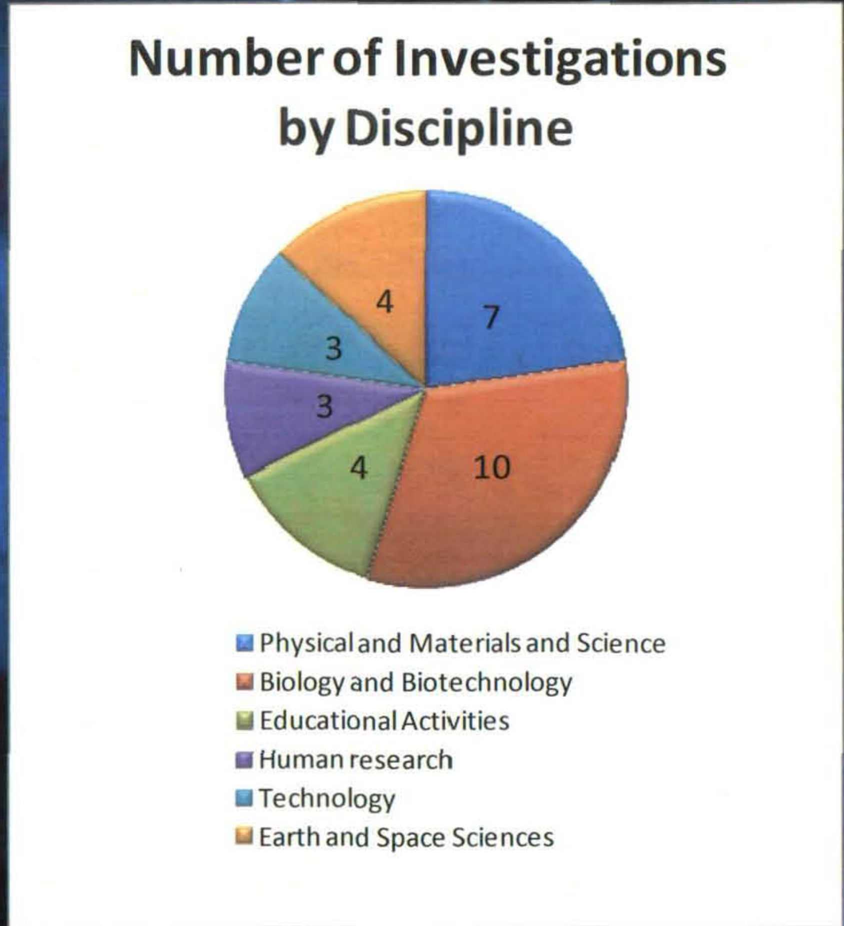


Image of the Facet-2 crystal facets grown during ISS Increment 25/26.

Future JAXA ISS Investigations

- JAXA has planned thirty-one (31) distinct investigations for operations from ISS Expedition 25/26 (October 2010) through 29/30 (April 2012) in six major scientific disciplines.



ISS Launch Vehicles

Shuttle

Soyuz

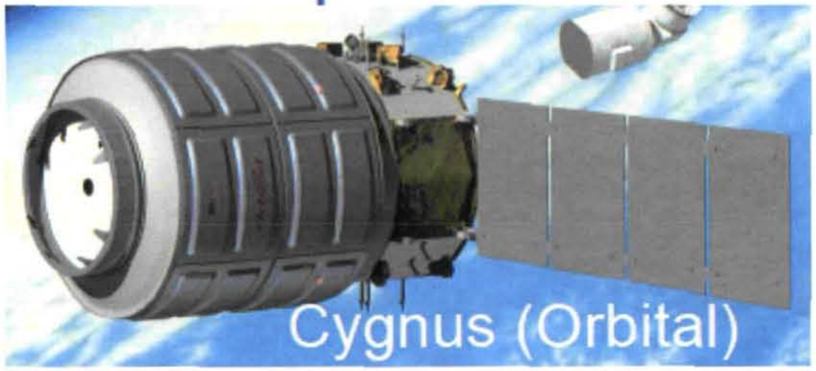
Ariane & ATV

HIIA & HTV

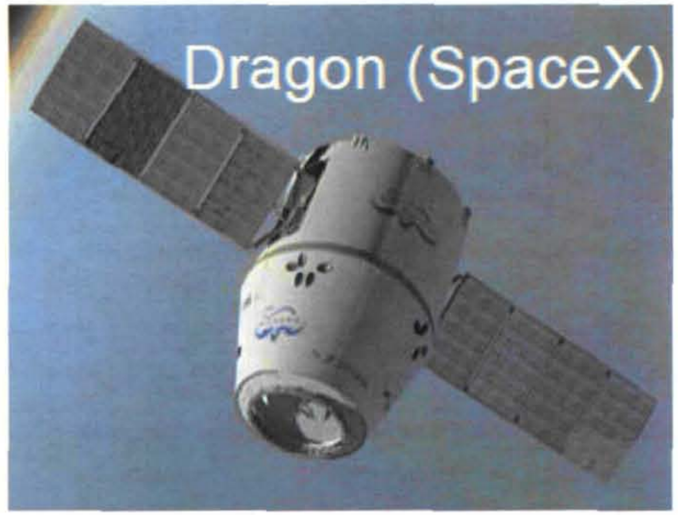
Falcon 9 & Dragon

Taurus II & Cygnus

ISS Transportation Post-Shuttle



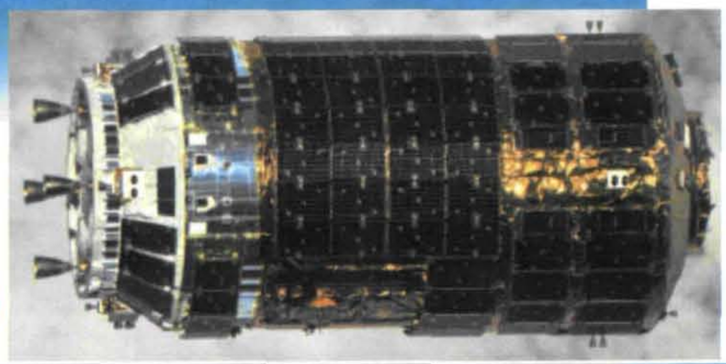
Cygnus (Orbital)



Dragon (SpaceX)

ATV (ESA)

Progress/Soyuz (Energia)



HTV (JAXA)

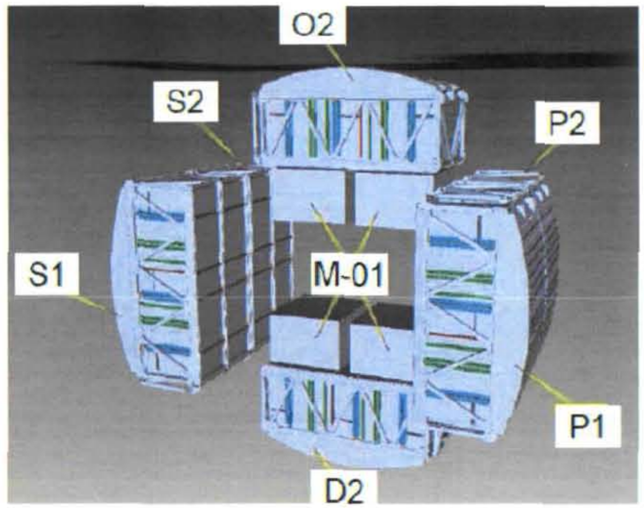
ATV Cargo Capabilities

Up mass

- Internal
  - Powered: None
  - Late Load
    - » Up to 28 bags (not CTBE) of late access
  - Racks
    - » Up to 8 passive racks
- External
  - None
- On Dock
  - Cargo: L-14 weeks
  - Late Load: L-4 weeks

Down mass

- Internal
  - Disposal only
- External
  - None



ATV-2 Racks with M-01 bags

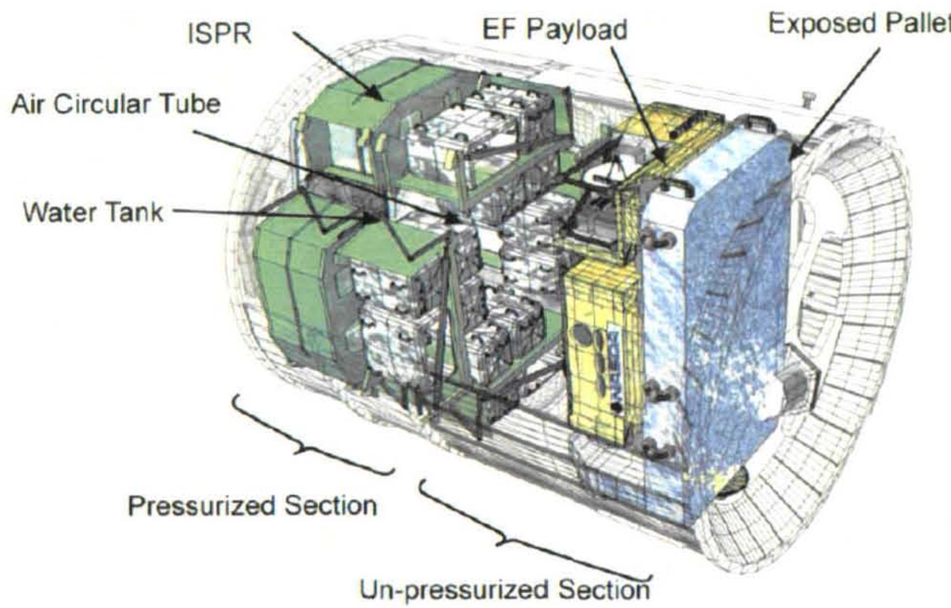
HTV Cargo Capabilities

Up mass

- Internal
  - Powered: None
  - Late Load
    - Maximum 3 CTBE (0.5 or 1.0 CTB), each <20 kg
    - Additional possible if negotiated in advance.
  - Racks
    - Up to 8 passive racks
    - Forward Bay: ISPR compatible
    - Aft Bay racks fixed: HTV Resupply Rack
- External
  - Exposed Pallet (on following chart)
- On Dock
  - Cargo: L-6 months
  - Late Load: L-6 weeks

Down mass

- Internal
  - Disposal only
- External
  - Disposal only



Progress Cargo Capabilities

Up mass

- Internal

  Powered: Special allowance only

  Late Load

  Racks: None

  Items up to 8-10 kg in vehicle containers

  Larger items installed in special transport frames

- External

  None

Down mass

- Internal

  Disposal only

- External

  None

Soyuz Cargo Capabilities

Up mass

- Internal

  Powered: Special allowance only

  Late Load

  Racks: None

  Items up to 5 kg in vehicle containers

  Larger items installed in special transport frames

- External

  None

Down mass

- Internal

  Items up to 5 kg in container under crew seat

  Special container available for larger items if only two crew on return

- External

  None

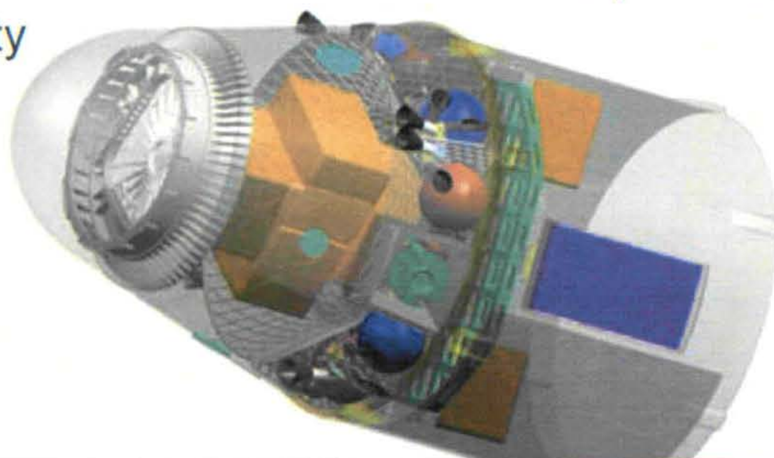
Dragon Cargo Capabilities

Up mass

- Internal
  - Powered: Double MLE
  - Late Load: T-12 hrs for powered MLE; TBD days for nominal
  - Racks (SpaceX-designed)
    - » ~3300 kg mass
- External
  - Trunk capability

Down mass

- Internal
  - Powered: Double MLE
  - ~1700 kg return
  - Early destow at dock available
  - Fast boat return available
- External
  - Disposal only



Cygnus Cargo Capabilities

Up mass

- Internal

    Powered: Double MLE

    Late Load: TBD

    Racks

    » 2000 kg mass (standard)

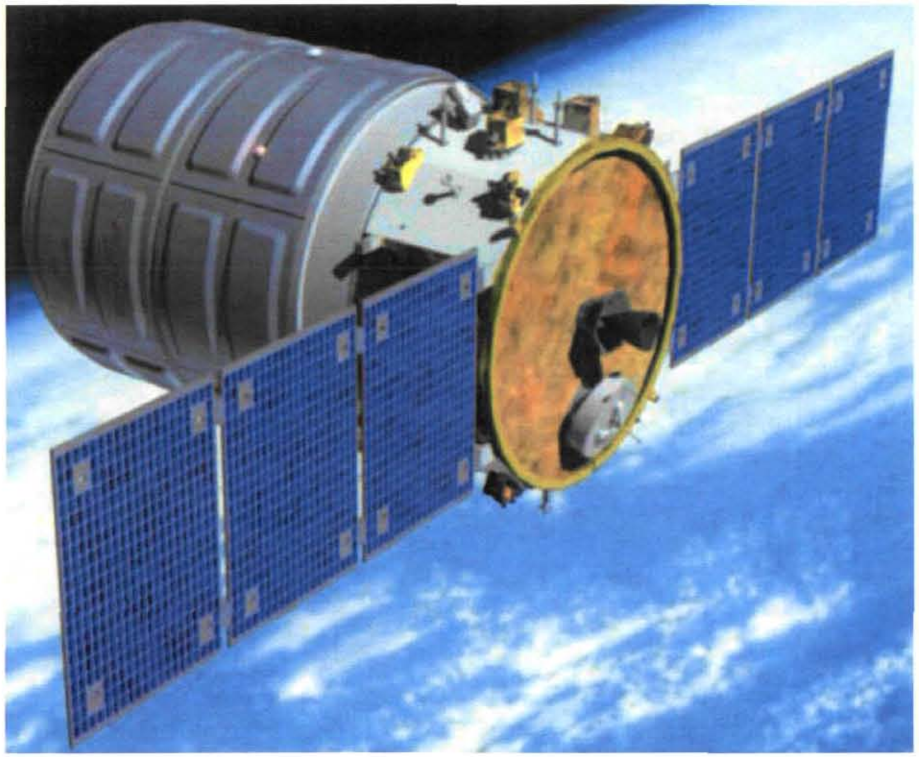
    » 2700 kg mass (expanded)

- External

    None

Down mass

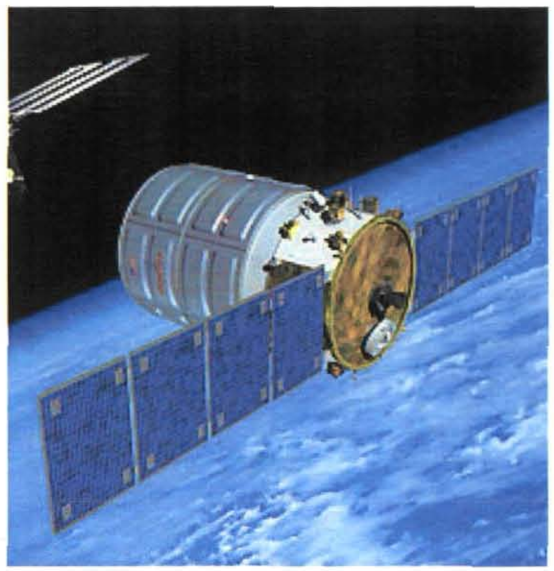
- Internal - Disposal only
- External – None



COTS - Commercial Orbital Transportation Services - Developmental Space Act Agreement

CRS - Commercial Resupply Services - Operational Contract

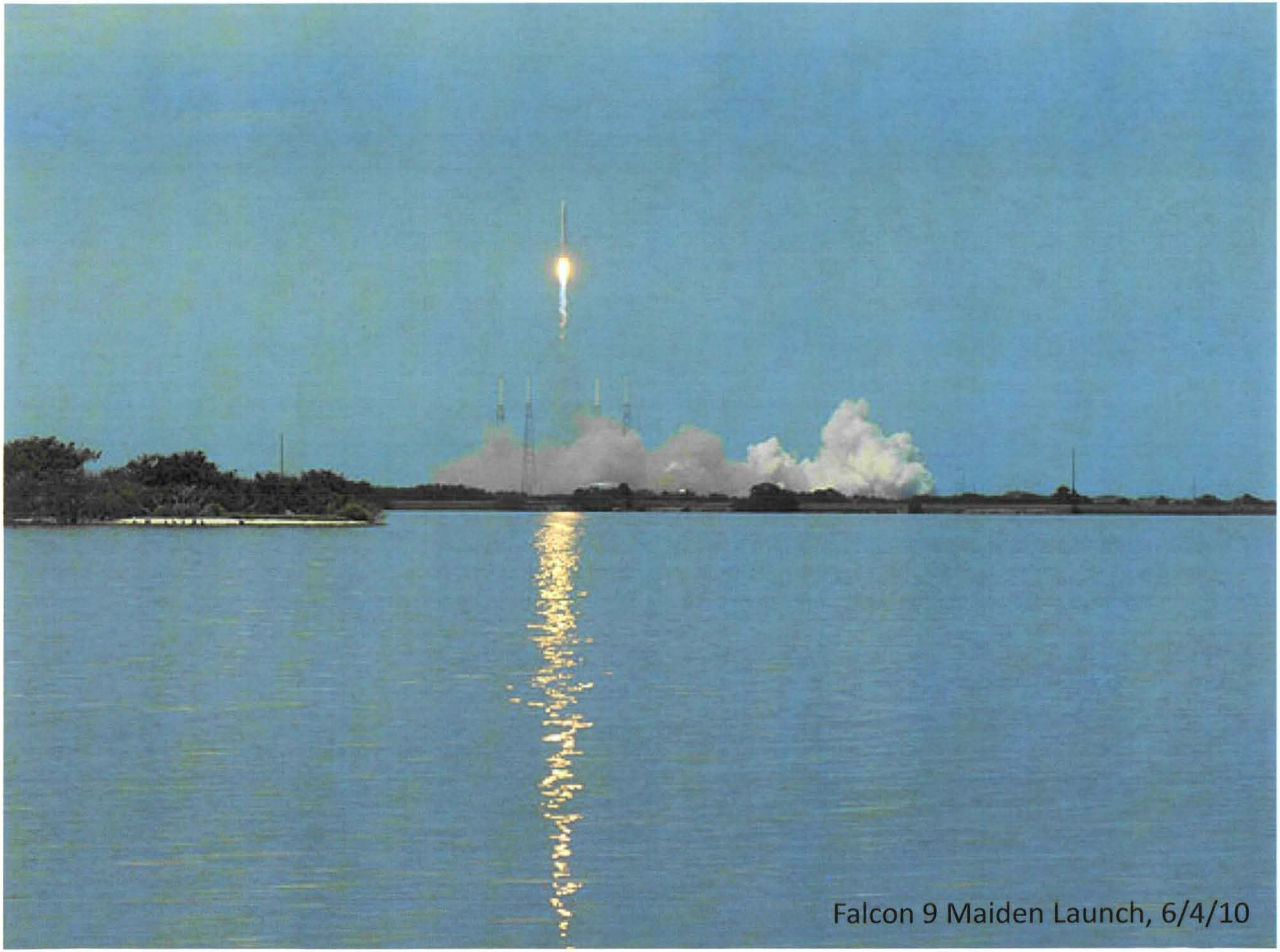
Company	SPACEX	Orbital Innovation You Can Count On™
Rocket	Falcon 9	Taurus II
Module	Dragon (reusable)	Cygnus (one use)
Launch	LC 40, Florida	Wallops, Virginia
Cargo	✓ Pressurized ✓ Unpressurized ✓ Return cargo	✓ Pressurized X No unpressurized X No rtn (burns up)



Falcon 9 Launch Objectives

Pathfinder		
First launch	6/4/10 successful	**Objectives**: • validate rocket structures, propulsion, and avionics • second stage separation • Dragon test unit & second stage enter lower Earth orbit.

COTS Launches		
Demo-1	11/8/10	**Additional objectives**: • Dragon Capsule separation and 1 to 4 orbits • Unpressurised "trunk" carrier separation from Dragon Capsule • telemetry transmission • orbital maneuvering • Splashdown and recovery of Dragon capsule in Pacific
Demo-2	4/12/11	**Additional objectives:** • approach within 10km of ISS • simulate docking by maneuvering to fixed location • telemetry transmission with ISS
Demo-3	6/6/11	**Additional objectives:** • approach ISS • Station robotic arm (RMS) will grapple Dragon and maneuver to mate with ISS • deliver pressurized cargo to ISS • recover cargo following Dragon splashdown



Falcon 9 Maiden Launch, 6/4/10


Belgium
Brazil
France
Spain
The Netherlands
Germany
INTERNATIONAL SPACE STATION
Japan
Sweden
Denmark
Canada
Switzerland
Norway
Italy
Russia
United Kingdom
United States