



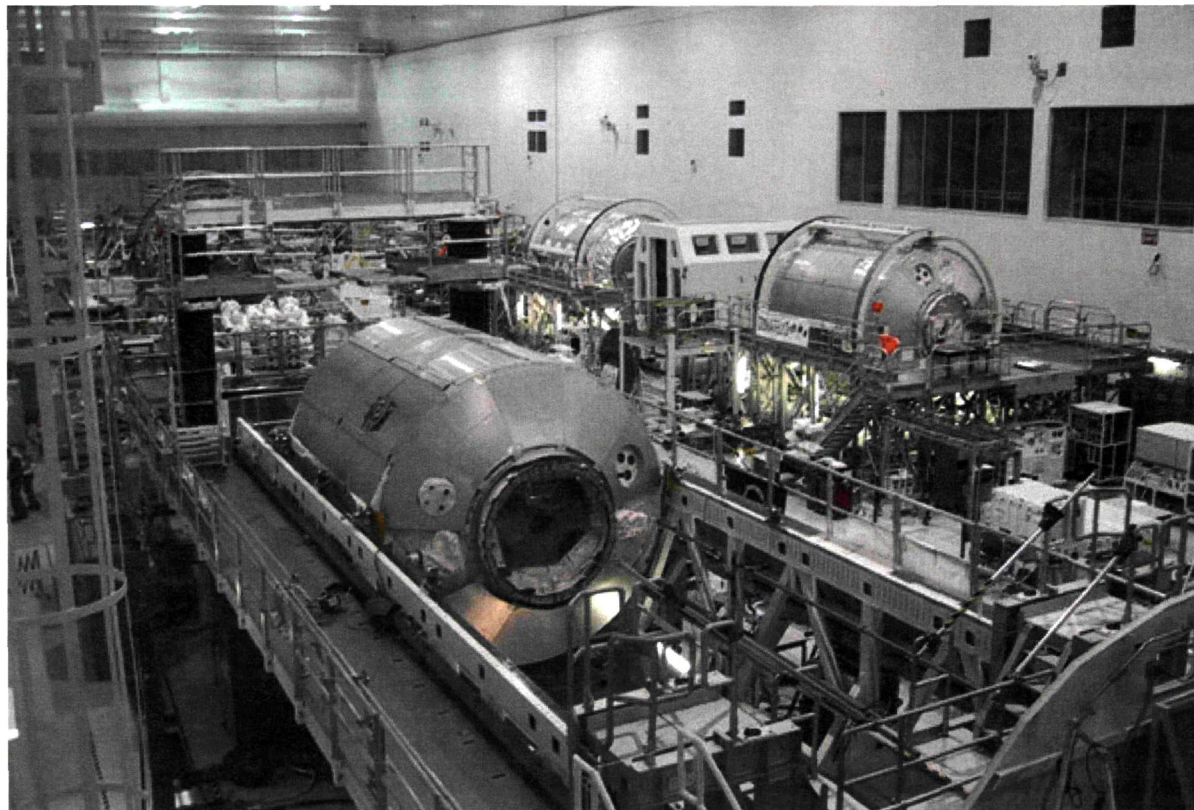
KENNEDY SPACE CENTER Payload Processing

**Ronnie Lawson
Ground Systems Division
ISS & Spacecraft Processing**



Agenda

- **Payloads Processed at KSC**
- **Typical Payload Processing Tasks**
- **Payload Processing Facilities**
- **Payload Processing Capabilities and Customer Services**





Payloads Processed at KSC



Expendable Launch Vehicle Payloads

- **Since 1998 Launch Services Program has launched over 30 payloads from KSC on a number of launch vehicles including Atlas and Delta**
- **Pervious notable payloads include**
 - Mars Exploration Rovers (2003, 2004)- Explored Mars
 - Stardust (1999) - Collected comet dust from comet Wild 2
 - Genesis (2001) - Collected samples of solar wind
 - Deep Impact (2005) - Study comet Tempel 1
 - NOAA GOES weather satellites
 - Tracking Data Relay Satellites
- **Upcoming payloads**
 - GRAIL (Gravity Recovery and Interior Laboratory)(2011) - Moon interior structure through gravity
 - Mars Science Lab (2011) - Mars Rover
 - RBSP (Radiation Belt Storm Probes) (2012) - Study Sun's influence on earth
 - MAVEN (Mars Atmosphere and Volatile Evolution) (2013)



Shuttle Launched Payloads

- **International Space Station (ISS) Elements**
 - ISS Pressurized Elements
 - US Laboratory (Destiny), Airlock (Quest), Nodes 1 (Unity), Node 2 (Harmony), Node 3 (Tranquility), Japanese Experiment Module (Kibo), ESA Columbus Laboratory, Canadarm 2, Multi-Purpose Logistics Modules (Leonardo, Raffaello), Cupola
 - ISS Truss Elements Z1, P1, P3/P4, P5, P6, S1, S3/S4, S5 S6
- **ISS Research Payloads (slide to follow)**
- **Non-ISS Shuttle Payloads**
 - Tracking and Data Relay Satellites (7) (1983 - 1995)
 - Interplanetary Explorer Missions (1989 - 1990)
 - Magellan (Venus), Galileo (Jupiter), Ulysses (polar regions of the Sun)
 - Great Observatory Missions (1990 - 2011)
 - Hubble Space Telescope (HST), Gamma Ray Observatory (GRO), Chandra X-Ray Observatory, Alpha Magnetic Spectrometer (AMS) (to be launched on STS-134)

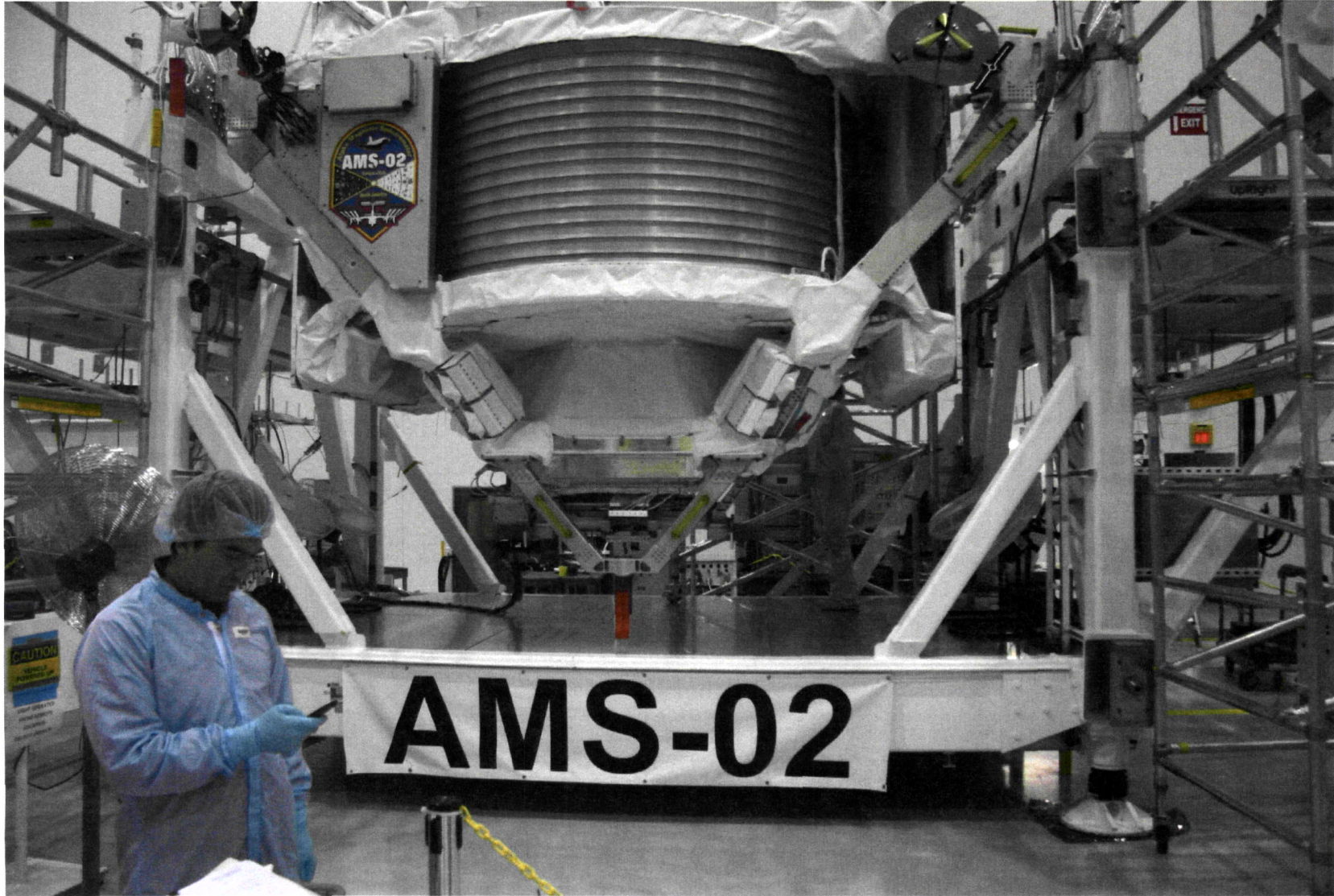


ISS Research Payloads

- **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 glove boxes)
 - Biological Research (incubators, growth chambers, centrifuges)
 - Human Physiology Research (neuroscience, cardiovascular, musculoskeletal, exercise equipment, and radiation sensors)
 - Physical Science and Materials Research (fluids physics, crystal growth, external test beds)
 - Earth and Space Science (radiation, thermal, Solar, geophysics)

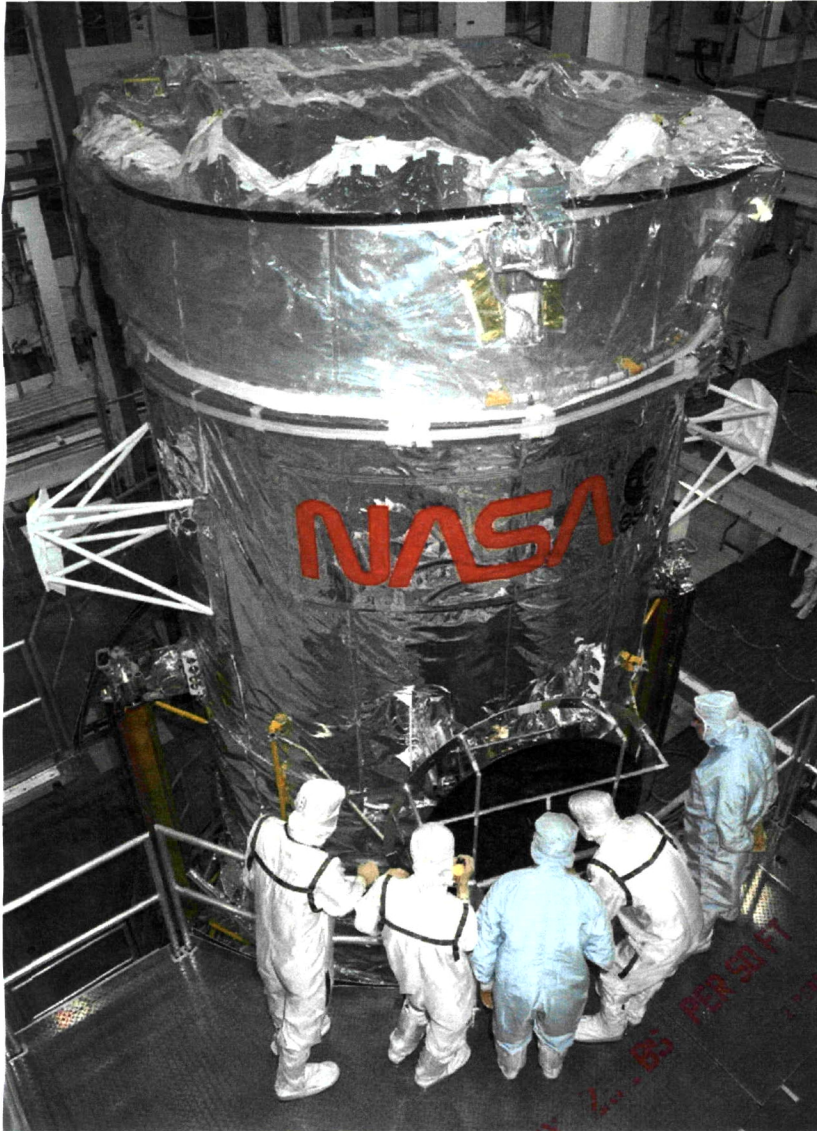


Alpha Magnetic Spectrometer

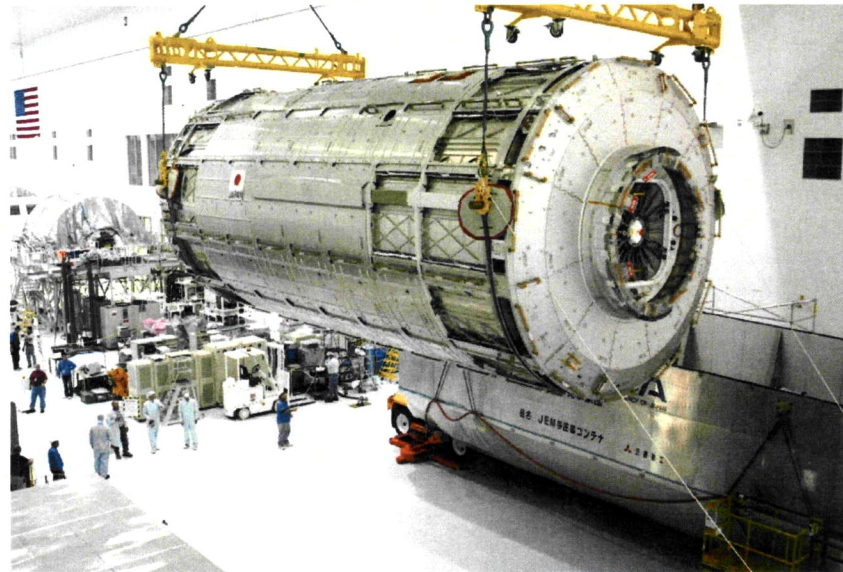




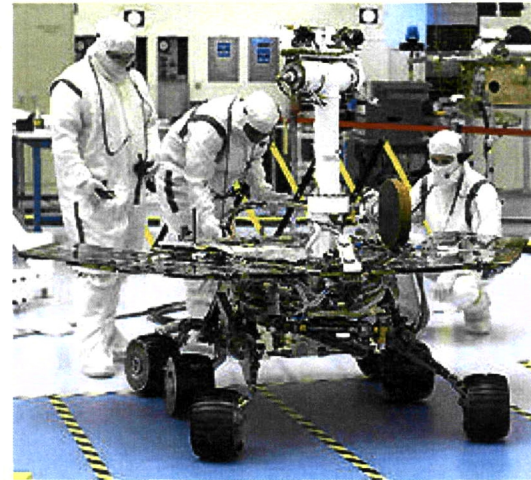
Previous Payloads



Hubble Space Telescope



Japanese Experiment Module



Mars Rover



Typical Payload Processing Tasks



Payload Processing Tasks

- **Transportation and Receiving**
 - Delivery of the Payload from Developers Site to the Launch Site for final processing
- **Post Delivery Checkout**
 - Inspection and testing of the payload upon arrival to the launch site to detect and address any damage to transportation
- **Final Assembly/Processing/Integration -**
 - This could include the installation of solar panels, antennas, flight battery installation
- **Payload Testing**
 - Payload systems tests to verify operation of the payload
 - Payload to launch vehicle interface verification tests
 - Simulated before payload installation or with launch vehicle after installation
 - Payload end-to-end test to test command and data flow between payload and control center

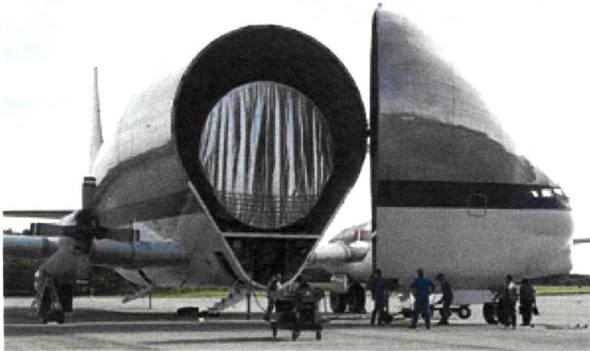


Payload Processing Tasks (cont)

- **Final Inspection and Close Out**
 - Verification that all final connections have been made and all non-flight equipment has been removed from the payload
 - Inspection for cleanliness and foreign object debris
- **Fueling**
- **Encapsulation**
- **Integration with Launch Vehicle**



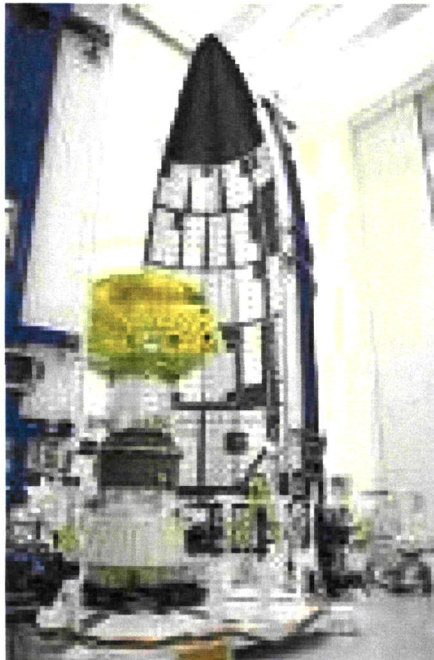
Typical Payload Processing Activities



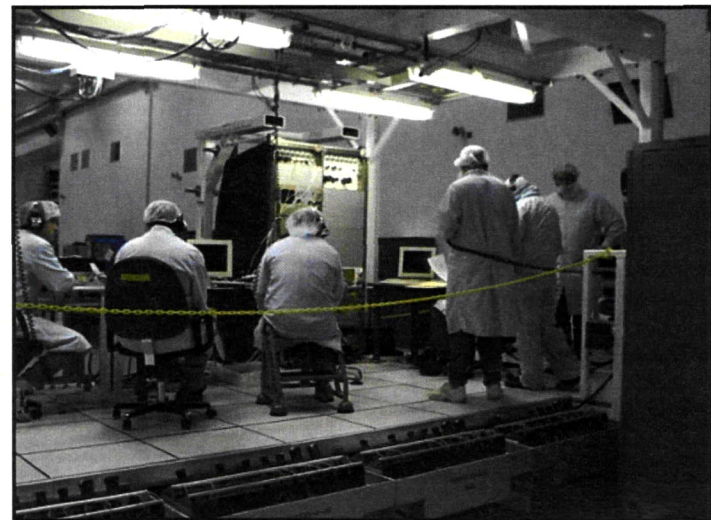
Payload Transportation



Inspection and Closeout



Encapsulation



Payload Testing

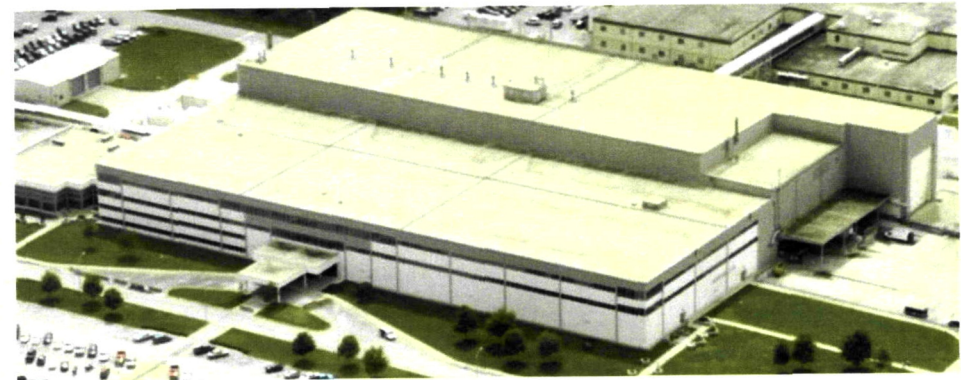


Payload Processing Facilities



Space Station Processing Facility

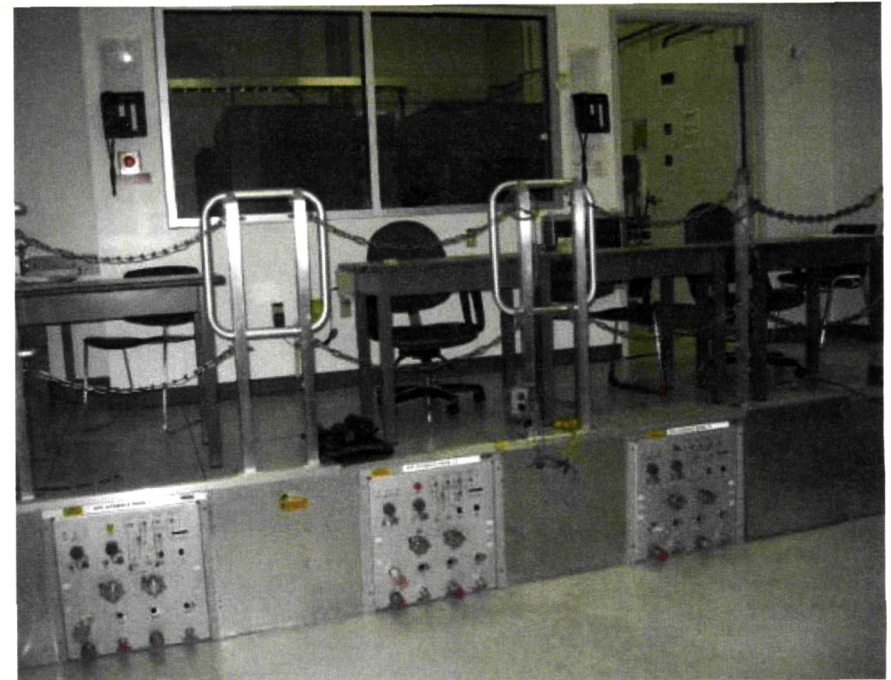
- **High Bay**
 - 38,000 ft² Class 100K clean work area
 - 8 footprints, completely reconfigurable
 - Available commodities include 208V/480V power, chilled water, GN₂, GHe, LN₂
 - Two 30-ton electrical bridge cranes with 50-ft hook height
- **Intermediate Bay**
 - 17,000 ft² Class 100K clean area
 - Two 5-ton electrical bridge cranes with 25-ft hook height
- **Airlock**
 - 5000 ft² Class 300K clean area
 - 15-ton electrical bridge crane with 50-ft hook height
- **Administrative Space**
 - Office Space for approximately 1000 employees
 - 25 Conference Rooms
- **Specialty Areas**
 - Off-Line Processing Rooms (7 Science Labs, 2 Central Services Labs, 8 Hardware Labs)
 - 9 control rooms located on raised floor areas
 - Vapor Containment Facility to house liquid anhydrous ammonia
- **Special Provisions**
 - Uninterruptable Power Supplies
 - Redundant Power Feeds
 - Dual Automatic Starting Backup Generators
 - Portable Backup HVAC Chiller





SSPF Testing Capabilities

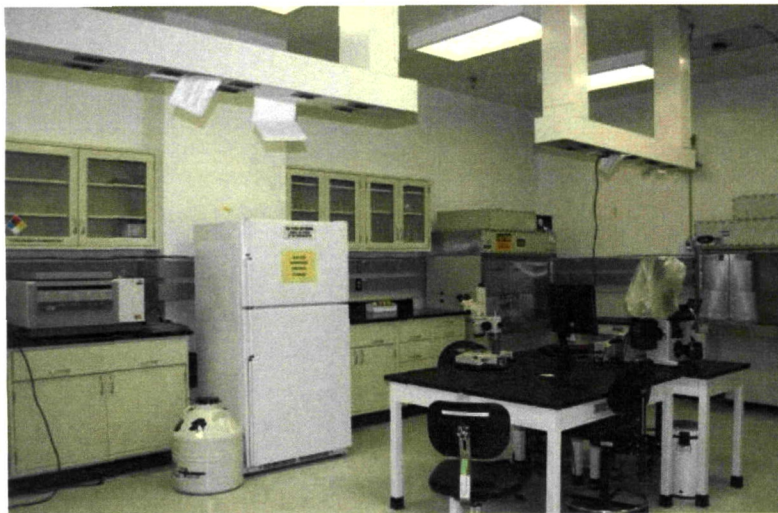
- **Payload Rack Checkout Unit (PRCU)**
 - Provides ISS interface verifications which include Power, Command & Data Handling, Video, Fluids, Vacuum, Fire Detection System, Impedance Analysis and GN₂
 - Includes a connection to MSFC HOSC for commanding and data monitoring
- **Testing Capabilities**
 - International Standard Payload Rack (ISPR)
 - Sub-rack payloads
 - Sub-pallet payloads (unpressurized) which will be mounted on a truss location or Express Logistics Carrier (ELC)
 - Includes final flight configuration testing with an ELC Simulator and verification testing
- **Fluids Servicing**
 - Spacecraft Fueling (Mono and Bipropellant)
 - Gases up to 6000 PSI (GN₂, GH₂, etc)
 - O₂ and NH₃ Servicing
 - Noble Gas servicing at lower pressures
 - Cryo Servicing





SSPF Lab Capabilities

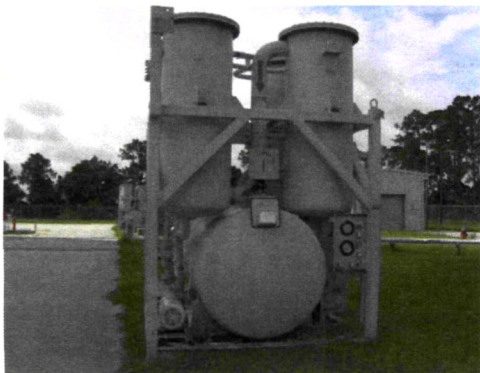
- **Lab Capabilities Summary**
 - Class 300,000 clean rooms
 - 7 Science Labs
 - 8 Hardware Labs
 - 2 Central Services
 - Specialized Science Equipment
(e.g. laminar flow benches, incubators, microscopes, biological safety cabinets, portable fume hoods, water baths, etc.)
- **Payloads Processing Support**
 - Skills, equipment and labs unique to pre/post mission support requirements at launch site for hardware integration, hardware/science integration, offline checkout, including life science & biological payloads





Payload Hazardous Servicing Facility

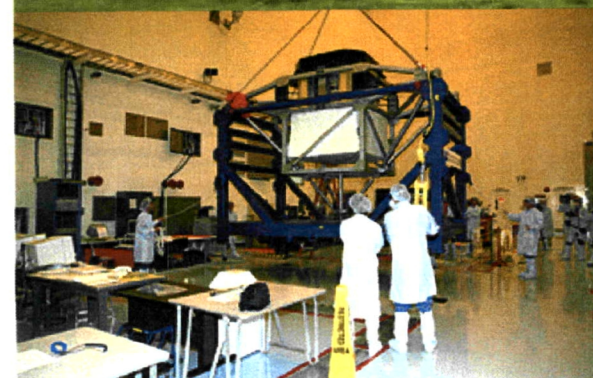
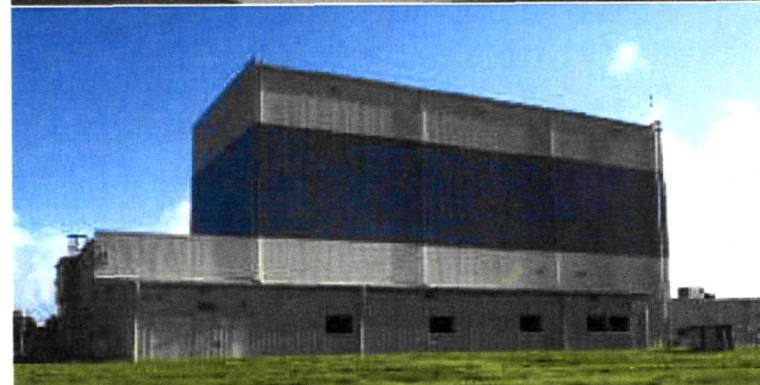
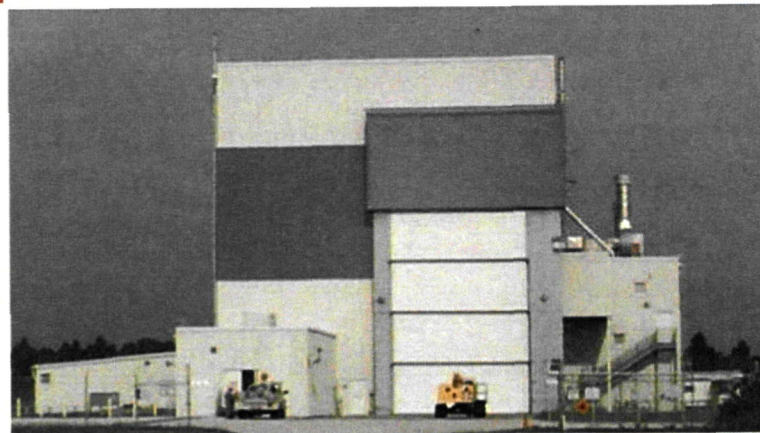
- **High Bay**
 - 38,000 ft² Class 100K clean work area
 - Available commodities include 208V/480V power, compressed air, GN₂, GHe, LN₂
 - Two 50-ton electrical bridge cranes with 74.5-ft hook height
- **Airlock**
 - 4,250 ft² 300K Clean Work Area
 - 15 -Ton Bridge Crane 72.5 - ft hook height
- **Hazardous Capabilities**
 - Hazardous fueling capability
 - 20' x 40' sloped floor for fuel servicing
 - Emergency exhaust system
 - Water deluge system
 - Drain trenches for waste fuel and oxidizer disposal
 - 7,500 gallon fuel and 1,500 gallon oxidizer stainless steel tanks
 - Drain vents equipped with aspirators and scrubbers





Multi-Payload Processing Facility

- **High Bay**
 - 7,920 ft² Class 100K clean work area
 - 20-Ton Bridge Crane 49 foot hook height
 - Available commodities include compressed air, GN₂, GHe, LN₂
- **Low Bay**
 - 1156 ft² 100K Clean Work Area
- **Equipment Lock**
 - 1,092ft² 300K Clean Work Area
- **Hazardous Capabilities**
 - Hypergolic vent system (not activated)
 - Propellant spill drain system (not activated)





Space Life Sciences Laboratory

- **Building Information**

- 73,000 ft² available area
- Population: 140 residents, 38 visitors
- 25 Science Labs
- 8 Hardware Labs
- 6 Animal Holding Rooms

- **Partnerships**

- NASA/KSC: Manages Research & Utilization
- Space Florida: Owner of SLS Lab and responsible for O&M
- University of Florida and Florida Tech: Resident university partners

- **Unique Agency Capabilities**

- Provides infrastructure to enable ISS Research including non-exploration research and maturation of critical Exploration technologies
- Skills, equipment and labs unique to pre/post mission support requirements at launch site of life science and biological payloads

- **Specialty Areas**

- Animal Care Facility (ACF) provides animal husbandry & support for space flight missions and meets all necessary Agency & Federal cert/license requirements
- Controlled Environment Lab (CEL)
 - Skills and infrastructure uniquely developed originally for biological sustainable systems (i.e. bio-regenerative life support systems), now serving multi-discipline investigations
 - Orbit Environment Simulators for science 'control' of STS/ISS pressurized environment payloads (temp, humidity, CO₂, lighting)





SLS Lab Capabilities

Controlled Environment Lab

15 Controlled Environment Chambers (CEC)
Low Pressure Test Bed
Lunar/Mars Vacuum Chamber

Animal Care

Rodent/Aquatic/Avian/Insect

Experiment Processing Support

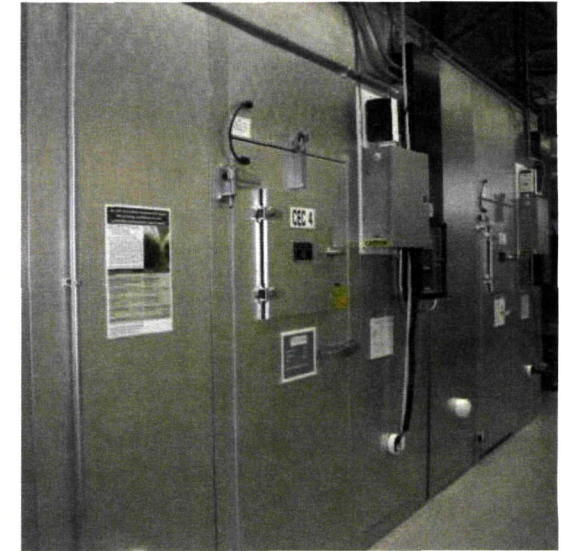
Shuttle/Station/Unmanned

Flight Experiment Development

Design/Testing/Integration

Flight Mission Support

Orbit Environment Simulators (OES)
Experiment Monitoring Area (EMA)





SLS Lab Capabilities

Bimolecular/Microbial Ecology

Genetic Identification, Quantification & Qualification

Analytical Chemistry

Organic/Inorganic/Volatile Gases

Astrobiology

UF & FIT Resident Science Programs

Microscopy/Imaging

Atomic Force (AFM), X-Ray Photoelectron Spectroscopy (XPS), Scanning Electron (SEM), Confocal Fluorescence

Applied Chemistry

In-Situ Resource Utilization (ISRU), Environmental Remediation, Corrosion Detection & Coatings, Polymer & Advanced Materials

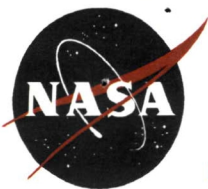
Applied Physics

Granular & Surface Systems

Electrostatics

Dust Characterization & Remediation, Surface Physics





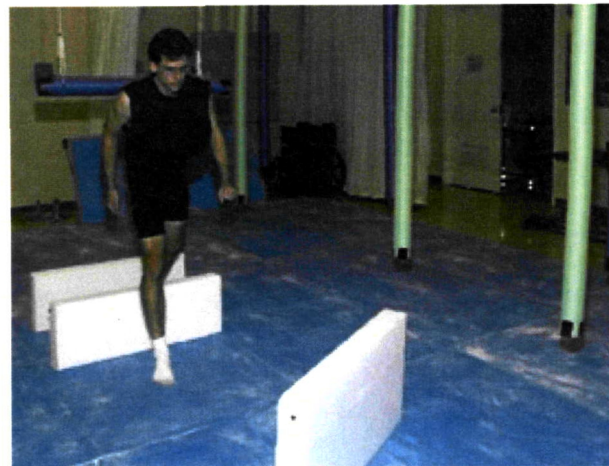
Baseline Data Collection Facility

- **BDCF Mission**

- Optimize the completion of Human Life Sciences Research
- Series of laboratories designed to study astronaut response to spaceflight immediately upon return to Earth

- **Experiment equipment**

- Magnetic Resonance Imaging (MRI)
- Densitometers
- Cardiovascular devices
- Vestibular testing equipment
 - Rotating chairs
 - Treadmills
 - Obstacle courses





Payload Processing Capabilities and Services



Payload Processing Capabilities

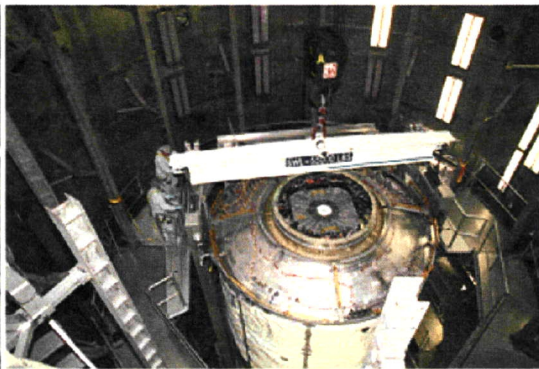
- **KSC offers a wide range of payload processing capabilities including but not limited to the following**
- **Support Stands**
 - Element Rotation Stands (ERS)
 - Express Logistics Carrier Rotation Stand (ELC RS)
 - Cargo Element Work Stand (CEWS)
- **Lifting Fixtures**
 - Cargo Element Lifting Assembly (CELA)
 - Strongback
 - Payload Lifting Slings
- **Payload Transporter Canister**
 - Transportation and vertical Installation of Shuttle Payloads at the pad
- **Vacuum Chambers**
- **Electromagnetics Laboratory**
- **Launch Equipment Test Facility**



Vacuum Chamber

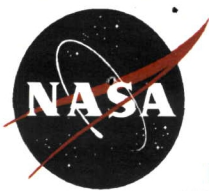


- Statistics
- **Status:** Existing
- **Purpose:** Simulate vacuum of space – leak check
 - payload elements
- **Quantity:** 2 - (1) deactivated 1975, (1) active from 1998
- **Weight:** N/A
- **Load Capacity:**
- **Size:** 50' tall, 33' wide

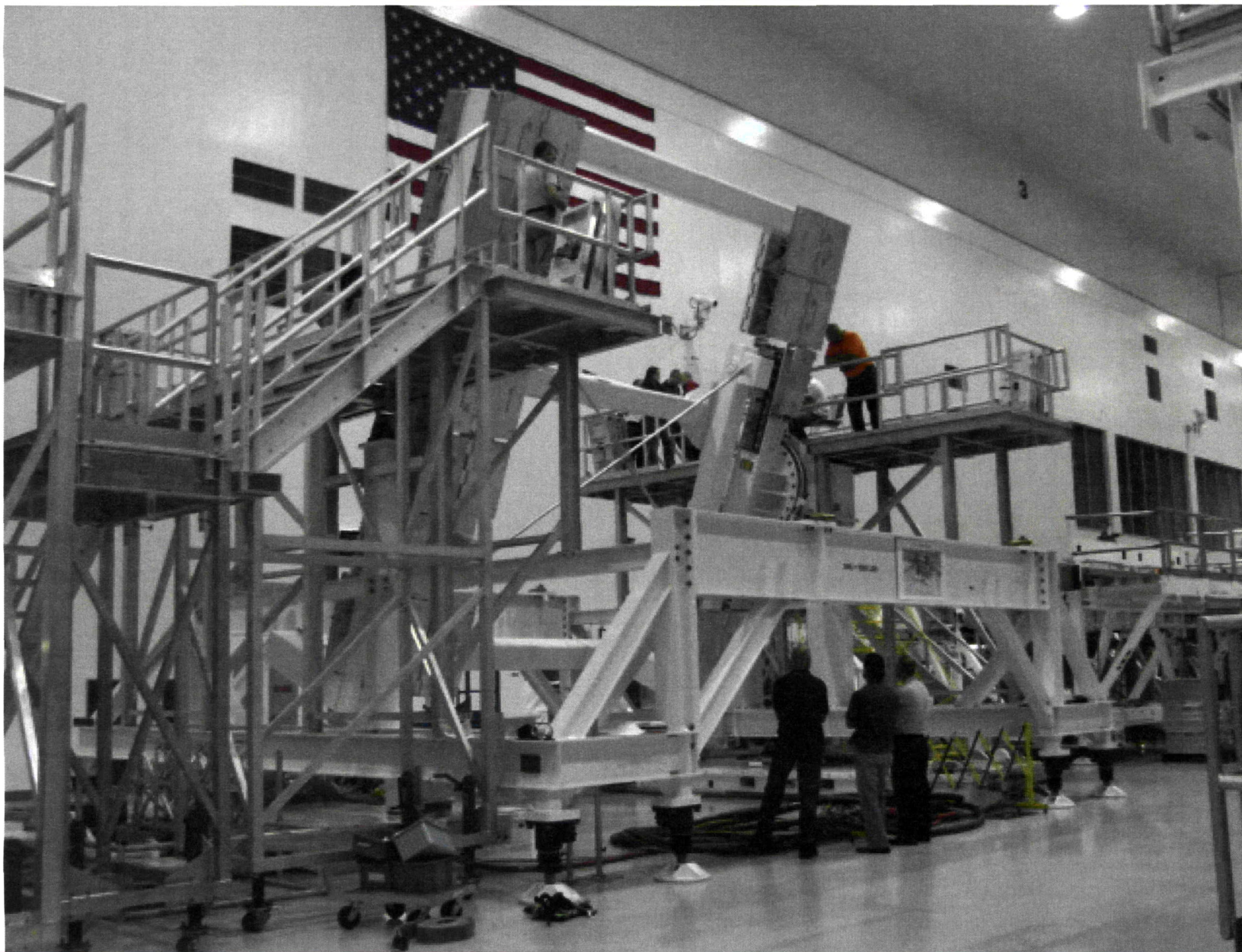


- General
- In 1998 the vacuum chamber's control system that oversees pressure/vacuum functions, gas detection, temperature and humidity sensors, system integrity, and facility security, as well as pumping and equipment controls, control room components, were refurbished.
- The three-story, stainless steel chamber is one of two built by NASA in 1964 to test the Apollo program flight hardware. The 33-foot-wide by 50-foot-tall chambers were used to simulate a low-Earth orbit environment for the command and lunar modules. Both chambers were deactivated in 1975 when the Apollo-Soyuz project ended.

- Capabilities
- Can create a vacuum environment equivalent to 257,000 feet altitude or 48 miles.
- In addition to monitoring and controlling pressure sensor units, the Series 90-70 PLCs also monitor the chamber's residual gas analyzer for partial pressures of water, hydrocarbons, nitrogen, helium, and oxygen. Both PLCs are housed in the control room accompanied by a Windows NT server and master and slave stations.

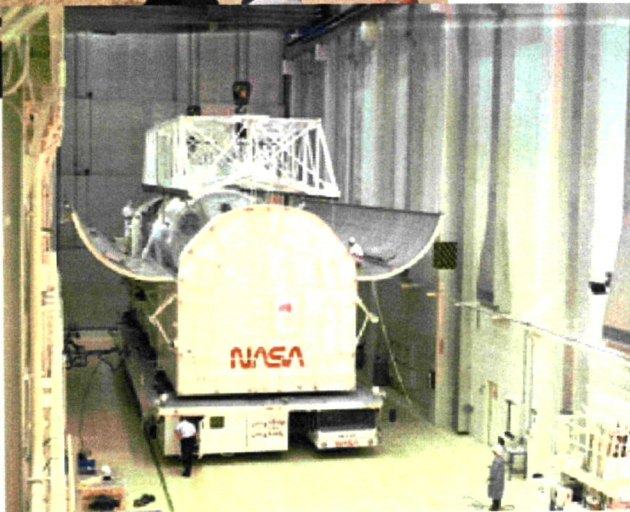
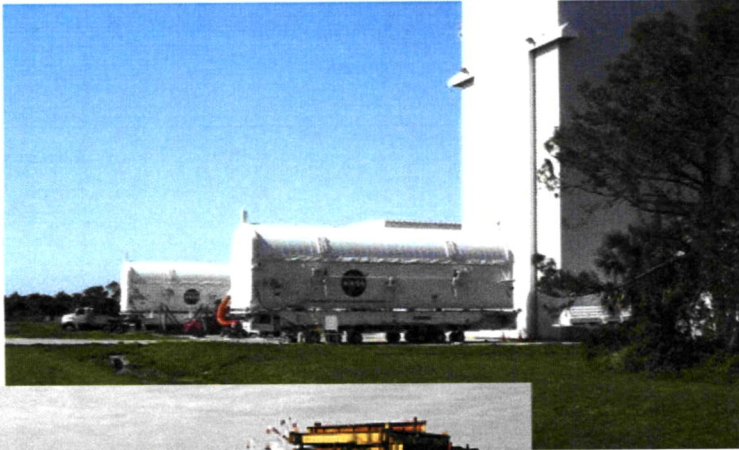


ELC Rotation Stand





Payload Transporter/Canister



• Transporter Statistics

• Status: Existing

- Purpose: Transport the payload canisters from processing facilities to launch facilities

• Quantity: 2

• Weight: 136,600 lbs

• Load Capacity: 172,000 lbs

• Size: 65' X 22'

• Speed: 5 MPH Loaded, 10 MPH Unloaded

- Built in 2000 to replace the two original transporters built in the 70's

• Canister Statistics

• Status: Existing

- Purpose: Provide environment protection for payloads during transportation from KSC processing facilities to KSC launch facilities

• Quantity: 2

• Payload Capacity: 65,000 lbs

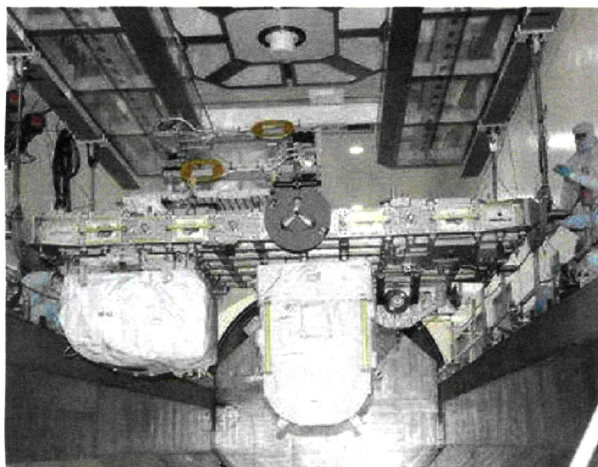
• Payload Size: 15' D X 60'L

• Transportation Configuration: Horizontal or vertical

Cleanliness: 100,000



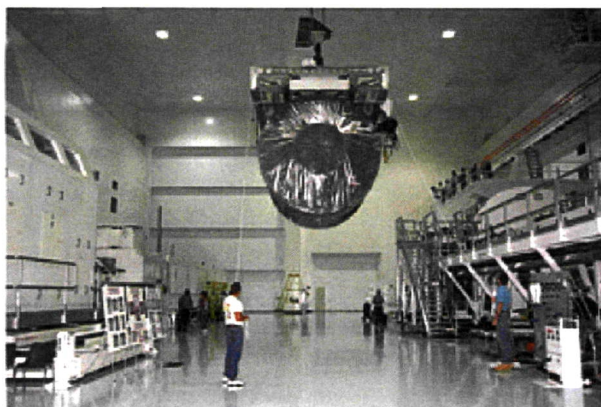
Cargo Element Lifting Assembly (CELA)



- **Statistics**
- **Status:** Existing
- **Purpose:** Rigid steel frame utilized to lift Space Shuttle payloads.
- **Quantity:** 1
- **Load Capacity:** 36,500 pounds
- **Payload envelop:** 15' dia. with trunnion spacing of 20'

- **General**
- Built to support Space Shuttle payloads program
 - The CELA is designed to handle all types of Space Transportation System (STS) and Space Station horizontal payloads with standard trunnions. The CELA is utilized during payload installation/removal operations to and from payload work stands, MMSE canister or other payload containers

- **Capabilities**
- Max. payload envelope – 15 feet
- Single crane lift operation





KSC Customer Services

- **Fabrication and Rapid Prototyping**
- **Machining**
- **Pneumatics Fabrication**
- **Thermal Protection Systems Manufacture and Repair**
- **Precision Measurement and Dimensional Analysis**
- **Materials Testing and Analysis**
- **Failure Analysis**
- **Precision Cleaning**
- **Chemical Sampling and Testing**
- **Nondestructive Evaluation**
- **Modeling and Simulation Support**
- **Ordnance Storage and Test**
- **Support Equipment Design and Fabrication**
- **Flight and Non-Flight Cable and Harness Development**



Backup



KSC Life Science Expertise

- **Areas of Expertise**

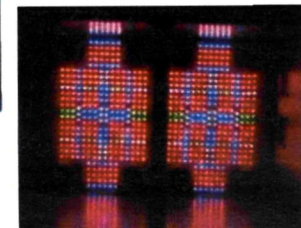
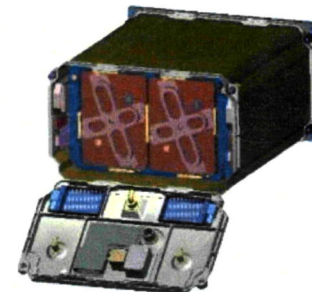
- Processing biological payloads
- Biological payload development and Flight execution
- Developing life support systems & flight hardware
- BRICs and ABRS flight facilities
- Maintaining commitments to Investigators
- Managing Labs to support space related research
- Managing Grants (e.g. ILSRA)

- **Critical Skills**

- Mission Integration
- Project Integration
- Payload Scientist
- Science Disciplines: Exploration Life Support, Molecular Biology, Plant Physiology, Analytical Chemistry, Microbial Ecology, Wet Solid Waste, Air Purification
- OES manager, engineer, and technician
- CMDS Software Manager
- Certified Animal Care Manager
- Engineering Disciplines: Optics, Communications, Electrical, Mechanical, Spacecraft Thermal, Fluids, Power Systems, Lighting, Structural

- **Customers**

- NASA HQ / ESMD & SOMD
- International Space Station
- International Science Community
- Florida State Partnership
- ISS National Lab Community
- Commercial



ABRS



BRIC Opti



NASA Science Laboratory "Rack" Facilities

Human Research

7 ExPRESS Racks

Materials Science Research Rack

Window Observational Research Facility

HRF-1

2A

3A with EMCS

HRF-2

5 with S'DRUMS

6 with C

Fluids Integrated Rack (FIR)

MELFI-3

Muscle Atrophy Research Exercise System (MARES)

3 Minus Eighty-Degree Laboratory Freezers for ISS (MELFI)

Microgravity Science Glovebox (MSG)

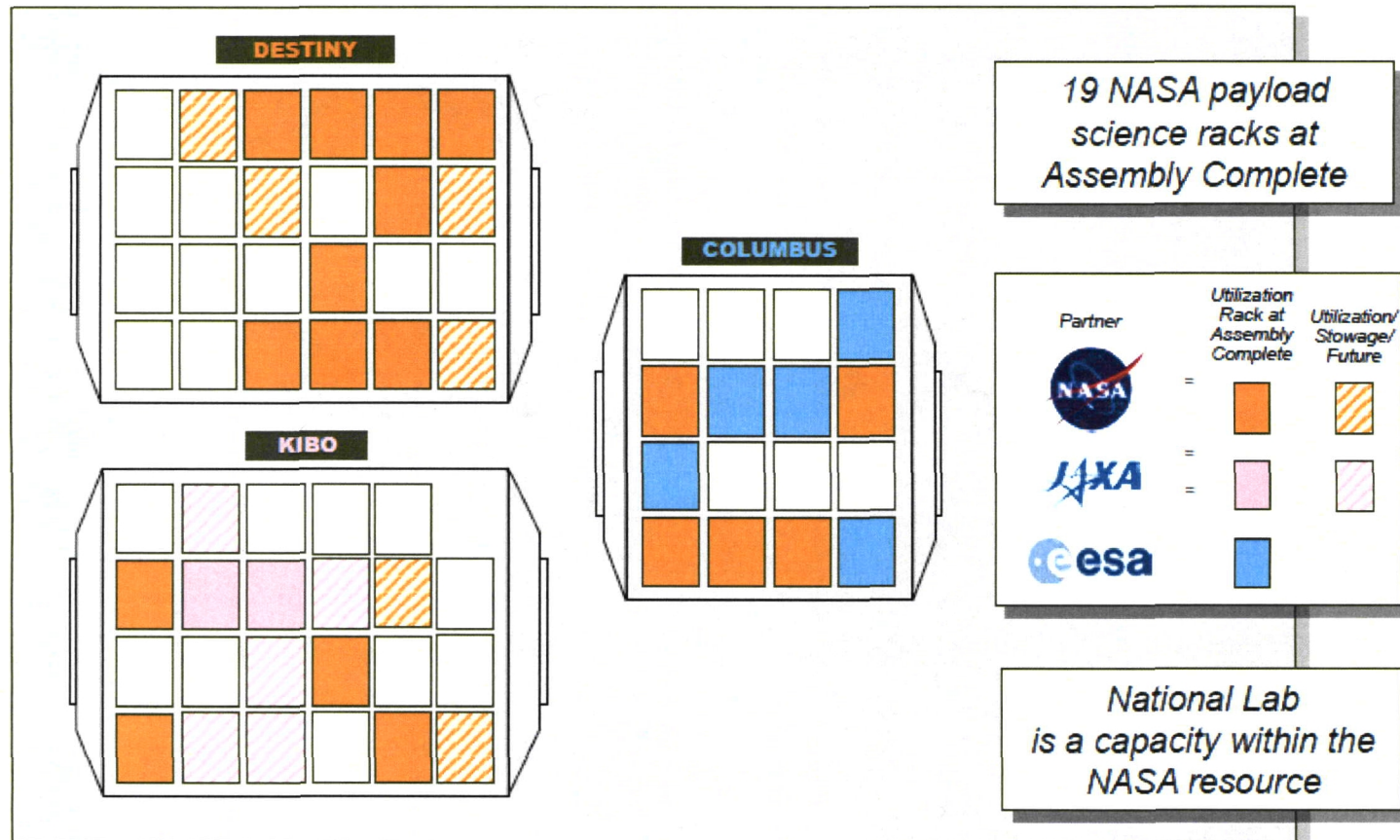
ExPRESS-8 Launch 11/2010

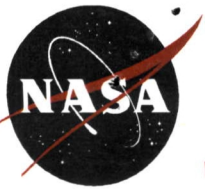
Combustion Integrated Rack (CIR)

The image displays a variety of scientific racks and facilities. On the left, there are two Human Research Facility (HRF) racks, labeled HRF-1 and HRF-2. In the center, seven ExPRESS racks are shown, labeled 2A, 3A with EMCS, 5 with S'DRUMS, and 6 with C. To the right of the ExPRESS racks is the Materials Science Research Rack and the Fluids Integrated Rack (FIR). Further right is the Window Observational Research Facility (WORF) and the MELFI-3 (Minus Eighty-Degree Laboratory Freezer for ISS). Below these are the Muscle Atrophy Research Exercise System (MARES) and three more MELFI units. At the bottom left is the Microgravity Science Glovebox (MSG). At the bottom center is the ExPRESS-8 rack, with a note 'Launch 11/2010'. At the bottom right is the Combustion Integrated Rack (CIR).

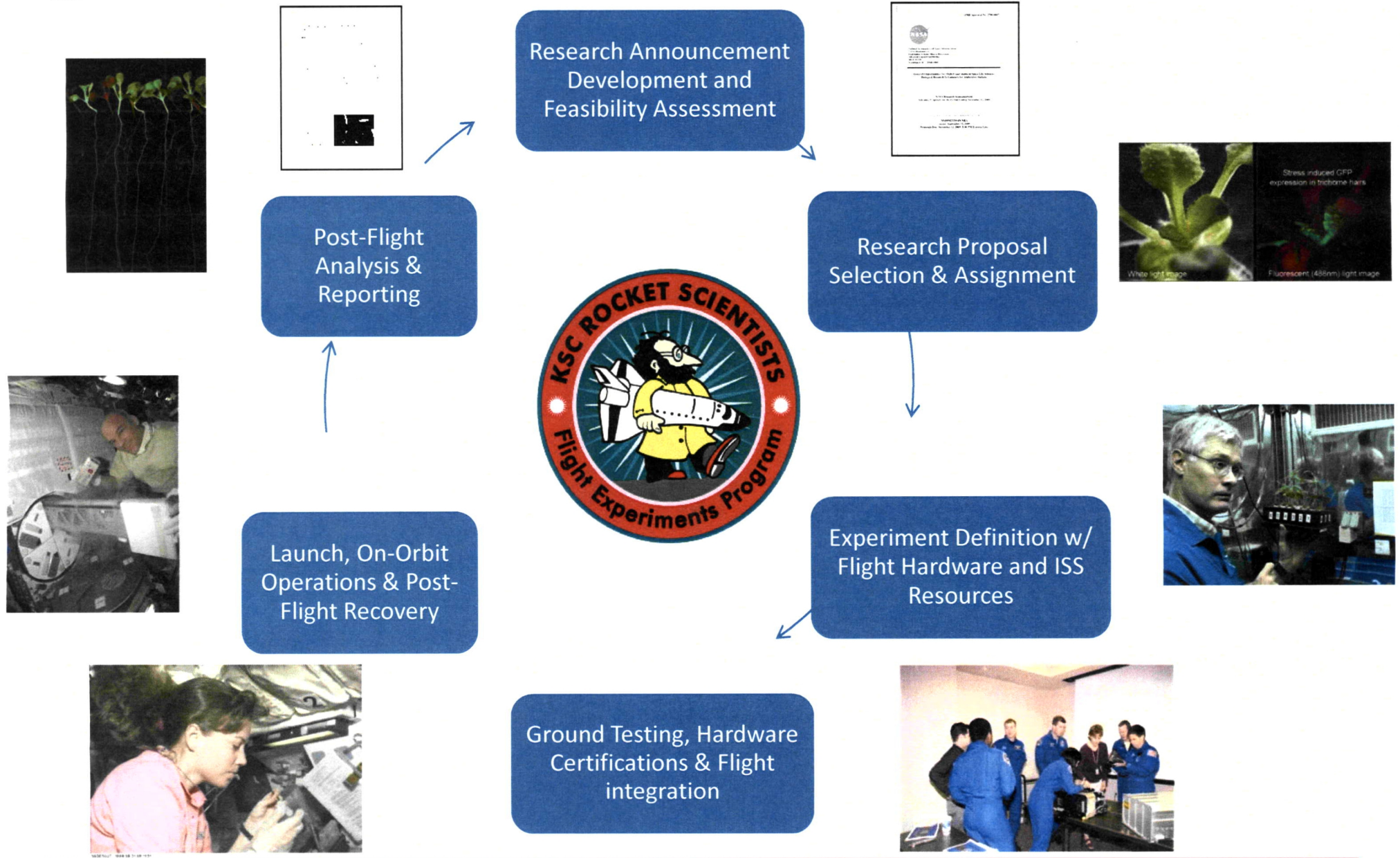


What internal space is available for research? *Science Rack Topology*





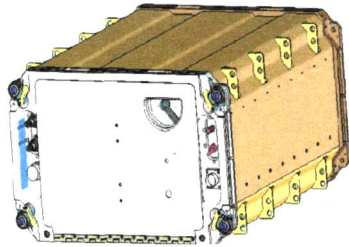
Research Payload Development





KSC ISS-Research Flight Hardware

ABRS



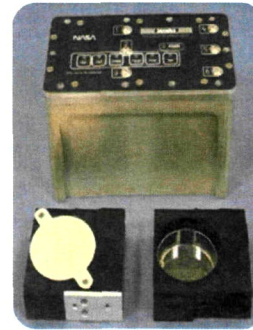
KFT



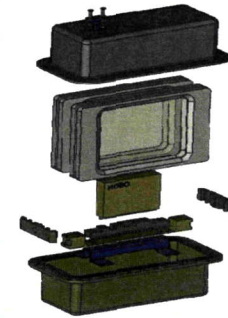
Biotube



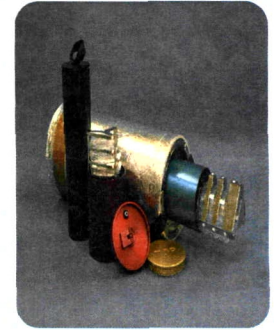
BRIC-PDFU & LED



BRIC-Opti



BRIC-60/100



Inventory

- On ISS
- At KSC
- Certification
- Planned Upgrades

1
1
STS & ISS
BFP & YFP imaging

4
70
STS & ISS
none

0
1
STS
ISS Cert

0
10
STS
Lid mods & ISS Cert

0
30
STS & ISS
none

0
16 (60mm)
15 (100mm)
STS & Progress
none



KSC Flight Payload History

