National Aeronautics and Space Administration

Kennedy Space Center

Resource Encyclopedia

December 2010
KHB-1863
Edition 1

Introduction

Welcome to the Kennedy Resources Encyclopedia (KRE). This resource has been created to document, describe and highlight the capabilities of Kennedy Space Center (KSC). Inside this document, you will find many of the extraordinary capabilities that exemplify the people, equipment and facilities that enable KSC to achieve the nearly impossible in pursuit of our nation's quest to further humankind's understanding of the Earth and the heavens. The KRE brings together a broad range of technical capabilities, facilities and laboratories that enable KSC to accomplish the highly technical challenges and missions the center executes. The information contained in the encyclopedia is not an exhaustive list of all of the center's capabilities, and will be updated via a recurring process to maintain data validity. Additional information on content included in the KRE can be requested from the KSC Center Planning and Development Office.

In 2010, NASA's new direction gave way to an agencywide refocusing. The changing and dynamic environment has warranted KSC to examine its role as a premier launch site and determine how to fully execute the agency's vision. This vision, through Congress' and the nation's commitment for exploration beyond low Earth orbit, inspires KSC to document its technical strengths, services and facilities. This document can aid KSC in understanding its resources and act as a decision-making tool to ensure we evolve in ways that make best use of the technical capabilities and facilities in support of this new direction.

The KRE can be used to broaden employee knowledge of resources and capabilities for awareness or utilization. This resource can provide the business development community with information to engage potential business partners and showcase KSC's capabilities. The KRE can be used to enable and grow participation and contribution to the long-range exploration of space, promote the development and use of technologies, and attract partnerships to advance the mission of NASA and KSC.

The National Aeronautics and Space Administration and the John F. Kennedy Space Center reserve the right to have priority for all its capabilities to support agency missions and not all capabilities may be available when requested. All technical information contained herein is deemed to be accurate at the time of publication; however, data accuracy should be validated based upon customer requirements.

The KRE was created by the 2010 KSC NASA FIRST team along with countless others who assisted in the compilation and validation of the data contained herein. We hope you find the KRE to be a useful document. Should you have further questions related to capabilities documented within the KRE or require additional information regarding the capabilities, services and facilities, please feel free to contact Kennedy Space Center's Center Planning and Development Office at 321-867-8545.

http://kscpartnerships.ksc.nasa.gov/

Original Signed by

Robert D. Cabana
Director, John F. Kennedy Space Center

Volume 1 Technical Capabilities and Services

Section 1.1 Ground Processing and Launch Operations

Section 1.7 Facility and Infrastructure Services

Volume 2 Facilities

Section 1.1
Ground Processing and Launch Operations

Kennedy Space Center offers a world-class experience base for the planning and execution of operations associated with transportation, assembly, integration, testing, launch and recovery of human rated, expendable, and reusable vehicles including payloads and spacecraft. Section 1.1 of the Kennedy Resource Encyclopedia provides details on ground processing and launch operations capabilities.

Section 1.1 of the Kennedy Resource Encyclopedia includes the following chapters:

Chapter 1.1.1
Launch Vehicle Processing

Kennedy Space Center has engineering expertise and multi-disciplinary services for human and expendable launch vehicle processing operations, including assembly, integration, testing, servicing, launch and recovery of flight elements.

Chapter 1.1.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.1 Launch Vehicle Processing

1.1.1.1 Environmental Evaluation for Launch Operations

The environmental evaluation for launch operations capability consists of the operation and maintenance of computer models such as the Rocket Exhaust Effluent Diffusion Model. Kennedy Space Center has the ability to recognize and recommend corrective measures for problems in the models and can specialize them for multiple types of launch operations. KSC also can function as an interface with the United States Air Force range safety personnel to provide catastrophic launch vehicle modeling. The Environmental Evaluation Console provides real-time predictions to launch team and emergency response personnel on model outputs.

1.1.1.2 Flight Readiness Reviews

Kennedy Space Center has the capability to perform readiness reviews. A readiness review is an aggregate of oversight and insight surveillance activities used in the assessment and evaluation of a particular activity (eg. flight of a launch vehicle).

In a flight readiness review, the process certifies that the flight hardware and software have met the design requirements. The team reconciles as-designed and as-built baselines and identifies and addresses exceptions. Prior to the review, the team conducts all required flight preparation activities, confirms that the hardware, software and supporting infrastructure are ready for the flight, and determines if any additional operations are required for mission success during in-orbit operations, return and postflight operations.

The flight readiness review process integrates the readiness products of multiple disciplines, based upon objective evidence, into decision packages for management consideration. The team brings together product quality and safety, risk management, engineering requirements for flight and ground support equipment (GSE), ground processing support (including facilities and support equipment), configuration management, operations and mission management.

In managing the flight readiness review process, the team works within and across program and project boundaries to coordinate and integrate the products. Typical tools used to produce flight readiness products include the Configuration Status Management Operations System™ (CoSMOS); Requirements Allocation Matrix™ (RAM); Open Items Status Report (OISR); Problem Reporting and Corrective Action System (PRACA); Operations and Maintenance Requirements and Specifications Document (OMRSD); Program Requirements Document (PRD); and configuration status accounting and verification systems such as Space Station Accounting and Verification System (SSAV), Configuration Status Accounting System (CSAS), and Integrated Checkout Assembly and Management System (ICAMS).

Just after liftoff, clouds of smoke billow up and around the Delta II rocket carrying the Solar Terrestrial Relations Observatory (STEREO) spacecraft on top. Liftoff is from Launch Pad 17-B at Cape Canaveral Air Force Station.

1.1.1.3 Insight and Approval for Expendable Launch Vehicle Services

Kennedy Space Center has the capability to perform the technical oversight (insight and approval) of launch vehicles. Activities related to this oversight include, participation in launch vehicle and launch site readiness reviews (systems review, Pre-Vehicle on Stand (PreVOS) hardware review, Flight

Readiness Review (FRR), Launch Readiness Review (LRR); performing technical and risk assessments (test plan, test data, procedure reviews); resolving anomalies; checking on hardware pedigree (tanks, payload adapters, avionic boxes, engines, etc.); and having production and operations insight.

Vehicle systems engineers, integration engineers and resident office personnel provide the systems engineering expertise and technical excellence, possess knowledge on multiple launch vehicle fleets, and have more than 50 missions in flow at KSC and field office locations.

Accomplishments:

- Identified and resolved problems early in the launch flow and in time to support successful launches
- Established and maintained mutual respect and trust with launch vehicle providers by demonstrating the appropriate technical oversight
- Established a structured, effective and efficient approach to perform government oversight

1.1.1.4 Integrated Launch Vehicle Technical Management

Kennedy Space Center has experience acting as the chief technical authority during launch countdown operations and selected activities involving astronauts and fully integrated launch vehicles. KSC can provide expertise in multisystem problem assessment and integration among various project elements, hardware providers, ground support operators and off-site support. KSC has experience integrating and resolving all technical issues regarding off-nominal conditions and configurations. The vast experience base of the KSC launch team allows the ability to fully integrate and complement the launch countdown process.

Accomplishments:

- KSC completed more than 130 successful shuttle launches and recoveries. The team worked through countless technical issues during those launch countdowns resulting in the safe and successful launch of a vehicle.

1.1.1.5 Launch Commit Criteria

Kennedy Space Center's work force has the capability to define, develop and implement the requirements and processes for payload-specific Launch Commit Criteria. The LCCs are requirements that must be satisfied prior to committing a payload for launch. To define LCCs, the payload processing team interfaces with the payload customer and the project engineering office to determine which technical requirements will generate LCCs. After identification, the team determines which technical requirements need to be monitored during launch countdown.

Accomplishments:

- Developed and implemented the LCCs for all shuttle payloads to date
- Expertise in leading LCC development along with required launch vehicle interfaces and preplanned troubleshooting steps
- Expertise in implementing the LCC requirements and reporting payload status and fitness for launch

1.1.1.6 Launch Countdown Simulation and Launch Team Training

Kennedy Space Center has experience in training and certification of launch operations personnel involved in ground processing, prelaunch and launch. KSC training experience includes coordinating with the simulation development team to ensure training objectives are met, practicing reporting protocol for anomalies with emphasis on terminal count operations and anomalies, and critical landing operations.

Training console operators is performed in normal working conditions with multisystem and multistage integrated models. The models are capable of providing system level training scenarios, supporting daily testing, launch countdowns, and include different contingency scenarios. The models simulate both the flight and ground support equipment elements.

Accomplishments:

- Certified Launch Team (prime console engineers, launch support teams and launch authority teams)
- Verified Command Control and Monitor software
- Verified launch countdown procedures
- Verified Launch Commit Criteria and pre-plan contingencies
- Designed and developed the ground support equipment training models
- Integrated the flight and ground system training simulations

1.1.1.7
Launch Image Analysis

Kennedy Space Center's imagery technology capabilities include providing millisecond timing of launch and facility events that system engineers utilize to assess flight hardware performance. Imagery analysis teams are capable of identifying and classifying off-nominal events for a multitude of engineering purposes. For example, imagery teams perform multiplatform imagery screening and analysis which utilizes the highest known projection resolution technology currently available in the eastern U.S. One of these analyses, displacement analysis, involves trajectory, vector and velocity, which is ideal for ground and in-flight mishap investigations. KSC also is capable of infrared image analysis. In addition, KSC is capable of archiving mass-scanning and digitizing of multiple imagery formats with zero loss of data (Perfect archiving capability).

During foreign object debris (FOD) analysis of a space shuttle launch, the red circles indicates water ice was detected by image analysis.

Accomplishments:

- Provided image analysis of 133 space shuttle missions
- Provided image analysis for many test flights, including the Ares I-X vehicle flight test, and the recent Space-X flight test of its Falcon 9 vehicle
- Image analysis of Delta, Atlas and Sea Launch vehicles
- Provided imagery services to law enforcement

1.1.1.8
Launch Pad Processing

Kennedy Space Center has experience with numerous pad processing and launch flows. All orbital U.S. human-rated launches since the Apollo Program have been launched from one of two Launch Complex 39 pads. KSC developed the know-how to effectively process and launch vehicles at the pads. From cryogenic and hypergolic commodities, to vehicle size constraints, to variable flame deflectors and sound suppression systems, KSC has the expertise to provide solutions.

KSC also has developed significant technical capabilities associated with emergency management. KSC has experience with various modes of contingency rescue and escape for astronauts and ground crews.

The pad is designed to support the mobile launcher platform, which allows for multiple launches in short turnaround time frames. KSC has technical expertise

NASA's Hubble Space Telescope Relative Navigation Sensor (RNS) Experiment is transferred to the payload changeout room at Kennedy Space Center's Launch Pad 39A.

At Kennedy Space Center's Launch Pad 39A, a specialized transporter carrying the payload canister, delivers the payload for integration into space shuttle Discovery in preparation for the STS-131 mission.

in the movement of vehicles and providing all necessary communications and commodities during the move. The mobile launcher platform and the crawler-transporter allow for the transport of launch vehicles, weighing millions of pounds, from the Vehicle Assembly Building to the launch pad.

1.1.1.9 Launch Radar Tracking

Kennedy Space Center is capable of performing real-time launch tracking of vehicle radar signature, staging dynamics, debris events and plume signature. KSC tracking teams utilize high-resolution C-Band, wide-band, coherent radar, two X-Band Weibel® Doppler radars (portable) and advanced software tools for debris analysis and ascent or orbital object analyses.

An aerial view of Kennedy Space Center's C-band radar station shows how engineers use information from this facility to analyze launch debris radar.

Kennedy Space Center utilizes one of the space shuttle solid rocket booster retrieval ships, Liberty Star, for X-band mobile radar.

These tools provide radar data required to identify release site, reconstruct trajectory and dimensions (down to 0.5 inches) and material composition of liberated debris as related to launches. These tools also provide relative in-flight motion, bending and flexure detection within the vehicle stack (includes wings, tail and engines).

Accomplishments:

- Detected and tracked an astronaut tool bag lost during an extravehicular activity, or spacewalk, on the STS-126 mission
- Successful Ares I-X relative in-flight motion detection of objects ranging from 0.2 to 0.4 inches in area

1.1.1.10 Launch Vehicle Element Processing

Kennedy Space Center has technical expertise in and is capable of performing flight element processing planning and execution. A detailed assessment can be performed to work out the variables involved in flight element receiving, build-up, integration, test and

A vantage point from high above in Kennedy Space Center's Vehicle Assembly Building yields a dramatic view of an orbiter being mated to its stack.

Various sections of the Ares I-X flight test vehicle are prepped and staged for integration inside Kennedy Space Center's Vehicle Assembly Building.

inspection. The majority of the execution of this work is completed in the Vehicle Assembly Building (VAB) and the Rotation, Processing and Surge Facility (RPSF).

The VAB can provide scalable processing with associated commodities supporting various test and flight configurations. The large transfer aisle allows for multiple vehicle concurrent processing and the storage of multiple flight sets. The VAB boasts the ability to store up to four external fuel tank-style flight articles without impacting the ability to process and store vehicles in the four unique high bay cells. The VAB is capable of protecting numerous unique vehicles during most if not all weather anomalies. KSC personnel are experts in utilizing the VAB as efficiently and effectively as possible and can provide processing solutions for various processing scenarios.

The RPSF is designed to allow for the receipt and inspection of solid rocket booster segments and installation of solid rocket motor engine nozzles. The RPSF can support hazardous propellant inspection and can provide surge facilities allowing for the storage of numerous solid rocket motor segments. KSC personnel have years of experience utilizing all of the facility's processing capabilities and can provide technical expertise to deliver processing solutions.

For flight element build-up, checkout and stacking timing is critical for the most efficient manifest plan. KSC has expertise in and is capable of providing a detailed processing assessment to preclude schedule risk items prior to execution.

Accomplishments:

- KSC has processed all launch element components during the 30-year history of the Space Shuttle Program and the Ares I-X flight test vehicle
- KSC provides the skills necessary to safely and successfully prepare these components for integration into the most complex launch vehicle ever developed by humans
- KSC has processed more than 1,000 solid rocket booster motor segments, and 130 orbiters and external fuel tanks for flight

1.1.1.11 Temporarily Installed and Removed Items Tracking

Kennedy Space Center is capable of tracking all of the temporarily installed and removed items inside and on the flight vehicle. This includes items used for ingress into areas of the flight vehicles that are not intended to be accessed during flight and any temporarily removed items that are required to be installed for flight. These processes are used to reduce the possibility of any tools or equipment creating foreign object debris and becoming a launch or in-orbit hazard.

Chapter 1.1.2
Spacecraft Processing

Kennedy Space Center has engineering expertise and provides multi-disciplinary services for human, expendable and reusable spacecraft processing capabilities, including integrated testing, servicing, launch and recovery.

Chapter 1.1.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.2.1 Crew Support Systems

1.1.2.2 Reusable Spacecraft Processing

1.1.2 Spacecraft Processing

1.1.2.1 Crew Support Systems

Kennedy Space Center has the capability to initiate plans and procedures, and establish techniques for pre-packing, modifying and stowing Flight Crew Equipment (FCE) in support of launch operations. KSC is the source of policy for FCE launch preparations and operational philosophy. Detailed test procedure development, testing and requirements definition of ground support equipment and test facility compatibility with spacecraft equipment are all within the KSC experience base. KSC also has technical expertise in FCE testing and engineering concepts, practices and procedures as it relates to Flight Crew Systems.

Accomplishments:

- Processed Flight Crew Equipment for 132 space shuttle missions

In Orbiter Processing Facility-1 at Kennedy Space Center, space shuttle Atlantis' STS-132 crew members participate in training activities.

In Kennedy Space Center's Orbiter Processing Facility-1, space shuttle Atlantis' STS-129 crew members familiarize themselves with equipment that will be used on their mission.

Discovery is towed into Kennedy Space Center's Orbiter Processing Facility-3 to begin processing for the next launch.

1.1.2.2 Reusable Spacecraft Processing

Kennedy Space Center has the experience and facilities to process reusable human spacecraft. The orbiter processing facility bays allow for in-depth test and repair and flight processing for the most complex vehicles. Efficient processing and turnaround of human spacecraft requires the use of many capabilities, including insertion of payloads via overhead cranes, clean room processing of vehicles and payloads, and a host of commodities necessary for advanced vehicle processing. KSC has experience with performing the most complex tasks involving removal and replacement of critical vehicle components.

Inside Orbiter Processing Facility-1 at Kennedy Space Center, technicians secure the overhead crane to the sling placed around the forward reaction control system that will be installed on Atlantis.

Chapter 1.1.3
Payload Processing

Kennedy Space Center has engineering expertise for the launch site support of pressurized and non-pressurized payload processing, transport, handling and integration of payloads, payload carriers, telescopes, and International Space Station components, including life sciences and biological payloads.

Chapter 1.1.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.3 Payload Processing

1.1.3.1 Experiment Payload Processing

Kennedy Space Center has the capability to provide payload processing for experiments designed and provided by external customers. These payloads can be launched and returned on a single flight, or remain on the International Space Station (ISS) for several months.

Processing activities consist of receiving a customer research payload, and preparing and testing it for flight and integration. KSC engineering personnel can document and plan laboratory and material support and technical requirements for integration and servicing for customers. Trained personnel also can develop and perform procedures to accomplish interface testing, physical integration, closeout activities and inspections. Testing can be performed in the Payload Rack Checkout Unit (PRCU), an integration and test environment that can provide a high-fidelity emulation of the data and interfaces between payloads and the space station.

Accomplishments:

- Supported multiple customers with pre- and post-flight processing of Bio-Safety Level 1 and 2 materials
- Provided laboratory space, materials and support for numerous payload customers
- Provided support to the Animal Care Facility for pre- and post-flight processing of animals
- Supported processing of 19 NASA space station utilization facilities including the following:
  - Expedite the Processing of Experiments to Space Station (EXPRESS)
  - Window Observational Research Facility (WORF)
  - Human Research Facility Rack 1 and 2
  - Minus Eighty-degree Laboratory Freezer for ISS (MELFI)
  - Commercial Generic Bioprocessing Apparatus (CGBA)
  - Advanced Biological Research System (ABRS)
  - General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER)
- Performed stowage and retrieval of powered and passive middeck research payloads for all shuttle launches and landings
- Performed the integration and flight closeouts of Robonaut 2

Technicians monitor the testing of an Expedite the Processing of Experiments to the Space Station (EXPRESS) rack.

Time-sensitive experiments are unstowed based on plans developed by the principal investigator and processing team.

1.1.3.2
Industrial Alignment Tools

Kennedy Space Center has the capability to provide expertise for utilization of industrial alignment tools such as lasers and photogrammetric cameras. These tools take precise measurements of flight elements in order to assist in high-precision manufacturing and design of a payload final assembly.

A highly trained alignment team operates lasers and retro-reflector targets to measure discrete points and surfaces of a payload. The laser tools allow the team to make three-dimensional precision measurements of x, y and z coordinates simultaneously to within several thousandths of an inch to ensure that precise tolerances are met.

In addition to lasers, the team utilizes photogrammetric cameras that use triangulation to measure points and surfaces. These cameras are useful in unstable environments where many measurements can be recorded over time to identify deformation of a payload.

Inside Kennedy Space Center's Space Station Processing Facility, a technician takes a precise measurement of a payload that will be delivered to the International Space Station.

Accomplishments:

- Frequently used to produce accurate assembly and integration of space shuttle payloads and space station elements
- Commonly used for verifying interfaces between hardware, aligning support fixtures, and ensuring proper alignment for mating operations of space shuttle and station components
- Utilized for alignment of various expendable launch vehicle (ELV) components

High-precision laser alignment ensures proper mating.

1.1.3.3
Payload Assembly Processing

Kennedy Space Center has the capability to develop plans and procedures for payload assembly processing, and is capable of performing the required processes and procedures. The three major categories of payload assembly processing include final assembly, test and closeout.

Upon delivery of the payload to KSC processing facilities, the processing team integrates the hardware with the common launch vehicle interfaces such as mechanical and electrical systems. Engineers collaborate with designers to integrate hardware and solve assembly, fit and testing issues that may occur during the assembly processes. After payload hardware is fully assembled, they are put through comprehensive checkout procedures that test each interface to ensure proper function. After the hardware has been tested, it is closed out, which indicates that the hardware is in its final flight configuration.

Accomplishments:

- Assembled and integrated all U.S. elements of the International Space Station
- Assisted with assembly and processing of international partners' space station elements
- Processed all Space Lab hardware and other deployable scientific research payloads
- Assisted international partners with processing and integration of orbital replacement units (ORUs) such as JAXA's HTV-2 mission
- Initialized collaboration efforts with NASA's commercial partners on ORU processing and flight hardware assembly and integration

In Kennedy Space Center's Space Station Processing Facility, technicians work to unload returning cargo from the International Space Station stored inside the multi-purpose logistics module Leonardo.

1.1.3.4
Payload Integration

Kennedy Space Center has the capability to integrate requirements and work any issues related to payload and vehicle interfaces, such as payload installation, online test, closeouts, launch, postflight payload removal and troubleshooting. KSC has experience working with payload representatives, vehicle systems engineers, and all levels of management in order to resolve issues and meet requirements for payload and vehicle processing.

Accomplishments:

- Performed the vehicle side of payload integration for every space shuttle mission, including support for all major payloads such as the Hubble Space Telescope, various logistics carriers with orbital replacement units (ORUs), multiple International Space Station elements, and many sidewall carriers

Technicians attach a common berthing mechanism onto the cupola, a seven-window module that was delivered to the International Space Station during the STS-130 mission in February 2010.

1.1.3.5
Weight and Center of Gravity Measurement

Kennedy Space Center has the capability to conduct precision weight and center of gravity measurements of payloads. These measurements require highly specialized equipment and take place during flight element and payload processing activities.

Payloads can be weighed using specially designed payload fittings. The fittings incorporate load cells of various capacities to determine the load at each fitting point.

Load data at each fitting point, along with leveling and distance measurements between points, are used to calculate the total mass and location of the center of gravity of the payload. These measurements are recorded and used for flight planning activities.

Accomplishments:

- Performed weight and center of gravity activities for all payloads that are mounted to the orbiter
- Performed weight and center of gravity activities for specialized payload bags that are mounted to the multipurpose logistics modules on the space station

A technician in the Space Station Processing Facility measures the weight and center of gravity of the EXPRESS Logistics Carrier-1 (ELC-1).

The multi-purpose logistics module Leonardo rests on the weight and balance scale in Kennedy Space Center's Space Station Processing Facility.

Chapter 1.1.4
Command, Control and Telemetry Monitoring

Kennedy Space Center has expertise in command, control and monitoring telemetry to operate and verify mission data from ground support equipment, launch vehicles and spacecraft, and for vehicle and payload troubleshooting.

Chapter 1.1.4 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.4 Command, Control and Telemetry Monitoring

1.1.4.1 Integrated Command, Control and Monitor

Kennedy Space Center is capable of providing a fully integrated command, control and monitoring system for interfacing with flight and ground systems during nominal operation, and providing real-time command capability for reactive and safing actions when systems deviate from established expected operating parameters. The system can provide critical launch execution commanding, verification and configuration checks with precise sequencing and timing. The system can be evolved to capture new or changing requirements, sequencing or revised launch procedures.

Accomplishments:

- Developed and verified console software for vehicle power-up, testing and launch while interfacing with the Launch Processing System (LPS).

1.1.4.2 Telemetry Data Analysis, Output and Storage

Telemetry teams at Kennedy Space Center utilize the Telemetry Processing System to perform processing and distribution, and data recording and retrieval. The Telemetry Processing System offers user-configurable displays, exception monitoring, event notification, and supports user-defined math and logic operations between data channels, both analog and digital, to yield a derived channel. Once processed, telemetry data can be transmitted via Ethernet to any location with network access. The primary data collection and display tool for the Launch Services Program, which supports several military expendable launch vehicles, has been IRIS. It is a real-time telemetry data processing display that can support multiple, simultaneous vehicles with multiple telemetry streams.

Components of Kennedy Space Center's Record and Playback Subsystem, including the Master Timing Unit, Dewetron client display and Dewetron recorders, are displayed.

The Record and Playback Subsystem is capable of extensive data recording and retrieval. This subsystem provides enhanced data processing tools and displays, accepts telemetry in Pulse Code Modulation (PCM) and analog formats and provides bit synch, frame synch, decommutation and engineering unit conversion. Data is captured by digital and analog tape recorders and archived before any data reduction is performed. The availability of archived raw data is invaluable in troubleshooting and identifying transmission system errors.

Accomplishments:

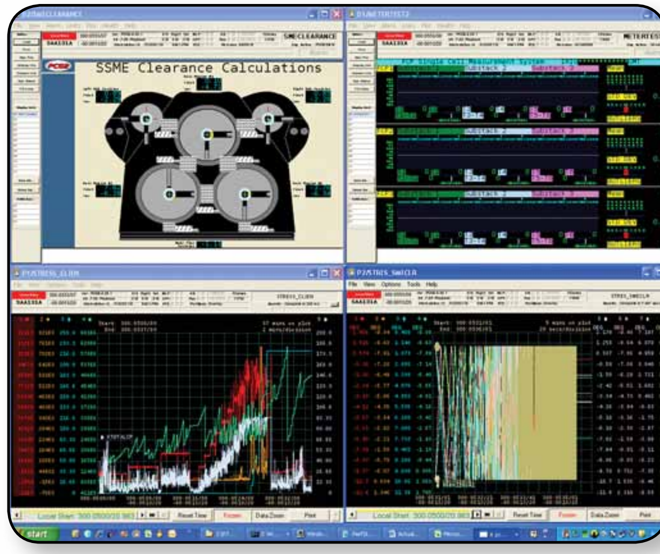
- Supported 132 space shuttle missions
- Provided telemetry support for Ares I-X flight test
- Supported hundreds of U.S. fleet expendable launch vehicle (ELV) launches since the mid-1970s.
- Monitored most U.S. launch vehicle fleet launches from the east and west coasts, including NASA, and U.S. civil and military launches

- Monitored NASA ELV launches taking place at remote locations (i.e., Wallops, Kwajalein, Kodiak Island)

1.1.4.3 Telemetry Data Management

Kennedy Space Center is capable of telemetry data management. To perform telemetry data management, KSC engineers utilize engineering tools such as the Plots Calculations and Graphic Tools (PCG2) and the NASA Engineering Shuttle Telemetry Agent (NESTA). These tools provide engineers the ability to create, manage and stream data in a way that conveys an accurate state of every engineering system-subsystem in a controlled environment or an office area.

Both PCG2 and NESTA are utilized for monitoring only and have no command or control capability. Engineers use the tools of PCG2 system to create and test displays that calculate and publish data, show state transitions with animations, translate data in information, and initiate high-resolution plots. NESTA allows engineers to receive around-the-clock notification of specified vehicle processing events and failure via e-mail. Data monitoring rules can be easily changed via a Web-enabled client to reflect a change in monitoring requirements for an engineering system.



A real-time monitor display of the telemetry monitoring system shows a sample of space shuttle main engine gimbaling data.

Accomplishments:

- Supported space shuttle tests and launches
- Supported Ares I-X flight test
- PCG2 was selected as NASA KSC Software of Year in 2010

Chapter 1.1.5
Commodity Storage, Handling and Servicing

Kennedy Space Center has engineering expertise and multi-disciplinary services for the storage, transfer and distribution of fluids, and gases, including the associated operations and maintenance of propellants, facilities, systems and equipment.

Chapter 1.1.5 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.5 Commodity Storage, Handling and Servicing

1.1.5.1 Breathing Air Equipment

Kennedy Space Center has the capability to provide breathing air to customers upon request. The typical breathing air requests are for the Self-Contained Atmospheric Protective Ensemble (SCAPE), airline operations, filling of mobile storage units for life support systems, purge gas for payloads and Launch Complex 39 breathing air batteries. The breathing air meets OSHA requirements to provide a safe breathing environment for personnel and contains low amounts of moisture and contaminants to accommodate use on flight hardware, and increase the life span and operability of equipment.

KSC's Life Support Group can provide self-contained breathing apparatus (SCBA) or supplied air respirators (SAR) to be used in emergencies and Immediately Dangerous to Life and Health (IDLH) environments to provide breathable air to users. The SCBAs are staged at various locations near launch pads prior to a launch, allowing technicians access to them in emergency situations prior to rescue or evacuation.

1.1.5.2 Chemicals and Specialty Fluids

Kennedy Space Center has the capability to provide solvents, high-purity water, chemical neutralizers, coolants, and limited supply of CFC, HCFC, and Halon products in containers ranging from tankers to drums. The individual containers can be filled, verified for purity, documented and delivered to in-use locations. After operations and fluids use are completed, the containers can be retrieved and returned to storage at KSC for future re-use.

1.1.5.3 Cryogen Storage, Handling and Servicing/De-servicing

Kennedy Space Center has the capability to handle, process and service cryogenic propulsion systems and provide cryogenic liquid atmospheric gases in containers ranging in size from tankers to small Dewar flasks.

Cryogenic propellant servicing includes not only cryogenic load, drain and safing operations in support of a human spaceflight vehicle during a launch countdown, but also cryogenic servicing of the Launch Complex 39 storage tanks. Processing of cryogenic systems includes the maintenance, test and checkout of the ground storage and transfer systems (liquid hydrogen and liquid oxygen), as well as integrated testing (ground and flight vehicle) prior to launch countdown.

The cryogenic propellants are provided in individual containers, filled, sampled to verify purity (chemical analysis report including certification), and delivered to in-use locations. Upon completion of operations unused propellants in the containers are returned to the KSC cryogenic storage area for future reuse.

The 850,000-gallon liquid hydrogen tank, pictured here, and the 900,000-gallon liquid oxygen tank and cryogenic supply systems support Kennedy Space Center's Launch Complex 39.

Accomplishments:

- Completed more than 235 Space Shuttle external tank cryogenic servicing operations.
- Completed more than 90 de-servicing operations in support of the Space Shuttle Program
- Performed 30 years of maintenance and problem resolution on cryogenic ground support equipment and flight hardware

1.1.5.4 Explosive Safety

Kennedy Space Center has expertise managing explosives, propellants and pyrotechnic safety programs. The safety programs are designed to meet all federal, state, local and NASA requirements for explosives, propellants and pyrotechnics. KSC can provide technical evaluation of deviations and waivers and review Memorandums of Agreement associated with explosive, propellant and pyrotechnic operations. KSC can determine quantity distance sitings and has experience reviewing operating procedures for handling and transportating of explosives, propellants and pyrotechnics. KSC also can provide technical input for design and modification of explosive handling facilities, operations and equipment.

1.1.5.5 Hydrocarbon Fuels

Kerosene-type fuels can be provided to customers upon request in liquid tankers and flight line refuelers. The individual containers can be filled and sampled to verify purity (chemical analysis report that includes certification). KSC can accommodate jet fuel deliveries for fueling of aircraft at the Shuttle Landing Facility.

1.1.5.6 Hypergol Storage, Handling and Servicing/De-servicing

Kennedy Space Center has the capability to handle, process and service hypergolic propulsion systems and hypergolically powered hydraulic systems and provide hypergols in containers ranging in size from liquid tankers to small cylinders.

The hypergolic propellant servicing team performs hazardous operations on hypergolic ground and flight hardware in a timely manner. The unique safety, facility and ground system risks and controls inherent to the operations are well understood by the team.

Hypergol-rated facilities are available for use on KSC property along with servicing equipment for hypergolic fuel and oxidizer. KSC has numerous fixed hydraulic pumping units capable of operating under local or remote control. The units each contain a fill, circulate and de-aerate (remove air or gas from) circuit capable of reducing total air content in hydraulic oil to less than 1 percent by volume.

The interface connections for the Forward Reaction Control System (FRCS) thrusters of the orbiter uses hypergolic propellants.

Technicians at Kennedy Spac Center perform hypergolic servicing of the Solar Dynamics Observatory spacecraft.

In providing hypergolic propellants, the individual containers are filled, sampled to verify purity (chemical analysis report that includes certification), and delivered to in-use location. Upon completion of operations unused propellant in the containers is returned to the KSC hypergolic propellant storage area for future reuse.

Accomplishments

- Loaded several different types of spacecraft with hypergolic propellants, including the space shuttle and long-duration uncrewed spacecraft like the Solar Dynamics Observatory (SDO)
- Safely loaded more than 390,000 gallons of hypergolic propellants onto the space shuttle
- Serviced hypergolic propellants on nine NASA science mission spacecraft

1.1.5.7 Operations Engineering

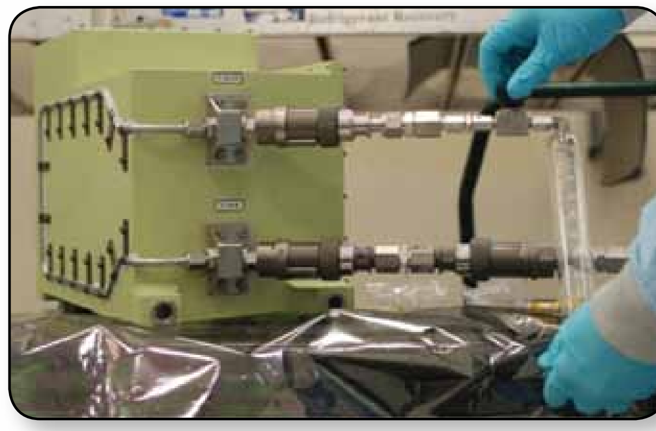
Kennedy Space Center has the capability to provide operations engineering and services to meet various customer requirements. This capability includes designing, building, maintaining and operating various propellant containers (e.g., dewars, tankers, compressed gas trailers), interface panels, pumps and compressors. The Propellants and Life Support (P&LS) organization can provide options to support various customer requirements for cryogenic, high-pressure gas and hypergolic operations. Utilizing a mobile fleet of more than 200 items, P&LS has the capability to meet a wide variety of customer requirements.

1.1.5.8 Payload, Spacecraft and Launch Vehicle Fluids Storage, Handling and Servicing/De-servicing

Kennedy Space Center has the capability to perform payload, spacecraft and launch vehicle fluids servicing operations and provide high-pressure gases in containers ranging in size from compressed gas trailers to small cylinders.

These servicing operations include servicing of liquid ammonia, high-pressure gaseous nitrogen, high- pressure gaseous helium into composite overwrapped pressure vessels (COPVs), high-pressure gaseous oxygen, Argon and specially treated coolant or potable water. Operations include servicing, de-servicing and safing in support of a human spaceflight vehicle and payloads. KSC also is uniquely qualified in the design, operation and maintenance of the ground processing equipment and transfer systems as well as the integrated testing (ground and flight vehicle) prior to launch countdown.

The high-pressure gases are provided in individual containers, filled, sampled to verify purity (chemical analysis report that includes certification), and delivered to in-use locations. Upon completion of operations and use of the gases, the containers can be retrieved and returned to storage for future reuse. Nitrogen, Argon and helium also can be made available via high-pressure pipelines within the KSC Industrial Area and the Launch Complex 39 area.



The ISS active thermal control system is serviced. This system uses ammonia as its coolant.

This composite overwrapped pressure vessel, which is used as a payload's high pressure gas tank, is an example of a tank that is serviced at Kennedy Space Center.

Accomplishments:

- Safely loaded ammonia more than 100 times onto space shuttles, seven International Space Station (ISS) truss elements, and five ammonia tank assemblies

- Safely loaded Composite Overwrap Pressure Vessels (COPVs) with nitrogen, oxygen and helium at pressures exceeding 2,000 pounds per square inch absolute (psia)
- Successfully serviced/de-serviced, integrated, and tested for flight hundreds of utilization payloads, EXPRESS rack experiments, ISS Orbital replacement units, and ISS Internal Active Thermal Control System Water

1.1.5.9
Propellants Standards Compliance Engineering

Kennedy Space Center provides engineering analysis and code guidance to customers to ensure all regulations (e.g., DOT 49CFR) and related national consensus safety codes (e.g., ASME) are met.

1.1.5.10
Self-Contained Atmospheric Protective Ensemble (SCAPE) for Toxic Operations

Kennedy Space Center has the capability to provide SCAPE for customers upon request. SCAPE provides protection from toxic propellant vapors and liquids, and supplies breathable, conditioned air to the wearer.

Two types of SCAPE are used on center:

Category I: Liquid air backpack mode (Environmental Control Unit (ECU))

Category IV: Supplied by airlines, SCAPE ventilator utilized to enter and exit areas.

KSC has the capability to provide the maintenance and operations services for all SCAPE. This includes:

- SCAPE suit maintenance post-mission/recycle and 60-use overhaul
- Ventilator Maintenance: Pre-deployment inspection, post-mission/recycle and annual maintenance
- Operations: Technicians suit user, fill ECUs and ventilator bottles and monitor SCAPE operations
- Quarterly inspection and annual maintenance
- Pre-deployment inspection and post-mission recycle
- Operations: Technicians deliver and place the air lines for operation

A technician helps a SCAPE operator secure his protective ensemble prior to a training session.

A SCAPE operator works on a propellant drum during training.

Accomplishments:

- Kennedy Space Center and Vandenberg Air Force Base in California are the only agencies with the SCAPE unit
- KSC has more than 20 years of expertise maintaining and operating SCAPE suits
- KSC has the unique expertise of utilizing SCAPE suits to fill orbiters and payloads with different types of hydrazines and oxidizers, which can be employed on any launch vehicle

Kennedy Space Center workers dressed in SCAPE suits prepare for training.

Chapter 1.1.6
Measuring, Managing and Planning for Weather Events

Kennedy Space Center has experience and capabilities in weather measurement, managing weather impacts, and planning for weather events for daily operations, launch activities and developing concepts of operations.

Chapter 1.1.6 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.6 Measuring, Managing and Planning for Weather Events

1.1.6.1 50 Megahertz Doppler Radar Wind Profiler

Kennedy Space Center is capable of providing measurements of wind speed and direction above the vicinity of NASA's Shuttle Landing Facility at 150 meter intervals and from a two to 18 kilometer altitude using a 50 megahertz profiler. A complete profile is provided every five minutes with a wind component accuracy of 1 meter per second (as good as the best wind-finding balloons).

1.1.6.2 Anomalous Weather Management

Kennedy Space Center has experience making processing and launch decisions based on complicated weather variables that can change frequently. Dynamic weather conditions at the launch site require intuitive analysis and planning to ensure the launch vehicle and supporting personnel are safe during anomalous weather and predicted weather systems. This includes considering KSC capabilities, the launch manifest and the processing rollback constraints in order to determine a decision timeline to ensure processing in an environment that is safe for personnel and flight hardware.

Accomplishments:

- KSC earned a substantial experience base performing assessments of and managing weather conditions

1.1.6.3 Integrate and Manage Vehicle Retest and Evaluation Process

Kennedy Space Center has expertise managing the process through which ground and vehicle configurations are assessed and tested during weather events, such as lightning, hail, high winds and excess rain. This process involves coordinating with all ground and vehicle elements to determine whether or not a retest is required per the retrieved data. This high-level coordination allows for complex system reviews and assures system integrity.

1.1.6.4 Launch and Ground Processing Weather Requirements Development

Kennedy Space Center can provide expertise for the development of weather-related requirements and constraints for ground operations and launch for payloads and launch vehicles. KSC also can provide meteorological consulting for all ground and launch operations.

The lightning protection system protects the space shuttle Endeavour as lightning strikes the launch pad at Kennedy Space Center.

1.1.6.5 Lightning Measurement

Kennedy Space Center can provide technical expertise in measurement of lightning and thunderstorm electric fields and lightning location in 4-D, strength and other characteristics. KSC also can provide data on these measurements to support operations and has the capability to develop complex lightning systems to ensure launch vehicle safety during anomalous launch pad weather conditions.

Accomplishments:

- Led major research programs in lightning and atmospheric electricity
- Experts in surface-based and airborne investigations into thunderstorm electric field development and decay

1.1.6.6 Thermodynamic Measurement, Weather Sensor Development and Winds Research

Kennedy Space Center can provide expertise in the in-situ measurement of temperature and relative humidity and in in-situ and remote measurement of winds from the surface to the lower stratosphere. KSC also can provide weather sensor development and technical analysis to ensure accurate and valuable data is received. KSC also can advise on the specification, acquisition and deployment of a wide variety of weather sensors.

Accomplishments:

- Operated the award-winning Applied Meteorology Unit that developed, evaluated, tailored and transitioned weather technology to operations in support of America's space program
- Published multiple peer-reviewed papers on the properties of surface, boundary layer, tropospheric and lower stratospheric winds

1.1.6.7 Weather Concept of Operations

Kennedy Space Center has the expertise necessary to develop effective concepts of operations for ground processing, launch, and weather infrastructure to improve safety while minimizing cost and unnecessary weather-related delays to operations.

1.1.6.8 Weather Data Archive

Kennedy Space Center can provide access to the Weather Data Archive, which is used to archive meteorological data from the KSC and Cape Canaveral Air Force Station weather infrastructure. Systems that have data archived include the Electric Fill Mill Network, 915 megahertz Wind Network, Doppler Radar Wind Profiler, Wind Towers, Jimsphere Balloons, Rawinsonde Winds, Lightning Detection and Ranging Network, Cloud to Ground Lightning Surveillance System and the Mesonet Network of soil moisture and visibility sensors. The archive also houses data from the Airborne Field Mill II research program.

Chapter 1.1.7
Operations Planning and Analysis

Kennedy Space Center has expertise in analyzing and planning the execution of work for operational systems work flows and developmental systems concepts of operations.

Chapter 1.1.7 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.7 Operations Planning and Analysis

1.1.7.1 Composite Flight Component Handling and Processing

Kennedy Space Center is capable of developing concept of operations and processing for potential flight elements manufactured with composites. To assist with this development, engineering teams perform assessments related to special handling fixtures, operations and facilities for repairs.

Accomplishments:

- Metal and composite thermal protection system replacing Spray-On Foam Insulation (SOFI) at the Service Module (SM)-Instrument Unit (IU), and First Stage (FS)- Upper Stage (US) interfaces
- Successfully completed and supported assessments for the development of the Ares V launch vehicle
- Supported a heavy-lift launch vehicle trade study, including operations assessments

1.1.7.2 Development of Flight Hardware Concept of Operations

Kennedy Space Center has the capability to develop concept of operations and processing for flight hardware. This involves operations integration and planning and development of specific timelines for new systems that are in development. The capability includes planning operations for complex systems that have never been operated before, such as developing operations scenarios, concepts, budget estimates and documentation.

The team develops concept of operations and processing for ground support equipment (GSE), including coordination with the designers to include operability into the design and streamline operations. For ground operations planning, they develop prelaunch, launch, landing and recovery, and post-mission timelines.

The team develops the preliminary concept of operations for crew vehicles and launch vehicles, including off-line activities prior to delivery to the integration facility and post-mission, final integration, landing and recovery activities, and disassembly. The team identifies processing capabilities required to ready the crew vehicle for launch vehicle integration and return to the launch site. They also coordinate concepts of operations and requirements with potential landing and recovery entities (e.g., Department of Defense) and ensure all agreements are implemented. The team develops processing timelines for these vehicles.

The team provides the planning and coordination of vehicles needed to support recovery of the crew module from the landing site, and for transportation to carry the crew module back to KSC. This involves performing trade studies and analysis to choose the most efficient recovery method.

KSC teams planned and coordinated a demonstration of the truck transportation concept for the Orion crew module.

Accomplishments:

- Performed Post-landing Orion Recovery Test Phase 1 (PORT 1) in April 2009
- Developed Orion ground operations functional flow and processing timeline
- Developed ground operations planning documents for the Constellation Program

1.1.7.3 Emergency Management

Kennedy Space Center has experience being responsible for training plans and procedures for emergency egress operations including training of closeout crew, flight crew and emergency response personnel. This includes daily operations, launch and landing operations and firing room emergency egress. This experience has given KSC an exceptional knowledge base and an established set of technical capabilities associated with emergency management of human spaceflight.

Mock astronauts were safely and successfully recovered from a space shuttle during a contingency simulation at Kennedy Space Center.

1.1.7.4 Multiflow Analysis and Integration

Kennedy Space Center has the capability to coordinate usage of critical processing space within specific facilities. Coordination allows planning and scheduling of critical processing activities to be shared among the various missions and customers. Trained personnel, with a broad vision of multiple inter-related processing flows, utilize CAD models and flow studies and perform multiflow analysis to coordinate shared space usage and hardware relocation.

The space within the Space Station Processing Facility high bay is coordinated among various customers.

Accomplishments:

- Supported 32 International Space Station assembly and servicing mission requirements (STS-108 to STS-132)
- Provided Design Visualization support by producing 239 configuration drawings and 751 configuration studies
- Coordinated more than 626 lifts, and 1,600 moves of space station components, and flight and processing hardware
- Coordinated space usage requests within the Space Station Processing Facility for nine years
- Performed various multiflow assessments of the Space Station Processing Facility
- Produced 13 new product processes including:
    - Hazardous commodities time slice
    - SSPF west side requirements schedule
    - Space request schedule
    - Design visualization configuration drawing
    - Design visualization configuration study

1.1.7.5 Schedules and Manifest Planning

Kennedy Space Center has the capability to develop and maintain an overall integrated processing site schedule and a launch manifest that integrate the needs of flight vehicles, facilities, flight/ground constraints and resource needs.

The project schedulers assist in the integration of activities and dependencies of both higher and lower level schedules. They ensure that the project is in compliance with all approved scheduling policies and procedures. The schedulers organize activities by order of importance to minimize delays.

This team also develops master schedules to control and document development and processing activities and to ensure key milestones are met and are within budget. The master schedules are populated with personnel, equipment and other resources that will be used for each processing and development activity for optimization of staffing levels and other resources.

There are numerous constraints and facility and resource limitations that drive manifest major milestones. The team balances the available resources (floor space, work force, ground support equipment, testing equipment, etc.) to successfully accommodate competing activities. The activities include all space shuttle mission work (processing multiple missions at a time), fueling operations for expendable launch vehicles (ELV) and payload processing for international partners and ground systems development. Due to the complexity of these variables, a simulation tool called Automated Manifest Planner (AMP) is utilized to assist in this effort. This tool is highly specialized software with preprogrammed logic to accommodate processing limitations.

Accomplishments:

- Successfully met all scheduled payload-to-pad dates for ISS payloads
- Successfully documented and managed the Ares I-X ground systems development and processing activities
- Successfully documented and managed the development of the Launch Control Center's Young-Crippen Firing Room (Firing Room 1) and Launch Equipment Test Facility

1.1.7.6 Support Services Planning

Kennedy Space Center has extensive experience and is capable of identifying, developing and providing the support services required for all launch vehicle processing operations. To plan and provide support services, a team identifies the resources, services and assets needed for ground processing and launch of flight vehicles.

KSC has developed a unique method for ensuring that services are provided to support launch vehicle processing. In collaboration with the customer, the KSC team identifies the specific support service or commodity requirements necessary for each single ground operation process from the vehicle assembly phase to launch. These support requirements can consist of many different kinds of services, such as chemical or physical analysis, testing, commodities, equipment, transportation or communications services (e.g., voice communications, video and data). After the support requirements are linked with individual operations, the team can determine whether the current level of required support can be changed (higher or lower) as processes evolve. This direct linkage allows for increased efficiency and reduction of costs.

Accomplishments:

- Developed a draft of support services requirements for Ares and Orion ground processing and launch at KSC

Chapter 1.1.8
Test and Checkout

Kennedy Space Center has technical expertise in the test and checkout of flight hardware and ground support equipment.

Chapter 1.1.8 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.1.8 Test and Checkout

1.1.8.1 Avionics

Kennedy Space Center is capable of testing all types of avionics hardware including hardware used for guidance, navigation, data processing, instrumentation, power distribution, communication tracking and environmental controls and displays. KSC has a variety of test equipment at its disposal. Testing capabilities include, thermal and vibration testing, microwave short-range antenna testing and radio frequency shielded testing.

1.1.8.2 Calibration Engineering and Measurement Analysis

Kennedy Space Center can provide subject matter expertise in the selection and use of measuring and test equipment. KSC maintains expertise in, and establishes policy and procedural requirements for, measurement uncertainty analysis and measurement decision risk analysis. KSC also can provide engineering support for evaluation of measurement applications and evaluation of risks associated with incorrect acceptance or rejection of products based on measurement results. Measurement uncertainty analysis can be used in calibration services to validate the quality of calibration processes, and can be used in all phases of measurement, including research, design and operations, to set design tolerances, aid in the selection of measuring and test equipment and verify conformity to specifications.

Measurement decision risk analysis is used in calibration services to control false accept risk in calibration processes, and can be used in all phases of measurement, including research, design and operations, to manage decision risks associated with the measuring and test equipment being used.

1.1.8.3 Far Field Antenna Testing

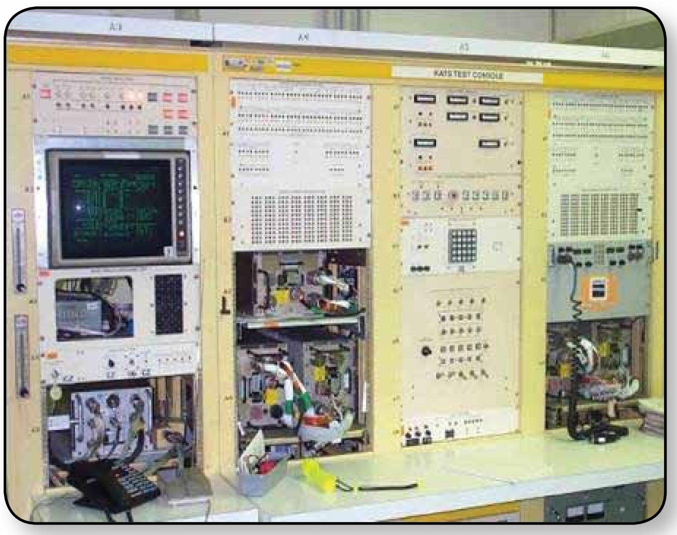
Kennedy Space Center is capable of performing frequency testing from 100 megahertz to 18 gigahertz (VHF, UHF, L, S, C, X and Ku Bands). The Far Field Antenna Testing Range can test a variety of antenna types, including parabolic, dipole, strip line, quadridged horn, mono-pulsed phased antennas. The range is a variable distance and height testing facility (50 to 450 feet in length and 6 to 42 feet in height) and can test antennas up to 450 pounds using traditional methods integrated with an advanced computer measurement system. The operations room and the building exterior recently were refurbished. All positioning and test equipment is fully functional and calibrated for use.

- The range was used to test antennas and entire spacecraft during the Gemini and Apollo programs.
- The range was used to test shuttle antennas, including S-band quads, Heim-GPS, TACAN L-band, MSBLS, RADAR altimeter, EVA airlock, and payload bay UHF antennas.
- The range has tested dipole telemetry and GPS positioning antennas for the B1-B Strategic Bomber, commercial phased array antenna systems and a multiband multiantenna array.

The adjustable source tower is positioned next to the Far Field Antenna Test Facility.

1.1.8.4 Offline Laboratory Test and Checkout

Kennedy Space Center is capable of performing off-line laboratory test and checkout of avionics systems. Test and checkout teams utilize the Kennedy Avionics Test Set (KATS) to test interfaces to the launch control center and ground equipment software, and trouble-shoot reusable spacecraft data processing systems, guidance, navigation and control, and instrumentation and propulsion avionics. As part of test and checkout, engineers develop software utilizing a combination of flight equivalent hardware and math models, trouble-shoot avionic systems, simulate propulsion avionics systems, provide data bus analysis, and load software onto flight computers and display systems.



KSC utilizes the Kennedy Avionics Test Set (KATS) console to perform test and checkout of various systems.

Accomplishments:

- Decades of experience in testing avionics systems including propulsion avionics for the space shuttle main engines
- Provided decades of support to NASA operational programs, including Space Shuttle, International Space Station and Launch Services programs, and other government-funded programs
- Provided testing and troubleshooting for the Ares I-X vehicle avionics systems
- Developed software using a combination of flight-type hardware and math models
- Performed decades of troubleshooting avionics systems
- Performed software loading of flight computers and display systems
- Developed several propulsion avionics system environment simulations

1.1.8.5 Payload Checkout Systems

Kennedy Space Center has the capability to perform payload checkout systems testing on various payloads, including International Space Station (ISS) hardware. This technical capability requires the skills of a checkout systems team and unique hardware and software.

The checkout systems team is trained in electrical, fluids, mechanical and avionics systems, maintaining the checkout systems in ready-to-use condition, and assisting with execution of test procedures.

The checkout systems involve unique hardware and software facilities used for prelaunch integrated testing and checkout of ground support equipment, flight hardware and software, and payloads. Some of these systems are capable of replicating the actual in-orbit configuration of space station interfaces.

Workers performing a "fit check" of an EXPRESS Logistics Carrier to test electrical and mechanical attachment mechanisms.

The PRCU provides a high-fidelity integration and testing environment by simulating the International Space Station interfaces.

Unique payload checkout testing systems utilize the Test Control and Monitor System (TCMS), which is a checkout system used for space station elements, including modules and laboratories. The Payload Rack Checkout Unit (PRCU) is capable of testing both pressurized and unpressurized experiments. The Electro Magnetic Lab (EML) is capable of electromagnetic compatibility testing, frequency control and analysis, and associated electromagnetic measurements to satisfy flight requirements.

Accomplishments:

- Performed online and offline checkout of space station payloads utilizing PRCU, TCMS, and Communications and Telemetry (C&T) lab
- Performed PRCU, TCMS, and C&T lab checkout of many types of International Standard Payload Racks (ISPR) and sub-rack payloads
- Performed PRCU, TCMS, C&T lab checkout of space station elements such as the European Space Agency's Columbus module
- Performed in-ground test requirements to mitigate space station element in-orbit operability
- Supported flight and ground data playback and data retrieval in support of anomaly resolution

1.1.8.6 Payload/Element/Orbital Replacement Unit (ORU) Testing

Kennedy Space Center has the capability to provide testing of payloads, flight elements and orbital replacement units (ORUs). As part of the testing process, test engineers develop and implement a set of documented procedures to verify acceptable interfaces between the flight support equipment, carrier, launch vehicle and the payload/space station element/ORU.

KSC's engineers have years of experience and testing expertise with launch vehicles and verifying the flight interfaces between the specific payloads, space station elements or ORUs. Interface testing is accomplished by utilizing existing checkout systems and payload-specific test support equipment provided by the customer, and the development of documented testing procedures. These procedures provide all the details for the test, which include supporting sequences such as pre-operation setups, operation instructions, post operations and emergency instructions for safety of personnel, hardware and payloads. Following these documented procedures ensures proper implementation of the test and checkout requirements levied by the payload customer, program or the design center.

Accomplishments:

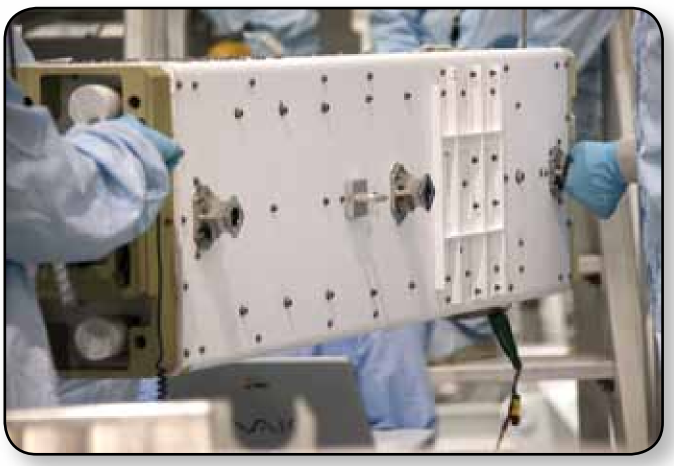
- Provided integration and checkout of all primary and secondary space shuttle payloadsincluding Galileo, Magellan and the Hubble Space Telescope
- Provided integration and checkout of all International Space Station elements, including U.S. Destiny Lab, Japan Aerospace Exploration Agency's (JAXA's) Japanese Experiment Module (JEM) and European Space Agency's Columbus Module
- Performed risk mitigation and interface verification tests using high-fidelity simulations to ensure successful on-orbit operability
- Successfully met on-orbit objectives of all space shuttle and space station missions

1.1.8.7 Real-Time Test and Checkout

Kennedy Space Center is capable of real-time field testing and checkout of avionics systems. Teams at KSC have expert knowledge and routinely perform real-time field testing and checkout of avionics systems on launch vehicles, spacecraft and payloads. The systems that are tested include flight computer hardware, software, sensors and instrumentation, guidance, navigation and flight controls, propulsion avionics, flight radio frequency and telemetry systems.

Accomplishments:

- Successfully retrofitted and integrated the space shuttle fleet with upgraded avionics systems, display systems, flight computers, instrumentation, navigation and control upgrades and the space shuttle main engine advanced heath management systems
- Assembled, processed and launched the flight control system and developmental instrumentation on the Ares I-X flight test vehicle
- Integrated space shuttle heritage avionics flight hardware with Atlas V derived avionics onto the Ares I-X flight test vehicle



Technicians in Kennedy Space Center's Space Station Processing Facility prepare to install the EXPRESS Pallet Controller Avionics-4 to EXPRESS Logistics Carrier-4.

Section 1.2
Design and Analysis Solutions

Kennedy Space Center has developed considerable design and analysis capabilities from its rich history of spaceflight. Many types of launch vehicles and payloads have flown from KSC over the past five decades, providing the center with a thorough understanding of design and analysis best practices and lessons learned. KSC's design and analysis capabilities can be tapped into to avoid potential design failures and increase reliability. Section 1.2 of the Kennedy Resource Encyclopedia provides details on design and analysis capabilities.

Section 1.2 of the Kennedy Resource Encyclopedia includes the following chapters:

Chapter 1.2.1
Design Certification

Kennedy Space Center has the capability to provide analysis and certification of launch vehicles and ground systems.

Chapter 1.2.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.1 Design Certification

1.2.1.1 Ground Systems Readiness

Kennedy Space Center is capable of providing guidance and technical expertise in the design, development and operational readiness of KSC ground support systems. To evaluate the ground systems readiness, KSC engineering teams perform requirements development and execution, engineering analysis, budget analysis, integration and management, contract management, and program and project processes. The team also ensures completion of ground operations requirements and readiness to support requirements for all ground support systems.

Accomplishments:

- Evaluated upgraded lightning protection towers' ability to adequately protect Ares vehicles
- Managed the designed and construction of the new mobile launcher with attached tower for the Ares vehicle
- Managed launch pad modification for new launch vehicles
- Performed redesign of the Launch Equipment Test Facility for umbilicals and vehicle motion simulator systems testing
- Provided Vehicle Assembly Building design of the platforms required for Ares launch vehicles

1.2.1.2 Launch Vehicle Certification

Kennedy Space Center has the capability to establish and execute implementation strategies and plans to mitigate risks on NASA missions to be flown for the first time on a new launch vehicle. This effort also enables new emerging launch vehicle providers, while maintaining the Launch Services Program (LSP) core capabilities and knowledge of current and new launch vehicle systems.

Launch vehicle certification requires significant leadership and project management skills to lead multidisciplined technical teams. Launch vehicle certification is a complex effort in technical, budgetary and schedule management as well as relationship building internally with LSP and externally with NASA, the U.S. Air Force and industry. Certification contributes to the success of NASA missions.

The ground-breaking ceremony for the SpaceX Falcon 9 rocket launch facility took place at Space Launch Complex 40 at Cape Canaveral Air Force Station.

Accomplishments:

- Accomplished launch vehicle certifications for Atlas V and Taurus XL launch vehicles
- Established and executed successful risk mitigation efforts per NASA Policy Directive
- Enables new emerging launch vehicle providers and increases launch vehicle options for spacecraft customers

1.2.1.3 Radio Frequency and Electromagnetic Interference Analysis

Kennedy Space Center is capable of Radio Frequency (RF) and Electromagnetic Interference (EMI) analysis. RF and EMI analysis capabilities include software development, rapid prototype electromagnetic compatibility (EMC) development and testing and design certification, EMC Programmable Logic Controllers (PLC) controls development, lightning sensors development and electromagnetic analysis, and RFI detection and resolution. Equipment used for analysis includes Automated RF Monitoring Stations (ARFMS), automated electromagnetic environment surveillance systems that are fixed and portable, lightning-induced voltage instrumentation system, and bus monitor unit transient response testing. Additional equipment includes three anechoic chambers and a lightning test simulator.

Accomplishments:

- Supported Ares I-X vehicle EMC flight certification
- Supported NASA programs, including International Space Station, Space Shuttle and Launch Services, and the U.S. Air Force 45th Space Wing
- Provided RADAR shielding and masking effectiveness measurements
- Provided detection of Wi-Fi signals entering into spacecraft processing facilities

The mobile electromagnetic van is a portable environment surveillance system used by Kennedy Space Center to detect electromagnetic interference.

Inside Kennedy Space Center's Payload Hazardous Servicing Facility, an electromagnetic interference verification test is conducted on the solar arrays for the Mars Reconnaissance Orbiter (MRO) and an antenna simulator (yellow horizontal rod).

Chapter 1.2.2
Design of Ground Systems, Flight Systems and Interfaces

Kennedy Space Center has the capability to provide multi-disciplinary design services for the full life cycle, including concepts, trade studies, design specifications, drawings and analysis. KSC can provide procedures and support through acceptance testing, component qualification and verification.

Chapter 1.2.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.2 Design of Ground Systems, Flight Systems and Interfaces

1.2.2.1 Design and Assurance of Electrical and Electromagnetic Systems

Kennedy Space Center has decades of engineering expertise and knowledge related to design and assurance of electrical and electronic engineering and systems. Teams at KSC sustain electrical and electromagnetic engineering design standards of selected flight hardware and software systems of flight vehicles from production through postflight analysis and evaluation. KSC engineering also provides design and quality assurance of aerospace flight hardware, ground support equipment (GSE), and electrical and electronic systems, including electrical and electronic components, modules and subsystems.

KSC has extensive Electromagnetic Interference (EMI) expertise, and is capable of rapid prototype Electromagnetic Compatibility (EMC) development, testing, design and certification. KSC has Automated Radio Frequency Monitoring Stations (ARFMS), which allow automated electromagnetic environment surveillance. KSC also supports lightning sensors development and electromagnetic analysis by providing a lightning-induced voltage instrumentation system, and bus monitor unit transient response testing.

NASA's Ares I-X flight test rocket soars past one of the nearby lightning protection masts at Launch Pad 39B.

Accomplishments:

- Provided support to the Constellation Program with requirements development, and hardware design and development for power, instrumentation and command and control systems
- Provided engineering expertise and resources for the Ares I-X flight test vehicle Electromagnetic Compatibility (EMC) flight certification
- Supported NASA programs, including International Space Station, Space Shuttle, Expendable Launch Vehicle, Ares I-X, and the U.S. Air Force 45th Space Wing
- Provided design support and development efforts and operation of Haz Gas 2000, which is the primary hazardous gas detection system for space shuttle launches
- Provided development and sustaining efforts for meteorological and lightning instrumentation systems at Launch Complex 39

1.2.2.2 Design of Avionics Systems

Kennedy Space Center engineering teams are capable of avionics systems design. Avionics engineers are capable of supporting design, fabrication, and system- or subsystem- level integration. Teams can support research and technology development projects.

Avionics teams support design projects for systems that include command and data handling, flight and ground support software, flight instrumentation, guidance, navigation and flight controls, and propulsion avionics systems.

The space shuttle flight deck, or cockpit, before (above) and after the Kennedy Space Center avionics team retrofitted it.

Accomplishments:

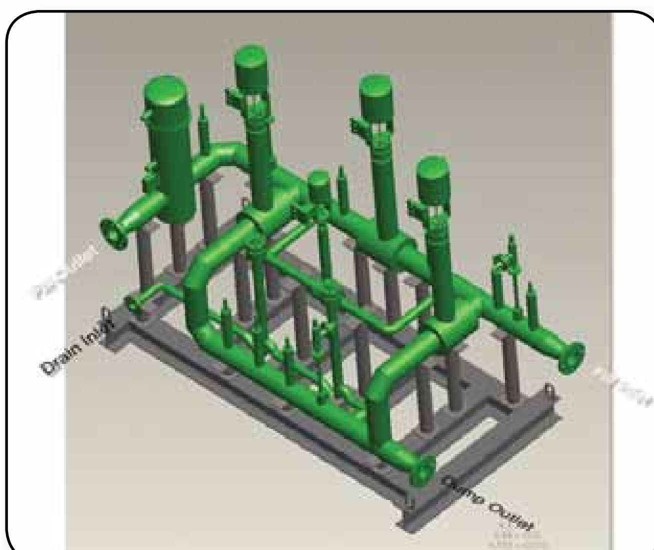
- Supported NASA operational programs including International Space Station and Launch Services Program and other government-funded programs
- Retrofitted the space shuttle fleet with upgraded avionics systems, display systems, flight computers, instrumentation, navigation and control upgrades, and advanced health management systems for the space shuttle main engines
- Assembled, processed and launched the flight control system and developmental instrumentation on the Ares I-X flight test vehicle
- Integrated space shuttle heritage avionics flight hardware with the Atlas V derived avionics flight hardware onto Ares I-X vehicle

1.2.2.3
Design of Fluids and Propulsion Systems

Kennedy Space Center is capable of designing, testing and developing fluids and propulsion systems from the individual components and modules up to integrated ground and flight subsystem levels. Full life cycle engineering is provided from requirements development, concepts and prototypes, design fabrication, installation, and activation and validation. KSC has extensive expertise with fluid systems related to hypergolic, cryogenic, hydraulic, high-pressure pneumatic, environmental control and life support systems. This expertise provides KSC with the knowledge for approval of fluids and propulsion systems required for assurance of launch vehicle readiness and mission success for expendable and human spaceflight.

Engineering teams develop systems for flight hardware and ground support equipment. These systems consist of a multitude of fluids and propulsion systems including liquid propulsion engines, solid propulsion, cryogenic, hypergolic, pneumatic and pressure control systems, active thermal control systems, water and waste management, fuel cells, hydraulics, ammonia systems and fluid servicing systems.

Design teams participate in fluids testing, and technology and software development. KSC has the unique capability to perform testing (including testing at cryogenic temperatures) and the capacity to conduct fluids system and technology development.



A computer-aided design (CAD) rendering of ground support equipment (GSE) for cryogenics systems control was created by Kennedy Space Center design engineers.

Accomplishments:

- Provided several billions of dollars in ground system development engineering and design development of ground support equipment for Apollo, International Space Station, Space Shuttle and Constellation programs
- Provides NASA with independent assurance of expendable launch vehicle readiness and mission success.
- Developed and validated Software operationally used for numerous Space Shuttle and International Space Station fluid subsystems
- Ph.D. level expertise and support
- Thermal performance enhancement test results for cryogenic transfer and storage

1.2.2.4 Design of Mechanical Systems

Kennedy Space Center is capable of performing and managing design, fabrication, analysis, system and subsystem level integration of mechanical and structural systems for flight hardware, ground support equipment (GSE) and payloads.

KSC engineering teams can plan, perform and monitor mechanical engineering activities for launch vehicles, ground systems and payload elements, including mechanical and structural design and analysis, and complex mechanisms design and analysis. KSC engineering teams develop and integrate complex flight and ground mechanical and structural systems

Ground support equipment designed at Kennedy Space Center is used to transfer cryogenic fluid. Condensation caused by the extremely cold fluid is visible in this image.

In the Vehicle Assembly Building, the yellow framework at center is about to undergo a fit check. Nicknamed the "birdcage," it is the lifting fixture utilized to lift the Orion crew exploration vehicle and launch abort system.

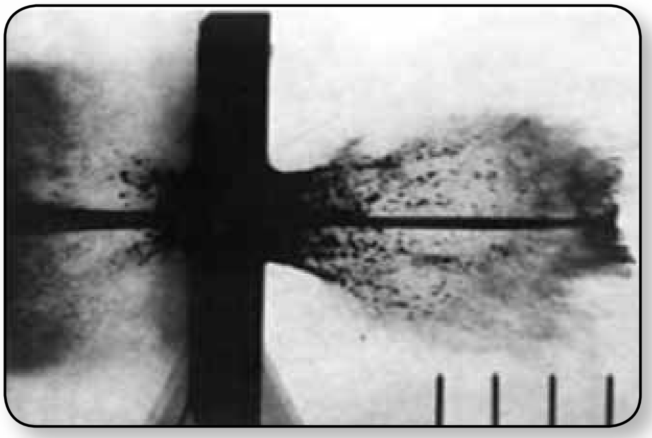
in areas related to umbilicals, vehicle access, launch accessories, environmental control, handling and assembly, access equipment, lifting hardware, transporters, pyrotechnics, flight stages and payloads, thermal protection systems, mechanisms, and field metrology for proper component alignment.

Accomplishments:

- Provided several billions of dollars in ground system development engineering and design development of ground support equipment for Apollo, International Space Station, Space Shuttle and Constellation
- Provided mechanical designs for X-33 T-0 umbilicals, and supercritical gaseous helium systems
- Active committee members for American Society of Mechanical Engineers
- Ph.D. level support in all major mechanical engineering disciplines

1.2.2.5 Design of Pyrotechnic Systems

Kennedy Space Center is capable of designing pyrotechnic systems. Engineers at KSC perform technical evaluation of ordnance devices throughout their life cycle. KSC has expertise in the design of pyrotechnic systems in a multitude of areas, including system initiation (initiators, detonators, assemblies, safe arming devices), Explosive Signal Transfer (flex cord assemblies, thin layer explosives, detonating cords), stage and payload fairing separation (linear shaped charge assemblies, linear explosive assemblies, frangible joints), solid rocket motor ignition and jettison systems (Thru-Bulkhead Initiator, igniters), and flight termination systems.



An X-ray shows the output of a generic conical shaped charge (CSC) device as it is functioned and then clearly ruptures through a thick plate of steel.

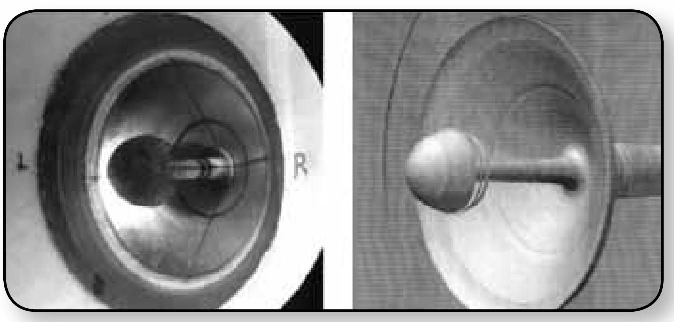


Image of the conical shaped charge output.

Accomplishments:

- Provided technical pyrotechnic support to NASA's Launch Services Program, Missile Defense Agency, U.S. Navy and Air Force, Alliant Techsystems (ATK), United Launch Alliance and ordnance manufacturers

1.2.2.6
Feasibility and Requirements Engineering Concepts Analysis

Kennedy Space Center has extensive experience with performing feasibility and requirements engineering concepts analysis. These studies are performed to select the best architectures for a program or project before large expenditures are committed to design.

KSC organizes a multidisciplinary team of program managers, scientists and engineers to perform feasibility, requirements, and engineering concepts analyses, required to identify the best technical solution from a set of proposed architectural concepts. These viable solutions are evaluated for a series of system measures and cost functions that contain the desirable characteristics to design optimum system architectures.

Accomplishments:

- Provided crawler-transporter feasibility analysis for options for Ares V
- Provided mobile launch pad trade study feasibility analysis of mobile launcher optimal lift loads
- Provided analysis of new materials for crawlerway
- Performed Ares V flight test studies to determine the feasibility
- Performed cryogenic systems analysis of the liquid hydrogen and liquid oxygen tanks to determine the level of corrosion inside the tanks

1.2.2.7
Flight Systems Design

Kennedy Space Center has specialized expertise in designing flight systems that relate to operation of all systems required for flight (avionics, propulsion, engines, fuels, electrical systems and mechanical systems). KSC engineering teams develop and review designs, and integrate all systems required for flight. The integrated design and review improves overall flight design and allows integration of flight systems with ground systems and operations.

Accomplishments:

- Developed Ares I-X avionics design, integration, assembly and flight, resulting in precision flight control from liftoff through end-of-mission
- Performed derivation of optical alignment for Ares I-X guidance and flight control direction cosine matrices
- Performed gyrocompass alignment data reduction for preflight analysis of Ares I-X azimuth error
- Developed advanced design of Ares I crew launch vehicle Redundant Inertial Navigation Unit (RINU), derived from off-the-shelf existing flight articles

1.2.2.8 Ground Command and Control Systems

Kennedy Space Center is capable of developing systems required for ground command and control. Command and control teams designed integrated computer systems, networks, displays, and hardware and software simulation systems utilized to control and monitor flight vehicle systems and the ground support equipment (GSE).

Inside Kennedy Space Center's Launch Control Center Firing Room 1(Young-Crippen Firing Room), mission engineers monitor ground command control systems in a countdown simulation for the Ares I-X flight test.

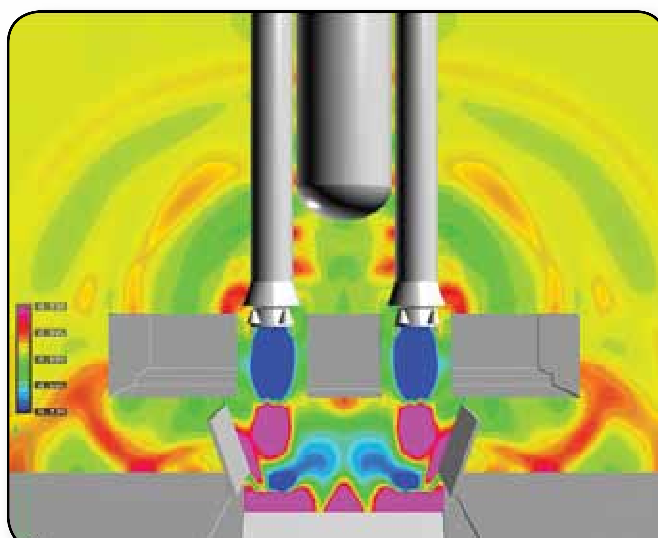
KSC engineering performs design and fabrication and testing of ground command and control in the following five major areas: (1) system hardware architecture design, user environment design and installation, lab and development set design and activation, control system platforms, front end and gateway services, and platform operating systems; (2) system software services for command and control, networks, application software, displays, information architecture, database services, system monitoring and control, compilers, debuggers, diagnostics, and utilities; (3) application and simulation software for command and control, advisory applications, displays, simulation services and math models; (4) operations and testing associated with control room set operations, configuration management, system administration, test, validation and release processing; (5) IT security, oversight of IT security plans, documentation, policies and procedures.

Accomplishments:

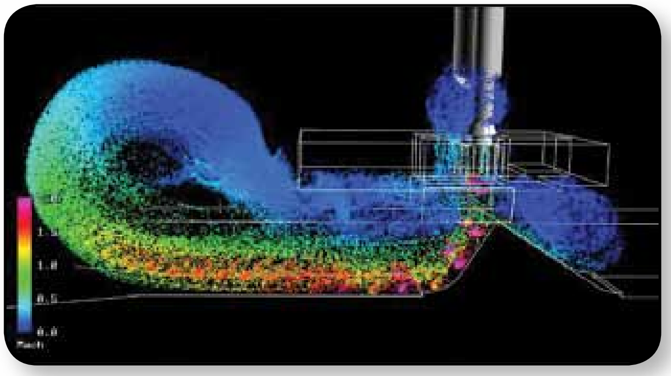
- Developed Constellation Program Ares I-X ground controls system (GCS), used to successfully launch Ares I-X, and controlled about 3,000 end items in three facilities
- Developed command and control simulations models for Space Shuttle Program Integrated Network Control System (INCS), and controlled about 30,000 end items in seven facilities
- Developed Command, Monitoring and Data System (CMDS) used to control, monitor, alarm, analyze and experiment command and control data
- Developed Emergency Safing System, which is the backup control system independent of mainline controls system, used on Ares I-X and space shuttle
- Developed automated regression testing tool for application software executed on modern launch control systems
- Developed IT security for the launch control system, Constellation ground systems and engineering labs

1.2.2.9 Ground Support Equipment Design for Launch-Induced Environments

Kennedy Space Center is capable of designing ground support equipment (GSE) to accommodate launch-induced environments. KSC performs analysis of dynamics and kinematics, structures, thermal systems, fluid systems, shock and vibration response, debris and water impact and radio frequency and electromagnetic interferences (RF and EMI) analysis.



KSC engineering analysts create a simulation of the space shuttle solid rocket boosters and pad structure that is designed to withstand the launch-induced environment.



Kennedy Space Center creates a simulation of the unsteady flow field in the flame trench to analyze particle traces (colored by mach number).

Accomplishments:

- Provided water suppressions system modeling for space shuttle, X-33, and Ares I vehicles
- Provided flame duct testing for Delta IV
- Provided Taurus II plume environments and protection analysis to Orbital Sciences Corp.
- Produced launch-induced environment documents for the Space Shuttle and Constellation programs
- Performed and provided highly accurate predictions of Ares I-X ground acoustics
- Produced more than 30 technical publications
- Provided Taurus II Transporter/Erector/Launcher (TEL) plume analyses and protection to Orbital Sciences Corp.
- Developed launch-induced environment documents for Space Shuttle and Constellation programs

1.2.2.10 Ground Systems Logistics Support Planning and Analysis

Kennedy Space Center has the capability to plan for logistics operations and to perform logistics support analyses (LSAs) for ground systems. This includes authoring integrated logistics support plans and developing logistics operational concepts, budget estimates and documentation for the logistics services required to sustain ground systems and to perform ground operations tasks. The ground systems logistics support analysis team at KSC evaluates new designs or legacy systems, operational concepts, and maintenance plans to identify system supportability requirements, the resources needed for sustained support, the procedures for accomplishing system support tasks, and the appropriate level at which individual support tasks should be accomplished. Source data developed for LSAs is used to plan a comprehensive logistics support infrastructure. Logistics support provided at KSC includes influencing designs for supportability, disposition of assets, facilities analysis, inventory and associated data and material management, laboratory support services, maintenance and repair planning, personnel assessments, supply support, support equipment and special test equipment, training, warehousing, and packaging, handling, storage and transportation.

Accomplishments:

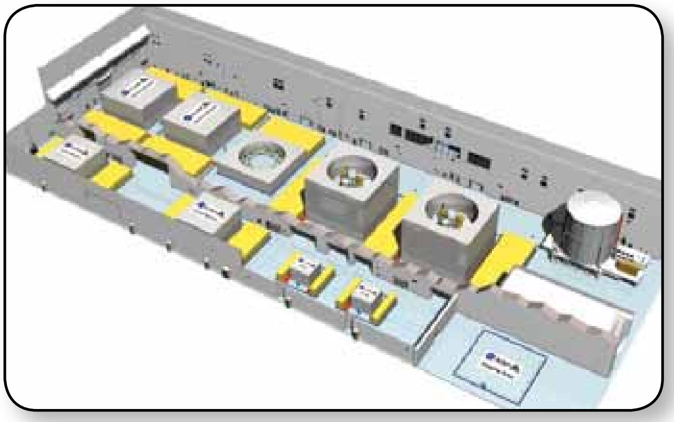
- Performed logistics analyses on 80 subsystems in the Constellation Program Ground Operations Project (GOP)
- Developed maintenance task outlines (MTOs) to aid in the work package development process of future ground operations contractors
- Identified potential costs savings by performing a standardization and commonality comparison among GOP subsystems
- Developed recommended spare parts lists (RSPLs) for both development and operational GOP subsystems

1.2.2.11 Lunar Systems and Ground Processing Design

Kennedy Space Center has the capability to provide trade study teams to organize and execute end-to-end architectural trade studies for the entire flow of a spacecraft and payload, including assembly, test and verification, launch vehicle integration and launch processing.

The team identifies key stakeholders from spacecraft project offices and KSC directorates to perform

Shown is a conceptualization of a design option of an Altair spacecraft processing in Kennedy Space Center's Orbiter Processing Facility



Shown is a conceptualization of a design option of Altair spacecraft processing in Kennedy Space Center's Space Station Processing Facility

analyses, including but not limited to, development, transportation, ground support equipment and facility usage. Based on these analyses, the trade study team develops a concept of operations, schedule of the activities for each part of the concept of operations, discrete event simulation for probabilistic timeline development, computer-aided design (CAD) payload production line concepts, and a comparison of the processing architecture options on a range of facilities.

Accomplishments:

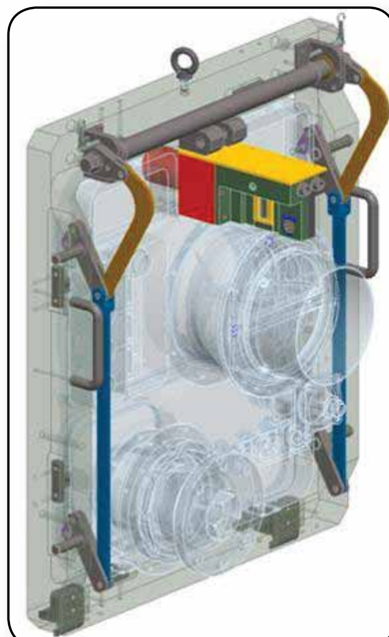
- Developed and optimized Constellation lunar spacecraft assembly, integration, testing, ground processing and operations architecture
- Organized trade studies for entire processing flow of Altair spacecraft and payload
- Evaluated potential processing of commercial launch services and payloads

1.2.2.12 Umbilical System Design and Development

One of Kennedy Space Center's core capabilities is umbilical system development. KSC is capable of complete umbilical system development, including design and testing of ground and flight side components for automated and technician-assisted umbilical mating for NASA and commercial space systems. KSC has extensive experience with developing active, retractable and passive rise-off- style umbilical systems, and ultra-reliable mechanical, electrical or fluid and pneumatic Time Zero (T-0) disconnect systems. KSC is capable of integrating design and testing ground and flight side umbilical connectors by performing full-scale umbilical and ground support equipment (GSE) vehicle motion and liftoff simulation.

Accomplishments:

- Designed flight and ground umbilical plates for the X-33 in a cooperative effort between Lockheed Martin, NASA and United Space Alliance
- Developed Delta IV Environmental Control System (ECS)
- Developed flight and ground umbilical plates for Ares I upper stage
- Supported development of Atlas V autocoupler
- Developed ground-to-mobile-launcher connections with Lockheed Martin and United Space Alliance
- Developed rise-off (Bottom Mount) space shuttle solid rocket booster joint heater
- Developed space shuttle tail service masts (TSM), Redstone Rocket long masts, Apollo tilt-up tail service masts and forward umbilicals



A computer-aided design (CAD) rendering of an integrated upper stage umbilical plate was created by Kennedy Space Center engineers.

This drawing created at Kennedy Space Center depicts a typical tilt-up umbilical arm system on a launch vehicle tower.

Chapter 1.2.3
Launch Vehicle Flight Analysis

Kennedy Space Center has technical expertise to provide launch vehicle flight analysis including controls, flight design, software, electromagnetic environments, fluids, stresses, and dynamic loads.

Chapter 1.2.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.3 Launch Vehicle Flight Analysis

1.2.3.1 Flight Controls

Kennedy Space Center has the capability to provide flight controls analysis of launch vehicles and spacecraft. Flight controls focuses on Six Degree of Freedom (6DOF) flight mechanics and body dynamics analysis, autopilot design and analysis, dispersion analysis, and guidance, navigation and control for launch vehicles and spacecraft. The flight controls team provides review and approval, independent verification and validation, requirements definition and postflight assessment for active missions, as well as separation analyses and guided trajectory simulation for active and advance missions.

The team provides detailed launch vehicle and spacecraft linear and non-linear guided trajectory simulation capabilities under both nominal and dispersed conditions. The high-fidelity vehicle systems inputs to these simulations include propulsion, autopilot, mass properties, actuators and flexible body dynamics. The team uses contractor-provided software tools as well as the in-house developed Universal Controls Analysis Tool (UCAT) and Linear Controls Analysis Tool (LINCAT) tools.

The flight controls team performs detailed analysis of spacecraft and launch vehicle separation events, as well as the dynamics of spinning bodies in space. The team is also instrumental in providing insight into crucial elements of day-of-launch support activities, including go or no-go placards for vehicle controllability during the early portion of flight before climbing out of Earth's atmosphere. Flight Controls supports launch vehicle certification activities by performing flight margin verification and independent analysis.

Accomplishments:

- Provided day-of-launch support for all Launch Services Program (LSP) managed missions
- Developed UCAT and LINCAT closed loop trajectory simulation software tools, as well as subsequent detailed models for Atlas V, Delta II, Falcon 9 and Taurus II vehicles
- Developed in-house tools to support detailed separation dynamics analysis for all launch vehicles in the NASA Launch Services Program fleet
- Developed and managed a spin-dynamics testing facility currently operated by Southwest Research Institute in San Antonio, Texas.
- Maintains an ongoing relationship with several educational institutions to facilitate numerous research projects, including propellant slosh characterization and high-fidelity controls system modeling
- Provided technical feedback leading to numerous improvements in launch vehicle capabilities (for example, the ability to support finite launch windows on inertially-targeted missions for Taurus XL)

1.2.3.2 Flight Design

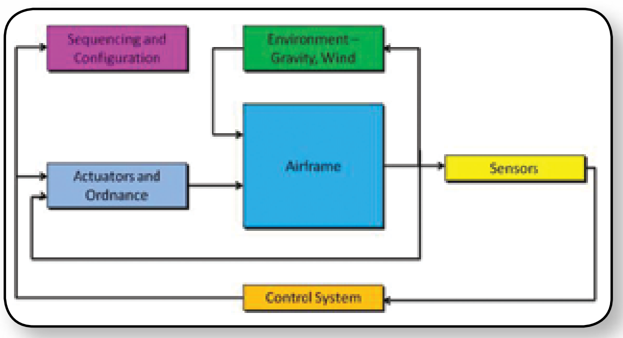
Kennedy Space Center has the capability to provide flight design analysis of launch vehicles and spacecraft. Flight design focuses on the design and optimization of launch vehicle trajectories to meet mission requirements within the constraints imposed by the launch vehicle. The flight design team's responsibilities encompass the entire mission life cycle, from preliminary trade studies as early as 10 years before launch, through launch vehicle selection and procurement, to postlaunch activities.

The team provides review and approval, independent verification and validation, requirements definition, postflight assessment, and mission success determination for active missions, and is ultimately responsible for ensuring that all spacecraft requirements are accurately defined and met. The team also provides analytical support for advance missions, and is capable of providing everything from launch vehicle performance estimates to detailed trajectory analysis results for spacecraft customers before a launch service is selected.

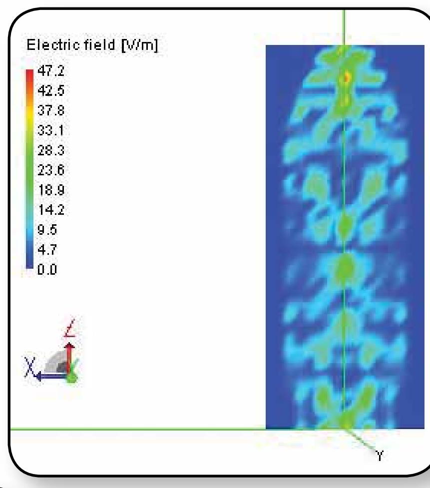
Flight design supports launch vehicle certification activities by performing flight margin verification and independent analysis for trajectory design and vehicle performance. The flight design team's capabilities also include in-orbit mission design, long-term orbit propagation and interplanetary mission design. These skills are frequently employed to provide independent assessment of spacecraft mission design and requirements definition. The team possesses a wide range of analytical skills, and employs a number of off-the-shelf and custom-developed software tools, including Optimal Trajectories by Implicit Simulation (OTIS), Program to Optimize Simulated Trajectories (POST), FreeFlyer®, and Aerospace Trajectory Optimization Software (ASTOS).

Accomplishments:

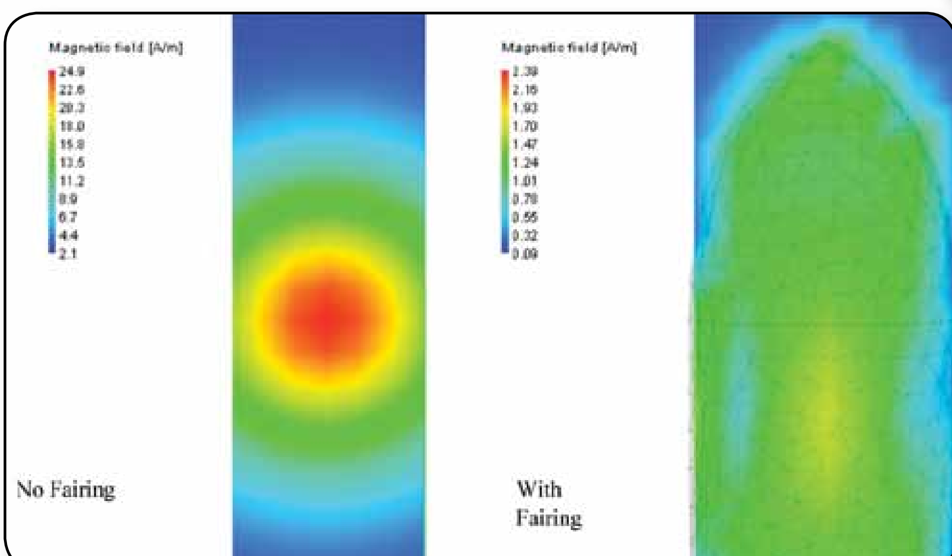
- Provided day-of-launch support for all Launch Services Program (LSP) managed missions
- Developed detailed Three Degree of Freedom (3DOF) trajectory simulations for Atlas V, Delta IV, Pegasus, Taurus, and Falcon 1 and 9 vehicles using OTIS and POST trajectory optimization software packages
- Developed and maintained the expendable launch vehicle (ELV) performance Web site used by spacecraft organizations across NASA and throughout the world to evaluate generic launch vehicle performance
- Performed detailed modeling of spacecraft mission elements for numerous missions, including Lunar Reconnaissance Orbiter/Lunar CRater Observation and Sensing Satellite (LRO/LCROSS), Image Reversal in Space (IRIS), and Mars Reconnaissance Orbiter (MRO)
- Developed software for identification of ground assets for launch vehicle telemetry coverage
- Provided advisory support for international partnership missions, including the James Webb Space Telescope, and Gravity Recovery and Climate Experiment (GRACE)



A simplified model of the in-house Universal Controls Analysis Tool (UCAT) developed in Matlab's Simulink. The Flight Controls team has UCAT models developed or in development for the following launch vehicles: Atlas V, Delta II, Taurus XL, Falcon 9, and Taurus II.



A Multilevel Fast Multipole Method (MLFMM) Electromagnetic analysis is performed inside the fairing of a launch vehicle to determine the field distribution.

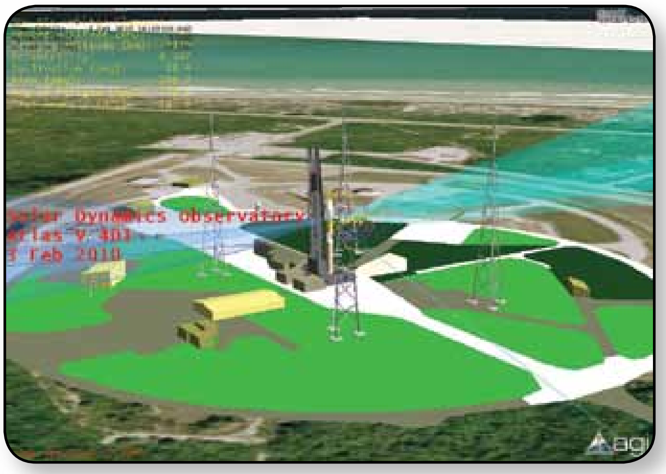


A Method of Moments (MoM) Magnetic Field Shielding analysis is performed on a composite vehicle fairing by evaluating fields at the spacecraft location with and without the launch vehicle fairing in place.

- Supported agencywide and governmentwide policy development for launch collision avoidance and orbital debris mitigation

Website

NASA Launch Services Program: Launch Vehicle Performance website http://elvperf.ksc.nasa.gov/elvMap

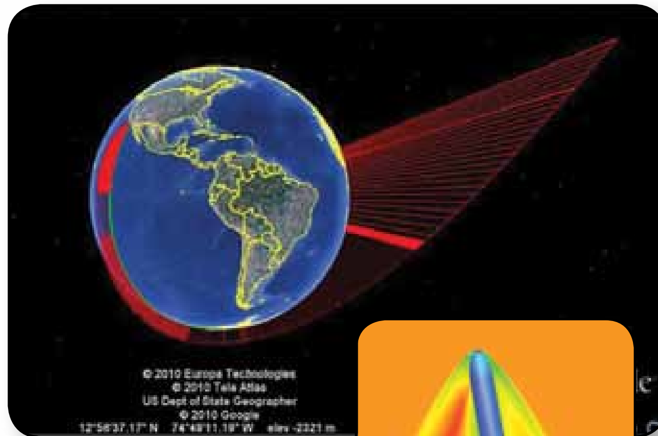


A radio frequency (RF) link analysis is performed for the Solar Dynamics Observatory (SDO) mission on an Atlas V at Launch Complex 41 of the Cape Canaveral Air Force Station using Satellite Tool Kit (STK).

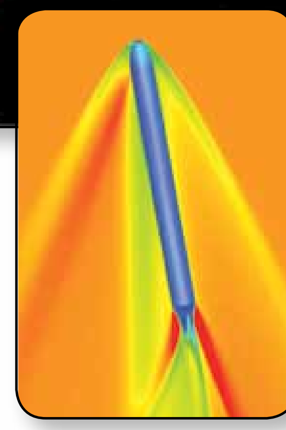
1.2.3.3 Flight Software Analysis

Kennedy Space Center has the capability to provide flight software analysis of launch vehicles and spacecraft. The flight software team bridges the gap between the more abstract mission requirements definitions process and the implementation of requirements on actual flight hardware. Flight software focuses on evaluation of flight software structure and algorithms, validation and testing of software design, evaluating the implementation of software changes, and understanding the interaction between flight software and vehicle systems.

The flight software team supports active missions by monitoring all flight software changes, mission constants development and validation, and flight software testing, and is instrumental in performing insight and oversight activities with respect to changes in vehicle avionics hardware or architecture. Flight software provides critical support to the Launch Services Program's (LSP) launch vehicle certification by performing a qualification evaluation of vehicle software, coding practices and configuration management approach. The team is required to maintain detailed knowledge of government and industry coding standards and a range of programming languages.



The launch trajectory of the Landsat Data Continuity Mission (LDCM) spacecraft on an Atlas V launch vehicle from Vandenberg Air Force Base. LDCM is going to a sun-synchronous orbit.



Mach contours and surface pressure coefficients for a blunted ogive-topped cylinder, Mach Number=2.5, Angle of Attack=10 degrees.

Accomplishments:

- Provided day-of-launch support for all LSP managed missions
- Supported all flight software testing activities for every LSP NASA mission
- Provided detailed insight into mission constants development for all vehicles in the NASA Launch Services fleet
- Performed detailed verification of every mission constant against source requirements for Delta II launch vehicles
- Successfully completed flight software qualification reviews to support Atlas V and Taurus XL launch vehicle certification activities
- Provided detailed insight into all launch vehicle upgrades with software implications (for example, Atlas V Block 2 avionics system upgrade)

1.2.3.4 Launch Vehicle Electromagnetic Environments

Kennedy Space Center has the capability to define the electromagnetic effects environments; perform applicable analysis to evaluate these environments; and promote compatibility between spacecraft, vehicle and range. These environments include the radiated environment produced by range and non-range transmitters, nearby lightning strikes, cable coupling and static charging. The electromagnetic environments team defines, implements and evaluates control techniques to prevent electromagnetic interference through radiated or conducted means. The techniques include shielding, grounding, bonding, filtering, component layout and wire routing.

Computational analysis tools are used by the team to evaluate fields within the payload fairing using techniques such as Method of Moments, Physical Optics, and Transmission Line Matrix. This discipline also includes the evaluation and analysis of adequate radio frequency (RF) link between launch vehicle and ground or space communications devices.

Accomplishments:

- Provided electromagnetic interference/electromagnetic compatibility (EMI/EMC) support for all Launch Services Program (LSP)-managed missions

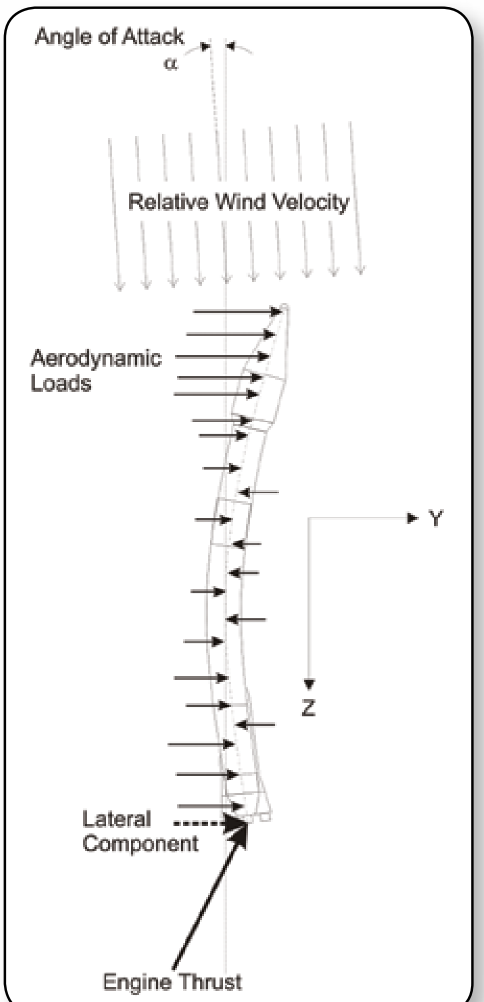
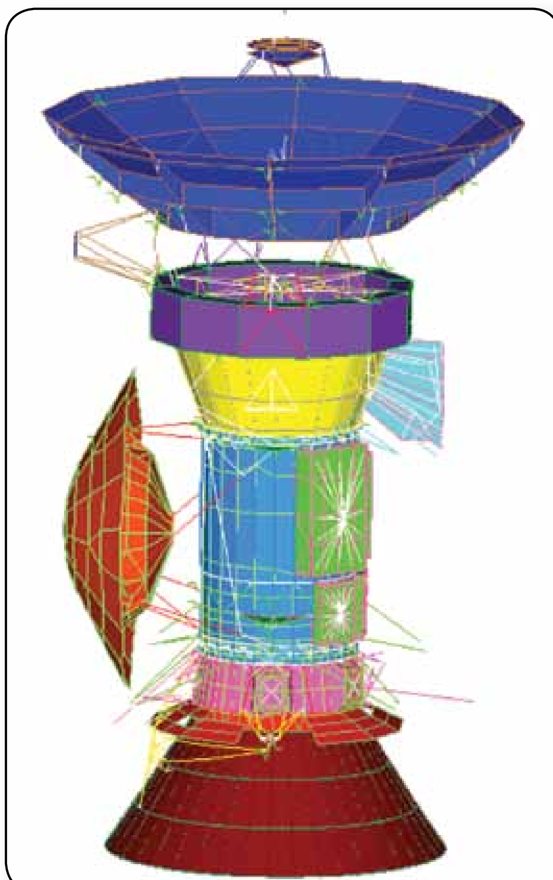


Illustration of lateral aeronautics and engine-trimming forces on a rocket flying with an angle of attack through steady wind.

- Performed EMC electro-explosive device (EED) analysis using field-to-cable coupling analysis to support launch vehicle design changes necessitated by NASA monitoring requirements
- Performed independent analyses to support vehicle certification
  - Cable coupling
  - Vehicle skin and fairing shielding effectiveness
- Modeled a generic composite fairing in time and frequency domains using electromagnetic analysis software to evaluate the effects of indirect lightning strikes
- Performed lightning damage analysis for NASA's Solar Dynamics Observatory mission which alleviated the need for lightning suppression circuitry
- Identified and analyzed cavity effects on the signal-to-noise ratio of spacecraft receiver
- Developed RF link analysis capability with a Satellite Tool Kit (STK) for mission support



The Cassini spacecraft finite element model is used in coupled loads analysis.

1.2.3.5 Launch Vehicle Fluids and Aerodynamics Analysis

Kennedy Space Center has the capability to provide fluids and aerodynamics analysis for launch vehicles and spacecraft. The fluids and aerodynamics team performs in-house verification of the launch vehicle provider's venting analysis, up to and including a complete and independent verification of the entire launch vehicle and spacecraft model. The team also has the capability to model internal flow associated with the payload fairing environmental conditioning system to examine flow impingement requirements particular to a spacecraft. Furthermore, the fluid flow characteristics and performance of the various launch vehicles' high- and low-pressure gas systems can be modeled using in-house codes.

The Cryogenic Orbital Testbed (CRYOTE) is studied on board a reduced gravity aircraft. The thermal group partnered with universities and industry in developing CRYOTE.

In the area of external aerodynamics, several industry and NASA standard codes, as well as classical methods, are available to perform analysis of vehicle pressures, protuberance loads, distributed loads and stability coefficients. The team supports fluids research appropriate to the launch vehicle industry through the funding of special projects.

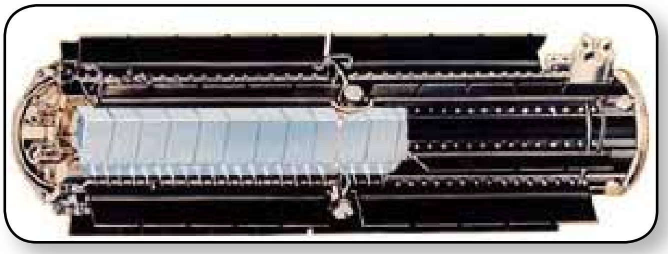
The CRYOTE tests demonstrate the feasibility of a liquid-sensing device designed for operation in microgravity environments.

Accomplishments:

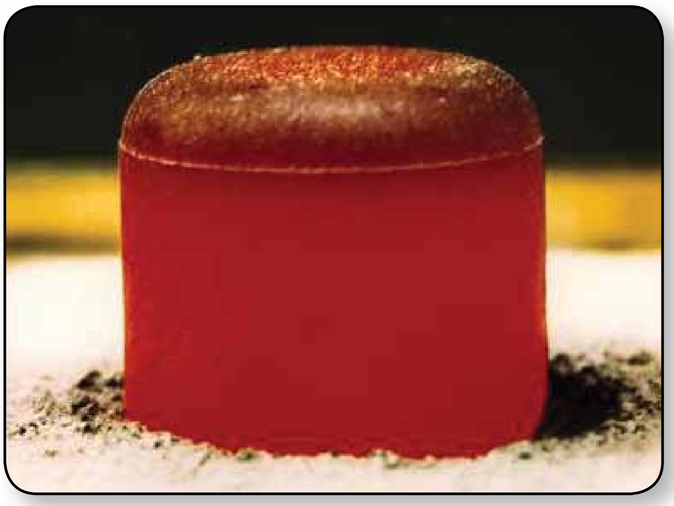
- Provided fluids and aerodynamics support for all Launch Services Program (LSP)-managed missions
- Performed aerodynamics and fluids analysis using in-house tools
  - Internal Pressure Predictions During Launch Vehicle Ascent (CHCHVENT and GFSSP)
  - External Launch Vehicle Environment Predictions (USM3D, OVERFLOW, Fluent™)
- Performed postflight performance verification on all NASA and non-NASA missions with available data launched on NASA Launch Services fleet vehicles by:
  - Independently reviewing the postflight data
  - Reconstructing Mach number and dynamic pressure histories
  - Verifying vehicle venting performance (delta pressures and venting rates)

1.2.3.6 Launch Vehicle Stress Analysis

Kennedy Space Center has the capability to assess the structural capabilities and margins of launch vehicle components. The flight structures stress team performs the assessments by using classic hand-analysis techniques and structural analysis codes. The team evaluates structural designs and determines margins for common failure modes such as buckling, crippling, fatigue and fracture, and overstress conditions. The stress team uses simulations to determine structural hardware stresses, and deflections by using finite element software. The team also determines fracture life of metallic components using industry standard methods and NASGRO® (fracture mechanics and fatigue-crack growth analysis software).



An illustrated view of a General Purpose Heat Source Radioisotope Thermoelectric Generator.



The radioactive element plutonium is used to fuel some nuclear spacecraft.

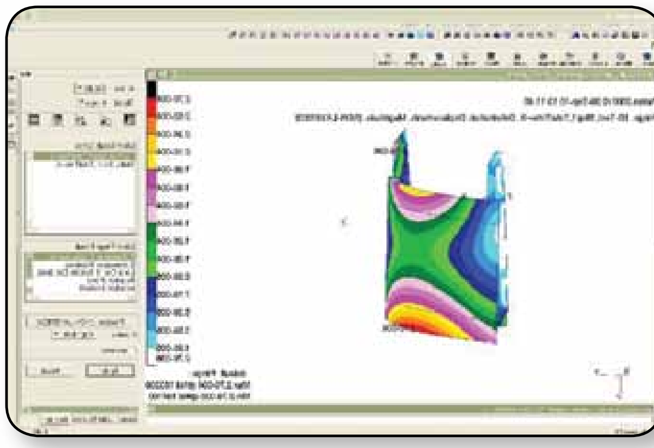
Accomplishments:

- Provided stress support for all Launch Services Program (LSP)-managed missions
- Performed structural and fatigue analysis to resolve non-conformances and test anomalies on pressurized components for multiple expendable launch vehicles (ELV) and missions
- Analyzed mission-specific loads to validate structural margins of safety
- Supported multiple design reviews for mission-unique and first-flight items of ELVs
- Performed structural reviews and provided inputs for ELV certifications
- Built independent finite element models of structural components to verify launch vehicle provider's structural analytical results
- Attended hardware reviews of ELV structural components to assess quality and flight worthiness of as-built hardware

1.2.3.7 Launch Vehicle Structural Dynamic Loads and Environments

Kennedy Space Center has the capability to analyze the forces and accelerations experienced by the spacecraft and the launch vehicle during the launch into space.

The dynamic loads team primarily uses analysis and focuses on frequencies up to about 50 hertz. The



Pre- and post-processing of finite element models (FEM) of vehicle hardware using PATRAN software.

The set-up screen for analysis of fracture mechanics using NASGRO® software.

loads team uses test-verified mathematical models of spacecraft and launch vehicles to run computer simulations (called "coupled loads analysis") of major loading events from liftoff through spacecraft separation. This includes time and frequency domain dynamic analyses for transient, random and sinusoidal excitations. From these analyses, the team calculates conservative forces, accelerations, displacements, stresses, and other measurements for the spacecraft and the launch vehicle. Currently, the team runs coupled loads analyses for Atlas V, Delta II, Taurus XL and Pegasus missions.

The dynamic environments team primarily uses test and flight data and focuses on frequencies from 50 to 10,000 hertz. The environments of concern are acoustics, random vibration, sine vibration and shock. Though hardware qualification to these environments is usually proven through tests, the team also uses analyses such as statistical energy analysis for acoustics predictions.

The dynamic loads and environments teams have significant experience in test and flight data processing, including performing data quality checks and calculating power spectral densities, shock response spectra, sound pressure levels and transfer functions.

Accomplishments:

- Provided loads and dynamic environments support for all Launch Services Program (LSP)-managed missions
- Implemented coupled loads analysis for Atlas II, Atlas V, Delta II, Taurus XL and Pegasus launch vehicles
- Performed pyro-shock data detrending and shock response spectrum analysis
- Supported spacecraft environmental testing, including acoustic, random, sine and model testing
- Ran mission specific acoustic analyses to assess the effect of removing or adding blankets
- Performed flight data analysis of accelerometers, microphones and pressure gages to verify flight-margin and investigate anomalies

1.2.3.8
Launch Vehicle Thermal Analysis

Kennedy Space Center has the capability to understand and manipulate the flow of heat energy throughout a mechanical assembly on launch vehicles and spacecraft. The thermal team performs analyses that range from simple hand calculations to highly complex computer simulations to quantify the amount of heat entering the system from external sources (e.g., the sun) and internal sources (typically electrical waste heat) and the amount of heat leaving the system via conduction, convection and radiation.

This distribution of heat through a system is tracked via temperature responses of components within the system, which is then used to assess material behavior and adequacy in the expected thermal environment. The thermal team then applies these assessments to optimize designs, set test environments to prove the design, and make recommendations on how the final-tested design should be used.

Accomplishments:

- Provided thermal support for all Launch Services Program (LSP)-managed missions
- LSP mission highlights in thermal analysis:
  - Mars Exploration Rovers A and B (MER-A and –B): responsive technical advice on damage to vehicle thermal protection in order to maintain the tight interplanetary launch window
  - Lunar Reconnaissance Orbiter/Lunar CRater Observation and Sensing Satellite (LRO/LCROSS): the LSP thermal team provided extensive analysis and design input to utilizing the Centaur stage as a lunar impactor
  - Mars Science Laboratory (MSL): established coupled thermal and fluids simulations of the on-pad environmental control system to assess spacecraft thermal responses under a failed ECS scenario (spacecraft uses a radioactive thermal generator for power)
  - Orbiting Carbon Observatory (OCO): the thermal team received commendation for support to the failure investigation teams
  - Wide-field Infrared Survey Explorer (WISE): the thermal team was recognized by the spacecraft project for proactive analytical support
- Supports and assists the development of several expanded thermal capabilities in collaboration with commercial launch vehicle providers

1.2.3.9
Nuclear Launch Approval

Kennedy Space Center has the capability to obtain regulatory approval and analyze public safety for all NASA Launch Services Program (LSP)-managed missions involving nuclear power sources. The Nuclear

Launch Approval team performs in-depth probabilistic risk assessments on launch vehicles and spacecraft to determine the driving risks to the nuclear power source for a given mission in the event of a launch mishap. When appropriate, the team will commission and manage the design and implementation of launch vehicle modifications to mitigate any high-impact risks found during this process. Throughout the launch campaign, this team also works closely with the Interagency Nuclear Safety Review Panel, Jet Propulsion Laboratory (JPL), NASA Headquarters and many other external organizations to obtain regulatory approval for these launches.

Accomplishments:

- Provided support for LSP-managed missions with nuclear payloads
- Developed a methodology for performing probabilistic risk assessments on launch vehicles that has become the gold standard for the aerospace industry
- Designed and implemented numerous launch vehicle modifications for expendable launch vehicle (ELV) missions, including more effective Flight Termination Systems for the stages of the launch vehicles.
- Successfully obtained presidential approval for all nuclear-powered robotic missions
- Collaborated with the U.S. Department of Energy, Department of Defense and several other agencies and national laboratories to reduce risks on NASA missions enabled by nuclear power sources.

Chapter 1.2.4
Modeling and Simulation

Kennedy Space Center has the capability to provide modeling and simulations in off-line laboratory environments for launch vehicle systems, ground support equipment and facilities.

Chapter 1.2.4 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.4 Modeling and Simulation

1.2.4.1 Design Visualization

KSC utilizes design visualizations to model operations and systems design interaction in a "virtual reality environment" using actual system designs. Design visualizations provide the ability to influence the design process to make systems more operable and interoperable.

KSC performed modeling and simulation of an Ares I rollout from the Vehicle Assembly Building to the launch pad.

Accomplishments:

- Supported multiple "what-if" scenarios to help Constellation designers develop systems based on the most efficient processing methods
- Conducted modeling and simulation to support validation and verification of Constellation facilities, ground support equipment (GSE) and flight hardware design concepts
- Utilized 3-D laser scanning techniques to verify the accuracy of models and simulation environments
- Conducted launch and processing studies to identify required GSE and launch requirements in support of human factors, space requirements and floor process flows
- Demonstrated functionality of concepts before potentially unnecessary analysis costs were incurred

Modeling and simulation of the Orion spacecraft was created to identify potential pitfalls and opportunities for processing improvements.

Modeling and simulation of the Orion spacecraft was created to identify potential pitfalls and opportunities for processing improvements.

1.2.4.2 Discrete Event Simulation Analysis

KSC utilizes Discreet Event Simulation (DES) analysis to develop a conceptual framework that represents the operation of a system, perform sensitivity analyses, and draw conclusions to inform the decision-makers throughout the system's life cycle.

Accomplishments:

- Provided requirements compliance analysis to support Constellation Ground Operations Project Preliminary Design Review (PDR)
- Performed a flight rate and launch spacing analysis to determine Constellation Program Ground Operations Project (GOP) architecture
- Performed an analysis to determine the 90-minute launch separation feasibility between Ares I and Ares V
- Performed an analysis to determine the most efficient high bay configuration for Constellation Ground Operations

1.2.4.3 Life Cycle Modeling and Simulation

Kennedy Space Center is capable of life cycle modeling and simulation of many projects in the areas of discrete event simulation, design visualization and distributed integrated simulations. This capability provides project managers with information in the design phase of a project which allows changes that can save time and money by exploring contingencies that could mitigate risks at simulated critical junctures in the operational life of a system.

IT specialists at KSC perform modeling and simulation to provide a level of confidence that no problems exist with fit, clearances and operability. Modeling and simulation is frequently utilized before systems are installed in their final location. Simulation also helps ensure that single or multiple event processes are as efficient as possible during the creation of a program's concept of operations. This includes planning for consumable replacement, upgrades to hardware or normal operational activities. Modeling and simulation services routinely performed at KSC include supply chain management, process flow modeling, operations development, integration verification, troubleshooting and reverse engineering.

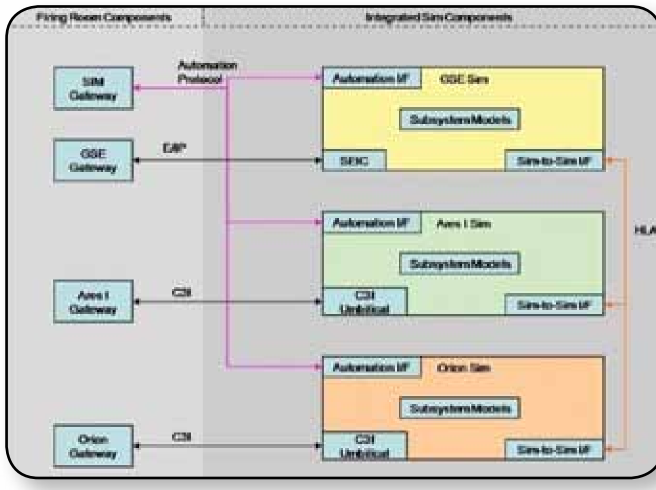
Accomplishments:

- Developed models and simulations to demonstrate process flows in the KSC Operations and Checkout Building for Orion final assembly processes
- Developed models and simulations to improve work flow efficiencies within the KSC Vehicle Assembly Building

1.2.4.4 Rapid Development of Command and Control Simulation Models

Kennedy Space Center has the capability and unique expertise to perform rapid development of command and control simulation models based on engineering drawings and integration with launch vehicle designs and simulations.

KSC developed a unique modeling technique to rapidly implement real-time simulations of electrical, fluid, gas and mechanical systems for the purpose of testing control systems and training operators to use them.



An integrated simulation test of a new firing room with Ares I, Orion and ground support equipment (GSE) simulation models.

This technique utilizes Simulink® (The MathWorks, Inc.®) to create functional model components, as reusable libraries, that correspond to the design drawings of the system components. These models are assembled into the complete system model using the engineering drawings to define relationships among the components. After the model is assembled and functional in Simulink®, a C++ programming language implementation of the model is generated using Real-Time Workshop Embedded Coder® (The MathWorks, Inc.®), and it is compiled into a library real-time for execution and testing. KSC also is able to exchange data with external simulations. This interface enables parallel, synchronized execution of independently developed simulations.

Accomplishments:

- Uncovered and resolved numerous problems with launch countdowns related to the Space Shuttle Program
- Developed reusable, shareable models for numerous ground systems
- Developed Real-time Simulated Interface (RSI) which provides all hardware and software required to support model execution, external Launch Processing System interfaces and user interfaces
- Developed a distributed simulation system which allows engineers desktop access to modeling information from locations across the country

Chapter 1.2.5
Software Development and Test Processes

Kennedy Space Center has expertise in open or closed loop software control of end items meeting human rating requirements, and software development processes for compliance with NASA and industry standards.

Chapter 1.2.5 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.5 Software Development and Test Processes

1.2.5.1 Advisory Systems

Kennedy Space Center can provide the capability to design, develop, test and validate advisory systems and tools to assist vehicle testing, checkout and launch. In addition, KSC has a system called the ground launch sequencer that can control launch vehicle operations during launch countdown to facilitate the final critical operations and test prior to launch as well as perform critical safing if conditions warrant immediate action. KSC personnel have extensive experience developing and using these types of systems and have learned many technical capabilities associated with advisory systems.

1.2.5.2 Offline Ground and Flight Software Integration Testing

Kennedy Space Center is capable of completing flight software integrated testing. To achieve this, integrated test requirements and success parameters are defined, then test cases for simulation are created, and tests are executed in an offline lab environment. KSC has the capability to perform virtual end-to-end tests without utilizing flight hardware. These tests are used to verify that end-item responses and integrated system reactions happen as they were designed.

Accomplishments:

- Verified ground and flight software interfaces for 34 software-version updates at the Shuttle Avionics Integration Lab

Chapter 1.2.6
Sustaining Engineering of Ground and Flight Systems

Kennedy Space Center has the capability to provide multi-disciplinary engineering services for post-initial system development, including modification of form, fit or function of existing ground and flight systems for upgrades, anomaly resolution and re-certifications.

Chapter 1.2.6 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.2.6 Sustaining Engineering of Ground and Flight Systems

1.2.6.1 Change Management

Kennedy Space Center has the capability to provide change management.

This includes assessing and approving all ground, flight hardware and vehicle modifications. The team performs closed-loop accounting of modification by tracking the completion of each modification through paper inception and vehicle work completion. They also synchronize with system engineers during all phases to assure agency visibility and compliance with agency and industry requirements. The change management focal person coordinates and consolidates all inputs from affected organizations and provides input to program or project management.

The team coordinates input, impacts and actions from the program with the supported organization to ensure the implementation and completion of actions in accordance with the documented processes and requirements.

For launch vehicle change management, the team maintains a published document reflecting the future upgrades to the launch vehicle. This document shows the current manifest as well as the flight effectivity of the performance of the modification. This document is reviewed by the flow managers for approval.

For International Space Station or payloads change management, the team develops an As-Built Configuration List for each flight of the hardware that verifies the configuration of installed hardware including part number and serial number for all flights. They also coordinate and consolidate the test and verification requirements for all hardware.

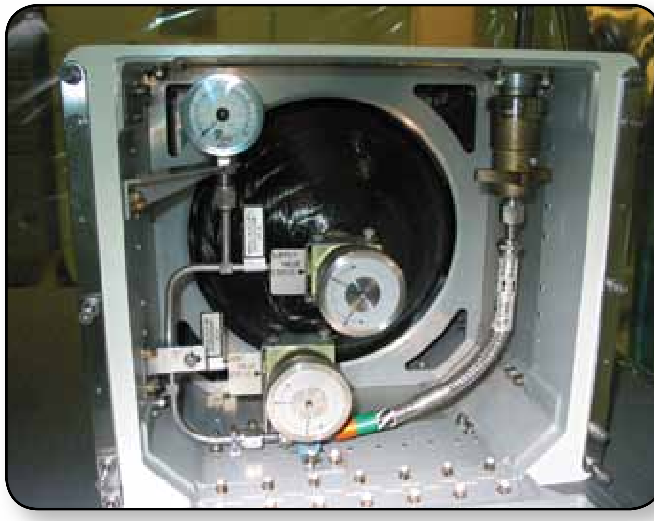
The team provides the overall management of the Control Board processes. The authority of each Control Board is defined by a Kennedy NASA Procedural Requirement (KNPR). The team integrates and coordinates personnel efforts to ensure products brought forward are technically accurate, complete, and meet program and review board requirements. The team also scopes the integration and coordination for engineering, operations, logistics and mission assurance. The team performs secretariat functions and associated coordination, and participates on the control board(s) as the configuration management representative.

1.2.6.2 Pressure Vessel and System Recertification

Kennedy Space Center is capable of providing pressure system and pressure vessel recertification. Engineering teams at KSC perform analysis of designs and drawings, and utilize independent reviews to ensure the design, fabrication, repair, alteration, integrity, safety and fitness for service of pressure vessels and pressure systems. These analyses enable in-service inspection and recertification efforts required for pressure systems based on historical data and industry guidelines. Types of pressure systems monitored range from fixed systems of routine metallic construction to that of composite fiber reinforced vessels. Examples of some vessels include Graphite/Epoxy (Gr/Ep) or Kevlar/Epoxy Composite Overwrapped Pressure Vessels (COPVs). Teams ensure compliance with federal regulations and national consensus codes and standards (NCS), including American Society of

This cryogenic valve is part of an overall pressure system, one of many that KSC certifies.

Mechanical Engineers - Section VII, Division 1/2, ASME 31.3, ASME PCC-2 (repair of pressure equipment and piping), American Petroleum Institute (510/570/571), and Department of Transportation (DOT) 49 Code of Federal Regulations Compliance for portable pressure systems. This engineering service also covers recommended in-service inspection and recertification efforts required for pressure systems based on historical data and industry guidelines.



A composite over-wrap pressure vessel (COPV) is being prepared for loading.

Accomplishments:

- Successful in-service inspection programs to maintain system life at safe operating conditions for more than 50 years
- Thousands of pressure systems and vessels recertified on a periodic basis, many with required modifications to restore or enhance systems to meet intents of latest code standards

Section 1.3
Materials and Processes Services

Kennedy Space Center can provide materials and processes services associated with materials selection, corrosion control, nondestructive evaluation, manufacturing, fabrication, machining, testing and contamination control. Section 1.3 provides details on the materials and processes services that KSC has to offer.

Section 1.3 of the Kennedy Resource Encyclopedia includes the following chapters:

Chapter 1.3.1
Manufacture, Fabrication and Machining

Kennedy Space Center has the ability to provide manufacturing, fabrication and machining of many products and materials including processes for fluids, pneumatics, sheet metal and thermal protection systems.

Chapter 1.3.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.3.1.1 Fabrication and Rapid Prototyping

1.3.1.2 Machining

1.3.1.3 Mechanical and Fluids

1.3.1.4 Pneumatics Fabrication

1.3.1.5 Sheet Metal Fabrication

1.3.1.6 Thermal Protections System Manufacture and Repair

1.3.1.7 Welding

1.3.1 Manufacturing, Fabrication and Machining

1.3.1.1 Fabrication and Rapid Prototyping

Kennedy Space Center has the capability to design, fabricate and test prototypes. Engineers utilize a prototype lab to create and test prototypes. These prototypes allow KSC teams to facilitate rapid solutions to complex problems by testing real-time prototypes. The Prototype Lab team provides support to operations customers through failure analysis and failure recovery, as well as customized tools and equipment to improve efficiency of operations. The team provides support to researchers and developers by designing and fabricating test articles and test fixtures for laboratories and test beds. Prototype team personnel also can provide consultation on “design for manufacturability.”

Accomplishments:

- Provided design and manufacturing of specialized tooling, flight hardware and support equipment components for X-33, International Space Station, Space Shuttle, and) Launch Services Programs and the U.S. Air Force 45th Space Wing
- Supported the Constellation Program with design and manufacture of prototype hardware for Orion crew module to White Room interface and aft bay simulator
- Design and fabrication of ground support equipment (GSE) and flight hardware for Ares I-X
- Provided one-seventh scale Delta IV launch duct to validate over- and under-pressure modeling
- Provided Taurus II fairing airflow mock-up for testing procedures
- Provided design and fabrication to support the Post-Landing Orion Recovery Test (PORT) article
- Provided design of a Glory mission spacecraft mock-up for fairing purge flow testing in conjunction with the Taurus rocket
- Developed prototype hardware to support lunar architecture analog testing

1.3.1.2 Machining

Kennedy Space Center can provide machining capabilities, including various mills and lathes, electrical discharge machining computer-aided machinery (CAM) engineering, and numerical control (NC) programming. The KSC machine shop can perform the fabrication, modification, refurbishment and repair of all types of ground support equipment, including components of processing facilities, structures and systems. Examples of products include the fabrication of platforms, work stands, towers, special tooling and many types of mechanical equipment components and mechanisms.

Skills include milling, drilling, turning, grinding, engraving, sawing and assembly.

1.3.1.3 Mechanical and Fluids

Kennedy Space Center has mechanical and fluid fabrication and analysis capabilities, including tube fabrication, surface finishing and thermal testing using various ovens (vacuum/bake, autoclave), welding and brazing, (instron) mechanical properties testing, cryogenic testing with large volumes of liquid nitrogen, high pressure pneumatic testing, helium mass spectrometer testing, Non-Destructive Evaluation (NDE) testing (dye penetrant, radiographic X-ray, ultrasonic inspections), Freon R-21, ammonia testing and precision cleaning.

1.3.1.4
Pneumatics Fabrication

Kennedy Space Center is capable of providing fabrication, modification and installation of precision tubing systems, including flaring, bending and assembly, as well as hydrostat and bubble testing. Work includes the fabrication of all types of high-pressure pneumatic panels, consoles and field systems. KSC also can fabricate flex hoses and service portable eyewash units.

The services that can be provided are tube flaring and bending, bubble testing, portable eyewash processing, hydrostatic testing, and pneumatic panel and flex hose fabrication.

Accomplishments:

- Fabricated a QD sense line tubing assembly for mobile launcher platform 3 (MLP-3)

1.3.1.5
Sheet Metal Fabrication

Kennedy Space Center can fabricate and modify all types of sheet metal products, including electronic chassis, pneumatic panels, vacuum-jacketed piping system components and ducts. Capabilities include rolling, shearing, bending, drilling, punching and assembly.

Accomplishments:

- Fabricated side plates for the Ares I-X drogue chute

1.3.1.6
Thermal Protection System Manufacture and Repair

Kennedy Space Center has the capability to manufacture and repair spacecraft thermal tiles, blankets and barriers. Reusable Surface Insulation (RSI) silica tiles for both low (up to 1,200 degrees F) and high temperatures (1,200 to 2,300 degrees F) can be manufactured on-site. The KSC Thermal Protection System Facility is capable of making production units (PUs) of silica tiles, special V-blenders and casting towers are used to produce these PUs. Several large 5-axis milling machines that are used to cut the specific tile out of the PU, all computer programmed. Equipment in the facility includes many large and small kilns, ovens and drying booths. KSC has the capability to manufacture complete RSI tiles, including machining, coating with Toughened Uni-Piece Fibrous Insulation (TUFI) and/or Reaction Cured Glass (RCG) coating, densifying the inner mold line (IML) and waterproofing.

KSC has many large and small industrial sewing machines used to fabricate soft goods. KSC has expertise in the manufacturing and repair of the following types of insulation blankets: Nomex® felt blankets (up to 700 degrees F) used on exterior surfaces, flexible insulation blankets made of quartz fiber and sewn together like a quilt (up to 1,200 degrees F) mainly used on exterior surfaces, and fibrous and multilayer insulation used mainly to protect electronic components.

The thermal barriers and gap fillers that KSC can manufacture and repair are used to fill voids in materials with complex geometric structures and are installed in operational spaces such as landing gear, egress and ingress hatches, and thrusters.

KSC also can provide ground support equipment (GSE) with different forms of thermal coatings (i.e., solid rocket booster hold-down cover thermal coating).

A technician points to some of the tiles on orbiter Atlantis that are being dried by clusters of 200-to-300 watt heat lamps.

Accomplishments:

- Manufactured flight hardware used in the orbiter thermal protection system (TPS) and thermal control system (TCS)
- Encompasses the widest range of TPS manufacturing and repair capabilities to ever exist within a single facility
- Sustains a production rate of more than 5,000 flight items per year
- Manufactured X-38 and crew exploration vehicle thermal protection system tiles and thermal seals
- Manufactured NASCAR thermal insulators

- Manufactured CRYogenic Orbital Testbed (CRYOTE) multi-layer insulation blankets

1.3.1.7 Welding

Kennedy Space Center is capable of performing welding in accordance with the American Welding Society and American Society of Mechanical Engineers welding codes and KSC welding specifications. Welders and welding procedures are certified in shielded metal arc, gas metal arc and gas tungsten arc welding. Certifications include welding of carbon steel, aluminum, stainless steel and plastics.

Capabilities include welding, brazing, silver soldering, burning and automated tube welding.

Accomplishments:

- Welded the outboard side flame deflector at Launch Pad A

Chapter 1.3.2
Materials and Processes Analysis and Testing

Kennedy Space Center has expertise in materials and processing evaluation, failure analysis, precision measurement and chemical analysis techniques.

Chapter 1.3.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.3.2 Materials and Processes Analysis and Testing

1.3.2.1 Chemical Analysis

Kennedy Space Center provides a comprehensive, on-site, rapid turnaround chemical analysis capability, including identification of unknown materials (solid, liquid or gas), material characterization (metallic and nonmetallic), organic and inorganic contaminant identification.

1.3.2.2 Failure Analysis

Kennedy Space Center provides an on-site, rapid-response metallurgical, mechanical, electrical and nonmetallic failure analysis and mishap investigation, both in the field and in the laboratory. The comprehensive suite of on-site, forensic laboratories, enables rapid-response and resolution to customer problems.

1.3.2.3 Materials Testing and Analysis

Kennedy Space Center provides a comprehensive, on-site, rapid turnaround materials testing capability that includes tensile, compression and fatigue testing, vibration testing, thermal vacuum and environmental chamber testing, materials compatibility testing (flammability, electrostatic discharge, hypergols, oxygen), thermal analysis, hardness, metallography, and accelerated testing for corrosion.

KSC specializes in accelerated testing for corrosion. Capabilities include laboratory (salt fog, Weather-Ometer®, Taber Abraser®, adhesion, gloss, colorimeter) and environmental exposure at the Beachside Atmospheric Test Facility. This facility is the most corrosive test site in North America and qualifies as accelerated testing.

Another KSC specialty is the ability to generate a wide range of hypergolic gas streams (0.01 – 500 parts per million). Very few laboratories in the United States are able to test at this range.

1.3.2.4 Precision Measurement and Dimensional Analysis

Kennedy Space Center provides in-house metrology that allows independent verification of quality, alignment, fit and finish and dimensional analyses of anomalies (e.g., scratches on sealing surfaces) in the lab and in the field. Precision dimensional analysis includes mold impressions of scratches, cracks and defects; 3-D measurements, modeling and reverse engineering to metrology standards (0.005 inches); traceable metrology graphical software that enables simultaneous measurements using Laser Scanner, Laser Tracker, Coordinate Measurement Machine (CMM), and theodolites; a wide variety of field tooling and instrumentation with the capability to measure, align and scan complex geometries supporting unique customer requests in industrial settings; flight hardware and equipment alignments; shaft and large component alignments; real-time tracking; hidden point target acquisition; and computer-aided design (CAD) capabilities.

Chapter 1.3.3
Materials Engineering Services

Kennedy Space Center has expertise in materials engineering services including corrosion and contamination control, welding, materials selection and nondestructive evaluation techniques.

Chapter 1.3.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.3.3 Materials Engineering Services

1.3.3.1 Contamination Control

Kennedy Space Center provides ground and in-orbit contamination control prevention, detection and mitigation. These services include compliance with environmental requirements, and monitoring and procedure development (repair, operations and maintenance).

Contamination detection and mitigation services include surface cleanliness verifications and inspections of systems and precision cleaning. A comprehensive, on-site, suite of materials testing and analysis laboratories enhances these services and provides customers with rapid-response problem solving.

Accomplishments:

- Developed in-orbit contamination solutions
- Provided root cause identification and implemented contamination process to prevent recurrence of in-orbit contamination of the Solar Alpha Rotary Joint (SARJ)
- Provided more than 20 years of environmental monitoring and contamination control services to a wide range of simple and complex payloads for low Earth orbit and interplanetary robotic missions (e.g., Hubble Space Telescope, Galileo, WISE, SDO, CHANDRA, TEDRIS and Magellan)

1.3.3.2 Corrosion Control

Kennedy Space Center provides corrosion control prevention, detection and mitigation. This includes identifying and validating solutions to corrosion problems; accelerated lab and field testing; remote telemonitoring; and investigation, evaluation and determination of material performance. KSC also has ongoing corrosion research and development in the areas of coatings, refractory and self-healing materials. KSC utilizes the Beachside Atmospheric Test Facility for corrosion research. This facility is the most corrosive test site in North America and qualifies as accelerated testing.

Accomplishments:

- National Association of Corrosion Engineers (NACE) Technical Fellow
- More than 10 patents related to corrosion developed at KSC
- Ph.D. chemists, corrosion and chemical engineers on staff
- Collaborated with U.S. Military, Department of Transportation, and numerous commercial and university affiliates
- Developed proven methodologies to evaluate and test coatings
- More than 40 years of test data and publications in the fields of corrosion and coatings

1.3.3.3 Materials Selection

Kennedy Space Center provides materials evaluation, assessment, and selection for design, development and operations. Materials selection for design and manufacturing capabilities include metallic and nonmetallic materials, welding, coatings, corrosion control and composites. A comprehensive, on-site, suite of materials testing and failure analysis laboratories enhances these services and provides customers with rapid-response problem solving. KSC has ongoing research and development for materials for life cycle optimization in the following areas: corrosion; composite manufacturing, inspection and repair; and electrostatics. KSC also has extensive expertise in the development of agency and international specifications and standards.

Accomplishments:

- Provided custom-alloy design and casting process for the crawler-transporter tread belt shoe
- American Welding Society (AWS D17) Chair, Committee on Welding in the Aircraft and Aerospace Industries
  - D17.1 Specification – Fusion Welding for Aerospace
  - D17.2 Specification – Resistance Welding for Aerospace
  - D17.3 Specification – Friction Stir Welding for Aerospace Applications
- Aerospace Materials Engineering Committee voting member
- American Society for Testing of Materials (ASTM G4) voting member
- ISO Technical Committee 44/Working Group 4, "Welding and Brazing in Aerospace" designated U.S. voting member
- National Association of Corrosion Engineers (NACE) Technical Fellow
- American Society for Nondestructive Testing (ASNT) Level III Certifications

1.3.3.4 Nondestructive Evaluation (NDE)

Kennedy Space Center's nondestructive evaluation capabilities (NDE) include standard and novel methods. KSC's specialty is the rapid development of advanced NDE methods to address unique problems. Standard NDE methods are provided by a certified work force (ASNT and NASA STD-410 Level I, II, III) and include visual inspection, magnetic particle, liquid penetrant, radiography, phased array ultrasonics, shearography, eddy current, infrared testing (thermography), radiography, large chamber Computed Tomography, microfocus X-ray, real-time X-ray, high-energy X-ray, portable X-ray and backscatter.

Accomplishments:

- Produced rapid development of advanced NDE methods for:
  - Thermographic inspection of space shuttle wing leading edge reinforced carbon-carbon (RCC) panels in response to the Space Shuttle Columbia accident
  - Shearography inspection method for space shuttle external fuel tank insulating foam
- Provided many solutions for difficult multidiscipline problems, including tool development and Commercial Orbital Transportation Systems (COTS) modifications

1.3.3.5 Non-Standard Materials

Kennedy Space Center has experience reviewing and using non-standard materials and chemicals in and around flight hardware and ensuring there is no hazardous exposure to personnel or damage to flight hardware. Specific areas of expertise in non-standard materials usage include:

- Identifying mass storage and handling requirements of commodities
- Ensuring compatibility between different chemicals in the process and surrounding hardware
- Ensuring the necessary warnings and cautions are in the Work Authorization Document (WAD)
- Ensuring safe handling of commodity quantities used in the workplace
- Ensuring Material Safety Data Sheets (MSDS) are available for all commodities
- Ensuring workers are outfitted with the appropriate personal protective equipment (PPE) for the tasks to be performed
- Ensuring workers have the appropriate training for the commodities used
- Ensuring proper disposal of waste

1.3.3.6 Welding Engineering

Kennedy Space Center provides welding engineering for requirements development, welding procedures and performance qualifications, inspection, and interpretation of standards for a wide range of welding processes, including custom applications for multiple methods. These welding methods include shielded metal arc welding, gas metal arc welding, gas tungsten arc welding, flux-cored arc welding, submerged arc welding, friction stir welding, resistance spot welding, and resistance-seam welding. KSC engineers have developed weld inspection requirements and standards applications for a range of welding processes, including the American Welding Society, America Society for Nondestructive Testing, American Society for

Metals, America Society for Testing and Materials, and Military (MIL) Standards.

Accomplishments:

- American Welding Society (AWS D17), Chair of Committee on Welding in the Aircraft and Aerospace Industries
    - Subcommittee (AWS D17K) Fusion Weld ing for Aerospace and (AWS D17D) Resis tance Welding for Aerospace voting members
    - Authored: D17.1 Specification – Fusion Welding for Aerospace
    - Authored: D17.2 Specification – Resistance Welding for Aerospace
    - Authored: D17.3 Specification – Friction Stir Welding for Aerospace Applications
- ISO Technical Committee 44/Working Group 4, “Welding and Brazing in Aerospace” voting member
- Provided welding engineering for life cycle cost savings for Constellation Program
    - Custom welding procedure developed for mass implementation of a new application for AL-6XN alloys in a KSC launch environment

Section 1.4
Research and Technology Development

Kennedy Space Center has established considerable expertise in developing technology to enable safe, efficient and cost effective operations related to the space industry. Many technological advances have been directly transferable to other industries. Section 1.4 provides details on the research and technology development capabilities that KSC has to offer.

Section 1.4 of the Kennedy Resource Encyclopedia includes the following chapters:

Chapter 1.4.1
Command, Control and Monitoring Systems

Kennedy Space Center has experience developing smart command, control and monitoring of ground and flight systems, including health management capability and tele-robotics.

Chapter 1.4.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.1 Command, Control and Monitoring Systems

1.4.1.1 Advanced Leak Detection Capabilities

Kennedy Space Center has unique capabilities for performing advanced leak detection. Engineers at KSC utilize a laboratory environment to generate vapors with calibrated humidity content, generate organic vapors (isopropyl alcohol, methyl ethyl ketone, toluene, xylene and others), and many hazardous vapors. Hypergolic (both hydrazine fuels and nitrogen tetroxide oxidizer) vapors can be produced at levels as low as five parts-per-billion, which provide engineers with the proper environment for development and testing of new hypergolic detection sensors, and verification and validation of commercial-off-the-shelf equipment.

The hydrogen leak and fire detectors test stand enables Kennedy Space Center to perform advanced leak detection.

Leak-sensing pigments are used in a sensing tape that changes color upon contact with hydrogen.

Accomplishments:

- Developed electronic nose (E-nose), nanosensors, chemochromic sensors, and verification and validation of Drager's PAC III, Interscan, and Honeywell's CM4®.
- Developed enhanced leak detection and fire detection sensors
- Developed and calibrated systems for leak and fire detection in the field

1.4.1.2 Critical Sensors and Transducers (Cryogens and Hydrogen)

Kennedy Space Center is capable of designing, implementing and operating critical sensors and transducers. Specifically, KSC has developed critical sensor and transducer systems required for cryogenic fluid monitoring and operations. Sensors monitor many attributes of cryogenic fluids, including temperature, pressure, flow, mass quantification and volume. Systems are developed to meet Class I Divisions I and II, and other hazardous requirements. Designs are

Cryogenic temperature probes are used for cryogenic operations at Kennedy Space Center.

This close-up shows the final splicing completed on the wiring between space shuttle Atlantis' external tank and the engine cutoff (ECO) sensor system. Cryogenic shielding is installed around the wiring.

developed for high reliability and low maintainability while meeting or exceeding safety requirements.

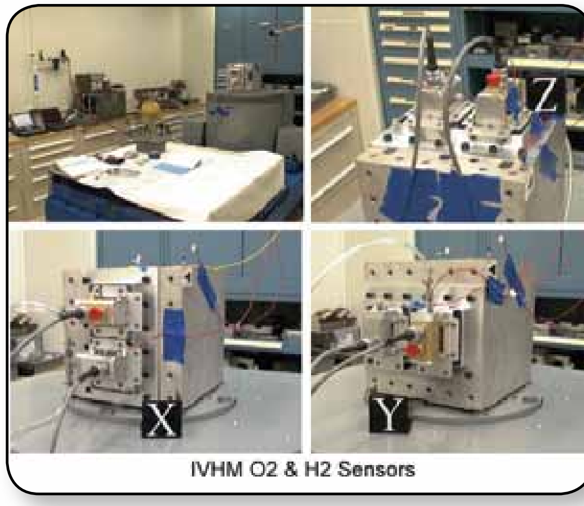
Accomplishments:

- Frequently enhance commercial off-the-shelf equipment to meet launch system requirements
- Developed silicon diode cryogenic temperature sensors
- Developed high-accuracy cryogenic signal conditioner for silicon diodes

1.4.1.3 Hazardous Gas Detection

Kennedy Space Center is capable of designing, implementing and operating hazardous gas detection systems. To detect hazardous gases, KSC utilizes systems that range from highly complex and specialized analytical instrumentation systems (mass spectrometry) to simple gas detection systems (point sensing devices). KSC detection systems are able to sense a multitude of gases including hydrogen, oxygen, nitrogen, helium, argon, hypergolic propellants (e.g., monomethylhydrazine and nitrogen tetroxide) and other gases of interest in air and inert background gases categories. KSC systems meet or exceed rigorous Class I, Divisions I and II, and other safety requirements to protect from hazards, and to provide high reliability and low maintainability.

An image of the third-generation Hydrogen Point Sensor that monitored hydrogen concentrations in the aft section of the orbiter during space shuttle missions STS-95 and STS-96.



Hydrogen and oxygen point sensors are qualified at Kennedy Space Center.

A hydrogen point sensor is mounted in the aft section of a space shuttle.

Accomplishments:

- Developed the third-generation Hydrogen Point Sensor in collaboration with Glenn Research Center in Cleveland, Ohio.
- Developed several hazardous gas detection systems, including the Hazardous Gas Detection System (HGDS2000) and the Hydrogen Umbilical Mass Spectrometer (HUMS) system, used for detecting hazardous conditions at Launch Pads 39A and B during terminal launch countdown tanking operations.
- Developed and demonstrated a miniaturized, portable mass spectrometer system

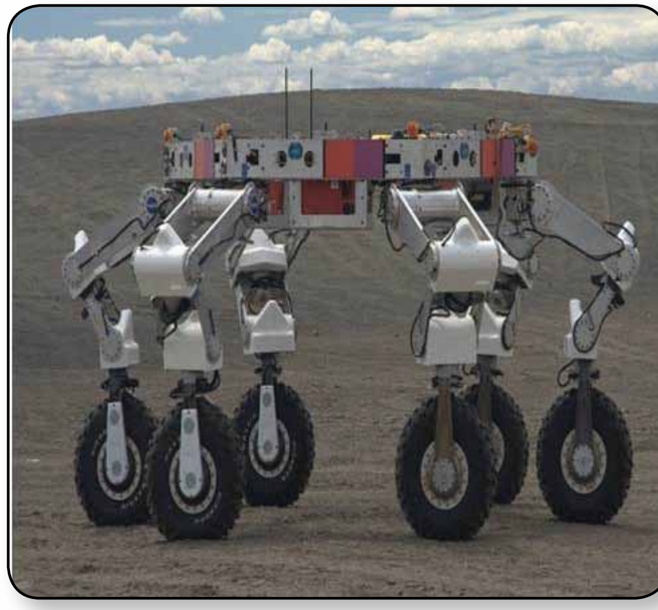
- Developed a Portable Refrigerant Leak Identification System (PReLIS), which identifies and monitors Freon leaks in refrigeration systems, in collaboration with Ames Research Center in Moffett Field, Calif.

1.4.1.4 Tele-robotics

Kennedy Space Center has developed and demonstrated command, control and monitoring systems of robotic mobility systems and excavators that operate in simulated planetary surface environments. KSC engineers develop these command, control and monitoring systems to meet the challenges involved with the communication time delay or latency that is the result of the transmitting signals across large distances. These long-distance communication systems are essential for communicating with assets on the moon, Mars or beyond. KSC tests these new technologies during the annual Desert Research and Technology Studies (RATS) field tests in Arizona.

Accomplishments:

- Developed command, control and monitoring systems, antennas and excavation devices for line-of-sight communications for the Space Exploration Vehicle, All-Terrain Hex-Limbed Extra-Terrestrial Explorer (ATHLETE), Centaur-2 and several other NASA mobile assets



A prototype of the All-Terrain Hex-Limbed Extra-Terrestrial Explorer (ATHLETE) currently is under development for lunar exploration.

An image of a concept Space Exploration Vehicle (SEV) that will be used for transportation on extraterrestrial surfaces is depicted. The prototype SEV currently is being tested in Flagstaff, Arizona.

Chapter 1.4.2
Energy Efficient Insulation, Storage and Distribution of Cryogenic Fluids

Kennedy Space Center has world-class expertise in the development, testing and evaluation of thermal insulation systems and advanced cryogenic systems and components.

Chapter 1.4.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.2.1 Aerogels for Unique Ground Heat Leak Applications

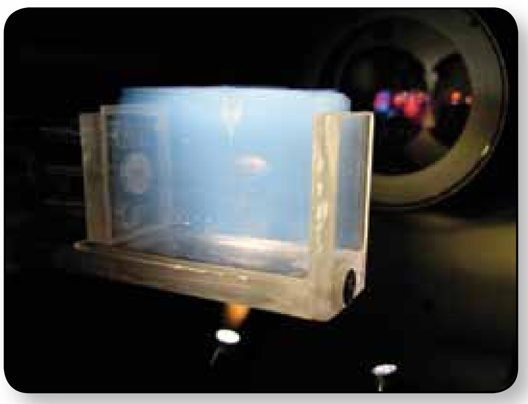
1.4.2.2 Multi-Layer Insulation Systems

1.4.2.3 Zero Loss Cryogenic Propellant Servicing

1.4.2 Energy Efficient Insulation, Storage and Distribution of Cryogenic Fluids

1.4.2.1 Aerogels for Unique Ground Heat Leak Applications

Kennedy Space Center has the capability to develop, test and apply aerogels. KSC utilizes aerogel materials to simplify insulation systems where high-performance insulation is required in various ground system applications. Aerogels are used in both bead and blanket forms, which are hydrophobic to prevent moisture uptake and minimize system degradation. KSC performs operation methods such as shrink wrapping, bulk fill and blanket wrapping of various complex geometries to create high-performance insulation for cryogenic and other heat-sensitive systems.



Aerogel's unique properties allow it to be used in many applications. This block of aerogel is an example of material used to insulate ground support equipment and cryogenic system components.

In Kennedy Space Center's Payload Hazardous Servicing Facility, the aerogel grid is deployed from the Stardust Sample Return Capsule (SRC). The unique properties of aerogel allowed the Stardust capsule to capture comet particles

Accomplishments:

- Developed an aerogel-based insulation system for reducing ice formation
- Partnered with Aspen Systems Inc. and received the "R&D 100" award for Aspen Aerogels in 2003
- NASA's Stardust mission used a block of aerogel to catch high-speed comet particles and specks of interstellar dust without damaging them

1.4.2.2 Multilayer Insulation Systems

Kennedy Space Center is capable of rapid building and testing of multilayer insulation systems. KSC builds and tests multiple multilayer insulation (MLI) systems annually for NASA customers and outside vendors.

A multilayer insulation system is prepared at Kennedy Space Center and readied for installation in a guarded liquid nitrogen calorimeter.

Accomplishments:

- Performed internal comparison of several different material systems and application methods
- Performed internal development of novel MLI systems using new materials and system configurations
- Performed coupon testing for the Exploration Technology Development Program's (ETDP) project Methane Lunar Thermal Control testing to help predict thermal performance of a 4-foot in diameter simulated lunar exploration vehicle (Altair) tank
- Performed testing to corroborate performance claims by multiple small business innovative researchers (SBIRs)
- Performed testing for outside venders such as Chart, Lydall, General Electric, the U.S. Department of Homeland Security and the European Organization for Nuclear Research (CERN)

1.4.2.3
Zero Loss Cryogenic Propellant Servicing

Current cryogenic servicing activities at Kennedy Space Center result in product losses from transportation, transfer and chill down, pressurization and depressurization, and daily boil off. Advanced propellant servicing systems are under research at KSC to eliminate these losses, making operations more safe and economical. These systems use an integrated refrigeration and storage system to remove heat from cryogenic propellants, which allows for zero loss storage and transfer operations and yields a higher economic payback. The proposed system also is capable of efficient liquefaction of cryogenic propellants at the launch site, and better control of the state of the propellant, including densification. Additional features of the advanced propellant system include high-efficiency propellant transfer lines, advanced control systems, modern cryogenic valves and use of health management instrumentation.

Accomplishments:

- Completed Integrated Refrigeration and Storage (IRAS) System testing for optimum heat exchanger position, free convective heat exchanger characterization, and preliminary liquefaction operations
- Completed carbon foam recuperative heat exchanger development with the University of Central Florida in Orlando
- Initiated liquid hydrogen testing with Florida Solar Energy Center
- Published IRAS test results in "Advances in Cryogenic Engineering," and recuperative heat exchanger development in the "Journal of Heat Transfer"

A 180-liter liquid hydrogen cryostat was configured with a Gifford McMahon cryocooler to achieve a zero loss hydrogen system. When configured, this system is also capable of hydrogen liquefaction (5 liters per day) and densification (bulk temp = 16K).

A 400 liter liquid oxygen cryostat has been configured with a liquid nitrogen cooling loop to achieve a zero loss liquid oxygen system. The cryostat has internal instrumentation to measure the temperature gradients and a reconfigurable heat exchanger.

Chapter 1.4.3
Environmental Mitigation and Green Technologies

Kennedy Space Center has experience in earth systems modeling, green technologies, and detection and mitigation technologies for improving quality of life.

Chapter 1.4.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.3.1 Air Quality Monitoring

1.4.3.2 Earth Systems Modeling and Data Management

1.4.3.3 Ecological Monitoring Program

1.4.3.4 Merritt Island National Wildlife Refuge

1.4.3 Environmental Mitigation and Green Technologies

1.4.3.1 Air Quality Monitoring

Kennedy Space Center has the capability to provide support in all areas related to air quality monitoring, research, management and permitting in both indoor and outdoor environments. The Environmental Management Branch has staff and equipment to conduct indoor air quality analyses (mold, asbestos, etc.,), monitor stack emissions, monitor fueling and launch emissions, and assist with the development of permit applications and requests for additional information from the Florida Department of Environmental Protection. Resources are available for the collection of specific parameters using canister samplers, drager tubes, field portable gas chromatography and mass spectrometry, and other technologies. Mold spore, asbestos and bacteria samples can be processed through in-house laboratory capabilities in order to assess sick building complaints and other potential contaminants in operational areas.

The Ecological Program in KSC's Environmental Management Branch has been monitoring EPA criteria pollutants as part of the Permanent Air Monitoring Station (PAMS) since 1982 as a continuation of the NASA Best Program. The following parameters are being monitored continuosly:

- Ozone (O3)
- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Sulfur dioxide (SO2)
- Inhalable particulates (PM-10)
- Solar radiation
- 10-m temperature
- 10-m relative humidity
- Wind speed
- Wind direction

These data are available for trends analysis, exposure assessments, and for use in National Environmental Policy Act (NEPA) documentation and permit applications.

1.4.3.2 Earth Systems Modeling and Data Management

Kennedy Space Center has the capability to provide the unique functions of the Earth Systems Modeling and Data Management Laboratory. This laboratory can offer customers access to proactive approaches to ecological research and environmental management through:

- Electronic warehousing and documentation of all environmental work performed at KSC since 1981, with a comprehensive Web portal to identify warehouse contents.
- Utilizing technologies for the analysis, synthesis and visualization of data. The laboratory can offer the expertise of five full-time staff professionals with data management, data evaluation, Geographic Information System (GIS), aerial and satellite imagery, and ecology and marine biology experience.

Earth Systems Modeling and Data Management Laboratory functions used to evaluate ecological and environmental monitoring data include:

1. Systems design and implementation
2. Development of Web-based and desktop data mining, gleaning and filter tools
3. Development of robust Environmental Database Management system (EDMS)
4. Design of an Oracle-based Environmental Integrated Model (EIM) to accommodate all environmental and ecological data sets
5. Management of long-term environmental data sets spanning more than 25 years, readily available upon request
6. Development of key Web-based Decision Support Tools:
    a. STS Launch Support Tool (LaSUP)
    b. Preliminary Environmental Assessment Tool (PEAT)
    c. Fire Management and Analysis Network (FireMAN)
7. Skilled in Geographical Information Systems and Remote Sensing:
    a. Environmental Systems Research Institute (ESRI) ArcGIS products
    b. Earth Resources Data Analysis System (ERDAS) Imagine products
8. GIS Projects:
    a. Geological Inventory for the Canaveral National Seashore
    b. Geology of the Cape Canaveral – Merritt Island Barrier Island Complex
    c. Dune line change (1969-2000) and shore line change (1870s-2000)
    d. Prop Scar mapping of sea grasses in Mosquito Lagoon
    e. 3-D Plume Dispersion Modeling of ground contaminants
9. Supported 132 shuttle missions from the Environmental Evaluation Console (EEC)

1.4.3.3 Ecological Monitoring Program

Kennedy Space Center has the capability to provide support in all areas of natural resource management, compliance, monitoring and mitigation. The KSC Environmental Management Branch ecological program is based on long-term, multidisciplinary scientific research and monitoring that encompasses critical components of local and regional ecosystems. The program goal is to develop an understanding of how the ecosystem functions and how natural and man-made aspects influence system dynamics and processes. Future customers can access information and knowledge necessary to support science-based management decisions for compliance with environmental laws and regulations related to natural resources, with a focus on current and future issues for KSC. Primary regulatory drivers include the National Environmental Policy Act (NEPA), the Endangered Species Act, the Migratory Bird Treaty Act, numerous executive orders and Florida state laws.

U.S. Fish and Wildlife Service (FWS), and Innovative Health Applications LLC workers help a green sea turtle move into deeper water at the Merritt Island National Wildlife Refuge in Florida.

Areas of Active Support Include:

- Environmental effects of rocket launches and launch operations on local ecosystems
- Atmospheric monitoring for Environmental Protection Agency (EPA) priority pollutants
- Rainfall patterns and deposition chemistry
- Long-term water and sediment chemistry monitoring
- Protected species identification, conflicts, monitoring and management

- Facility siting and NEPA documentation support
- Endangered Species Act consultation support
- Land use planning and management related to natural resource conflicts
- Wildlife and habitat mitigation planning and monitoring support
- Climate change adaptation planning and recommendations

1.4.3.4 Merritt Island National Wildlife Refuge

The Merritt Island National Wildlife Refuge (MINWR) was created under an interagency agreement with NASA in 1963 to manage and maintain the lands outside launch operational areas owned by the agency, as part of the John F. Kennedy Space Center. Only a very small portion of the 140,000 acres owned by NASA has been developed or designated for NASA operational and industrial use. The remaining lands are managed as a wildlife refuge for a multitude of animal species and habitat types, some of which are threatened and endangered. Within the boundaries of the refuge, there are more than 30 species of federally and state protected animal species, and habitats critical to those species continued existence. The MINWR is one of the last extensive undeveloped barrier islands along the east coast of Florida. Located within the MINWR is the Indian River Lagoon, which is classified as an Outstanding Florida Water and an Essential Fish Habitat. Due to the refuge's importance to resident and migratory birds, the refuge was designated as one of three gateways to the eastern section of the Great Florida Birding Trail. The Banana River portion of the Lagoon within KSC boundaries also is designated as a manatee sanctuary.

An unidentified baby bird waits, probably for its next meal, in its nest in the Merritt Island National Wildlife Refuge.

The location of the MINWR, which is partially located within secured areas of KSC, provides for an extraordinary capability to conduct research under controlled conditions with little to no outside interference from rural populations, vehicle traffic and other variables. The habitat types at MINWR include coastal dunes, estuarine wetlands, open water estuarine lagoon, freshwater wetlands and hardwood hammocks, oakscrub and pine flatwoods.

Ongoing research is part of the NASA and MINWR management plans. Data sources are available to support future research projects. The MINWR is a one-of-a-kind refuge that offers a unique look at pristine wildlife habitats that have had little to no anthropogenic impacts.

Chapter 1.4.4
In-situ Surface Resource Utilization (ISRU) and Surface Systems

Kennedy Space Center has expertise developing in-situ resource utilization, volatiles extraction and environmental protection on surfaces beyond earth, including oxygen, water, fuel production, excavation and handling.

Chapter 1.4.4 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.4.1 Habitation System Development

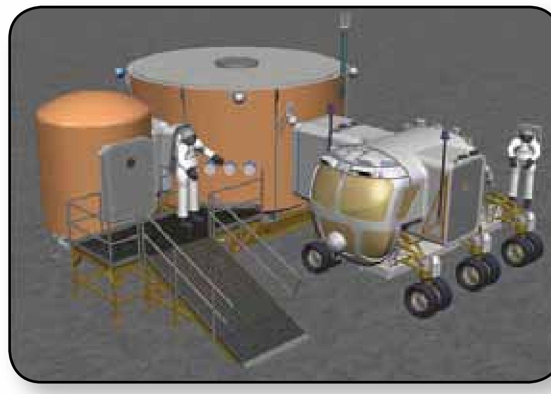
1.4.4.2 Regolith Excavation and Handling

1.4.4.3 Rocket Plume Blast Effects

1.4.4 In-situ Surface Resource Utilization (ISRU) and Surface Systems

1.4.4.1 Habitation System Development

Kennedy Space Center has the capability to coordinate systems engineering and project management functions for habitation system development. Teams at KSC can perform complete project management and integration functions for all aspects of habitation system development projects. These functions include schedule management, systems engineering coordination, development requirements, testing procedures, and integrating design and assembly processes. KSC also is capable of developing operations and experiment plans to be performed within habitation units.



Kennedy Space Center participated in designing the concepts for habitation units.

Accomplishments:

- Co-managed the development of the full-scale mock-up of the Habitat Demonstration Unit (HDU), the first-ever surface habitat prototype for utilization on extraterrestrial environments

In partnership with many organizations, Kennedy Space Center played a key role in the development of the Habitat Demonstration Unit mock-up. This unit is a conceptual mock-up for habitation of extraterrestrial surfaces.

1.4.4.2 Regolith Excavation and Handling

Kennedy Space Center is capable of performing research and development of regolith excavation and handling systems. Engineers utilize laboratories and fabricating facilities to develop surface mobility vehicle systems for extraterrestrial surface excavation, habitat emplacement and support equipment, and commodities handling. Research also is conducted in support of potential lunar water ice prospecting missions, and reduced gravity flight testing for investigation of regolith handling challenges, such as pneumatic transport, fluidization, magnetic transport and soil mechanical properties.

A hydrogen reduction system is part of the Precursor In-Situ Lunar Oxygen Testbed (PILOT) Program.

Accomplishments:

- Developed a regolith excavation and handling vehicle with multiple end effecter attachments (drilling, excavation, clearing) for the Constellation Program
- Developed technology proving that solar energy can be used for oxygen extraction from lunar regolith via carbothermal reduction

1.4.4.3 Rocket Plume Blast Effects

Kennedy Space Center is capable of performing research on rocket plume blast effects on extraterrestrial surfaces. This research is conducted to evaluate protection of regolith surfaces from rocket plume exposure in extraterrestrial environments. Research includes surface particle Discrete Element Modeling (DEM), computational fluid dynamic (CFD) modeling of rocket plume effects on regolith systems, geotechnical testing and wind tunnel testing.

A solid rocket motor is fired into a prepared granular medium bed and recorded by high speed cameras in order to study the interaction of the rocket plume exhaust flow and the granular medium particles, and determine the physics of rocket plume blast effects.

Accomplishments:

- Engaged in Small Business Innovation Research (SBIR) partnerships and Innovative Partnerships Program (IPP) contracts, enabling collaboration with students and fellows from universities performing extraterrestrial soil study and prototype projects
- Provided Constellation Level II lunar plume effects study to develop software, predict the blast effects on the moon and how to mitigate them
- Publication in Journal of Aerospace Engineering related to new flow regime in rocket exhaust cratering

Chapter 1.4.5
Life Sciences and Biomedical Research

Kennedy Space Center has expertise in the development of life support and monitoring systems and technology for earth, earth orbit and beyond.

Chapter 1.4.5 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.5 Life Sciences and Biomedical Research

1.4.5.1 Air and Water Purification

Kennedy Space Center is capable of designing air and water purification systems and performing purification processes. These systems involve Advanced Life Support research related to bioregenerative life support for space exploration. The areas of research are conducted in many biological systems, including plant gas exchange (photosynthesis, respiration and transpiration); plant responses to elevated carbon dioxide and hypobaric pressures; plant growth and development under different lighting systems (spectral quality studies); and the use of hydroponic approaches for growing crops.

Kennedy Space Center's wastewater bioreactors purify wastewater by utilizing fiber membranes and microbial communities that convert ammonium nitrogen (e.g., from urine) into nitrate, or N2 gas.

Accomplishment

- Developed the Aerobic Rotational Membrane System (ARMS), which is a system for biological treatment of water in space
- Collaborated with a small business partner to develop the Forward Osmosis Bag (FOB) for flight certification

1.4.5.2 Bioinstrumentation Checkout of Space Vehicles

Kennedy Space Center has the capability to provide bioinstrumentation checkout of space vehicles. One component of this checkout includes the design of ground support equipment (such as physiosimulators) for biomedical instrumentation checkout to ensure the operation and flight readiness of the system. Also, fabrication and maintenance of equipment (i.e., flight medical instrumentation and sensors), and writing checkout, launch countdown and landing procedures can be provided.

Astronaut Jeffrey Williams, an Expedition 13 space station science officer, works with the Passive Observatories for Experimental Microbial Systems in Micro-G (POEMS) payload in the Minus Eighty Degree Laboratory Freezer for ISS (MELFI).

1.4.5.3 Biological Research and In-orbit Planning

Kennedy Space Center has the capability to provide expertise in planning in-orbit operations of biological research experiments. Planning in-orbit operations for these experiments requires a team of flight hardware design engineers and technicians, payload developer project engineers and project managers. This team can perform a multitude of functions required for planning and executing in-orbit biological research, including feasibility analysis; flight hardware design, fabrication and testing; mission integration; crew procedure development and training; in-orbit payload operation development;

ground control experiment services; International Space Station verification and certification; and post-flight analysis.

Biological experiment payloads are received from various NASA, international, commercial and National Lab research organizations. To achieve experiment objectives, the KSC team can utilize a variety of research hardware, including the Advanced Biological Research System (ABRS) on the space station, Biological Research In Canisters (BRICs), BioTube and Kennedy Fixation Tubes (KFTs), specialized hardware labs, growth chambers and a control center.

Astronaut Cady Coleman harvests plants as part of the Plant Growth In Microgravity (PGIM) experiment during the STS-93 mission.

Accomplishments:

- Collaborated with the Russian Space Agency's Institute of Bio-Medical Problems (IBMP) to utilize the Russian "Lada" greenhouse across four 100 percent successfully completed space station missions
- Successfully completed seven months of Advanced Plant Experiments (APEX-Cambium) on the space station during five shuttle missions in collaboration with the Canadian Space Agency and NASA investigators
- Successfully executed Biological Research In Canisters–16 (BRIC-16) as a pathfinder for rapid experiment turnaround (seven months from research announcement release to launch)
- Initiated two new plant research experiments as selected from the International Life Sciences Research Announcement (ILSRA) in 2009, including Dr. Karl Hasenstein's (University of Louisiana, Lafayette) "Microgravity and Magnetic Fields" investigation, and Dr. Gary Stutte's (Dynamac Corporation) Symbiotic Nodulation in a Reduced Gravity Environment investigation.

1.4.5.4 Closed Environment Plant Production Research

Kennedy Space Center is capable of providing closed environment plant production research. Research is conducted on collapsible plant growth chambers and light production systems in order to produce fresh vegetables for crews on long-duration space missions. Plant production research includes capillary rooting mats; vibration and acoustic effects; plant gas exchange (photosynthesis, respiration and transpiration); responses to elevated carbon dioxide and hypobaric pressures; lighting systems (spectral quality studies); and the use of hydroponic approaches for growing crops. Research also is conducted in environmental biology, phytochemistry, metabolomics and volatile organic compound sensing technology. State-of-the-art analytical instruments are utilized to provide both qualitative and quantitative analyses of non-volatile organics, volatile organics, elements and ions to meet diverse operational and research needs.

Kennedy Space Center's Controlled Environment Laboratory houses several controlled environment chambers that can be used to study plant growth for life support systems, preparing plants for spaceflight payloads, or testing under tightly controlled conditions.

Lettuce and other plants are being studied as a supplemental food source for astronauts on space station and exploration missions, where fresh, perishable foods could add flavor, color, texture and additional nutrients to their diet.

Accomplishments:

- Established a partnership with Orbital Technologies Corp.
- Developed light-emitting diode (LED) arrays that doubled the lighting output for collapsible plant growth chambers
- Developed VEGGIE, a small vegetable production experiment to be utilized in orbit

1.4.5.5 Development and Testing of Life Support Apparatus

Kennedy Space Center has the capability to conduct design, testing and evaluation of cryogenic-air-supplied personal protective equipment (PPE) such as whole bodysuits and self-contained breathing apparatus. This human testing is performed in lab, environmental chambers and field condition environments.

Accomplishments:

- Development, testing and implementation of cryogenically powered whole body protective suits (Propellants Handler Ensemble or Self-Contained Atmospheric Protective Ensemble)
- Development, testing and implementation of the Liquid Air Pack used by the shuttle closeout crew and the pad rescue team, and development of a supercritical self-contained breathing apparatus with liquid-cooled garment

1.4.5.6 Testing and Assessment of Adverse Environmental Factors on Human Capabilities

Kennedy Space Center has the capability to perform testing of adverse environmental factors in actual conditions using the protective apparatus and/or vehicle (in-situ) to allow acquisition of high-fidelity electronic data by calibrated instruments. This type of testing determines the effects on humans when exposed to adverse conditions such as high noise, toxins and heat.

Accomplishments:

- Testing of adverse environmental associated with hot ambient temperatures, noisy, reduced atmospheric pressure and underwater environments
- Data collection from NASA helicopters to determine effects of noise on humans and onboard conversations

Chapter 1.4.6
Materials for Life Cycle Optimization

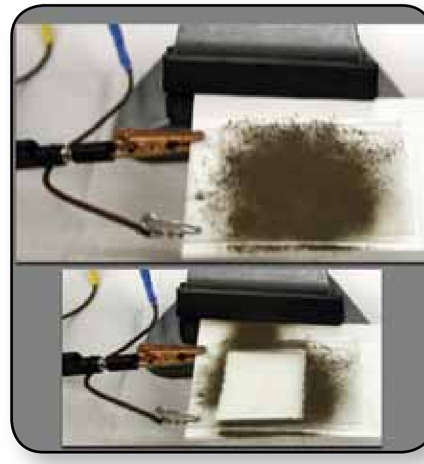
Kennedy Space Center has expertise in cutting-edge materials and processes to detect, prevent and mitigate damage from operations and from the environment such as corrosion, extreme temperatures and dust.

Chapter 1.4.6 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.6 Materials for Life Cycle Optimization

1.4.6.1 Corrosion

Kennedy Space Center is capable of performing corrosion research and evaluation of materials for life cycle optimization. KSC utilizes methods to detect, prevent and mitigate degradation of materials caused by natural and operational environments. Experiment and analysis capabilities include real-time and accelerated corrosion testing, salt fog testing, seawater immersion, metallurgical failure analysis, microchemical and electrochemical analysis, analysis of impingement and erosion corrosion, cavitation, other velocity effects, cathodic protection measurement and analysis, and corrosion potential mapping.



Electrodynamic dust removal from glass demonstrates how this technology can provide dust mitigation for optical systems and optical instruments.

Research is conducted at several on-site laboratories, including the most corrosive beachside corrosion test site in North America (qualifies as accelerated testing). This site includes, configurable exposure stands for atmospheric exposure; a test area for reinforced concrete testing; a weather station to obtain parameters that correlate with corrosion data; two seawater immersion tanks for seawater immersion exposure, tidal exposure, and seawater spray and splash zone exposure; and an indoor laboratory. Other facilities include, an accelerated corrosion laboratory, a coatings application facility and an applied research laboratory.

The Beach Corrosion Test Site is located near the Atlantic Ocean. In this photo, Launch Complex 39 is in the background.

Accomplishments:

- National Association of Corrosion Engineers (NACE) technical fellow, Ph.D. level chemists and materials science and engineers on staff
- Produced more than 10 patents
- Collaborated with the Department of Defense, Department of Transportation, and numerous commercial and university affiliates
- Developed proven methodologies to evaluate and test coatings
- Generated more than 40 years of test data and publications in the fields of corrosion and coatings
- Provided recommendations to the National Research Council of the National Academies on a national strategy in fundamental corrosion research

A close-up image of exposure racks used for research and testing at the Beach Corrosion Test Site.

1.4.6.2 Extreme Temperatures and Low Flammability

Kennedy Space Center is capable of performing research and development of novel composites for extreme environments, including high and low temperatures. Engineers perform research related to fire-resistant materials with the potential of extending the life of KSC utilization properties. Teams employ unique fire testing capabilities using state-of-the-art cone calorimeter equipment. For low temperature material applications, research is conducted to provide reduced heat transfer, enhanced thermal performance, improved vibration dampening, and storage and transfer capabilities for cryogens.

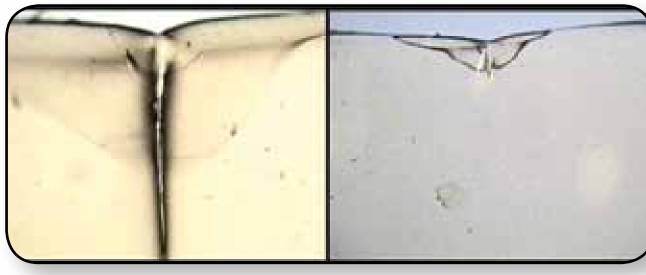
A close-up image of how hydrophobic aerogels are used in composites for low temperature applications at Kennedy Space Center.

Accomplishments:

- Ph.D. level chemists on staff
- Patented a flame retardant additive technology for fire-resistant materials
- Patented two aerogel composite technologies for low-temperature applications
- Received NASA Turning Goals into Reality Award (TGIR) for developing thermal insulation materials with NASA Langley Research Center in Hampton, Va.

1.4.6.3 Smart and Self-Healing Materials and Composites for Detection and Repair Systems

Kennedy Space Center is capable of conducting research and development of “smart” materials and processes to prevent, detect and mitigate damage caused by the environment and during operations. Smart materials and systems research includes wire construction with an integrated miniaturized detection system capable of in-situ integrity monitoring, detection and identification of life cycle system health. Research also includes a permanent manual repair system for damaged wire insulation, and damage tolerant wiring systems with self-healing capabilities. These detection and self-healing technologies are applicable to inflatable habitation for power systems and wall construction.



The success of a self-healing material is depicted in these before, left, and after, right, photos of self-healing capabilities.

Accomplishments:

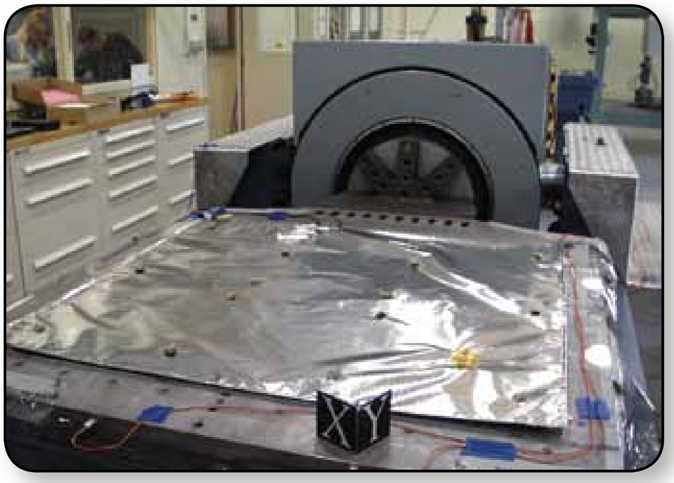
- Patents in self-healing wiring technologies
- Patent applications for in-situ early damage detection of wiring insulation
- Partnering with NAVAIR in wiring technologies certification
- NASA Environmental Energy Award in hydrogen sensing technology
- Member of American Chemical Society (160,000 plus voting members) and Society for the Advancement of Material and Processing Engineering

1.4.6.4 Static Electricity and Dust Mitigation

Kennedy Space Center conducts research and development dedicated to investigations in electrostatics, dust mitigation and surface physics with applications to spaceflight and planetary exploration. KSC scientists conduct laboratory research and development of materials to assist in the detection, mitigation and prevention of electrostatic charge generation on spaceflight hardware and ground support equipment. These experiments are conducted on materials for evaluation of electrostatic discharge properties that may cause ignition and explosions in the presence of flammable materials. Development of dust mitigation technologies has many applications and is aimed at efforts related to lunar and Martian exploration.

Accomplishments:

- Developed technologies and methods for mitigating dust on critical surfaces including spacesuits, solar panels and mechanisms



An electrostatic evaluation is performed on the space shuttle thermal control system multilayer blankets.

- Developed electrodynamic dust shields for dust mitigation on the moon and Mars
- Developed a unique spark incendivity test to characterize materials used in ground operations for the space shuttle and International Space Station
- Provided electrostatic characterization of space shuttle and International Space Station thermal control system blankets
- Provided electrostatic characterization of space shuttle crew escape equipment life preserver and life raft inflators
- Provided electrostatic characterization of space shuttle hydrogen fuel lines
- Performed electrostatic characterization and design modification of the shuttle thrust vector control actuator blankets
- Performed investigation of dust-generated plasma discharges on Mars as a mechanism in the degradation of organic matter
- Provided electrostatics evaluation and design recommendation of the Hubble Space Telescope Imaging Spectrograph

Chapter 1.4.7
Modeling and Simulation Research

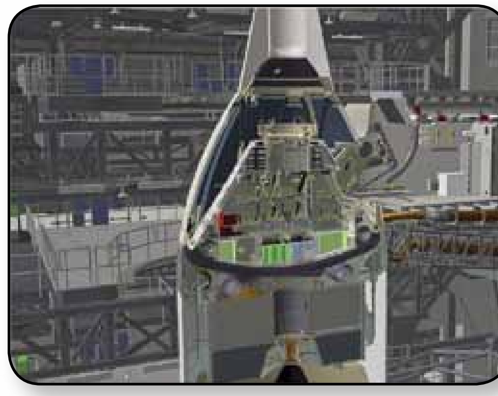
Kennedy Space Center has expertise developing modeling and simulation tools including virtual reality environments and design visualization with human factors impacts.

Chapter 1.4.7 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.4.7 Modeling and Simulation Research

1.4.7.1 Design Visualization Research

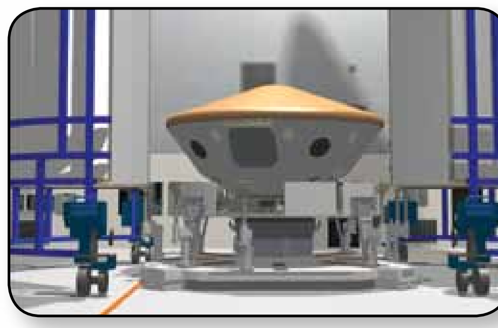
Kennedy Space Center has the capability to provide design visualization research. This research includes analysis and optimization of current and proposed systems, in a planned operational environment and with subject matter expertise, to ensure or enhance system operability, maintainability, sustainability and effectiveness. The research gives the best return on investment (ROI) in Early Lifecycle (Pre/Phase A); however, it also can give significant returns throughout system lifecycle (concept development through test and operations).



A simulated cutaway view shows the Orion spacecraft in the Vehicle Assembly Building.

Accomplishments:

- Partnered with Space Florida in developing models and simulations
- Created models and simulations of Orion operations and Orion recovery



The Mars Science Laboratory (MSL) spacecraft is simulated in the Payload Hazardous Servicing Facility.

Website:

KSC Center Planning and Development Office – Technical Capabilities - Modeling and Simulation http://kscpartnerships.ksc.nasa.gov/techCap/ModelSim.htm

1.4.7.2. Distributed Simulation

Kennedy Space Center has the capability to provide distributed simulation. This is system integration and test of proposed system interfaces (physical and data). The purpose is to ensure, enhance and fully understand system requirements, including interfaces and testing approaches, as well as the overall system of systems. This capability has significant returns throughout system lifecycle (concept development through test and operations).

A distributed integrated simulation involves models of the Kennedy Space Center launch control system, and Johnson Space and Marshall Space Flight centers' flight elements.

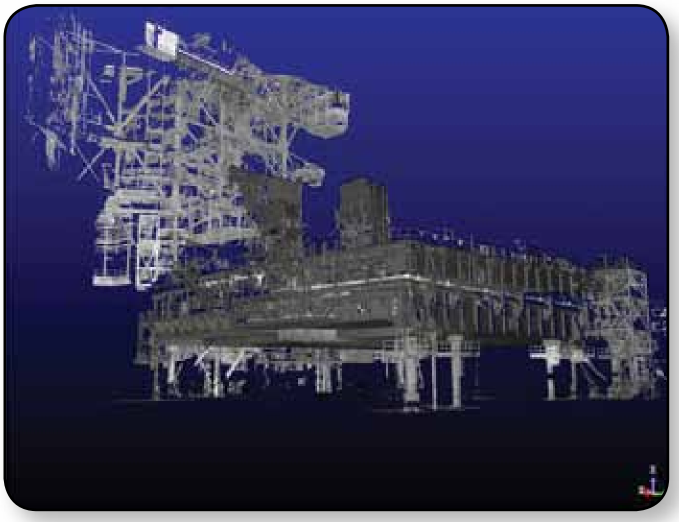
Website:

KSC Center Planning and Development Office – Technical Capabilities - Simulation Systems / Model Development http://kscpartnerships.ksc.nasa.gov/techCap/simSysMod.htm

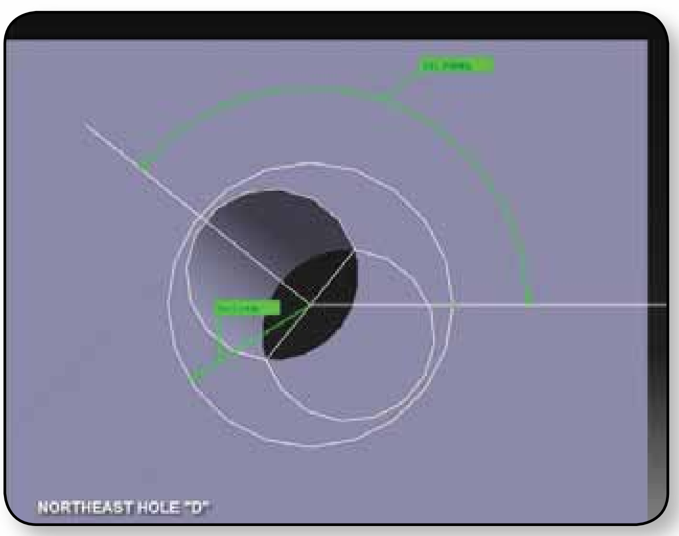
A screen shot shows the distributed simulation setup page in Maestro.

1.4.7.3
Reverse Engineering

Kennedy Space Center has the capability to develop models and other information associated with existing or legacy systems. This allows the systems to be included in design, visualization and operational analysis activities as well as support operational planning and recovery.



A point cloud rendering of Launch Pad 39B was created using a long-range scanner.



The rendered results of a scan with the ATOS scanner (3-D digitizing optical measuring machine) shows the angle of a drilled hole in a floor.

Accomplishments:

- Scanned Space Shuttle Columbia parts to help in its accident investigation by creating a model for use by the investigators

Website:

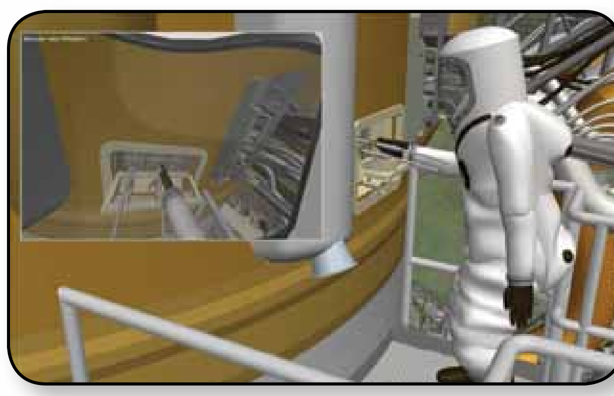
KSC Center Planning and Development Office – Technical Capabilities - Modeling and Simulation
http://kscpartnerships.ksc.nasa.gov/techCap/ModelSim.htm

1.4.7.4
Simulation-Based Human Factors

Kennedy Space Center has the capability to analyze human factors. These factors include sight lines, visibility, reach, motion, joint loading, repetition, calories and any additional impediments caused by safety or life support systems. The analysis is to ensure that proposed processes are as safe and ergonomic as feasible. The capability has significant returns throughout system lifecycle (concept development through test and operations).

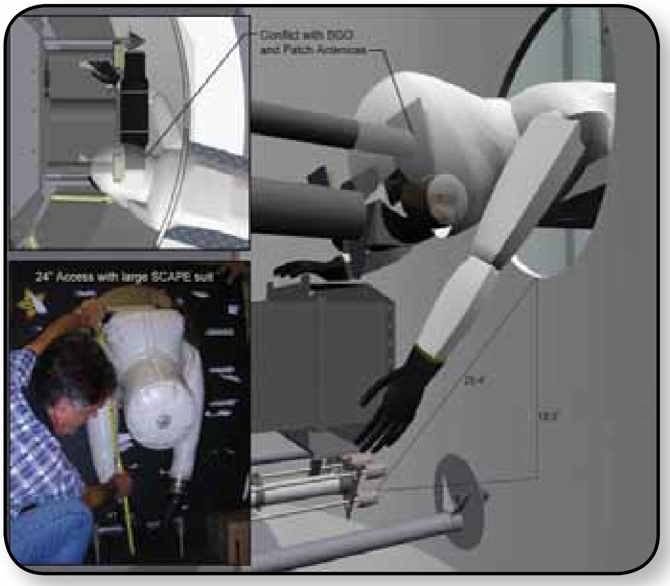
Website:

KSC Center Planning and Development Office – Technical Capabilities - Modeling and Simulation
http://kscpartnerships.ksc.nasa.gov/techCap/ModelSim.htm

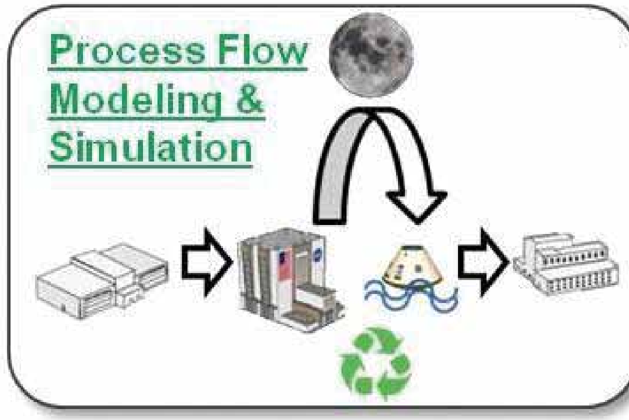


A simulated field of view is shown through a Self-Contained Atmospheric Protective Ensemble (SCAPE) suit helmet.

A simulation shows a human factors operation developed as an input to design hardware. The intent is to improve ease of use of the hardware in the operation.



A simulation shows a human factors operation developed as an input to design hardware. The intent is to improve ease of use of the hardware in the operation.



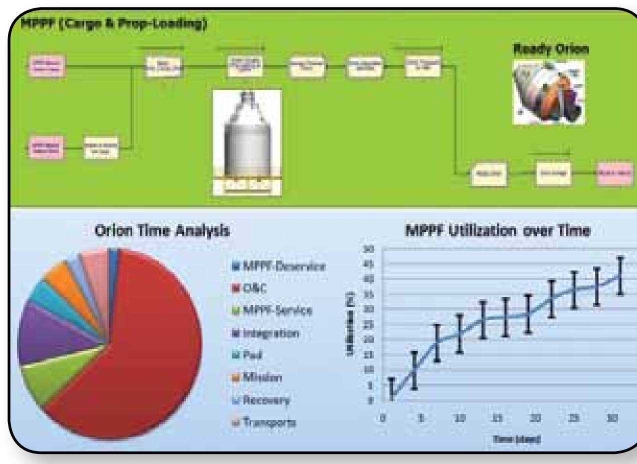
A high-level processing flow of the Orion vehicle from ground processing through vehicle recovery.

1.4.7.5 Supply Chain and Discrete Event Simulation

Kennedy Space Center has the capability to analyze and optimize current and proposed system supply chains. The supply chains include initial suppliers through utilization and disposal, with subject matter expertise. This is to ensure, enhance and fully understand system capacity, maintainability, sustainability and associated sensitivities.

Website:

KSC Center Planning and Development Office – Technical Capabilities - Modeling and Simulation
http://kscpartnerships.ksc.nasa.gov/techCap/ModelSim.htm



The output of a discrete event simulation (DES) analysis for the Orion vehicle and the Multi-Payload Processing Facility is displayed.

Section 1.5
Organizational Planning, Assurance, and Execution

Kennedy Space Center has established considerable expertise in project management, integration, safety and mission assurance and systems engineering techniques for space and space related endeavors. Section 1.5 provides details on the organizational planning, assurance and execution capabilities that KSC has to offer.

Section 1.5 of the Kennedy Resource Encyclopedia includes the following Chapters:

Chapter 1.5.1
Project Management and Integration

Kennedy Space Center has the capability to provide all types of project management and integrations support from advanced mission planning and major systems integration efforts to providing technical expertise in risk management.

Chapter 1.5.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.5.1 Project Management and Integration

1.5.1.1 Advanced Mission Planning

Kennedy Space Center has the capability to provide information on launch service capabilities in support of various agency mission-planning efforts. The Launch Services Program (LSP) mission manager is responsible for this activity. LSP provides expendable launch vehicle (ELV) cost, performance, launch vehicle compatibility and other technical information required to design a spacecraft to be flown on an ELV. LSP participates with NASA Headquarters mission directorates in the development and review of Announcements of Opportunity.

The advance mission planning occurs in the first block of the Launch Services Program mission flow.

Accomplishments:

- Provided advanced mission planning support to more than 100 missions since the inception of the program in 1998

1.5.1.2 Crew Vehicle Project to Ground Operations Integration and Coordination

Kennedy Space Center has the capability to perform overall integration of spacecraft processing and coordinating spacecraft plans with ground operations, including landing and recovery. To support this capability, engineers develop ground systems operations and requirements, and coordinate with the spacecraft design teams to ensure appropriate integration of the two systems during the design phase.

Kennedy Space Center teams planned and coordinated a landing and recovery demonstration of the Orion crew module by utilizing Department of Defense resources.

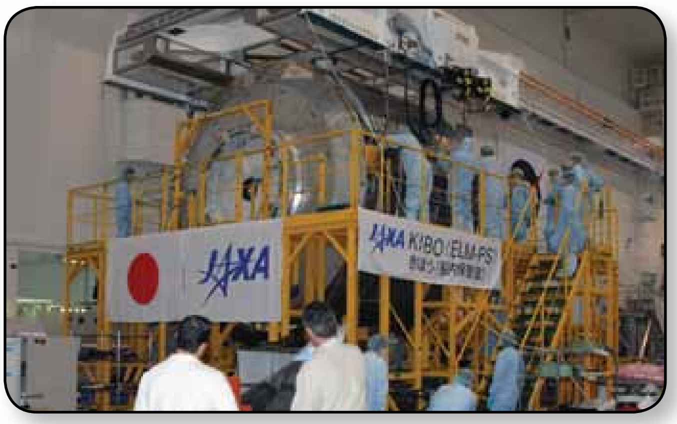
Accomplishments:

- Increased operations efficiency by incorporating offline hazardous servicing and single piece Orion installation
- Improved Orion design features (e.g., servicing panel location, hatch and landing and recovery aids) with respect to ground operations by collaborating with flight hardware design teams

1.5.1.3 Customer Support and Launch Services Support Management

Kennedy Space Center has the capability to provide customer support and launch services management. An experienced team can serve as liaison to coordinate services and equipment necessary for a customer to complete a successful mission. The team can also utilize their technical knowledge of payload processing and integration to produce an efficient and effective payload processing flow. This knowledge is critical to customers during the advanced planning phase of payload development.

The team understands KSC's International Space Station (ISS) interface capabilities, ISS testing requirements, and knowledge of KSC resources and how they can be applied to support payload processing. With knowledge of ISS requirements, specific payload requirements and KSC resources, the team is able to coordinate services and equipment related to payload processing, pad operations, and fluid and gas servicing. Specifically, the team may provide fluids experts and meet with the customer for details on the type, amount, method and interface of the hardware that needs to be serviced.



In the Space Station Processing Facility, workers attach a crane to the Experiment Logistics Module Pressurized Section, or ELM-PS, of the Japanese Experiment Module, called Kibo, so that Japan Aerospace Exploration Agency workers can begin processing work.

International partners install the Passive Attach System (PAS) to the Alpha Magnetic Spectrometer (AMS). The scheduling of resources to support multiple customers' needs is carefully coordinated by Kennedy Space Center and spacecraft customer support personnel.

Accomplishments:

- Provided support to hundreds of payload developers for on-orbit scientific research, including:
    - All pressurized and unpressurized experiments aboard Spacelab missions and the International Space Station
    - Numerous other deployable payloads, including Galileo, Magellan and the Hubble Space Telescope
- Provided support to international partners' ISS assembly missions:
    - Japan Aerospace Exploration Agency's (JAXA's) Japanese Experiment Module (JEM)
    - The Canadian Space Agency's (CSA's) Canadarm
    - The European Space Agency's (ESA's) Columbus module, and Nodes 2 and 3
    - The Russian Space Agency's (Roscosmos') docking module

1.5.1.4 Information Technology Project Management and Systems Engineering

Kennedy Space Center has the capability to provide external support for management of information technology (IT) projects and services. The group supports project development, analysis, alternatives investigation and services acquisition.

1.5.1.5 Integration of Spacecraft Requirements and Ground System Services

Kennedy Space Center has the capability to provide launch site integration. The launch site integration manager (LSIM) for a mission serves as the spacecraft customer advocate to the Mission Integration Team (MIT) and shares spacecraft impacts to mission integration with the MIT.

The LSIM supports early planning meetings and spacecraft reviews with the customer, assists the customer in defining launch site requirements and documents them in the Launch Site Support Plan (LSSP). The LSIM ensures that the customer meets launch site requirements and provides the necessary supporting documentation. The LSIM seeks to continually make improvements to launch site processing for the benefit of the customer.

The LSIM assigns facilities and resources, and provides launch site budget projections to support the expendable launch vehicle (ELV) manifest. The LSIM coordinates with the Eastern Range to ensure spacecraft test and launch support. The LSIM ensures the integration of spacecraft activities into launch vehicle schedules, and supports dress rehearsals and launch countdown.

The encapsulated Mars Reconnaissance Orbiter (MRO) leaves the Payload Hazardous Servicing Facility on its move to Launch Complex 41 at Cape Canaveral Air Force Station.

The LSIM co-chairs launch management coordination meetings, and coordinates input from the customer, MIT, and the range. The LSIM coordinates the KSC planning effort, serving as the interface to the customer to receive, track, negotiate and document the commitments for KSC to fulfill the customer's ground processing requirements. Once the customer is on-site, the LSIM ensures the launch site integration team implements the requirements. The LSIM, customer processing support manager (CPSM), facility manager, and other support personnel, attend the customer's daily spacecraft processing meetings to gain an understanding of the plans and requirements.

During coordination meetings, the customer discusses the support required for upcoming activities. The LSIM and CPSM provide the customer with information about other center activities that might impact operations (e.g., nearby facility closures, controlled burns, resource conflicts, emergency preparedness (hurricane) protective measures, etc.). The LSIM and CPSM will serve as the customer's advocates to resolve these issues and minimize the impact on the processing schedule.

The LSIM also provides the customer with insight into NASA ELV launch operations and preparatory activities. The LSIM works closely with the launch services contractor (LSC) to accommodate coordination between the processing activities of the launch vehicle and the spacecraft. When the spacecraft moves to the launch pad, the LSIM continues to support the implementation of the customer's requirements. The LSIM works launch day management plans with the customer and KSC management, scheduling the reviews and preparing briefings.

The LSIM maintains agreements and policies with the 30th Space Wing to provide users with operational services at Vandenberg Air Force Base (VAFB) in California. Services include but are not limited to hazardous operations support, propellant loading related support and radio frequency scheduling.

Accomplishments:

- Provided launch base support to more than 80 spacecraft since the inception of the program in 1998

1.5.1.6 Launch Site Integration Manager

Kennedy Space Center has experience working with flight experiment customers to develop requirements for launch site processing of hardware, developing documentation for experiment customer requirements and agreements, and acting as liaison during experiment processing at KSC.

Accomplishments:

- Acted as launch site integration Manager for many flight experiments and helped process up to and including launch. Examples include European Proximity Sensor (EPS), the Autonomous Extravehicular Robotic Camera (AERcam) Sprint, the Trajectory Control Sensor (TCS), Orbiter Space Vision (OSVS), and the Laser Dynamic Range Indicator (LDRI).

1.5.1.7 Launch Vehicle to Ground Operations Integration and Coordination

Kennedy Space Center is capable of providing coordination and integration of ground operations with launch vehicle operations to ensure that ground operations considerations are included during the design of both systems' processes. To ensure effective integration of the two systems, KSC teams facilitate and ensure that ground operations design is included and engaged with the flight hardware designs. Collaboration between the two teams ensures design efficiencies processing design and requirements development.

Accomplishments:

- Developed and reviewed the Constellation Program Ground Operations Project (GOP) planning document
- Successfully integrated operational time line for GOP, Ares I and Ares V
- Collaborated with Ares project on selection of one aft skirt configuration for Ares I
- Reduced number of first stage ground support umbilicals from four to one for Constellation Program spacecraft
- Reduced the Ares operations time line from 100 plus hours to 16 hours
- Supported Ares aft skirt thermal shield design and development
- Coordinated with Ares designers to establish hydrazine and propellant loading requirements, which optimized ground processing procedures

1.5.1.8 Manage Launch Services for Expendable Launch Vehicle Missions

Kennedy Space Center has the capability to manage all activities related to the integration and launch of spacecraft aboard expendable launch vehicles (ELV). The Launch Services Program (LSP) mission manager for the mission is responsible for this activity. The LSP mission manager leads the multidisciplined mission integration team (LSP, spacecraft and launch vehicle provider) in the execution of integration activities (including mission unique design and analysis), launch site processing and launch. The LSP mission manager is the primary interface to the spacecraft program and project. The LSP mission manager represents the LSP to the customer and stakeholder community by providing information on capabilities and services as well as current programmatic and fleet status, issues and concerns for all missions. The LSP mission manager also provides project management expertise to LSP special studies and projects.

Mission management is executed through established LSP processes, contracts and guidelines as specified in NASA Policy Directives. The LSP Business Operating Success Strategies (BOSS) provide project management guidelines for mission management execution within established LSP processes and parameters.

Accomplishments:

- Managed the successful integration and launch of 63 missions (one launch vehicle failure)

Website

Launch Services Program Website
http://lsp.ksc.nasa.gov/

Engine ignition lifts the United Launch Alliance Atlas V rocket carrying NASA's Solar Dynamics Observatory off Launch Complex 41 on Cape Canaveral Air Force Station.

1.5.1.9
Mission Processing Team (MPT)

Kennedy Space Center has the technical capability to manage all ground processing activities for payloads. The Mission Processing Team (MPT) provides the overall leadership for a mission by ensuring that the critical sub teams are represented within the MPT. This leadership ensures that payload processing is completed on time, within budget and in accordance with the launch vehicle schedule.

The MPT ensures that all official technical and functional requirements set forth by the payload customer are met by facilitating multidisciplinary systems integration. At a minimum, these multidisciplinary systems include logistics, configuration management, safety, testing, and teams of each required engineering discipline. The MPT organizes collaboration of these teams to ensure that engineering products are properly incorporated into payload processing activities while simultaneously managing schedules and budget. The MPT also coordinates communication and expertise between the payload customer, design center, launch vehicle provider, program management and processing teams.

1.5.1.10
Risk Management

Kennedy Space Center can provide risk management expertise and services to facilitate the implementation of risk management strategies and processes. Risk management programs identify, communicate and resolve potential issues arising within and across programs. KSC has developed considerable expertise in the development and usage of risk management processes. Additionally, KSC can provide an Integrated Risk Management Application (IRMA), which tracks risk management data.

Accomplishments:

- Provided effective coordination of top risks and mitigations with the Space Shuttle Program, Safety and Mission Assurance, other affected organizations and KSC Center Risk Management.

1.5.1.11
Vehicle Management

Kennedy Space Center has experience in the oversight, management and coordination of every phase of launch vehicle processing. This includes integrating with all disciplines and systems to ensure safety, manifest and supportability is maintained.

Vehicle managers track and manage all ground processing milestones, objectives, threats and contingency plans and assist flow directors in managing overall operation integration, flow planning and scheduling, workmanship and contractor adherence to work area rules.

The vehicle managers also coordinate postflight ground system support for resolution of vehicle anomalous conditions that occur on orbit. Vehicle managers can assist and act on behalf of facility integration managers in order to ensure availability of processing facilities, including integration of modifications and outages.

Chapter 1.5.2
Safety and Mission Assurance

Kennedy Space Center has technical expertise to provide safety and mission assurance support in the independent assessment of the safety, reliability, maintainability, and quality of systems and operations.

Chapter 1.5.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

Chapter 1.5.2 (Continued)

1.5.2.17 Range Safety Analysis

1.5.2.18 Reliability, Maintainability and Availability Modeling and Predictions

1.5.2.19 Root Cause and Data Analysis, and Statistics Related to Quality

1.5.2.20 Safety Support to Ground Support Equipment Certification

1.5.2.21 Software Independent Verification and Validation Integration

1.5.2.22 Software Safety, Quality and Reliability

1.5.2.23 Software Verification and Validation

1.5.2.24 Tailoring Range Safety Requirements for Specific Programs

1.5.2 Safety and Mission Assurance

1.5.2.1 Certificate of Expendable Launch Vehicle Payload Safety Compliance

Kennedy Space Center has experience reviewing payload safety data packages to ensure payload safety requirements are satisfactorily accomplished or implemented with equivalent levels of safety in order to provide concurrence to the certificate of ELV payload safety compliance. Successful completion of the review results in the issuance of the certificate, which is required prior to processing.

1.5.2.2 Compliance Evaluations of Safety Requirements

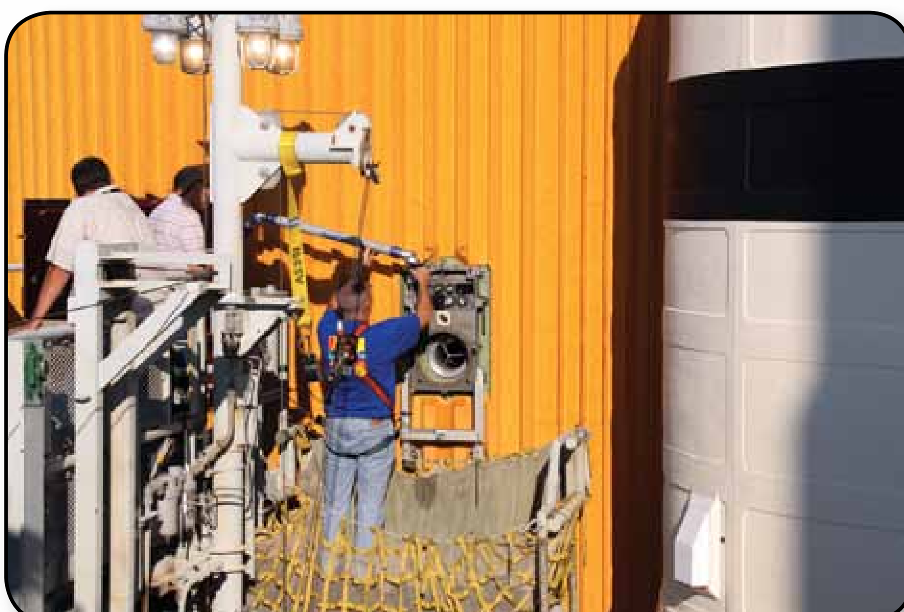
Kennedy Space Center has experience performing safety surveillance and periodic inspections to assure compliance with NASA safety policies and to assess the effectiveness of NASA safety activities as required by national consensus standards, Federal, state, and local regulations and NASA policy.

Examples include:

- Performing assessments of contractor safety programs to ensure compliance with the Occupational Safety and Health Administration (OSHA), NASA, KSC, safety requirements and specific contract safety provisions. Compliance with safety requirements can be assured through daily, weekly, monthly, and annual reporting requirements, process surveillance, record audits, and periodic review of safety requirements documentation.
- Providing assurance that contracted construction projects are compliant with 29 CFR 1926/ Construction Safety. Compliance evaluation entails pre-contract involvement in determining project hazards, review of site-specific safety plans, attendance at pre-work meetings, and site inspections.

1.5.2.3 Criticality Assessment

Kennedy Space Center has experience performing formalized reviews of a system's functions to determine potential risks and establish the requirements for further safety evaluations. Functional Criticality Assessments categorize the effect of loss of all redundancy (like and unlike) for a given function, and are typically the assessments completed at KSC to establish failure tolerance requirements and determine if more in-depth safety and reliability analysis is required.



Work is performed on the ground umbilical carrier plate, which has been identified as part of a critical system.

1.5.2.4
Define and Implement Processes Controls and Surveillance Points

Kennedy Space Center has experience defining processing quality checkpoints in order to identify nonconformities in hardware, production materials and processes. Quality checks are defined during fabrication and processing so that nonconformities can be corrected with minimum impact. Quality checks are used to ensure drawing requirements are met during fabrication and to ensure design testing and acceptance objectives are being satisfied.

KSC quality engineers and quality program specialists can conduct process evaluations and analyze the resultant data to determine the stability and accuracy of processes and related controls. Evaluation subjects include flight hardware and related support equipment.

1.5.2.5
Develop and Maintain Risk Management Program for Major Programs and Projects

Kennedy Space Center has experience in developing Risk Management Programs for major programs and local projects. This includes developing program documentation, establishing risk management panels, identifying panel membership, and developing risk approval and acceptance processes.

Major elements of risk management programs are:

- Establishment of requirements applicable to all levels of the organization
- Providing a framework that integrates the Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM) processes at all levels
- Establishing the roles, responsibilities and authority to execute the defined requirements
- Building on the principle that program and project requirements should be directly coupled to strategic goals, and applying this principle to risk management processes within all organizations at a level of rigor commensurate with the stakes and complexity of the decision situation being addressed

1.5.2.6
Electrical, Electronic, and Electromechanical Parts Control and Management

Kennedy Space Center is capable of assisting flight programs and projects with selecting and acquiring the best electronic parts for the applications. Considerations for parts selection can include resources constraints, risk tolerance and schedule.

Parts are carefully selected for the highest levels of quality and reliability.

The objectives are met by (1) establishing guidelines for selection, procurement screening and application of electronic, electrical and electromechanical parts; (2) reviewing performance relative to the program and project requirements; and (3) generating, maintaining and controlling an approved parts lists, as required.

1.5.2.7
Expendable Launch Vehicle Safety Certification

Kennedy Space Center has experience in the assessment of the launch service vehicle providers program safety document plan and documentation to verify that design and operation requirements are robust and in compliance with applicable safety regulations and methodologies. For each mission, KSC reviews the expendable launch vehicle integrated Missile System Prelaunch Safety Data Package to ensure the launch provider complies with applicable safety requirements.

1.5.2.8 Failure Modes and Effects Analysis

Kennedy Space Center is capable of performing Failure Modes and Effects Analyses (FMEA). FMEA is a method of analysis that systematically reviews all components in a system to determine potential causes of failure, the downstream effects of the failure and the consequence of failures. FMEA identifies single points of failure and critical items, evaluates redundant configurations, and helps identify and evaluate controls. FMEA can be used as a tool to identify and communicate residual risks associated with a given design.

Accomplishments:

- Completed Failure Modes and Effects Analysis on Constellation ground support equipment designs to prevent single failure points in critical systems.
- Completed Failure Modes and Effects Analysis on space shuttle ground support equipment designs and modifications to prevent single failure points in critical systems.

1.5.2.9 Fault Tree Analysis

Kennedy Space Center is capable of performing Fault Tree Analysis (FTA). FTA is used to analyze a system in the context of its environment and operation to identify all the ways in which an undesired event can occur. FTA is completed by decomposing a system failure event into sub events that may cause the failure event to occur. This technique employs Boolean concepts to identify and relate the events in the fault tree.

In addition to showing the logical relationships of failure events to a defined top event, failure probabilities can be applied (often derived from a reliability prediction) or techniques such as cut set methods may be employed to evaluate system failure probability. FTA also may be used in support of hazard analysis development.

Accomplishments:

- Completed Fault Tree Analysis on ground support equipment to ensure that all events that could cause loss of life or vehicle have sufficient hazard controls.

1.5.2.10 Independent Risk Management

Kennedy Space Center has experience providing final acceptance of risk packages performed by independent senior risk managers. The multiple safety panels are an independent approval authority for the KSC risk products developed in accordance with program or project requirements. Risks identified to these panels are typically in the format of critical items or hazard reports.

1.5.2.11 Independent Safety Assessment

Kennedy Space Center has the capability to perform independent assessments for internal and external customers. KSC has experience investigating a wide variety of subjects from very technical issues to systemic processes.

Some information and products may be restricted, based on the sensitivity of the issue, while independent assessments are completed. The independent assessment (IA) team works with the Inspector General on some assessments, but does not assess criminal activity.

An assessment was performed to evaluate the risks of an electrostatic discharge from ungrounded metallic thermal blankets located in the aft compartment of the orbiter.

The bright markings on the base of the bullet are aluminum deposits from the window casing indicating that the bullet impacted tail first and sideways. This evidence indicates that the bullet was tumbling as it would after a ricochet.

The IA team provides nonbinding recommendations for improvement. Results can be presented in out-briefings and final reports. The customer may choose to implement, modify or ignore the recommendations.

Accomplishments:

- Confirmed an Emergency Response Team incident report after a stray bullet impacted a control tower window at the Shuttle Landing Facility. Interrogations, energy analysis, and material science lab evidence were used to confirm the report that the errant bullet was the result of a ricochet.
- Performed an assessment to review the implementation of shuttle requirements to verify all Government Mandatory Inspection Points (GMIPs). The original proposed approach would have required the addition of approximately 50 personnel. The assessment was able to provide an approach that reduced the personnel requirements to approximately 3 with an increase in risk of only 1.5 in a million.
- Developed a risk assessment of helicopter operations after several operational incidents had occurred. The assessment suggested several procedural improvements to decrease the risks.
- Completed an assessment of lifting operations wherein a contractor supervisor made implied threats against further employment after a subordinate employee had reported a safety violation.

1.5.2.12 Mishap Investigation

Kennedy Space Center has the capability to provide initial incident response to secure mishap scenes and establish an Investigating Authority. KSC has the capability to perform in-depth investigative analysis of mishaps, accidents or incidents. This includes data collection, failure analysis, root cause analysis, documentation, corrective action identification and implementation. KSC also can provide endorsement of the report prior to public release.

1.5.2.13 Problem Reporting and Corrective Action

Kennedy Space Center has decades of experience ensuring corrective actions are addressed and taken to an acceptable closure. This is accomplished by reviewing corrective action reports, participating in preventative and corrective action board meetings, issuing corrective action requests, reviewing contractor's functional failure reports, consulting with subject matter experts, assessing the functional failure reports, and tracking corrective actions as they move through the management systems.

1.5.2.14 Qualitative Hazard Analysis Systems and Operations

Kennedy Space Center has extensive experience implementing the hazard analysis approach for ground processing equipment, facilities, launch vehicles, payloads and associated operations. KSC has experience using a variety of analysis techniques to provide insight into potential hazards, and various levels of detail depending on risk levels. These analyses are used to identify hazard causes, propose mitigations and provide a management overview of residual risks.

Accomplishments:

- Completed operating and support hazard analyses for the ground processing and launch of Ares I-X
- Completed hazard analyses including fault trees and failure modes and effects analyses for the development and sustaining engineering of space shuttle and Constellation ground support equipment
- Completed an integrated hazard analysis of the Constellation Ground Operations Project.

1.5.2.15 Quality Assurance Management and Planning

Kennedy Space Center is capable of developing Quality Planning and Requirements Documents (QPRD) to establish inspection points for critical hardware. KSC develops and plans surveillance to ensure conformance to these requirements and to manage risks associated with ground support equipment, payload and flight vehicle noncompliances.

1.5.2.16 Quality Assurance Surveillance

Kennedy Space Center is capable of performing quality surveillance at manufacturing, supplier and launch sites. Surveillance can be performed before, during, and after industrial and service applications to assure the quality level of the product or service is within acceptable design standards. The data acquired as a result of surveillance is evaluated by quality engineers in order to determine the level of quality needed in the future.

Accomplishments:

- Successfully planned, coordinated and performed the inspection of the application of EMI copper wrap over pyrotechnic cables of the Russian orbiter docking mechanism
- Performed wiring inspections of all orbiters
- Created tools for hardware surveillance analysis

A technician inspects the inner core of a solid rocket motor.

1.5.2.17 Range Safety Analysis

Kennedy Space Center has experience performing range safety analysis. Range safety analysis incorporates the elements of risk management, risk assessment, risk mitigation and containment. The range safety risk management process includes assessments of risks to the public, work force and property.

The range safety risk management process incorporates the requirements of NPR 8715.5A, Range Flight Safety Program, as well as requirements for the specific range, launch site, or landing site conducting the range operations. A range safety analysis assesses all potential hazards (launch area and downrange) for input to the risk management process.

For launch, these requirements apply to all hazards in the launch area and to debris hazards up to orbital insertion. For an entry operation, these requirements apply to any debris that might be generated, intentionally or not, after the deorbit burn or sample return capsule release. Any potential orbital debris is subject to the requirements of NASA Procedural Requirements for Limiting Orbital Debris.

In the case of a catastrophic failure of a vehicle in flight, the fire, explosion, reactivity and safety hazards of propulsion and power fluids (e.g., hydrazine, nitrogen tetroxide, solid rocket motor propellants, and their combustion or decomposition products) may be released. NASA Range Safety assesses the risk due to these toxic commodities and takes appropriate mitigation actions to protect the public and KSC work force during certain meteorological conditions that may allow these materials to drift over populated areas at levels greater than emergency health standards permit.

NASA Range Safety also assesses the risks to the public and the KSC work force due to any distant focusing overpressure (e.g., potential for broken windows and related casualties) from potential explosions during vehicle operations for input to the risk management process.

Accomplishments:

- Performed debris risk analyses for the Department of Homeland Security Civil Border Patrol Project called “Guardian” which is a Predator flight vehicle and its support ground stations
- Performed debris risk analyses for the Globalhawk unmanned aerial system being flown from NASA’s

Range Safety terminated an errant Delta II rocket on 1/17/1997 to protect the life, health, and property of the surrounding public.

Dryden Flight Research Center in Edwards, Calif., to study developing hurricanes.

- Coordinated with 45th Space Wing all KSC launches and ELV launches with the potential to cause harm to the KSC population and/or high value assets.

1.5.2.18 Reliability, Maintainability and Availability Modeling and Predictions

Kennedy Space Center has experience using design and failure rate information to develop simulation and stochastic models to aid in reliability allocation, prediction, and availability to evaluate competing design options, to assess operational constraints/costs, evaluate repair strategies, sparing and other logistical attributes, and to verify design reliability and maintainability.

Depending on the model employed and the phase of the life cycle, predictions may be used to support design trade-offs, assist in allocation of reliability or maintainability to subsystems or components, evaluate potential or actual reliability growth, or evaluate maintenance alternatives. Predictive modeling techniques include recognition of uncertainty that is inherent with any prediction technique.

Simulation and modeling can be used to divide the overall system reliability into appropriate subsystems or line replaceable unit (LRU) reliability or maintainability requirements. The decomposition and requirement allocation process includes consideration of factors such as complexity, existing experience, risk, design alternatives, functional time lines, and functional and physical requirements.

The use of reliability, maintainability and availability modeling and predictions ensures that reliability and maintainability requirements are identified early in the program and are included in the programmatic life cycle. Requirements influencing the design are translated into specific goals in the design process.

1.5.2.19 Root Cause and Data Analysis, and Statistics Related to Quality

Kennedy Space Center is capable of using a number of tools to investigate problems, determine root causes, and verify that corresponding corrective actions are effective. Corrective action effectiveness can be monitored, trended and analyzed through probability determinations and analysis of data using statistical process control techniques. Control effectiveness data can be generated from surveillance audits, reviews and inspections.

1.5.2.20 Safety Support to Ground Support Equipment Certification

Kennedy Space Center has experience reviewing equipment documentation, drawings and testing results to verify system as-built configurations and functionality. This includes operating safety and reliability.

To accomplish this task, KSC:

- Supports design teams and reviews to identify hazards and attempt to remove or mitigate identified hazards through design changes.
- Ensures ground support equipment is safe for personnel to operate, is within certification period and is properly marked.
- Identifies the need for special training and personnel certifications to ensure safe performance of the task.
- Identifies operating hazards of ground support equipment and the need for area clears if required for safe operation.

1.5.2.21 Software Independent Verification and Validation Integration

Kennedy Space Center has decades of experience providing the integration of the Fairmont, W.Va., Integration, Verification, and Validation (IV&V) Facility with software projects. This facility does financial and management independent verification and validation on Class A safety-critical software projects.

Accomplishments:

- IV&V was selected for the Launch Control System (LCS) project and is currently doing independent assessments on safety-critical computer software configuration items.

1.5.2.22 Software Safety, Quality and Reliability

Kennedy Space Center has experience ensuring that software safety requirements are clearly identified, documented, traced and controlled throughout the lifecycle. KSC can perform analysis of the consistency, completeness, correctness and testability of software safety requirements. KSC is capable of testing software safety critical components on actual hardware to ensure that the safety requirements were sufficiently implemented and that applicable controls function as intended.

For quality control, KSC has experience using quality checks to make sure the project follows the proper processes and procedures. KSC Quality Engineering can complete software analysis, audits and reviews on requirements, designs and codes.

KSC has experience developing technical requirements and design solutions that build reliability into systems through fault tolerance, failure tolerance, fault detection, isolation and recovery, error handling and redundancy. Measuring and analyzing defects in the software products during development activities can identify and address possible problem areas in the software.

1.5.2.23 Software Verification and Validation

Kennedy Space Center has the capability to perform software verification and validation. Validation is the process of evaluating software throughout its development process to ensure compliance with software requirements. User acceptance tests are completed on the targets or duplicate hardware and operating systems. This process ensures that the right products are built.

Verification is the process of determining whether or not the products of a given phase of the software development life cycle fulfill the requirements established during the previous phase. This process ensures that the product is built correctly.

Accomplishments:

- All KSC programs (shuttle, IIS, CxP) have software projects which are undergoing verification and validation activities such as assessments, audits and reviews

1.5.2.24 Tailoring Range Safety Requirements for Specific Programs

Kennedy Space Center has experience tailoring range safety requirements. The overall intent of the range safety requirements tailoring process is to ensure appropriate oversight of agency requirements while providing the centers and program managers with the authority and flexibility needed to accomplish their tasks.

Tailoring is defined as the process where the range user and the authorities responsible for the range safety requirements review each requirement and jointly document whether the requirement is applicable to the range user's operations and, if it is applicable, document whether the range user will meet the requirement as written or achieve an equivalent level of safety through an acceptable alternative.

NASA actively participates with the national range safety community in order to effectively conduct its range operations. It is necessary for the NASA range safety tailoring process to be consistent with the approach used at the national ranges. Range safety tailoring may include an approximately equal level of safety determinations.

Accomplishments:

- Developed a tailored set of Ares I-X range safety requirements in coordination with NASA and the 45th Space Wing
- Developed a tailored set of Ares I range safety requirements with NASA and 45th Space Wing
- Developed a tailored set of generic range safety requirements for NASA ELV payloads

Chapter 1.5.3 Systems Engineering

Kennedy Space Center has technical expertise in the systems engineering approach for the design, realization, technical management, operations, and retirement of systems including requirements and design solution definition, technical planning, assessment and control processes, and product realization, integration and evaluation processes.

Chapter 1.5.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.5.3 Systems Engineering

1.5.3.1 Architecture Planning

Kennedy Space Center is capable of architecture management and planning, including defining, developing, and managing architectural baselines for ground systems, ground processing and launch operations.

Kennedy Space Center has the ability to plan architectural and operational concepts for the vehicles and ground equipment of the future.

As launch vehicle and spacecraft designs mature, and as launches are manifested, potential changes to ground systems are assessed. Through experience, KSC teams have developed a unique knowledge set that enhances the ability to integrate and assess impacts to spacecraft and ground system processes as they occur. By implementing and managing technical architecture baselines and utilizing design visualizations, KSC can evaluate and coordinate alternate architectures that result from changing requirements. Through these activities, KSC architecture management and planning is capable of managing and integrating information necessary for convergence on architectural issues and decisions.

Accomplishments:

- Defined a technical baseline for Constellation Program ground systems architecture involving facilities, ground support equipment (GSE), interfaces and launch operations
- Completed all trade studies related to Constellation Program and Ground Operations Project initial operational capabilities (IOC)
- Completed initial trade studies to define Human Lunar Return (HLR) ground systems point of departure
- Completed 21st century Space Launch Complex Architecture Refinement Cycle 2.0, which defined the high-level architecture and infrastructure as a launch site point of departure
- Provided data to Human Exploration Framework Team (HEFT) related to architecture assumptions, costs, risks and schedules

1.5.3.2 Post Launch Facility and Systems Anomaly Process

Kennedy Space Center has the capability to perform postlaunch safing and securing of the launch facility including real-time assessment of system damage and debris liberation. Real-time assessments are performed after each launch using system teams to assess facility and system performance including postlaunch system conditions.

A view of the flame trench on Launch Pad 39A at Kennedy Space Center, shows where damage occurred during launch of space shuttle Discovery on the STS-124 mission, May 31, 2008.

KSC utilizes a systems engineering approach to postlaunch assessments and documentation of anomalies. All postlaunch facility and system anomaly inputs are reviewed and documented to allow for fast identification and resolution of systemic problems that require in-depth review, repair or modification prior to the next mission.

Accomplishments:

- KSC has performed more than 130 integrated flight anomaly reviews comprised of numerous individual assessments
- All of this review and data collection yielded vast improvements within systems, components and processes

1.5.3.3 Post-launch Recovery and Retrieval

Kennedy Space Center has the capability to manage and integrate the operations and requirements of landing and recovery. Landing operations can take place at the Shuttle Landing Facility, which is one of the largest runways in the country, and can provide shelter, storage and privacy to users. The landing and recovery teams lso are accustomed to performing the same functions and operations at alternate sites such as Edwards Air Force Base in California. Postlanding processing includes verifying that all landing requirements are accomplished and the flight elements are in the correct configuration for transport. This includes many operations, such as verifying no hazardous commodities are present that would prevent personnel from approaching the vehicle, supplying portable purge air to the vehicle while still on the runway, inspecting the vehicle to verify it is safe to transport, and towing the vehicle to the processing facility.

Members of the 920th Rescue Wing secure a flotation collar around a mock-up of the Orion crew exploration vehicle at the Trident Basin at Port Canaveral in Florida.

The Freedom Star solid rocket booster recovery ship returns to Kennedy Space Center with a booster in tow.

Shuttle Endeavour is towed toward an orbiter processing facility.

For recovery of solid rocket boosters, KSC is capable of providing two recovery ships to rendezvous with the boosters after launch. Divers plug the motors and fill the boosters with air to float them horizontally for towing back to KSC.

Accomplishments:

- KSC has supported and performed more than 50 vehicle recoveries at Dryden Flight Research Center in Edwards, Calif.
- KSC has supported and performed more than 130 vehicle recoveries at the Shuttle Landing Facility
- KSC has supported the ocean retrieval of more than 260 solid rocket boosters and one flight test vehicle first stage

1.5.3.4 Requirements Development, Integration and Verification

KSC has the capability to write, integrate, evaluate and approve requirements and requirement changes. KSC's expertise in requirements development includes the development of ground and flight system requirements for pre-launch processing, launch, landing, recovery, and post-mission processing derived from operational concepts and baselined system designs.

A large part of requirements development is to manage the change traffic associated with evolving designs as projects mature the system designs. This involves the coordination and assessment of proposed requirement changes for impacts against project baselines.

KSC has experience developing and managing the process for verifying and certifying that requirements are met. These activities include the development of the overall strategy to satisfy all of the design requirements. The strategy includes preparation of lower level verification and validation plans, test procedures and configurations, based on early verification and validation events, building into large scale systems integration testing, across the project. This activity requires integration of tasks associated with the subsystem design and development teams and the operations organizations for the system.

Additionally KSC has expertise in the execution of verification of multi-system baselined configuration requirements by the implementing systems, this is managed through a review of the accomplished work documents prior to the key processing milestones that are identified as constraints for completion of work. Closed-loop verification includes resolution of any nonconformances experienced during implementation of the baselined requirements and as-built configurations.

For International Space Station (ISS) payloads, KSC personnel have in-depth knowledge of ISS, various launch vehicles, associated facilities and ground support equipment. KSC has the ability to verify that a particular design fits within those constraints. KSC can ensure the technical and operational needs of the payload customer and stakeholders are met. Payloads have two basic sets of requirements: requirements for the payload to function properly and achieve its purpose (i.e., objectives), and requirements for the payload to interface successfully with its launch vehicle and spacecraft (i.e., constraints). This extends into processing activities in the form of test, maintenance and support requirements. For example, the processing activities may require liquid helium, which involves special procurement and handling. KSC can track all of the objectives and constraints in order to ensure mission success.

Accomplishments:

- Provided management and integration of all Constellation Program Ground Operations Project (GOP) requirements
- Developed closedloop verification and validation processes and strategies to address all Constellation Ground Operations Project requirements

1.5.3.5 Systems Engineering Processes and Tools

Kennedy Space Center has the capability to develop, coordinate and manage a technical roadmap to successfully lead projects through all required technical milestones based on the applicable NASA Procedural Requirements (NPRs) and ensure operational readiness. The roadmap requires developing and integrating systems engineering processes by developing a Systems Engineering and Management Plan (SEMP). The SEMP describes the technical approaches for organizing people, products and processes to define and develop the facilities, facility infrastructure ground support equipment, and software to accomplish launch site ground processing, integrated testing, logistics services and launch services for flight systems and cargo.

Engineering teams interface with configuration management (CM) for developing System Engineering and Integration (SE&I) processes and products (e.g., product structure, readiness review processes), integration of modeling and simulation approaches, implementation of technical standards, boards and panel structures and management of tools among many other activities to efficiently manage the project. SE&I provides support to various activities, control plans, logistics, and integrating testing of project components to ensure consistent implementation of systems engineering processes and tools for an engineering project.

Accomplishments:

- Provided management of Constellation Ground Operations Project (GOP) requirements using requirements management software
- Developed and managed the technical roadmap for the GOP readiness reviews from concept to operational turnover

- Led and coordinated all aspects of GOP by interfacing with all other Constellation projects
- Successfully completed the GOP Preliminary Design Review (PDR)

1.5.3.6 Verification Management

Kennedy Space Center has the capability to provide verification management, a key component of the Certificate of Flight Readiness (CoFR) process. Verification management occurs during production or development of a system, and is a component of configuration management, a project management discipline that reduces the risk of costly product reworks and unexpected schedule delays.

Verification management teams at KSC use integrated systems including Engineering Release Systems, Change Management Systems, Configuration Status Accounting and Verification Systems to provide real-time product status. Through technical and analytical reviews of engineering drawings and specifications, supplier Acceptance Data Packages (ADPs) and manufacturing orders, KSC ensures that technical requirements for products have been met. When all specified requirements have been met for a product, a “verified” status is achieved. This status provides assurance to management that technical analysis has occurred for decision-making through the CoFR process.

Accomplishments:

- Achieved configuration management verification and audit activities to verify, protect and preserve the technical baseline for all space station flight elements and ground support equipment (GSE) processed and operated by KSC
- Provided Physical Configuration Audits (PCA) and Interim Hardware Integration Status Review (IHISR) on ISS Node 2 and the Permanent Multipurpose Module (PMM)

Section 1.6
Center Capabilities and Services

Kennedy Space Center offers many institutional services from protective services, and business system and application development to occupational health and training courses. Section 1.6 provides details on the capabilities and services the center has to offer.

Section 1.6 of the Kennedy Resource Encyclopedia includes the following chapters:

Chapter 1.6.1
Business Systems and Applications

Kennedy Space Center has the capability to provide business systems and applications services related to application development, data management and work flow management.

Chapter 1.6.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.1 Business Systems and Applications

1.6.1.1 Application Development Services

Kennedy Space Center has the capability to deliver custom software and database development services. The group uses standardized software development processes to provide secure, flexible and scalable applications. The full cycle of software development services can be provided for new activities, including concept and requirements development, design and architecture, programming up to deployment, training, maintenance and future enhancement. The group also can provide customization services for commercial off-the-shelf products, application integration assistance and conversion and migration services to transition a legacy application from one platform or architecture to another. KSC also has the capability to develop Knowledge Management Systems, including data acquisition, report, application and dashboard development, and integration with other collaboration software.

Accomplishments:

- Developed applications that have been nominated for the NASA Software of the Year Award
- Developed or customized numerous applications that have been expanded to support other centers and/or become agencywide capabilities (e.g., SSMT, TechDoc, iMart, Maximo)

1.6.1.2 Automated Utility Database Reporting and Information System (AUDRIS)

Kennedy Space Center has the capability to utilize the Automated Utility Database Reporting System (AUDRIS). This system is a Web-enabled and automated database for utility reporting, accounting and managing. AUDRIS adds considerable advantages to previous reporting tools such as automated functions, shared web-enabled reporting, graphing capability for energy data, visibility to electronically gathered data from digital meters, configured reporting tools and bulk load capabilities.

AUDRIS functions:

- Provides increased flexibility with types of energy and water data input and report format capabilities
- Reduces the time it takes to perform data analysis and problem isolation
- Provides energy and facility managers with instantaneous, useful energy consumption data
- Increases the ability to isolate and analyze facility problems using energy consumption
- Provides increased flexibility in required change, allowing for introduction of new meters, technology and federal reporting requirements
- Extends visibility in energy and water consumption to all KSC personnel, increasing awareness

Accomplishments:

- For annual reporting of energy metrics and federal energy goals
- For trend analysis of facility performance
- For tracking and recording billing information
- For monitoring renewable energy investment and status of system performance

1.6.1.3 Configuration Data Management

Kennedy Space Center can provide configuration management capabilities through the use of the Configuration Management Data System (CMDS). CMDS is a centralized automated system for maintaining design configurations of ground facilities, systems and equipment. Center organizations and contractors use CMDS to find the latest data about configurations and operations.

CMDS information includes identification, ownership, responsibility, official released engineering documentation, technical instructions and records of project progress. CMDS is functionally oriented to manage engineering design documentation, integrate configuration identification and change processing. CMDS can provide real-time visibility and tracking of controlled engineering documentation and status of change processing.

CMDS is the finder tool pointing to the latest official configuration data. It includes three release centers at KSC, the Engineering Documentation Center (EDC), the Technical Documentation Center (TDC) and the Cargo Documentation Center (CDC).

Accomplishments:

- Provides a centralized configuration data repository for KSC organizations and NASA programs
- Provides configuration data that conforms to industry practices (engineering documentation, change documents, configuration identification)

1.6.1.4 Documentation and Process Management

Kennedy Space Center has the capability to provide document management, command media and process management.

The Documentation Management Team insures all documentation is published and maintained in a controlled format. They also manage and maintain program documents and records and associated archival responsibilities. The team provides safe and secure services that allow customers to meet NASA and federal document management standards. These services include appropriate access to past systems, processes and documentation for research and lessons learned.

The command media team organizes and manages the documentation of business processes and procedures, work authorization documents, standard practices and procedures, and plans or user guides. They ensure all records and documentation are maintained in a format that is compatible with tools or systems currently in place at KSC.

The Process Management Team manages the business processes for an organization. This includes the planning and monitoring of documented processes used by the organization and maintaining the documentation to support compliance and ISO compliance audits. The Process Management Team continually reviews processes and the utilization of tools and applications that ultimately improve processes and efficiency. They develop, document and implement the processes in accordance with requirements and the ISO 9001 standards. The team holds the following certifications: National Archives and Records Administration (NARA) Certified Records Manager; Certified ISO 9001 Lead Auditor; and Six Sigma Green, Yellow and Black Belts.

The team conducts an annual audit and report of records to ensure compliance with respect to record retention and archiving per a KSC NASA Procedural Requirement (KNPR). They coordinate and conduct external and internal audits for ISO 9001/AS9100 for compliance to documented processes and procedures.

Accomplishments:

- Implemented the data flow tool Appian to track review and release of all documents with the exception of work authorization documents; the use of this tool improved efficiency and review processing
- Conducted more than 20 process improvement activities during a calendar year resulting in efficiencies to hardware processing, business processing and daily activities as well as cost avoidances

1.6.1.5 Export Control

Kennedy Space Center has the capability to provide experienced personnel to ensure full compliance with U.S. import and export laws and regulations, and protect and educate employees, customers, and contractors through the enforcement of export and import compliance regulations.

1.6.1.6
Geographic Information System (GIS)

The Kennedy Geographic Information System (GIS) is the center's single source for map information. The GIS is a unique map viewer that tracks KSC's evolving infrastructure, facilities and utility systems. The viewer displays buildings, roads, utilities and environmental data from the GIS database and can be customized by selecting specific layers and adding drawings or text. The KSC GIS also links to electrical tools, floor plans, cable engineering tools and planning report subapplications. KSC maintains and operates the GIS.

1.6.1.7
Support Requirement Management

Kennedy Space Center can provide the Automated Support Requirement System (ASRS). ASRS is an electronic processing and transmission system used to coordinate support across agency, programs and center operations for internal and external customers. ASRS is used for ground processing support, and mission flight and on-orbit support. ASRS documents support requirements and supplier commitments in the NASA and Department of Defense Range Commanders Council (RCC) Universal Documentation System (UDS). Various reports that can be generated include, Program Requirements Document (PRD), Program Support Plan (PSP), Operations Requirements (OR), and Operations Directives (OD). ASRS can help supplier organizations, sub suppliers and contractor-managed requests for the use of shared services.

Accomplishments:

- Enabled effective management of shared resources with one centralized automated system (ASRS) using Universal Documentation System format (NASA/DoD RCC) for simultaneous use by multiple agency programs (requestors) to as many organizations (suppliers) as needed within the agency and with external entities
- Streamlined process for obtaining, documenting and reporting supplier support commitments

1.6.1.8
Team Collaboration

Kennedy Space Center has the capability to develop tools, systems and processes for team collaboration. These developments allows for secure, efficient and effective data and information interchange between teams, team members and customers (domestic and international). The developments adhere to standard processes and information technology laws and regulations. The group also provides test, training, development and integration laboratories for team collaboration.

The Press Site studio control room, at Kennedy Space Center.

The Institutional Multimedia Studio in Kennedy Space Center Building 1605 has a stage area.

The Institutional Multimedia Studio in Kennedy Space Center Building 1605 has a control room.

Kennedy Space Center's Press Site studio has a video editing area.

1.6.1.9
Web and Multimedia Services

Kennedy Space Center has the capability to develop websites and products using HTML, JavaScript/Applet programming, Active Server Pages and Cold Fusion. These are launch site specific. The capability includes graphics creation and Flash animation and simulation products necessary to support planning, training and outreach. The NASA KSC Press Site and Photo Services Operations, Building 1605 on Cape Canaveral Air Force Station, provide photographic and video support.

Accomplishments:

- Providing multimedia products to the Launch Services Program (LSP) and NASA Public Affairs for presentation material and Web content
- Supported website development and maintenance for KSC organizations
- Developed Flash and Web applications in support of special projects
- Providing video editing and magnification for engineering analysis

Websites:

Kennedy Media Gallery
http://mediaarchive.ksc.nasa.gov/
NASA Simulations – Interactive Media
http://imedia.ksc.nasa.gov

1.6.1.10
Work Flow and Work Control

Kennedy Space Center has the capability to provide a safe and secure service allowing customers to plan, develop, distribute, execute and archive work processes, plans and records associated with high-dollar and one-of-a-kind systems. The system provides a common work area for developing, testing, documenting and distributing common or unique work flow processes. The system provides for evaluation of new work flow processes to reduce time, cost and/or risk. The system provides the ability to integrate high-level project schedules into to the work flow and work control processes of multiple contractors. This is for tracking the required resources and the completion dates of individual tasks that are required to complete the overall project. The system also includes test, training, development and integration laboratories.

Chapter 1.6.2
Environmental Programs

Kennedy Space Center has the technical expertise to provide environmental services for remediation, hazardous waste disposal, permitting and compliance, and energy sustainability.

Chapter 1.6.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.2 Environmental Programs

1.6.2.1 Environmental Compliance Consultation and Assistance

Kennedy Space Center has the capability to evaluate proposed activities and identify the applicable environmental compliance regulations and requirements. The NASA-KSC Environmental Office can consult with the customer to identify optimal compliance strategies or solutions.

Capabilities:

- Subject matter expertise of federal and state of Florida environmental compliance regulations in the areas of hazardous waste, controlled waste, universal waste, used oil, ordnance waste, biomedical waste, air emissions, storage tanks, spill prevention plans, stormwater management, potable water, dewatering and consumptive use, domestic wastewater and septic systems, industrial waste water and pesticides
- Share past experience, regulatory agency norms, regulatory agency interpretations, and previous agreements established with regulatory agencies with customers
- Coordinate and participate in meetings with regulatory agency personnel to discuss compliance requirements or negotiate agreements
- Assist the customer with reporting and correcting violations

1.6.2.2 Environmental Compliance Oversight and Internal Auditing

Kennedy Space Center has the capability to oversee and audit customer and contracted activities to ensure compliance with environmental regulations and permit requirements.

Capabilities:

- Extensive knowledge of federal and state of Florida environmental compliance regulations in the areas of hazardous waste, controlled waste, universal waste, used oil, ordnance waste, biomedical waste, air emissions, storage tanks, spill prevention plans, stormwater management, potable water, dewatering and consumptive use, domestic wastewater and septic systems, industrial waste water and pesticides
- Perform environmental compliance assistance visits or inspections of customer activities, processes and construction projects
- Ensure adequate recordkeeping
- Recommend corrective actions to the customer for findings
- Recommend best management practices to improve performance and reduce risk
- Assist the customer with self-reporting of violations to regulatory agencies when required

An environmental specialist conducts routine surface water quality monitoring of Kennedy Space Center sdrainage systems to ensure that operations do not adversely affect the environment, particularly the adjacent estuarine system.

1.6.2.3 Environmental Compliance Sampling, Monitoring and Reporting

Kennedy Space Center has the capability to provide environmental compliance sampling associated with or required by an environmental regulation or permit. This includes environmental compliance sampling, monitoring and report preparation services.

Capabilities:

- Experienced technicians with extensive knowledge of state of Florida standard operating procedures (SOPs) for environmental media sampling
- Groundwater monitoring well sampling, surface water sampling, treatment system sampling, effluent sampling, emission stack sampling, waste sampling, soil sampling, etc.
- Review laboratory results and perform quality assurance reviews
- Preparation of regulatory reporting forms and operating reports

Environmental specialists collect depth specific groundwater samples using Direct Push Technology.

1.6.2.4 Environmental Permitting Consultation and Assistance

Kennedy Space Center has the capability to evaluate proposed activities and identify applicable environmental permitting regulations and requirements. The NASA-KSC Environmental Office consults with customers to identify optimal permitting strategies or solutions.

Capabilities:

- Subject matter expertise of federal and state of Florida environmental permitting regulations and processes in the areas of hazardous waste, ordnance waste, air emissions, stormwater management, potable water, dewatering and consumptive use, domestic wastewater and septic systems, and industrial waste water
- Share past permitting experience, permitting processes, regulatory agency norms, regulatory agency interpretations, and previous agreements established by regulatory agencies with customers
- Coordinate and participate in pre-application meetings and site visits with regulatory agency personnel
- Assist with permit application preparation
- Coordinate and participate in post-application meetings and negotiations with regulatory agency personnel
- Assist the customer with self-reporting of violations to regulatory agencies when requested

1.6.2.5 Environmental Remediation Project Management

Kennedy Space Center has the ability to provide customers with environmental remediation project management and consultation. The Remediation Group includes project managers who have expertise in overseeing and implementing a full spectrum of environmental projects from remedial investigation to construction and cleanup, in accordance with customer requirements, best management practices, and all applicable state and federal regulations. The group has experience in developing and establishing technical requirements, project scope, budgets and schedules for groundwater and soil investigations, work plans and in-situ/ex-situ remedies. The Remediation Group has expertise in applying cutting-edge technologies to environmental restoration while planning and integrating multiple contract efforts to ensure successful execution of all project elements.

A hazardous waste soil excavation is performed at the Kennedy Athletic Recreation and Social (KARS) Park.

Excavation activities in the Launch Pad 39A area resulted in removal of a contaminated source area.

Accomplishments:

- Investigated more than 260 sites to date
- More than 130 No Further Actions approved by the Florida Department of Environmental Protection
- Experience managing more than 80 remediation projects concurrently in all phases of the Resource Conservation and Recovery Act (RCRA) Corrective Action Process
- Project management expertise, including duties and tasks associated with design, construction management, resource management, regulatory interface, and hazardous waste disposal tasks
- Extensive experience managing complex Dense Non-Aqueous Phase Liquid (DNAPL) sites, including Trichloroethylene and its daughter products
- More than 15 years of experience implementing remedial technologies, including excavation, bioremediation, biosparging, soil vapor extraction, air sparging, chemical oxidation, pump and treat, and long-term monitoring

Excavation activities at the Kennedy Athletic Recreation and Social (KARS) Park resulted in the removal of more than 100,000 tons of contaminated soil.

1.6.2.6 Hazardous Waste Sampling and Characterization

Kennedy Space Center has the capability to provide hazardous waste sampling and characterization. Hazardous and controlled wastes must be appropriately characterized for proper management and disposal. KSC has an established hazardous waste evaluation process that provides consistency for waste characterization. The Florida Department of Environmental Protection Central District Office is very familiar with KSC's process and terminology.

Waste generators coordinate necessary sampling and submittal of Process Waste Questionnaires (PWQs) for evaluation. Experienced personnel review the PWQs, characterize the waste, and issue a Technical Response Package (TRP) to the generator with specific packaging, labeling and disposal instructions.

Capabilities:

- Extensive knowledge of federal and state of Florida hazardous waste regulations and interpretations
- Established and consistent process for hazardous waste evaluation and characterization
- Existing forms and database to facilitate and store hazardous waste determinations
- An interactive, Web-based management system is under development
- Share past experience, regulatory agency norms, regulatory agency interpretations and previous agreements established by regulatory agencies with customers
- Experienced waste sampling technicians

1.6.2.7 Kennedy Space Center Landfill

Kennedy Space Center operates a permitted Class III solid waste landfill. The NASA-KSC Environmental Office maintains the landfill permit, manages landfill compliance, conducts internal inspections and interfaces with regulatory agency personnel.

Capabilities:

- Accepts Class III wastes (such as construction and demolition debris, vegetative matter, unpressurized treated wood, and unregulated asbestos-containing materials) from customers for disposal
- Saves transportation costs and tipping fees associated with off-center disposal

- Truck scale for load weighing
- Load checking by the landfill operator to look for unauthorized wastes

Aerial view of Kennedy Space Center's Schwartz Road Class III Landfill.

1.6.2.8
Liaison with Regulatory Agencies and Personnel (Partnering)

Kennedy Space Center's environmental staff has developed strong relationships and established trust with regulatory agency personnel. This allows for candid, non-adversarial discussions about environmental compliance topics.

Capabilities:

- Strong relationships and established trust with regulatory agency personnel
- Participation in regular partnering team meetings with regulatory agency personnel, NASA contractors, U.S. Air Force personnel, Air Force contractors and other mission partners
- The teams (air quality, water quality and waste management) discuss pending regulations and compliance issues, and develop agreements and norms for environmental practices at KSC and CCAFS
- Share past experiences, regulatory agency norms, regulatory agency interpretations and previous agreements established by regulatory agencies with customer
- Request and participate in compliance assistance visits with regulatory agency personnel
- Assist the customer with self-reporting of violations to regulatory agencies when requested

1.6.2.9
Spill Cleanup Response and Notification to Regulatory Agencies

Kennedy Space Center has the capability to provide non-emergency spill cleanup services. The KSC Environmental Office can report spills and releases to regulatory and emergency response agencies (if required).

Capabilities:

- Trained and experienced spill cleanup personnel
- Spill waste containerization, sampling and disposal
- Knowledge of release and spill reporting requirements
- Ability to assist customers with release and spill reporting to outside agencies, such as the National Response Center, state of Florida Warning Point Hotline, and the Florida Department of Environmental Protection

The Post Emergency Spill Cleanup Team removes contaminated soil from Launch Complex 39A.

Post Emergency Response Cleanup Team practices deploying booms to prevent spill migration within the Turn Basin.

1.6.2.10 Waste Management, Storage and Disposal

Kennedy Space Center has the capability to provide customers with waste disposal support for a variety of waste streams, such as hazardous waste, controlled waste, universal waste, domestic wastewater, industrial wastewater and ordnance. KSC provides hazardous, controlled and universal waste pickup and disposal.

The 45th Space Wing operates certain facilities at Cape Canaveral Air Force Station (CCAFS) for domestic wastewater, industrial wastewater and ordnance disposal. The NASA-KSC Environmental Office provides support to customers by serving as the single point of contact to the 45th Space Wing and coordinates the use and access of Air Force services.

Capabilities:

- Extensive knowledge of federal and state of Florida waste management regulations and requirements
- Pickup, storage, manifesting, packaging, shipment and disposal of hazardous, controlled and universal waste
- Extended on-site storage of hazardous waste (greater than 90 days) at the KSC permitted hazardous waste Treatment, Storage and Disposal Facility (TSDF)
- Vacuum tanker truck support to remove industrial wastewater from processes, sumps, compressor condensate reservoirs, and secondary containment for disposal at CCAFS
- CCAFS domestic wastewater treatment plant
- CCAFS wastewater pretreatment plant
- CCAFS Explosive Ordnance Disposal (EOD) Range with an open detonation area and burn boxes for disposal of ordnance items less than 100 pounds net explosive weight

A technician removes contaminated oil from a Kennedy Space Center transformer.

Kennedy Space Center waste technicians prepare laboratory waste for shipment.

Chapter 1.6.3
Logistics Services

Kennedy Space Center has technical expertise in logistics services, including maintenance planning, supply support (warehousing, inventory and property management), handling, transportation, technical documentation, and test equipment for operations and maintenance of ground and flight hardware.

Chapter 1.6.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.3 Logistics Services

1.6.3.1 Electronic Equipment and Cable Fabrication and Repair

Kennedy Space Center has many capabilities associated with electrical components and cabling. KSC can provide fabrication, modification, testing and repair of all types of electronic equipment as well as the assembly of printed circuit boards. Principal services that can be provided include cable fabrication, certified soldering, potting and molding, cable testing, preventive maintenance and electrical panel fabrication. Principal skills that can be provided include personal computer board assembly, electronic equipment repair and maintenance, test and checkout, soldering and wire wrapping. KSC also can provide fabrication and installation of power and instrumentation cables including potting and molding of wiring harnesses and cable connectors.

Accomplishments:

- Installed conduit and Hoffman Box enclosures at the Launch Pad 39A water tower

1.6.3.2 Fluids Acquisition and Administrations

Kennedy Space Center has the capability to provide acquisition, requirements planning, logistics, technical support and cost tracking of propellants and fluids. Cradle-to-grave expertise is maintained for hydrogen, oxygen, nitrogen, helium, ammonia, hydrazines, methane and other aerospace fluids. Customer assistance is provided throughout the process of production considerations, market conditions, supplier capabilities and supply alternatives. KSC's objective is to meet customer fluid requirements cost-effectively with maximum reliability.

Accomplishments:

- Supporting all launch programs at KSC and CCAFS with nearly 2 billion pounds of propellants and fluids per year.
- Supporting all NASA centers through consolidated contracting for propellants and fluids

1.6.3.3 Ground Support Equipment Assembly and Repair

Kennedy Space Center is capable of performing modification, refurbishment and repair of all types of processing systems and ground processing equipment. KSC has an Assembly and Repair Shop that is a certified Line Replaceable Unit Shop. The shop is able to return equipment back to its original manufacturer condition. Services include assembly, repair, installation and refurbishment.

Accomplishments:

- Repaired and refurbished solid rocket booster heater umbilical assemblies

1.6.3.4 Integrated Logistics System

Kennedy Space Center utilizes an Integrated Logistics System, which can provide unified management of all logistics elements to plan, operate and maintain logistics support for flight and ground systems. Typical integrated logistics elements include maintenance planning, supply support (warehousing, inventory and property management), training, packaging, handling and transportation, technical documentation and support, and test equipment for operations and maintenance.

Accomplishments:

- System required for and used to support all space station and space shuttle mission logistical needs
- Supported many Launch Services Program logistical needs
- Supported payload customers with integrated logistical needs

1.6.3.5 Life Support Equipment

Kennedy Space Center has the capability to inspect and maintain life support equipment owned by others, including protective suits, respirators, life preserver units and HAZMAT suits. This in-house capability includes inspecting the customer's life support equipment, which allows the customer to maintain their equipment on site (reducing shipping costs and time). KSC's Life Support Division has more than 30 years of experience and training in maintaining various pieces of life support equipment. Customers can drop off Life Preserver Units (LPUs) and HAZMAT suits for maintenance as needed. Life Support runs through testing of each LPU by visual inspection; inflation by CO2 cartridge and manual; accessories inspection and testing; cleaning; and fold and pack after inspection.

The KSC Life Support division maintains HAZMAT suits for the fire department, the U.S. Air Force Class A and B protective suits, and HAZMAT training suits. Life Support's training, experience, and on-site capability, provide an ideal environment for HAZMAT suit maintenance. Life Support conducts suit cleaning, visual inspections, and pressure checks on each suit to ensure integrity and repair any defects.

1.6.3.6 Logistics Warehousing

Kennedy Space Center can provide about 550,000 square feet of combined warehouse space in several facilities. Some warehouse space is environmentally controlled. These facilities include areas for laboratories, shops, shipping and receiving, bonded storage and a Hardware Disposition Area (HDA). Retrieval systems consist of a mini-load for storage and retrieval of small parts and a robotic transportation system. The facilities also provide administrative areas.

1.6.3.7 Repair of Hydraulic Components

Kennedy Space Center is capable of providing original manufacturer level repair of flight hardware hydraulic components.

Chapter 1.6.4
Occupational Health

Kennedy Space Center can provide occupational medicine and medical program services for the physical and mental health of the KSC work force. Additionally, KSC can provide many other occupational health services, such as food services support and fitness centers.

Chapter 1.6.4 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.4 Occupational Health

1.6.4.1 Employee Assistance Program

Kennedy Space Center has the capability to provide access to the in-house Employee Assistance Program. This program can be made available to customers and their families who need assistance with issues related to stress, workplace, mental health, relationship and substance abuse.

1.6.4.2 Fitness Centers

Kennedy Space Center features two fitness centers. They are located at the Operations and Checkout Building and the Operational Support Building. These fitness centers can offer customers access to aerobic devices (treadmills, elliptical trainers), free weights, exercise machines, mat areas, aerobic area and classes taught by KSC fitness instructors. KSC Fitness Centers provide multidimensional programs, classes and services to help members improve their physical and mental health and wellness so they may maximize their personal and professional potential.

Services Available include:

- Personal training
- Fitness and body composition assessments
- Fitness and wellness classes
- Motivational and incentive programs
- Outreach presentations and programs

1.6.4.3 Food Services Support

Kennedy Space Center provides all KSC customers, stakeholders and tenants with the opportunity to purchase meals and snacks at seven strategically located cafeterias, four snack bars operated by the Division of Blind Services, and an assortment of vending machines.

1.6.4.4 Health Physics Services

The Kennedy Space Center Health Physics Program (HPP) worked with national and local government organizations to assure personnel safety and regulatory compliance for major radiological source missions including:

- Cassini in 1977
- Mars Exploration Rovers in 2003
- Pluto New Horizons in 2006

The KSC HPP is responsible for functional integration and implementation of aerospace operations involving nonionizing and ionizing radiation. KSC's HPP serves as the key liaison with other governmental agencies and media outlets. HPP actions for planning, coordination and launch monitoring for radiological launches include:

- Conducting detailed analyses of payload processing and source integration activities to assure source security and worker protection

- Conducting contingency planning meetings and exercises with a diverse group of government agencies, including the U.S. Department of Energy, Department of Defense, and state and county emergency response agencies
- Identifying appropriate monitoring locations and capabilities necessary to effectively evaluate radiological conditions during and after a launch
- Directing the KSC Radiological Control Center (RADCC) during countdown, launch and postlaunch to evaluate radiological monitoring results, and to implement emergency response procedures in the event of a launch anomaly

The most recent radiological launch was the Pluto New Horizons mission, which successfully launched from KSC, Jan. 9, 2006. New Horizons contains a Radioisotope Thermoelectric Generator (RTG), which converts radiation from the decay of plutonium-238 into energy to power the spacecraft. The launch of an RTG-powered vehicle can be cause for intense public and media scrutiny and concern for public safety. The KSC HPP provided key technical support and information for public meetings, responses to media inquiries, and developed an Environmental Impact Statement that addressed radiological exposure, safety measures and emergency contingency plans for the New Horizons mission.

1.6.4.5 Industrial Hygiene Services

Kennedy Space Center has the capability to provide industrial hygiene consultation services under the direction of certified industrial hygienists. These consultation services are available for development of industrial hygiene programs and policies tailored to aerospace industry operations, laboratory operations, facilities operations and maintenance, and construction. Typical program and policy consultations include general Occupational Safety and Health Administration compliance, Process Safety Management, Hazardous Waste Operations and Emergency Response, Hazard Communication and Chemical Exposure, Noise and Hearing Loss Prevention, Ergonomics, Indoor Air Quality, Public Health, and Heat Illness Prevention.

KSC has the capability to provide industrial hygiene operational support services upon request. The services include baseline hazard analysis and risk assessment of new operations, chemical exposure monitoring for Occupational Safety and Health Administration-regulated operations and processes, atmospheric testing in support of confined space entry, employee complaint investigations, hazard communication, Material Safety Data Sheet Management and public health/sanitation surveys of food service facilities, potable water testing and animal pests.

1.6.4.6 Musculoskeletal Rehabilitation Services

Kennedy Space Center has the capability to provide an on-site rehabilitation program (RehabWorks). This program is designed to return employees back to their pre-injury working status quickly and safely, with decreased sick time and minimal time away from work. RehabWorks is an on-site musculoskeletal rehabilitation service for employees suffering from work, non-work, or sports-related injuries. The RehabWorks program provides services by Certified and Licensed Athletic Trainers (ATC/L). The staff can provide injury assessment and rehabilitation services to the industrial athlete in order to maximize long-term recovery and reduce lost-work time. The program laso can accommodate post-surgical rehabilitation. RehabWorks is located in the Operations and Checkout Building in KSC's Industrial Area.

Advantages:

- Prompt treatment for injuries
- Diminished travel time to and from therapy
- Maintenance of employees' normal work routine during the rehabilitation process
- The unique combination of injury prevention, rehabilitation, education, and fitness/wellness reduces workers' compensation costs while promoting a healthier work force

1.6.4.7 Occupational Medicine

Kennedy Space Center has an Occupational Medicine Program that develops and maintains Center Occupational Medicine policy, and is responsible for providing medical program services for the physical and mental health of the KSC work force. The program can offer services that include aspects of health promotion and wellness, physical examination programs, medical surveillance examinations as required by the Occupational Safety and Health Administration, an Employee Assistance Program for personal counseling, fitness centers, and an athletic training and treatment program for employees with musculoskeletal disorders.

Chapter 1.6.5
Protective Services

Kennedy Space Center can provide protective services, including security, hazardous material response, and emergency medical support and fire suppression services.

Chapter 1.6.5 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.5 Protective Services

1.6.5.1 Advanced Life Support

Kennedy Space Center has the capability to provide Advanced Life Support (ALS) level emergency medical service response. This is provided by two certified firefighter paramedics on each ambulance. Emergency medical technicians also are utilized on ambulances during emergency conditions if required. KSC ambulances operate at the ALS level and are certified as ALS ambulances by the state of Florida. ALS ambulances carry critical care equipment, including a 12 lead EKG monitor and defibrillator, external pacemaker, prehospital medications, and advanced airway equipment with specialized monitoring equipment.

All paramedics are certified to perform advanced procedures and skills on the patient, which including the following:

- Cardiac monitoring
- Cardiac defibrillation
- Transcutaneous pacing
- Intravenous cannulation (IV)
- Interosseous (IO) access and intraosseous infusion
- Surgical cricothyrotomy
- Needle cricothyrotomy
- Needle decompression of tension pneumothorax

Kennedy Space Center firefighters conduct their annual Federal Aviation Administration (FAA) required Aircraft Rescue Fire Fighting (ARFF) training.

Kennedy Space Center Fire Department paramedics practice vehicle extrication.

Kennedy Space Center's Fire Department uses a Florida state certified Advanced Life Support ambulance.

1.6.5.2 Aerospace Medicine Planning and Operations

Kennedy Space Center has the capability to support planning and operational activities for current and future launch and landing activities, and payload processing for NASA and commercial ground crew, passengers, and space tourists. Activities would include assessment of hazards, identification of hazard mitigation, emergency planning and response, contingency planning and operational oversight of launch and landing contingency support. Activities also would support a medical education training program for medical students, medical residents (postgraduate physicians in training) and graduate students in medical research.

Accomplishments:

- Conducted high-fidelity space shuttle launch pad contingency exercise that simulated a hazardous condition on the launch pad. The exercise required rapid evacuation of the space shuttle crew and fire, crash and rescue personnel from the pad. The exercise included shuttle launch and astronaut support personnel, rescue personnel, victim volunteers, medical triage forces, medical evacuation air and ground assets, Department of Defense medical personnel, local medical treatment facilities and senior NASA leadership. These types of exercises can be adapted to support other emergency medical services operations.
- Staff member is vice-president of the Aerospace Medical Association (AsMA) and provides evaluations on position papers for several topics, including aviation and space operations, commercial spaceflight crew member medical issues, and fatigue management in flight crew.
- Provides the only medical representative to the NASA Space Radiation Working Group, which evaluates the effects of space radiation beyond low Earth orbit on systems and flight crew
- Principal investigator in the development of a portable, hand-held device that can produce medical-grade water for injection from drinking water.
- Provides the Space Flight Medical Support Training Course for local medical providers that helps familiarize them with preflight and postflight medical issues, including hazardous material treatment and the physiological effects of microgravity on the human body, to better enable them to care for crew members in any contingency.
- Serves as liaison with SOS International for emergency medevac for all NASA employees.
- One of the medical students who completed the program helped form the first United Kingdom Space Medical Association.
- Provided support to a research partnership effort between NASA and the Canadian Space Agency. This research project placed participants in an environment similar to a space environment at a high altitude, remote location, to study in-situ resource utilization for lunar and Mars missions. The support included general on-site medical evaluation and treatment, telemonitoring and data collection for future analog remote studies. This type of support can be provided to other agencies conducting efforts in remote areas.
- Clinical services include 24/7 support to astronauts, families and support personnel, access to physical examination facilities and equipment, and patient transport to designated medical treatment facilities.

1.6.5.3 Aircraft Rescue Firefighting (ARFF) Certified Fire Department

Kennedy Space Center has the capability to provide fire rescue services, aircraft rescue and firefighting. The KSC Fire Rescue Services Aircraft Rescue and Firefighting (ARFF) operations meets and or exceeds all activities and duties defined in Federal Aviation Regulation (FAR) Part 139 and National Fire Protection Association (NFPA) 402, 405, 1003, 1710, regarding assigning subordinates to specific duties; establishing procedures and techniques; recruitment and training of personnel; inspection of airport premises for safety and fire hazards; maintenance and repair of fire equipment and the fire station; and coordination of fire rescue personnel assignments.

Kennedy Space Center firefighters conduct their annual Federal Aviation Administration (FAA) required Aircraft Rescue Fire Fighting (ARFF) training.

1.6.5.4
Canine Units (K-9)

Kennedy Space Center has the capability to provide K-9 units for explosive detection requirements to support launch, the RAMs program, law enforcement and Emergency Response Team, and narcotics detection. Available K-9 teams are used for explosive detection in support of launch operations at launch minus 30 days through a successful launch. KSC can provide customers with its capability, experience and familiarity with KSC property, critical facilities, and the hazards associated with KSC and launch operations. Local law enforcement cannot provide K-9 support for launch operations and they cannot provide immediate K-9 response when necessary for law enforcement-related incidents.

1.6.5.5
Emergency and Protective Centers

The KSC Emergency Management program is an in-house capability that provides comprehensive services for preparedness, mitigation, response, and recovery from all emergencies and disasters, including those unique to KSC. Due to the vast number of specialized hazards and one-of-a-kind launch and propulsion systems, it is imperative that KSC and its customers have indigenous emergency response capabilities. KSC's size and geographical location, coupled with the long response time from any surrounding mutual aid department demands that a Protective Services Communications Center (PSCC) and an Emergency Operations Center be provided on-site to manage the day-to-day alarm and detection system monitoring as well as emergency responses. The PSCC is a function under emergency management that provides a day-to-day central communications point for monitoring all fire and security alarm systems, and dispatching fire, security and emergency medical to the scene of an emergency. The PSCC operates 24/7 and activates the Paging and Area Warning System, and the Tornado Area Warning System to ensure center safety.

1.6.5.6
Emergency Response Team (Security)

Kennedy Space Center has the capability to provide an Emergency Response Team with the expertise to protect and save lives endangered by the criminal acts of others. KSC's experienced personnel are trained to resolve complicated, tense and violent situations in the critical and unique environments that exist at KSC. The ERT is supplied with a variety of weapons, breaching tools, protective devises, cameras and rescue equipment. ERT members meet a higher physical standard for entry and retention on the team and receive significantly more training than normal KSC security officers.

1.6.5.7
Fire Prevention Inspection

Kennedy Space Center has the capability to provide fire prevention inspection across the center. This capability includes fire investigations, extinguisher maintenance, fire safety education, hot-work permits, fire prevention training, pre-fire planning, walk downs, and building evacuations.

Kennedy Space Center Fire Department Inspectors perform fire safety education public outreach.

Kennedy Space Center engineers participate in fire protection activities.

1.6.5.8
Fire Protection Engineering

Kennedy Space Center has the capability to provide fire protection engineering services. The Fire Protection Engineering Section performs fire safety design reviews on all new projects, modifications, and refurbishments, including designs unique to KSC (e.g., mobile launchers, crawler-transporters). This department also ensures compliance with National Fire Protection Association (NFPA), NASA and KSC standards for life safety, egress, hazardous electrical classifications, and fire alarm and fire suppression systems. They also perform detailed fire risk analysis on existing facility construction, operations and fire protection systems. Fire protection engineers conduct testing on water supplies, perform hydraulic calculations and ensure adequate water is maintained for fire sprinkler and fire suppression activities.

1.6.5.9
Fire Services

Kennedy Space Center has the capability to provide protective services and fire rescue services. The complexity of the missions and facilities of KSC require the Protective Services and Fire Rescue Division be divided in two major components. The first component is fire rescue operations and the second is fire prevention inspection and fire engineering services. There are three fire stations on KSC that are staffed 24 hours a day, 365 days a year, to meet the emergency response mission of KSC.

All firefighters are trained and certified in structural firefighting, Aircraft Rescue and Firefighting (ARFF)

Kennedy Space Center's pad rescue team participates in training to rescue astronauts at Launch Pad 39A.

Kennedy Space Center uses state-of-the-art emergency response equipment.

Kennedy Space Center's flight crew rescue team performs an exercise involving the rescue of closeout crew and flight crew members at Launch Pad 39A.

Kennedy Space Center's fire and rescue Search and Rescue (SAR) team conducts a remote site response exercise for flight crew rescue.

Kennedy Space Center's flight crew rescue team perform an exercise involving the rescue of closeout crew and flight crew members at Launch Pad 39A.

transportation vehicle response and rural/urban interface firefighting operations. Additional training includes confined space rescue; vehicle rescue; trench rescue; high/low angle rope rescue; structural collapse; non-typical and unique accidents as a result of natural disasters (i.e., hurricanes); and human-made disasters involving chemical, biological, radiological and nuclear agents (CBRN).

KSC Fire Rescue Services meets all NASA Space Shuttle Program requirements for astronaut flight crew rescue and is responsible for launch and landing rescue operations. This rescue service is deemed launch and landing critical. Based on documented proven success, regarding astronaut rescue, KSC Fire Rescue Services has the technical expertise required to accommodate any and all future human spaceflight endeavors from KSC.

1.6.5.10 Hazardous Material (HAZMAT) Response Team

Kennedy Space Center has the capability to provide professional Hazardous Material (HAZMAT) Response Teams. The team is self-contained and is not dependent on mutual aid assistance to respond to emergencies on KSC.

The HAZMAT Response Team is comprised of firefighters who are HAZMAT technician-level trained. This level of training provides the KSC HAZMAT Team the expertise to operate in Level A protective personnel equipment (PPE) to mitigate extreme HAZMAT emergencies involving spacecraft propellants, industrial chemicals, fuels, and materials and weapons of mass destruction incidents.

1.6.5.11 Launch and Landing Emergency Medical and Communication Equipment

Kennedy Space Center has the capability to provide, develop and maintain training for emergency medical and communications equipment for emergency rescue response by helicopters and ambulance in space launch and landing scenarios. The designs are responsive to major program requirements and specifications and are implemented only when commercial-off-the-shelf equipment is unavailable. All concepts are created and implemented with the intent of technology transfer. Typically, designs include communication innovations involving the modification of state-of-the-art or operational communications systems for use in very noisy environments or while personnel are encumbered by personal protective equipment.

Kennedy Space Center firefighters performs hazardous material (HAZMAT) training to ensure technician-level certification.

Kennedy Space Center firefighters participate in HAZMAT training to ensure the team is technician-level certified.

Accomplishment:

- Adaptation of civilian communications equipment for use on military platforms, such as implementation of KSC trucking radio nets into U.S. Department of Defense rescue helicopters (HH-60G)

1.6.5.12 Marine Patrol Unit

In order to patrol the many miles of river line and unfenced KSC property boundary the KSC security program utilizes a Marine Patrol Unit (MPU). Its mission is to detect and deter unauthorized personnel and vessels, and respond to alarms and emergencies on the water. The KSC security contractor is required to provide a well-trained MPU to support the KSC security program. They use airboats and small motorboats for patrol. KSC is the only NASA center with marine vessel security patrols.

Types of Marine Vessels used at KSC:

- 20-foot Pathfinder used in all inland waterways of KSC
- 22-foot Pathfinder used in all inland waterways of KSC
- Three Diamondback airboats used for shallow water and marsh surfaces of KSC
- 18-foot flat-bottom river boat

Kennedy Space Center has the capability to provide minor maintenance and full-operations services for all marine unit vessels.

Marine Unit Services includes:

- Trained marine vessel operators
- Minor engine and hull maintenance from the Maintenance and Operations Facility
- Major repairs must be outsourced

Accomplishments:

- KSC Protective Services Office has used marine vessels to patrol KSC waterways for more than 45 years
- KSC marine units have provided mutual aid support to Brevard County in a life-saving capacity during Hurricane Rita (2005), Hurricane Wilma (2005), and Tropical Storm Fay (2008)

1.6.5.13 Personnel Security

The KSC security program is responsible for conducting and overseeing several types of personnel security investigations (background investigations) leading to authorized access to NASA facilities and classified or sensitive information.

The Personnel Security Support Office (PSSO) is responsible for NASA's Protective Services at KSC. The major programs they support are the Homeland Security Presidential Directive-12 (HSPD-12) Access Program, Personnel Reliability Program (PRP), Federal Employee Security Program and Foreign National Program.

Investigations are processed electronically on e-QIP. Currently, only the civil servants are submitting their investigations electronically, but in the near future all employees will submit electronically. All information is reviewed by the PSSO senior case examiners for completeness and accuracy prior to forwarding it to the Office of Personnel Management (OPM).

When the investigations return from OPM, the PSSO investigators adjudicate and summarize minor cases. If discrepant or derogatory information is developed, they call in the employee for a personal interview, and do whatever they can to resolve the issue(s), many times working with outside agencies, including local law enforcement, the State Attorney's Office, Department of Motor Vehicles and medical personnel. These cases are then referred to the appropriate security specialist in Personnel Security.

KSC has an Automatic Fingerprint Information System (AFIS) with direct connection to the FBI. All fingerprint reports go directly into PSSO. If fingerprints were taken as part of an investigation, the results are forwarded to OPM. If they were taken for unescorted access, they are kept in PSSO. Any with severe adverse information are forwarded to the security specialist in Personnel Security.

PSSO has access to the National Crime Information Center (NCIC) through the Florida Department of Law Enforcement (FDLE). The NCIC is used by PSSO for individuals requiring access onto KSC for less than 180 days, or with Remote IT access they also are conducted on foreign national visitors. This information is not given to anyone other than personnel in the Protective Services Office. All individuals with access to this system are required to maintain their certification, which is accomplished through training every two years with FDLE.

All foreign national visitors are processed through the PSSO. All visit requests are reviewed and processed and all checks are completed by PSSO. The senior case examiner who works on foreign visitor requests, works closely with the requesters, the export control administrator and representatives, and the International Visits Coordinator (IVC), and has occasional contact with support personnel in the NASA Headquarters Security Office when a visitor is from a designated country. After all the information has been received and the request is in order, the senior case examiner requests the appropriate pass or badge from the KSC Badging Office.

1.6.5.14 Secured, Patrolled Perimeter with Intrusion Detection Systems

On a daily basis the contractor provides perimeter access control at the three Kennedy Space Center gates (including multiple lanes during rush hours), and controls access to critical and mission essential infrastructure (MEI) facilities. They provide routine mobile patrols and respond to security incidents and emergencies anywhere on KSC property.

Current Fixed Security Posts:

- KSC perimeter gates
- Orbiter processing facility high bays 1, 2 and 3
- Launch Pad 39A
- Launch Control Center
- Vehicle Assembly Building
    - Personnel access control
    - Vehicle access control
    - Alarm response
    - Evacuations

Current Mobile Security Patrols:

- Various roving patrols
    - Alarm, fire and medical response
    - Building and facility checks
    - Barricade checks
    - Peak traffic access control responsibilities
    - Random anti-terrorism measures
    - Traffic control points
- Traffic patrols
    - Selective enforcement
    - KSC roadway patrols
    - Traffic accident response
    - Random vehicle inspections
    - Federal Magistrate Program
    - Random anti-terrorism measures
    - Traffic control points
- Emergency Response Team
    - Tactical response to critical incidents
    - Random vehicle inspections
    - Selective enforcement
    - Building and facility checks
    - Helicopter operations
    - Random anti-terrorism measures
- K-9 Team
    - Response to critical incidents
    - Explosives and narcotics sweeps
    - Random vehicle inspections
    - Selective enforcement
    - Building and facility checks
    - Random anti-terrorism measures

Accomplishments:

- Timely alarm response dependent upon criticality of resource
- Response priority
- KSC K-9 units have provided explosive detection support to Brevard County numerous times
- Workplace violence response and escorts
- Personal security for VIPs and special events

1.6.5.15 Space Vehicle Rescue and Medical Evacuation (Medevac)

Kennedy Space Center has the capability to conduct planning, designing, implementing and training for space vehicle rescue and medevac methods to include helicopter and ambulance unique communications and medical equipment. This includes planning for rescue and medevac of space-flight crews to meet program requirements by efficiently using available resources and assets.

Accomplishments:

- Developing the rescue scenario for recovery of Orion astronauts from the launch pad
    - Developing procedures and equipment that will allow the astronauts to be self-rescued; extracted by the closeout crew; or extracted by the pad rescue team
    - Developing personal protective equipment options to meet potential hazards during rescue
- Utilizing Orion-based rescue to determine generic solutions for Commercial Space Launch providers

Chapter 1.6.6
Training

Kennedy Space Center can provide a host of technical training and certification programs.

Chapter 1.6.6 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.6.6 Training

1.6.6.1 Flight and Ground Hardware Technical Training and Certification

Kennedy Space Center has the capability to provide flight and ground system hardware technical training and certification. Technical training and certification ensures competency on handling flight and ground system hardware. Certification courses include tests, that demonstrate required knowledge and skills. These courses and certifications consist of many categories, including safety, regulatory, technician skills (hands-on), operations, area access, Emergency Life Support Apparatus (ELSA), and flight hardware depot.

Accomplishments:

- Supported training of STS-130, STS-131 and STS-133 mission payload customers
- Developed a large number of new training courses
- Certification and re-certification of key processing personnel
- KSC is capable of providing training in many processing fields:
  - Behavior-based safety
  - Oscilloscopes familiarization
  - Drawing and Specification familiarization (basic and advanced)
  - Polymeric applications
  - Surface mount technology
  - Fiber optics
  - Hazardous materials transportation
  - IPC-JST-001ES including new NASA Soldering Addendum
  - ELSA training
  - OIS training

1.6.6.2 Training on Metrology Techniques

Kennedy Space Center can provide instructor-led basic and advanced metrology training courses, along with the corresponding training material, and NASA handbooks covering significant metrology topics. Training materials include technical presentations, reports and papers covering measurement applications, measurement uncertainty analysis and measurement decision risk analysis.

Significant Metrology Topics Include:

- End-to-end measurement quality assurance
- Measuring and test equipment specifications
- Measurement uncertainty analysis
- Measurement decision risk analysis
- Calibration interval analysis

Section 1.7
Facility and Infrastructure Services

Kennedy Space Center offers an abundance of available infrastructure to match the needs of any space industry or related technology business. From facility construction, heavy equipment, and networks, to rail, sea, air and road transportation, KSC has the infrastructure available. Section 1.7 provides details on the facility and infrastructure services that KSC has to offer.

Section 1.7 of the Kennedy Resource Encyclopedia includes the following Chapters:

Chapter 1.7.1
Facility Activities

Kennedy Space Center has the capability and technical expertise to provide a host of institutional, infrastructure, and facility related services.

Chapter 1.7.1 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.7.1 Facility Activities

1.7.1.1 Construction Inspection Services

Kennedy Space Center has the capability to conduct construction inspection services. These include field inspection services in support of construction management personnel by construction inspectors with expertise in all required disciplines. The construction inspectors can provide daily site inspections, monitoring and enforcement of technical requirements. Inspectors also can act as witnesses for performance and acceptance tests and mandatory inspection points, including soil, concrete, electrical systems, piping systems, fire detection and suppression systems.

1.7.1.2 Construction Management

Kennedy Space Center has the capability to provide contract management and construction management expertise and services to plan, schedule, advertise, award, and execute construction contracts in accordance with customer needs and schedules. Experienced construction managers can ensure compliance with technical requirements of drawings and specifications and contractual provisions; manage field implementation activities from pre-work through activation; approve final installation of all project work; approve shop drawing submittals, progress schedules and pay requests; conduct final inspections and certify all contract requirements and punch list items are completed; and prepare and process operation and maintenance and real property turnover documents.

1.7.1.3 Corrosion Control

Kennedy Space Center can provide corrosion control expertise and services, including alloying of aluminum parts, high steel cleaning, and painting facilities, structures and ground support equipment. Work can be performed in the field or at the Launch Equipment Paint Shop.

Major services that can be provided are sandblasting, working at heights, spray painting, high-steel cleaning, and rigging of access scaffolds and temporary platforms. Also, silk screening, photo etching and embossing productions, and fabrication of painted silk-screened and vinyl-lettered signs and panels, can be completed.

1.7.1.4 Custodial

Kennedy Space Center has the capability to provide custodial services for about 2.6 million square feet of general office, shop, warehouse and support areas at KSC. Regularly scheduled services for customers include trash container emptying, restroom cleaning and restocking, hard floor surface cleaning, and carpeted floor vacuuming. KSC also can provide cleaning of walls, light fixtures, glass installations and air vents upon request.

NOTE: Bulk garbage collection and transportation is provided under the 45th Space Wing's Refuse Collection and Disposal Contract.

1.7.1.5 Electric Power Distribution System

Primary Distribution System

Kennedy Space Center is served by Florida Power and Light's 115-kilovolt transmission system configured in a loop that includes NASA's C-5, C5-A and Orsino substations that are verified as closed (i.e., service is available from two geographically diverse FPL transmission line groups). The utility service is transformed to nominal distribution levels of 13.8 kilovolts and 13.2 kilovolts, respectively, by power transformers set in NASA-operated C-5, C5-A and Orsino substation yards. The C5 and C5A substation serves loads in the vicinity of the launch complex, while the Orsino substation provides power to Industrial Area customers. The C5 portion of the substation and the Orsino substation utilize outdoor open exposed bus and appropriate outdoor feeder and bus circuit breakers, while the C5A portion of the substation features enclosed bus and an indoor feeder circuit breaker lineup. Each substation incorporates three power transformers and associated bus work or cable ties to provide distribution redundancy. Launch complex pads and vehicle processing facilities also enjoy emergency medium voltage power afforded by a 10 mega watt automated diesel generator plant. KSC's predominantly underground distribution system will be protected by technologically advanced multifunction feeder breaker relays and by tiered outboard protective devices that will provide optimal overcurrent selective coordination.

Secondary Distribution System

Unit substation transformers with nominally rated secondary voltages of 4160Y/2400V, 480Y/277V and 208Y/120V serve the majority of Kennedy Space Center's infrastructure systems, which include both industrial and commercial and industrial loads. Many of the low voltage substations feature doubled-ended configurations affording separate primary feeder power sources or dedicated standby power provided by permanently installed generators. Secondary distribution schemes serving loads sensitive to power quality discontinuities also feature uninterruptible power supplies for power backup and conditioning. NASA also maintains a fleet of portable low-voltage generators to satisfy a wide range of standby customer facility power distribution requirements. The majority of launch vehicle and space station processing facility power distribution schemes feature modern microprocessor–based protective devices and programmable logic control.

1.7.1.6 Facilities Program Planning

Kennedy Space Center has the capability to provide customer interface, planning and integration for KSC Construction of Facilities Program and Local Authority Program, and provide coordination, planning and support for projects implemented by commercial entities and others. These services include assistance with project requirements development, schedule planning and budget estimates, and integrating multiple funding sources as required. KSC's experienced facilities personnel can establish program and project priorities, develop and coordinate project approval documents with NASA Headquarters for appropriated, non-appropriated, and reimbursable fund sources (NASA 1509/1510) for projects implemented by NASA and others.

1.7.1.7 Facilities Systems and Services

Kennedy Space Center, through its Facilities Systems and Services Division, has the ability to provide infrastructure oversight of the engineering and maintenance functions performed under the Institutional Services Contract and other base support contracts. Services available to customers include ensuring mission readiness, long-term sustainability, and day-to-day understanding of operational support issues. Experienced personnel can provide discipline engineering and design engineering support for shuttle facility systems, projects and services.

Accomplishments:

- Oversight of the Space Program Operations Contract Ground Support Systems contractor as it relates to shuttle facility power; Kennedy Complex Control Set; heating, ventilating, and air conditioning; sound suppression and fire; and pneumatics
- Responsible for sustaining engineering and the operations and maintenance program for KSC institutional facilities, facility systems and related center infrastructure
- Serves as the contracting officer technical representative (COTRfor the grounds and janitorial center contracts

1.7.1.8 Facility Configuration Management

Kennedy Space Center has the capability to conduct configuration management (CM). This team can establish policies and procedures to manage the configuration of critical, configured and mission essential facilities, systems, equipment and utilities (FSEU), and directly related software through the use of a Configuration Control Board (CCB) and associated processes.

Capabilities:

- Identifying and establishing baselines for design and development of deliverables and project end items.
- Implementing a disciplined system to facilitate management review and approval of changes to established baselines to include change tracking and action items.

- Maintaining and updating the configuration management data system of record to reflect configuration changes.
- Identifying new facilities and their associated FSEU and incorporating them into the data system.
- Conducting configuration audits to verify assigned configured systems are in compliance with the associated technical documentation and in accordance with established procedures.
- Maintaining a closed-loop accounting system that incorporates verification and validation activities conducted throughout a project's lifecycle to ensure requirements are properly implemented and traceable. The traceability of changes is reviewed by the CCB, CM audit teams, and through the document closure process.

Accomplishments:

- Maintained proper documentation (drawings, criticality analyses, maintenance instructions, etc.) for the configuration of institutional FSEU to ensure that systems are properly configured and maintained in order to support launch.

1.7.1.9 Facility Design Engineering

Kennedy Space Center has the capability to manage design efforts and ensure all project and customer requirements are properly reflected in design documents. This capability includes managing the design review process, ensuring proper coordination of design products and appropriate disposition of comments from customer and project stakeholders (users, safety, environmental, fire department, etc.).

1.7.1.10 Facility Modification and Operation Integration Planning and Coordination

Kennedy Space Center has the capability to manage and oversee all phases of facility operations and maintenance by working closely with all contracted operations and maintenance teams to ensure facility support for all vehicle operations. KSC has the expertise to determine schedule risks and facilitate resolution of any schedule conflicts ensuring program manifests are maintained.

KSC can oversee and evaluate facility modifications and upgrades for technical content. Facilities utilized for launch vehicle processing routinely undergo modification enhancements. Often this is done during normal processing activities. Whether the facility is deemed unavailable during these modifications periods, or can be conducted during normal launch vehicle processing activities, they need to be integrated into the processing schedule to make best use of available resources and compliance to NASA safety standards. KSC is capable of tracking scheduling modifications to the facility to ensure proper integration into the processing schedule.

Accomplishments:

- Integrated Vehicle Assembly Building doors and siding modifications and refurbishment to be completed concurrently with processing activities

1.7.1.11 Facility Project Management

Kennedy Space Center has the capability to provide project management expertise to implement projects in accordance with customer requirements. Facility project managers are experienced in the development and establishment of technical requirements, and management of project scope, budgets and schedules. The project managers can aid customers in planning and integrating multiple contract efforts and fund sources (construction, outfitting and activation) to ensure successful execution of all project elements within allocated budgets.

1.7.1.12 Fire Alarm Systems

Kennedy Space Center Central Fire Monitoring System has hardwired network and radio-based communication capabilities for connection of multiple fire alarm manufacturers' control panels. Primary reporting and dispatching for fire and security throughout the center is located in the Protective Systems Control Center (PSCC). A redundant monitoring station, Ground Support Fire Alarm (GSFA), is used to support launch activities, final acceptance and testing of new fire alarm systems and to support National Fire Protection Association (NFPA) reacceptance testing. The PSCC is a modern central dispatch facility in the Launch Control Center (Building K6-0900) and is used to provide the remote monitoring of Fire Protection Systems, Security Systems, and "911" phone service for KSC. KSC also has a Central Radio Monitoring System (CRMS) that uses self-healing mesh net radio-based reporting technology.

KSC has been able to provide fire alarm solutions for unique applications to multiple programs. KSC has the capability to maintain all fire alarm systems located on center.

1.7.1.13
Fire Suppression Systems

Kennedy Space Center has conventional and one-of-a-kind fire suppression systems. These types of systems protect office areas, industrial areas and unique flight hardware processing areas. KSC has several types of systems, including Inergen, FM-200, Halon 1301, CO2, STAT-X, wet chemical kitchen suppression, single and double interlock preaction, wet pipe, dry pipe, and specialized deluge and fixed spray systems. KSC has also developed and implemented specialized deluge suppression systems to protect flight hardware and flight hardware fueling stations. KSC has a testing and maintenance certification program that covers the maintenance and testing requirements for technicians that work on all of the systems listed above. KSC has the capability to maintain all fire suppression systems located on center.

1.7.1.14
Grounds, Landscape Maintenance and Pest Control

Kennedy Space Center has the capability to provide customers with grounds maintenance, landscaping maintenance and pest control service. These services can be provided on a regularly scheduled or as-needed basis.

1.7.1.15
Heating, Ventilating, and Air Conditions (HVAC) and Mechanical Systems

Kennedy Space Center infrastructure includes the heating, ventilation, and air conditioning (HVAC) systems, which ensures a comfortable working environment for mission essential and support personnel. KSC HVAC systems also provide stable, humidity controlled, non-corrosive environments necessary for computer systems and other electronic equipment to function properly. KSC maintains HVAC systems installed in about 200 NASA facilities with equipment, including:

- Chilled water cooling systems
- Packaged or split direct expansion (DX) cooling systems
- Room (wall and window) heating and cooling systems
- Hot water heating systems
- Direct fired boilers using natural gas and oil as fuel
- Electric heating systems
- Campus-type heating and cooling plants and cooling plants

Together, these systems provide heating, cooling, dehumidification, and air circulation for buildings and equipment at various facilities throughout KSC. Chilled water systems use chillers to cool water to a low temperature (around 40 degrees F). This chilled water provides space cooling via remotely located water coils in air handling or fan coil units. Water can be chilled by an air-cooled chiller or by a water-cooled chiller, typically using a cooling tower. Facilities may have their own chilled water system, or be served from a central chiller plant. KSC has two primary central plants: the Vehicle Assembly Building Utility Annex (Building K6-0947) and the Industrial Area Chiller Plant (Building M7-0407). DX systems come in two major types, packaged units and split systems. These systems make up the bulk of installed HVAC systems at KSC. KSC has a variety of heating systems installed, including hot-water systems in conjunction with gas or oil fired boilers, resistance heating and a few heat pumps. Central plants providing heat include the VAB Utility Annex (Building K6-0947) and the Hypergol Maintenance Facility Heating Plant (Building M7-1112).

1.7.1.16
Heavy Equipment

NASA owns heavy equipment with the following capabilities:

- Mobile cranes
- Forklifts and pallet jacks
- Trucks (bucket, forklift, fire, SWAT, rescue, utility, fuel, cable, wastewater, mobile lube)
- Trailers (fuel tank, cargo, utility, flatbed, low-bed, A/C, radar, sign, port-o-let)
- Miscellaneous vehicles (utility, 4x4, golf carts, M-113 armored personnel carriers)
- Lifts and work platforms (up to 125-foot reach)
- Excavation, earthwork and demolition (backhoes, compactors, concrete mixers, dozers, ditch diggers, tractors, graders)
- Sprayers, spreaders and cleaners (pressure washers, floor sweepers, paint strippers)
- Marine equipment (security boats, airboats, outboard engines, trailers)
- Aircraft equipment (aircraft jacks, jet starters, helicopter landing platforms, tow bars, engine stands)
- Rail transport equipment (locomotive engines, railcars, hoppers, whee-handling equipment)

- Tools (saws, cable cutters, drills, impact wrenches, jackhammers, welders)
- Miscellaneous assets (air compressors, safety lights, fuel tanks, foggers, mobile pumps)

1.7.1.17 Institutional Maintenance

Kennedy Space Center can provide modification and alteration of facilities to support various usages. KSC also can provide trench excavating for underground communications and electric cable installations.

The principal services provided include carpentry, masonry work, personnel moves, excavating and facility alterations.

1.7.1.18 Kennedy Complex Control System (KCCS)

Kennedy Space Center has the capability to use KCCS to provide monitoring and control of facility equipment that is required to support customers. Monitoring is provided 24 hours a day, 7 days a week, 365 days a year, from the Complex Control Center (CCC), room 1P9 in the Launch Control Center (LCC).

KCCS Subsystems:

Power: Monitors low, medium and high voltage, Uninterruptable Power Supplies (UPS), Oxygen Deficiency Monitoring System (ODMS), elevators, special power (28V DC), and power meters.

Utility: Heating, Venting and Air Conditioning (HVAC), sound fire suppression water, potable water and pneumatics (gaseous helium, nitrogen and oxygen , compressed air).

Capability Accomplishments:

- For the two subsystems (power and utility), KCCS currently monitors more than 200,000 points, provides real time trending for more than 20,000 points, and alarm monitoring for more than 10,000 items
- Server and workstation hardware and software were recently upgraded to provide capability to support future growth
- KCCS has interfaced with several models of Programmable Logic Controllers (PLCs), including Modicon, Allen-Bradley® and GE Fanuc
- KCCS has been in operation for more than 10 years, maintaining and operating facility equipment
- KCCS utilizes off-the-shelf Supervisory Control and Data Acquisition (SCADA) software, called CitectSCADA, that is capable of interfacing with hundreds of Modbus-compliant field devices that provides great flexibility

1.7.1.19 On-Call Architect and Engineering Services

Kennedy Space Center has the capability to provide on-call architect and engineering services contracts to provide design, drafting, cost estimating, project management and construction management support. Multiple firms have been retained to provide technical expertise in all required disciplines. These firms have developed significant expertise and corporate knowledge regarding KSC infrastructure (facilities, systems, utilities, etc.). NASA and KSC technical standards, and KSC requirements and processes (design, environmental, safety, fire protection, etc.). Indefinite Basic Ordering Agreements (BOAs) are in place to provide design and development support for Constellation and follow-on launch development programs, including 21st Century Space Launch Complex initiatives.

These include the following disciplines:

- Non-conventional structural (buildings, towers, ground support equipment, access and handling structures, mobile launch platforms, test stands, etc.)
- Conventional structural (buildings, towers, structures, foundations)
- Mechanical, electrical, plumbing (fire protection, HVAC, piping and fluid systems, elevators, cranes, medium and low voltage power, communications systems, etc.)
- Specialized fluids (cryogens, hypergols, high-pressure gases, environmental control systems)
- Civil and environmental (site development, water and sewer systems, roads and parking, facilities and structures)
  - Recurring five-year BOAs or Indefinite Delivery/Indefinite Quantity (IDIQ) contracts are in place for routine design and development support to institutional, space shuttle and Launch Services programs.
  -

    These include the following disciplines:
    - Civil and environmental
    - Structural
    - Mechanical
    - Electrical

1.7.1.20 On-Call Construction Contractors

Kennedy Space Center has the ability to provide customers with on-call facility construction contractor support. The Procurement Construction Contracting Office and the Center Operations Construction of Facilities Division includes contracting officers and construction managers who have expertise in overseeing and implementing facility project construction contracts from renovation and repair to new construction and demolition, in accordance with customer requirements, best management practices, and all applicable state and federal regulations. This construction management team has developed recurring, five-year on-call Indefinite Delivery Indefinite Quantity (IDIQ) general construction contracts to provide multidisciplinary facility construction support. IDIQ contracts provide a pool of pre-qualified contractors (based on relevant experience, past performance and price factors) with expertise in KSC infrastructure (facilities, systems and utilities), requirements, and processes (design, environmental, safety and fire protection). Twelve contracts were awarded in 2007, and all are given fair opportunity to bid on multidisciplinary KSC facility projects. All but one of these contracts includes design and build capabilities. The IDIQ contracts have a minimum contract value of $10,000, with a $4 million aggregate value for all task orders for all 12 contracts combined (each individual contract also has a $4 million limit).

Accomplishments:

- As of the end of Fiscal Year 2010 -
    - In the fourth year of a five-year contract
    - 54 task orders awarded
    - Value of awarded contracts is about $87 million
- IDIQ contracts have supported facility projects for the Institutional Program, Hurricane Repair Program, Space Shuttle Program, Launch Services Program, American Recovery and Reinvestment Act and Constellation Program
- The IDIQ contracting strategy provides for a competitive, streamlined advertise and award process, which provides the benefits of a competitive environment with highly pre-qualified existing IDIQ contractors throughout the duration of the contract while minimizing the delays of conducting separate procurements

1.7.1.21 Structural Systems

Kennedy Space Center has the capability to maintain all structural components in offices, shops, storage buildings and towers for mission critical and ordinary duties. KSC facility exterior structure construction is concrete block for 45 percent of the facilities, metal for 38 percent of facilities, poured concrete for 14 percent of facilities, steel for 1 percent of facilities, and other for 2 percent of facilities. KSC roof structure construction is built-up for 49 percent of facilities, metal for 48 percent of facilities, concrete for 1 percent of facilities, asphalt shingle for 1 percent of facilities, and rolled for 1 percent of facilities. KSC has many towers (defined as any structure, freestanding or guyed, that is not part of the electrical distribution system). These include radar towers, camera towers, weather towers and lightning protection towers.

1.7.1.22 Wastewater Systems

Kennedy Space Center includes a wastewater collection and treatment system that safely collects, treats and disposes of the wastewater streams from KSC. The system consists of about 46 miles of sewer mains, 73 lift stations, two operated pretreatment facilities, and a Regional Wastewater Treatment Facility located on Cape Canaveral Air Force Station (CCAFS). Sewage Treatment Plan (STP) 4, located near the Vehicle Assembly Building (VAB), pumps sewage in the VAB Area to STP 1, which is located in the southern part of the Industrial Area. The storage tank and accompanying pumps at this facility function as a high-capacity lift station that pumps all KSC sewage to the treatment facility on CCAFS for final treatment.

1.7.1.23 Water Systems

Kennedy Space Center operates a water distribution system that safely distributes potable water and provides chlorine booster treatment for KSC. The City of Cocoa supplies potable water via water mains that enter KSC at two locations: near the KSC south gate and near the CCAFS south gate. The system currently consists of about 103 miles of water mains, two elevated potable water storage tanks, two booster pump stations, one rechlorination facility in a pump station, and three stand-alone rechlorination facilities. KSC maintains the operations and maintenance responsibility for the main components of the water distribution and retreatment system. In addition to interconnecting to Cocoa's water system, KSC also interconnects with CCAFS via two water mains. KSC's primary water main crosses the Banana River Causeway from the CCAFS Industrial Area. The secondary water main connects the KSC system with the CCAFS system at Launch Pad39A. The interconnection between the KSC and CCAFS water distribution systems represents the increased partnership efforts between NASA and the U.S. Air Force to develop a fully functional and efficiently unified spaceport.

1.7.1.24 Work Management

Kennedy Space Center is capable of processing and monitoring requests for support, maintenance, engineering or other services provided by KSC. The work management program incorporates all work planning and prioritization, quality assurance, safety analyses, documentation, procedure compliance, monitoring, tracking and reporting.

Chapter 1.7.2
Information Technology Infrastructure and Communications Systems

Kennedy Space Center has the capability to provide secure networks, data systems, communication systems, security and support.

Chapter 1.7.2 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.7.2 Information Technology Infrastructure and Communications Systems

1.7.2.1 Data Center Services

Kennedy Space Center has the capability to provide safe and secure data center services. These services include partial or complete hosting of customer-developed or commercial off-the-shelf applications and systems, housing of customer-provided equipment and systems, data and requirements analysis, business services, and the necessary information technology (IT) security components to enable customers to focus on mission needs. Coupling with field systems services allows for widely available data center services.

The data centers, such as the Kennedy Data Center (KDC), provide institutional, business, scientific and engineering applications, specialized systems and Web hosting services for KSC and NASA agency organizations. The KDC is an access controlled area that consists of state-of-the-art storage, backup, disaster recovery, environmental monitoring and industrial-size uninterruptible power supply (UPS). It offers options ranging from basic co-location to full-service hosting.

The Kennedy Data Center provides agency patchlink and reporting services.

1.7.2.2 Information Technology Security

Kennedy Space Center has the capability to provide information technology (IT) security. Among its functions is providing secure IT interfaces and systems for use by Spaceport customers. IT security also assists customers in NASA and federal security compliance as well as providing secure configuration recommendations to protect any sensitive information and data.

From a programmatic stance for highly specialized systems, IT security develops highly specialized IT planning, implementation and project management requirements. IT also provides security assessment and insight to the aforementioned systems used to support launch capability involving numerous products or data required to meet agency or center time lines. The systems have data to be analyzed using statistical analysis and enumeration and extensively large scale integration of dataset with analysis (i.e., actions involving hundreds of thousands of transactions, data with terabytes of information, and risk assessments).

Accomplishments:

- Ensuring NASA information technology systems are in full compliance with federal laws and regulations, including the Federal Information Security Management Act (FISMA) of 2002
- Providing subject matter expert (SME) support on National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53 control guidance
- Providing guidance to KSC on the development and implementation of NIST security controls, security plans,

policies, procedures for institutional, mission unique and specialized systems, including non-NASA systems holding and processing NASA data

- Supported the security assessment and authorization (certification and accreditation) of NASA IT systems, including mission, institutional and lab systems
- Providing wide-area network and network security perimeter support to KSC IT systems; including KSC firewall and network monitoring and intrusion detection service and secured remote access (VPN) capability
- Providing agencywide patch management service, support and oversight
- Providing centerwide monthly network vulnerability scan reports to ensure IT systems are protected and mitigated from network vulnerabilities
- Worked closely with Space Operation Mission Directorate teams to ensure mission systems are secured and in compliance (even with operational constraints)
- Supporting the development of IT security controls for the Launch Control System, Constellation Ground Systems and Engineering Labs

1.7.2.3
Mission and Administrative Networks, Voice and Imagery

Kennedy Space Center has the capability to provide several communications services for the spaceport, including infrastructure and transmission, voice and visual. These services also provide links back to home sites as well as other locations, as requested.

Kennedy Space Center's Mobile Mission Command Center supports NASA's Extreme Environment Mission Operations in Key Largo, Fla.

The communications infrastructure and transmission services include copper, fiber, radio frequency (RF), optical, asynchronous transfer mode (ATM), transmission control protocol/internet protocol (TCP/IP), and synchronous optical network technologies (SONET), as well as others. The voice communications services include operational intercom, paging and area warning, mobile and fixed radio service, telephones and secure voice services. The services also provide acquisition, archiving and distribution of voice services for launch operations and other spaceport events, such as tests. The visual communications services include voice, video, film, high-speed digital film, data, RF voice and optical tracking services. These services collect, store and deliver imagery of launches and other spaceport events.

1.7.2.4
Remote Operations and Telescience Support

Kennedy Space Center has the capability to provide remote operations and telescience support. The remote operations group provides advanced operations support to remote site(s) to meet mission and operational needs. The support includes IT services and methods to access telescience systems if needed. The telescience group extends KSC basic and advanced IT services to any location (on Earth, or simulated off Earth) to support design, development, research, operations, outreach or general support activities.

Equipment in the Telescience and Internet Systems Laboratories support video streaming over Internet Protocol (IP).

Accomplishments:

- Providing communications support to NASA analogs activities in the northern hemisphere
- Supporting regional and national For Inspiration and Recognition of Science and Technology (FIRST) robotics competitions by streaming video from remote locations for NASA distribution

Website:

KSC Center Planning and Development Office – Technical Capabilities - Life Cycle Modeling and Simulation and IT Services
http://kscpartnerships.ksc.nasa.gov/techCap/lifeCycleModSim.htm

Kennedy Space Center Telescience Lab supported the global flyer operations at the center's Shuttle Landing Facility.

1.7.2.5
Site User Services

Kennedy Space Center has the capability to provide on-site, temporary and permanent, end user information technology (IT) resources and capabilities. These resources include computers, laptops, printers, plotters, network access, phones, cell phones, radios and associated infrastructure. The group has the ability to provide the resources on a monthly model that reduces customer costs associated with spaceport operations.

The end user services group is primarily responsible for providing leadership, design, development, sustaining engineering, and guidance for the planning, acquisition, implementation, operations, maintenance, and/or use of new and existing operational information technology systems, applications, services and processes. This includes Outsourcing Desktop Initiative for NASA (ODIN) management and surveillance, multifunction (copy/scan/fax) devices, cellular telephones, pagers, and source evaluation board IT support. The support includes graphics, micrographics, library, forms, printing and reproduction, and engineering documentation services and processes. The group performs multiple center and agency delegated functions including KSC Site Representative for Space Operations Mission Directorate, ODIN Lead Service Center, KSC ODIN contracting officer's technical representative (COTR), KSC Printing Officer, KSC forms manager, technical management representative for the Agency Multifunction Device Contract, and the KSC postmaster.

Kennedy Space Center supports the Desert Research And Technology Studies with communications equipment and logistics support.

Kennedy Space Center communications equipment is deployed during the 2010 Pavilion Lake Research Project in British Columbia, Canada.

Chapter 1.7.3
Transportation and Handling

Kennedy Space Center can accommodate rail, air, road and sea transportation methods including lifting and handling expertise. KSC has expertise in providing and coordinating transportation and packaging services.

Chapter 1.7.3 of the Kennedy Resource Encyclopedia includes the following capabilities:

1.7.3 Transportation and Handling

1.7.3.1 Lifting Devices and Equipment Program

Kennedy Space Center has experience ensuring compliance with NASA and the Occupational Safety and Health Administration Lifting Devices and Equipment (LDE) requirements, as well as conform to American Society of Mechanical Engineers (ASME) design, testing, inspection, maintenance and operations guidance. KSC also can ensure compliance with NASA Standard for Lifting Devices and Equipment.

Workers carefully lift a solid rocket motor segment for the Ares I-X project.

1.7.3.2 Railroad Operations and Maintenance

Kennedy Space Center has the capability to perform locomotive/train operations and locomotive/rail car maintenance. KSC owns and maintains 42 miles of track throughout Kennedy Space Center. The KSC railroad consists of three SW1500 locomotives and 47 railcars. Railcars include flatcars, hopper cars, gondolas and special cars. The rail crew can support railcar deliveries and moves throughout the center, and can arrange to support two trains when scheduled to support two simultaneous operations.

KSC railroad has the capability to perform maintenance using American Association Of Railroads (AAR) standards. Additionally KSC can complete repairs, modifications and refurbish railcars and locomotives.

1.7.3.3 Roads, Bridges and Parking

The road and bridge network serves all facilities and operations on Kennedy Space Center and Cape Canaveral Air Force Station. KSC has 1.5 million square yards of parking areas, 2.8 million square yards of roads, seven major automotive bridges, and one railroad bridge that serve KSC and CCAFS.

The KSC Industrial Area roadways are constructed in a grid system with avenues oriented north and south and streets oriented east and west. This grid system is accessed from NASA Parkway East via C, D and E Avenues and from Kennedy Parkway South via 5th Street. The Industrial Area grid system provides access to numerous vacant lots available for development and access to numerous key facilities that already exist, such as the Hypergolic Maintenance Facility (HMF), the KSC Headquarters (HQ) Building and the Space Station Processing Facility (SSPF). Two-lane roadways were constructed in the Industrial Area to support the SSPF. First and Second Streets were extended eastward to connect with new local access roads built to funnel traffic into parking areas for the SSPF. A newly constructed road connects East NASA Parkway with these extended roads.

Vehicle Assembly Building (VAB) area roadways include:

- Saturn Causeway

- Utility Road
- Launcher Road
- Fluid Service Road
- Ordnance Road
- Instrumentation Road

Saturn Causeway provides direct access to Launch Complex 39, pad A. Pad B is accessed via Pad B Road. The tow way and Astronaut Road provide access to the Shuttle Landing Facility.

Parking lots on KSC are primarily located in four areas: Launch Pads 39A and B, Vehicle Assembly Building Area, KSC Industrial Area, and the Kennedy Space Center Visitor Complex. There are more than 120 parking lots in these areas. In addition to employee parking, parking lots serve as heavy equipment storage areas that have special requirements due to the weight and properties of the materials and equipment stored on them.

All KSC bridges are Department of Transportation (DOT) rated for standard loads. Eight main bridges exist at KSC (seven automotive bridges and one railroad bridge):

- Haulover Canal Bridge (E4-2414)
- Indian River Bridge – eastbound (M3-003)
- Indian River Bridge – westbound (M3-003)
- NASA/Kennedy Interchange Bridge – eastbound (M6-232)
- NASA/Kennedy Interchange Bridge – westbound (M6-232)
- Banana River Bridge (M7-1150)

1.7.3.4. Shipment Packing Capabilities

Kennedy Space Center has the capability to provide shipment packing for customers in order to minimize damage during transportation. The Institutional Services Contractor, URS, performs all packing, packaging, marking, labeling and manufacture of cardboard and wooden containers in accordance with applicable military and federal regulations, standards and customer identified specifications for domestic and international shipments by all modes of transportation. This support also conducts Performance Oriented Package (POP) testing on packages to be used to transport HAZMAT (hazardous materials) in accordance with the Code of Federal Regulations (CFR) 49 for domestic shipments and the International Civil Aviation Organization's Technical Instructions (ICAO) for international shipments.

1.7.3.5. Transportation of Flight Hardware and Related Equipment

Kennedy Space Center has the capability to transport flight hardware and ground support equipment to and from the center, and among facilities throughout KSC and Cape Canaveral Air Force Station (CCAFS).

Transportation specialists at KSC have the ability to execute transportation needs. Services include transportation planning, packing, crating, receiving and coordination with freight forwarders and the KSC Export Control Office. Specialists can coordinate delivery of equipment required to complete transportation tasks including pallet jacks, tractors and trailers, box trucks, flatbed trucks, and various types and sizes of gasoline and diesel forklifts. Unique equipment, such as the payload canister and transporter and the Mobile

The U.S. Tranquility Node 3 is loaded onto a flatbed truck for delivery to KSC.

The Alpha Magnetic Spectrometer (AMS) is offloaded from an Air Force C-5M aircraft at KSC's Shuttle Landing Facility, after its transatlantic flight from Europe.

Launch Platform, enable relocation of flight hardware from their processing facility to the launch pad while maintaining their required launch environment and configuration.

Accomplishments:

- Supported all space shuttle mission logistical requirements
- Planned, coordinated and executed transportation of NASA and International Space Station partner elements to KSC
- Provided logistics support for multiple space station elements, including multipurpose logistics modules (MPLM), nodes, Express Logistics Carriers (ELC), the European Space Agency's (ESA) Columbus module, Japan Aerospace Exploration Agency's (JAXA) space station elements, and the Alpha Magnetic Spectrometer (AMS) experiment payload

Volume 2
Facilities

With more than 218 square miles of land, hundreds of facilities, and a potential significant investment to modernize and expand center capabilities, Kennedy Space Center is sure to have facilities and infrastructure available to suit the needs of any space, technology development or related industry endeavor. From processing facilities, control rooms, clean rooms and launch pads to storage areas, office space, auditoriums and classrooms, KSC has it all. Volume 2 of the Kennedy Resource Encyclopedia is dedicated to providing information about 38 of the highly valuable and unique facilities KSC has to offer.

2.1 Assembly and Refurbishment Facility (ARF)

Description:

The Solid Rocket Booster (SRB) Assembly and Refurbishment Facility (ARF) Complex opened in August 1986 for SRB component manufacture, assembly and refurbishment. The 45-acre complex contains seven buildings constructed between 1986 and 1992. These include the Engineering and Administration Building, the Chiller Building, the Manufacturing Building, the Service Building and the Aft Skirt Test Building, all constructed in 1986. The Storage Building was constructed in 1988 and the Hazardous Waste Staging Building in 1992. The Manufacturing Building is used to fabricate,

The main entrance to the Assembly and Refurbishment Facility.

process and refurbish inert or non-propellant SRB elements, including the forward and aft skirts, frustrums and nose caps, before delivering them to the Rotation Processing and Surge Facility (RPSF) for final assembly. The Manufacturing Building contains an 80-foot by 250-foot central high bay with three-story wings to the north and south, two ordnance room cells with conditioned space, three TVC 100K build-up cells, and 9,260 square feet of TVC 100K clean rooms. The facility also has two thermal protection system (TPS) robotic paint cells with air turntables, two TPS cure cells, 10,260-square-foot TPS high bay conditioned prep and finish areas, and 5,800-square-foot Electronics and Instrumentation (E&I) conditioned electronics labs, as well as a machine shop. Other operations include the replacement of thermal protection on the SRB components, installation of electronic and guidance system, integration of SRB recovery parachutes, and automated checkout. It also is where the steering elements of the thrust vector control system are assembled and

Assembly and Refurbishment Facility Storage Building loading dock area.

tested, and where the explosive devices for booster separation are installed.

The ARF complex also contains engineering and administration and modular office buildings (with 106,500 square feet of total office space); two ground support equipment (GSE) service buildings; Aft Skirt Test Facility (ASTF) (with two test bays Class I, Div. 2, for hot fire testing); Hazardous Waste Storage Facility; Multi-Purpose Storage Building; MPSF Storage Facility (with 27,900 square feet of high bay storage, 2,980 square feet of high bay conditioned storage, 18,000 square feet of low bay conditioned storage and shipping, and receiving area and docks); and a supporting chiller building situated to the north.

Ammonia Servicing:

Not available

Building Management System:

The building management system is a Carrier ComfortView 3.0 system, which monitors processing areas temperature, humidity, HVAC system status and out-of-spec alarms.

Chilled Water:

Yes

Clean Room:

Not available

ARF (Continued)

Electrical Service
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is available at 115 pounds per square inch gage at 800 cubic feet per minute.

Gaseous Nitrogen:
Gaseous nitrogen available incoming at 5,000 psi and outgoing at 3,000 psi.

Gaseous Helium:
Gaseous helium is available via a Tube Bank at 2,200 psi.

Control Rooms:
Not available

Cranes:
There are two, 15-ton capacity bridge cranes available within the facility. Hook height was unknown at this time.

There is one, 5-ton capacity bridge crane available within the facility. Hook height was unknown at this time.

Relative Humidity:
These systems can maintain a relative humidity of 40 to 60 percent. Also, the TPS spray cells have the capability to add humidity based upon customer requirements.

Temperature Range:
These systems can maintain a minimum 68 degrees F. The large cure ovens can operate at up to 130 degrees F.

Uninterruptible Power Supply (UPS):
Multiple UPS systems are available in various buildings within the ARF complex. Individual specifications can be provided based upon customer needs and requirements.

Vacuum Chamber:
None

Video Camera/Recorders:
The Assembly Check Out (ACO) area and ASTF cells have cameras and recording capability.

Floor Space:
168,014 square feet

Door Height:
The main door is 35 feet high (two each in manufacturing building).

Door Width:
The main door is 30 feet wide (two each in manufacturing building).

Processing Area:
High bay is 80 feet by 200 feet.

Office Space:
106,500 total square feet in all buildings.

2.2 Canister Rotation Facility (CRF)

Description:
The Canister Rotation Facility consists of a 7,200-square-foot high bay building that contains a 100-ton bridge crane, canister support stands and access platforms, and associated site work utilities. The facility was designed to perform rotation of the canister from the horizontal position to the vertical and vice-versa. The facility is outfitted with power, lights, HVAC system, grounding and lightning protection, fire detection, fire protection, paging and area warning, telephone system, shop vacuum cleaning system and shop compressed air.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
The high bay is classified as a class 300,000 clean work area (CWA).

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

The payload canister containing the payload for space shuttle Endeavour's STS-126 mission backs away from the Canister Rotation Facility at Kennedy Space Center.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The specifications of the compressed air system is 125 psi at 105 cubic feet per minute.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
There are two cranes available in the CRF. One is a 100-ton crane with a 119-foot hook height, and the other is a 10-ton crane with a 104-foot hook height.

Relative Humidity:
The air-conditioning system is designed to maintain a relative humidity of 55 percent (+/- 5 percent).

Temperature Range:
The air conditioning system is designed to maintain 71 degrees F (+/- 6 degrees).

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
25,121 square feet

Door Height:
The main door is 74 feet high.

CRF (Continued)

Door Width:
The main door is 30 feet wide.

Processing Area:
7,200 square feet

Office Space:
Approximately 4,000 square feet of the facility is used as office space.

The payload canister containing the S6 truss and solar arrays leaves the Canister Rotation Facility at Kennedy Space Center to head for Launch Pad 39A.

2.3 Component Refurbishment and Chemical Analysis (CRCA) Facility

Description:

The Component Refurbishment and Chemical Analysis (CRCA) Facility (K6-1696) includes a laboratory that is dedicated to the analysis of environmental media. The laboratory occupies the northern half of the building and holds a national Environmental Laboratory Accreditation Certification for the analysis of multimedia (soil, water and gas) samples obtained from the Kennedy Space Center facility.

The southern half of the facility is dedicated to the cleaning and refurbishment of mechanical and operations parts. Each part is received in the materials receiving area located on the western side of the facility. If a part is contaminated with fuel or oxidizer compounds, it is routed to the fuel and oxidizer Decontamination Facility (K6-1747) that is located at the southeastern corner of the site. Decontaminated parts are then returned to the materials receiving area where each part or component is tagged and labeled with a

A view of the main entrance to the Component Refurbishment and Chemical Analysis Facility.

unique process flow specifically designed for that part. Although each individual part is processed differently, a general description of the process follows: decontaminated parts are processed through the Pre-clean Disassembly Room (Room 1325); from this point they are transferred to Rough Clean (Room 1400) and then Field Clean (Room 1500). The Rough Clean and Field Clean areas utilize a series of chemical, detergent, caustic, or acid-filled dip vats. After cleaning, the parts are reconfigured and readied for reuse. In some cases, specialized coatings may be applied. The coating process is conducted in the northern half of Room 1500.

A view of the Component Refurbishment and Chemical Analysis Facility.

The parts are then subjected to quality assurance (QA) procedures prior to repackaging and preparing for shipment or pickup in the Clean Room (Room 1319).

The Rough Clean and Field Clean rooms include an interconnected subfloor collection system designed to collect any spills from the dip process vats. The vats contain a variety of chemicals, including solvents, detergents, caustics and acids. The subfloor drain systems contain sumps and drain lines that contain and transport any spill that may occur in that area. The drain lines are interconnected, double-walled, and exit the CRCA in a concrete trench located on the eastern side of the building. The trench leads to a wet well located near the Solvent Distillation Tower (K6-1696B). After the wet well has reached its capacity, the fluids are pH adjusted, if necessary. Then they are manually pumped from the wet well to either Tank 1 (10,000 gallons) or Tank 2 (10,000 gallons), depending on the capacity remaining in each tank. United Space Alliance then takes control of the waste, which it pumps into the sanitary sewer lift station on site.

Other CRCA facilities include the Dry Chemical Storage Building (K6-1748), which is used to store miscellaneous goods, pallets and spent chemical totes; the Hazardous Waste Storage Building (K6-1748A), which is adjacent to K6-1748 and is used as a satellite accumulation area for hazardous waste; and Building K6-1745 which is located southwest of Building K6-1696 near Contractors Road and functions as a communications cross connect terminal.

CRCA Facility (Continued)

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Yes

Clean Room:
There are multiple clean rooms within the CRCA facility. The main clean rooms are Class 100, while secondary clean rooms are Class 1000.

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
There are two compressed air systems; both have 240-gallon tanks with dual compressors. Compressor one is dedicated to clean room humidification and provides air at 75 psi. The second provides air for the rest of the facility at 150 psi.

Gaseous Nitrogen:
Gaseous nitrogen is provided at 5,600 psi.

Gaseous Helium:
Gaseous helium is provided at 5,000 psi.

Control Rooms:
Not available

Cranes:
Two cranes, each with a 4,000-pound capacity and about a 15-foot hook height, service the pre-clean area. One crane services the field cleaning area and is capable of a 4,400-pound capacity with about a 15-foot hook height.

Relative Humidity:
The HVAC system conforms to industry standards for comfort air relative humidity for an office environment.

Temperature Range:
The HVAC system conforms to industry standards for comfort air temperature for an office environment.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
57,044 square feet

Door Height:
The field cleaning double doors are 10 feet high. The pre-clean/hydraulics room roll-up doors are 12 feet high.

Door Width:
The field cleaning double doors are nearly 8 feet wide. The pre-clean/hydraulics room roll-up doors are 8 feet wide.

Processing Area:
There is about 42,000 square feet of processing area.

Office Space:
There is about 6,750 square feet of office space available.

2.4 Crawler Transporter Maintenance Facility

Description:
The Crawler Transporter Maintenance Facility is used for daily operations and maintenance tasks on the two crawler-transporters. The facility includes a north and south parking location (crawlerway extension) for the two transporters, a maintenance high bay with limited shop capability (25-ton bridge crane shop, air, and other miscellaneous maintenance equipment), and office and shop areas for transporter personnel. Electrical shore power and fire system cable connection panels are located at each crawler-transporter parking location.

The Crawler Transporter Maintenance Facility.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Not available

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is available within the facility. At press time specifications were unavailable.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
25-ton bridge crane with a 25-foot hook height.

Relative Humidity:
Processing area is non-conditioned space.

Temperature Range:
Processing area is non-conditioned space.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
10,772 square feet

Crawler Transporter Maintenance Facility (Continued)

The Crawler Transporter Maintenance Facility.

Door Height:

South door - 16 feet high
North door - 12 feet high
Southeast door – 32 feet high
Northeast door - 17 feet high

Door Width:

South door - 18 feet wide
North door - 12 feet wide
Southeast door - 30 feet wide
Northeast door- 30 feet wide

Processing Area:

Not applicable

Office Space:

About 5,000 square feet is currently configured as office space.

2.5 Engineering Development Laboratory (EDL) Building

Description:
The Engineering Development Laboratory, located in Kennedy Space Center's Industrial Area, is a two-story technical support office building, with 64,044 square feet of total space. The Design Engineering (DE) Development Laboratories, including hazardous gas detection, transducer, navigation aids, electronic security, optical instrumentation, computer interface development, electronic development, real-time systems and artificial intelligence are located in this building. There also are a mechanical shop and a visitor tour stop in the building.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
120 psi service air provided from the Space Station Processing Facility.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
The HVAC system conforms to industry standards for comfort air relative humidity for an office environment.

Temperature Range:
The HVAC system conforms to industry standards for comfort air temperature for an office environment.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
68,755 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
7,600 square feet of office space is available.

An exterior view of the Engineering Development Laboratory.

2.6 Hangar AE

Description:
NASA's Launch Services Program, managed at Kennedy Space Center, uses the Mission Director's Center (MDC) and Launch Vehicle Data Centers (LVDCs) to independently monitor vehicle testing and launch of all expendable launches procured by the program. They also are available to commercial and Department of Defense customers on a reimbursable basis, and have supported Delta II, Delta III, Delta IV, Atlas II, Atlas V, Pegasus, Taurus, Falcon 1 and 9, and Ares I-X launch vehicles.

Hangar AE Data Centers: Three, 24-seat Launch Vehicle Data Centers
Each room contains 24 console positions. Each console position allows the user access to telemetry data displays, voice communications, switchable video displays and timing. The room also has a large central display that can be customized to show video, computer displays, or a mix of both, and includes two broadcast quality cameras for public affairs use. The telemetry system can be easily customized to show custom screens and special processing of available telemetry measurements. The console also includes access to an administrative telephone and online access to electronic documentation.

Hangar AE Data Centers: 38-seat Mission Directors Center
The room contains seats for 34 managers, and a special console for up to two public affairs representatives for commentary. These consoles provide the same access to voice, video, data, timing, administrative telephone and electronic documentation that the LVDCs provide in an executive setting. The room also contains cameras for public affairs, including high-definition cameras and a highly customizable central display system. An adjoining VIP guest room has seats for 16 visitors with a glass wall with good noise suppression. The facility includes a newly renovated lobby with a catering area.

Hangar AE Data Centers: Telemetry Laboratory
This room contains seats for eight engineers with the same capabilities as the consoles in the LVDCs, but with six screens per console rather than one or two. This area is intended for advanced engineers or those who need direct access to the facility operations staff.

The telemetry lab also has an extensive array of links to downrange sites and can provide connectivity back to launch site facilities. This can be in either a bent pipe mode, or processed telemetry mode, depending upon the customer's needs. The lab also can provide recording of telemetry in formats popular within the industry. The lab also includes a set of fixed antennas for monitoring, recording and processing RF systems on the ground. The telemetry software, Iris, is designed for highly robust and flexible monitor-only display of telemetry measurements and can easily integrate several streams into a single display. Iris can display a virtually unlimited number of user-customized pages containing both text and graphical representations of measurements from any available telemetry stream.

Hangar AE Data Centers: Public Affairs Office Production Support
The facility can be used to gather broadcast quality video and audio from a variety of sources and pass that to the user's production site. The facility also can be used to host a mobile commercial production trailer and uplink truck if required.

Hangar AE Data Centers: Remote Telemetry Display System
The telemetry system used within the facility has the flexibility to provide locally processed telemetry to users anywhere, using leased lines or the internet, depending upon the customer's bandwidth and security requirements. The system is very low impact on end users' workstations. Various levels of encryption and

A view of the front entrance of the Hangar AE facility at Cape Canaveral Air Force Station.

Hangar AE (Continued)

user authentication can be provided. Past customers have used this system to acquire launch vehicle embedded telemetry in addition to the spacecraft streams back at the operations facility.

Hangar AE Data Centers: Telemetry Special Processing

The telemetry processing system allows for rapid turn-around of display capability for embedded or discrete telemetry streams. This is generally used by those with small spacecraft projects who do not wish to field telemetry systems at the launch site but would desire a display of spacecraft measurements embedded in the launch vehicle stream. It also has been used by vehicle engineers to display specially-calculated measurements without requiring modification of their primary command and control systems.

Hangar AE Data Centers: Downrange Telemetry Tracking and Relay

A mobile S-band tracking antenna can be staged at remote sites for coverage of short term orbital events. The system allows for on-site recording of received telemetry or video. This system also includes C-Band and Tracking and Data Relay System (TDRS) uplink capability for real-time relay back to the launch site or operations center. The complete system can be transported by aircraft and assembled and operated by a small crew.

Hangar AE: Payload Processing Facility

Building AE is used for prelaunch preparations and checkout of NASA nonhazardous payloads launching on an expendable launch vehicle. The building contains a telemetry ground station, an extensive communications center for data, voice and video, three launch vehicle data centers (LVDCs), the Mission Director's Center (MDC), and offices for payload and contractor personnel.

Ammonia Servicing:

Not available

Building Management System:

HVAC parameters are controlled and monitored by the Andover Building Automation System, which consists of stand-alone control panels located throughout the building and dedicated programs to maintain set point conditions.

Chilled Water:

Yes

Clean Room:

The clean work area in the high bay is rated as a level two (laminar flow) that is 51 feet, 6 inches long, 43 feet, 10 inches wide, and 42 feet, 3 inches tall.

The high bay air lock, the test and storage area and the precision cleaning lab are rated as level three Clean Work Areas (CWAs).

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Compressed air within Hangar AE is provided at 100 pounds per square inch gage (psig) (6.89 bars) at 25 cubic feet per minute.

Gaseous Nitrogen:

Building AE does not have built-in gaseous nitrogen storage capability. However, depending on customer requirements, portable tube banks may be located on the corner of Room 1425.

A distribution panel, located outside room 1425 on the northwest corner of the building, is tied to a floor mounted reducing panel near the west wall of room 1430, with two one-quarter-inch (0.32-cm) outlet hand valves and a 3,000 psig (206.9-bars) gauge indicating available delivery pressure, which can be regulated from 0 – 2,400 psig (165.5 bars).

Gaseous Helium:

Not available

Control Rooms:

Not available

Hangar AE (Continued)

Cranes:
The Hangar AE clean room contains a 5-ton (4.5-metric- ton) bridge crane with a 33-foot, 9-inch hook height.

The facility's test area also contains a 2-ton (1.8-metric-ton) monorail crane with a 38-foot, 10-inch hook height.

The air lock contains a 6-ton (5.4-metric-ton) monorail crane with a 38 foot, 5-inch hook height.

Relative Humidity:
The air conditioning system within Hangar AE is designed to maintain a relative humidity of 50 percent or less in clean work areas, and a relative humidity of 50 percent or less in office areas.

Temperature Range:
The HVAC system within the Hangar AE clean room can be maintained to 71 degrees F (+/- 6 degrees F). The air-conditioning system also can maintain 71 degrees F (+/- 6 degrees F) for the rest of the building.

Uninterruptible Power Supply (UPS):
The payload telemetry ground station, the MDC, and the telemetry laboratory are connected to a permanently installed emergency generator outside the west end of Hangar AE. The changeover to this generator is manual. The minimum lapse time is approximately 30 seconds for the changeover and power stabilization. The emergency generator provides 350 kilowatts at 440 volts/60 Hertz DC. UPS also is available for more critical systems.

Vacuum Chamber:
None

Video Camera/Recorders:
The CCTV provides surveillance of payload processing from operational areas to control areas in Hangar AE. Areas under CCTV camera surveillance include Rooms 1012 (MDC) and 1410 (CWA). CCTV camera capability also can be provided on an as-needed basis for other areas of the building.

There are two cameras mounted 23 feet high in the high bay test area on each side of the west wall. Views from these cameras can be seen on the internal Hangar AE video system. Portable cameras can be installed in other areas to observe specific activities as needed or required.

Floor Space:
40,333 square feet

Door Height:
The Hangar AE door is 36 feet, 1 inch high into the high bay airlock and high bay test area through high bay airlock.
The door leading from the test and storage area into the high bay test area is 7 feet, 1 inch high.

Door Width:
The Hangar AE door leading from the high bay air lock into the high bay test area is 14 feet, 9 inches wide. The door leading from the test and storage area into the high bay test area is 8 feet, 1 inch wide.

Processing Area:
The Hangar AE air lock measures 33 feet long (5.2 meters), 17 feet wide (11.9 meters), and 40 feet high (12.2 meters).

Office Space:
About 700 square feet of office space within Hangar AE is currently configured for use by spacecraft customers.

2.7 Hangar M Annex

Description:
Hangar M Annex is a two-story concrete block building, with a total of 10,462 square feet of space. It is primarily used as office space. A portion of the first floor was converted to laboratory space.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Not available

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The compressed air system in the Hangar M Annex provides air at 115 pounds per square inch gage (psig) at 30 cubic feet per minute.

Gaseous Nitrogen:
Gaseous nitrogen is available only by delivered bottles as required.

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

The Hangar M Annex facility at Cape Canaveral Air Force Station.

Relative Humidity:
These systems can maintain a temperature range of 70 to 80 degrees F with a maximum relative humidity of 55 percent.

Temperature Range:
These systems maintain temperatures of 70 to 80 degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
41,450 square feet

Door Height:
Personnel doors are 7 feet high.

Door Width:
Personnel doors are 6 feet wide.

Processing Area:
Not applicable

Office Space:
5,000 square feet

2.8 Hangar N

Description:
Hangar N is a concrete and steel frame building with full-opening sliding doors on the east and west walls, and main hangar building with two-story office and laboratory areas on the north and south sides. The main hangar contains four single-story clean work area (CWA) complexes. There is also one X-ray test cell and control room and four small paint booths and one cure oven. The remaining high bay is used to store flight hardware. There also is a 5,000-square-foot concrete stand alone storage building with a 20-foot by-20-foot sliding door.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Not available

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

The Hangar N facility at Cape Canaveral Air Force Station.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The compressed air capability is 115 pounds per square inch gage (psig) provided by a 20 horsepower unit.

Gaseous Nitrogen:
The gaseous nitrogen system consists of K bottles tied into a manifold.

Gaseous Helium:
The gaseous helium system consists of K bottles tied into a manifold.

Control Rooms:
Not available

Cranes:
The facility is serviced by two, 25-ton bridge cranes, each with a maximum hook height of 25 feet.

Relative Humidity:
These systems can maintain a temperature range of 70 to 80 degrees F, with a maximum relative humidity of 55 percent.

Temperature Range:
These systems can maintain a temperature range of 70 to 80 degrees F.

Uninterruptible Power Supply (UPS):
20 KVA output 208/120/3/60 55A

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
43,062 square feet

Hangar N (Continued)

Door Height:
Hangar N has two doors, each with a 30-foot door height.

Door Width:
Hangar N has two doors, each with a 120-foot door width.

Processing Area:
Total high bay is 130 feet wide by 160 feet deep.

Office Space:
4,000 square feet

2.9 Hangar S

Description:

Hangar S is a concrete and steel frame building with full-opening sliding doors on the east and west walls,

along with a main hangar building with two-story office and laboratory areas on the north and south sides. The main hangar contains one single-story clean work area (CWA) complex. The north and south CWAs can be used individually, or if necessary, both bays may be used for one larger payload. The CWA is now being used primarily as a training area. The remaining high bay is used as a weld shop and for flight hardware storage. Hangar S is considered a customer-operated facility where the customer is responsible for day-to-day operations, with the exception of crane pre-operation checks and clean work area (CWA) door opening and closing. Crane pre-operation checks are the responsibility of the U.S. Air Force 45th Space Wing (45th SPW) contractor, and CWA openings and closings are normally handled by either 45th SPW or NASA personnel. The area of the south clean work area is 2,475 square feet and the area of the north clean work area is approximately 1,260 square feet. Equipment enters the south clean work area through the airlock (room 20) or through the air shower (room 15B). Equipment enters the north clean work area through the common air lock or through the large air shower (room 21A). The south clean work area has a 2-ton bridge crane with a north to south travel, and the north clean work area has a 2-ton monorail crane with a north to south travel. The outside entrance into the air lock is through a 16-foot, 1-inch-wide by 19-foot, 8-inch-high door. Both north and south clean work areas (from the air lock) have doors that are 14 feet, 9 inches wide by 19 feet, 8 inches high. Please see the facility handbook, K-STSM-14.1.4, for more information.

Ammonia Servicing:

Not available

Building Management System:

Not available

Chilled Water:

Yes

Clean Room:

The facility is equipped with clean work areas, however they are currently configured to be used as training rooms.

The Hangar S facility at Cape Canaveral Air Force Station.

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Compressed air within the facility is provided at 115 pounds per square inch gage (psig) at 40 cubic feet per minute.

Gaseous Nitrogen:

Not available

Gaseous Helium:

Not available

Control Rooms:

Not available

Cranes:

The facility is serviced by two, 15-ton cranes, each with a 30-foot maximum hook height.

Relative Humidity:

These systems can maintain a temperature range of 70 to 80 degrees F, with a maximum relative humidity of 55 percent in offices and clean work areas.

Hangar S (Continued)

Temperature Range:
These systems can maintain a temperature range of 70 to 80 degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
61,382 square feet

Door Height:
Hangar S has two doors, each 30 feet high.

Door Width:
Hangar S has two doors, each 120 feet wide.

Processing Area:
Total high bay is 130 feet wide by 160 feet deep, with 20,800 square feet of area.

Office Space:
8,290 square feet

2.10 Hypergolic Maintenance Facility (HMF)

Description:

The Hypergolic Maintenance Facility (HMF) is comprised of various buildings, including the Hazardous Waste Staging Area, General Warehousing (clamshell), Hypergols Module Processing North, GSE Storage Building (HMF support), HMF Mix Crib and Petroleum, Oil, and Lubricants (POL) storage, Hypergolic Maintenance Facility Support Building No. 2, Hypergols Support Building (HMF control room), Gaseous helium and Gaseous nitrogen storage, Hypergols Module Processing South, Storage Area, Firex Pump Station, Water Storage Tank, and Temporary Building (pad A liquid hydrogen area). Today, the HMF receives the Orbiter Maneuvering System (OMS) pods and Forward Reaction Control System (FRCS) modules for offline processing. Within the HMF complex the hypergols support building houses the control room used to monitor activities in the test cells. Hypergols Module Processing North contains the east and west test cells used currently for pod hypergolic service and de-service. The east handles the right orbiter pod, and west handles the left orbiter pod. Hypergols Module Processing South is used for pressure vessel testing and FRCS or other storage. The west test cell is used for FRCS hypergolic service and de-service.

At the Hypergolic Maintenance Facility at NASA's Kennedy Space Center in Florida, preparations are under way to move the Forward Reaction Control System, or FRCS, for space shuttle Discovery to Orbiter Processing Facility Bay 3.

The HMF complex comprises a group of buildings in the Kennedy Space Center Industrial Area that is about eight miles southeast of the Vehicle Assembly Building. The HMF provides all the facilities required to process and store hypergol-fueled modules that are periodically removed from the orbiters for maintenance and modification activities. The Hypergols Module Processing North Building is a 10,307-square-foot building; the east cell is used to perform maintenance on the right-hand OMS pod and the west cell is used for left-hand OMS pod maintenance. The Hypergols Support Building is a 17,295-square-foot building that houses support personnel and launch processing system (LPS) consoles to provide monitoring and control of all HMF functions. These consoles interface with the LPS Central Data Subsystem in the Launch Control Center, and with the hardware interface modules. The Hypergols Module Processing South Building is a 6,549-square-foot building where maintenance is performed on the FRCS module. The Hypergols Storage Building West is a 2,381-square-foot facility where the FRCS can be stored. The Hypergols Storage Building East is a 1,809-square-foot facility where OMS pods can be stored.

At the Hypergolic Maintenance Facility at Kennedy Space Center, the Forward Reaction Control System for space shuttle Discovery is secured on a truck bed and ready for transport to Orbiter Processing Facility-3.

HMF (Continued)

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and is capable of being reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is available in HMP North and South at 125 psi and 150 cfm.

Gaseous Nitrogen:
Gaseous nitrogen is available in the HMF complex at 3,000 psi and 1,300 cfm. Specifications for individual buildings can be confirmed based upon customer requirements.

Gaseous Helium:
Gaseous helium is available in the HMF complex at 6,000 psi and 3,000 cfm. Specifications for individual buildings can be confirmed based upon customer requirements.

Control Rooms:
Yes

Cranes:
The HMP North and South facilities are serviced by 20-ton-maximum-capacity cranes with an approximate 45-foot hook height.

Relative Humidity:
HMP North (M7-0961) and HMP South (M7-1212) HVAC systems are capable of maintaining a 55 to 65 percent relative humidity range.

Temperature Range:
HMP North and South HVAC systems are capable of maintaining a temperature range of 72 to 76 degrees F.

Uninterruptible Power Supply (UPS):
Portions of the HMF complex are served by an UPS system, however actual ratings were not readily available.

Vacuum Chamber:
None

Video Camera/Recorders:
HMP North and South are monitored by a CCTV video system with recording capability.

Floor Space:
There is 6,549 square feet available in Hypergol Module Processing South (M7-1212) and 10,309 square feet available in Hypergol Module Processing North (M7-0961).

Door Height:
HMP North and South are equipped with a main door that is 40 feet high.

Door Width:
HMP North and South are equipped with a main door that is 22 feet wide.

Processing Area:
There are four individual processing areas; each measures 43 feet wide by 43 feet long (1,849 square feet).

Office Space:
Currently, there is about 35,000 square feet of office space within the HMF Support Building and Support Building No. 2 facilities.

2.11 Launch Complex 39 Turn Basin and Dockage

Description:
The Launch Complex 39 Turn Basin and Dock receive external fuel tanks and other elements too large to travel over open roadways in support of the Space Shuttle Program. The turn basin was built in 1965 to support the Apollo Program. It is located adjacent to the Vehicle Assembly Building and receives the space shuttle's external fuel tanks which are shipped to Kennedy Space Center by barge from Lockheed Martin's Michoud Assembly Facility in New Orleans, Louisiana.

Capabilities include, receiving the external fuel tanks that travel by barge from Louisiana, through the Gulf of Mexico, around and up the coast of Florida in the intercoastal waterway, to the Barge Canal. The Barge Canal Waterway is limited to a minimum 12-foot depth at the low watermark and the turn basin is located at the end of the canal. The dockage area is 1,800 feet long and 1,700 feet wide.

Ammonia Servicing:
Not available

Building Management System:
Not applicable

Chilled Water:
Not available

Clean Room:
Not applicable

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Not available

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

The space shuttle external tank barge is moored at the KSC Barge Facility.

Control Rooms:
Not applicable

Cranes:
Not applicable

Relative Humidity:
Not applicable

Temperature Range:
Not applicable

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:

Floor Space:
Not applicable

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
Not applicable

2.12 Launch Control Center (LCC)

Description:

The Launch Control Center (LCC) was built in 1966 to support the Apollo program. The four-story building, 378 feet wide by 181 feet long, by 77 feet high is a secured facility, encompassing 230,436 square feet, with an access-controlled perimeter housing several individually accessed controlled centers. The LCC is connected to the east side of the Vehicle Assembly Building by an elevated, enclosed bridge, and replaced the blockhouse concept of locating launch control adjacent to the launch pads.

Members of the space shuttle launch team watch Atlantis' launch through the newly installed windows of Firing Room 4 in the Launch Control Center at Kennedy Space Center.

The LCC is the centralized command and control facility within the Launch Complex 39 area, and directly and indirectly supports space shuttle ground processing, launch and recovery. The fourth floor contains offices for launch operations personnel. Each firing room is equipped with the Launch Processing System (LPS) which monitors and controls most space shuttle assembly, checkout and launch operations. In addition, KSC emergency response coordination is managed with specialized communications equipment within each firing room, including Paging and Area Warning System (PAWS) panels and specialized panels to support launch countdown contingences. The Central Operations Facility (COF) provides duty office and emergency operations support, and houses the Emergency Operations Center (EOC) ride out location.

The Launch Control Center at NASA's Kennedy Space Center in Florida is ready to support NASA's 21st century space program.

The first floor is used for administrative activities and houses the Launch Complex 39 area utilities system control room (1P9) and the Fire and Rescue Center (1P10). The second floor is occupied by the LPS Central Data Subsystem which consists of large scale computers that store data, including test procedures, vehicle processing data, master program library, historical data, pre- and post-test data analyses and other essential information for launch operations. The third floor is occupied by the four firing rooms and adjacent engineering support areas. The LCC is capable of supporting the simultaneous power-on processing operations of three orbiters in flow, from Firing Rooms 1, 3 and 4. Firing Room 2 can be used to support space shuttle software development or orbiter power-on operations while an orbiter is being processed in one of the three orbiter processing facilities.

LCC (Continued)

The LCC also is home to several unique centralized support control rooms and functions within its four stories, including RF and tracking, instrumentation, data reduction and evaluation, security and utility control. The LCC Complex Control Center provides facility systems control, Kennedy Complex Control System (KSCCS) for remote monitoring and control of field equipment associated with more than 150 systems, including high voltage, low voltage, oxygen deficiency monitoring system, pneumatics, heating, ventilation and air conditioning (HVAC), Firex and the Sound Suppression Water System.

Ammonia Servicing:
Not available

Building Management System:
The Complex Control System within the LCC monitors HVAC, power and fire suppression with varying degrees of visibility.

Chilled Water:
Yes

Clean Room:
Not applicable

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Not applicable

Gaseous Nitrogen:
Not applicable

Gaseous Helium:
Not applicable

Control Rooms:
The LCC is the primary control and monitoring site for all Launch Complex 39 processing facilities.

Cranes:
Not applicable

Relative Humidity:
The HVAC systems within the LCC are capable of maintaining a relative humidity of less than 60 percent.

Temperature Range:
The HVAC systems within the LCC are capable of maintaining a temperature range of 68 to 78 degrees F.

Uninterruptible Power Supply (UPS):
Four UPS supply three-phase 480V and one-phase 120V capability. Four hour maximum building load capability. Back up generated power is available from the C5 area at a maximum 10 megawatts.

Vacuum Chamber:
None

Video Camera/Recorders:
Public Affairs Office firing room cameras only. Additional security cameras may be installed as required.

Floor Space:
230,436 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
Approximately 7,500 square feet of the LCC is currently configured as office space.

2.13 Launch Equipment Shop (LES)

Description:
The Launch Equipment Shop is a 41,000-square-foot facility that includes a number of technical shops which have the capability to provide a wide range of technical skills and equipment for the fabrication, modification, refurbishment, maintenance and repair of space shuttle facilities, systems and ground support equipment (GSE). The facility is capable of limited on-site fabrication and repair of Launch Complex 39-facilities, systems and equipment. It includes a machine and weld shop, sheet metal and assembly and repair shops, a paint shop, electrical, electronic and institutional maintenance shop, pneumatic shop and a Thermoform Laboratory. The shop also provides mechanical and electrical assembly and repair and has office areas that house 120 shop personnel. Capabilities include parts machining, utilizing a variety of mills and lathes, welding and brazing, painting and silk screening, corrosion control, sheet metal fabrication, cable fabrication and repair, and fabrication and installation of pneumatic lines.

A view of the Launch Equipment Shop.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is delivered at 125 psi by the air compressors. The flow rate of the air compressors is approximately 160 cubic feet per minute.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
The facility is serviced by a 5-ton bridge crane.

Relative Humidity:
There is no requirement to control humidity at this facility.

Temperature Range:
The Launch Equipment Shop can maintain a temp range of 74 to 78 degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
36,000 square feet

LES (Continued)

Door Height:

The Launch Equipment Shop is equipped with four large, 12-foot-high roll-up doors on the west, east and south sides of the building.

Door Width:

The Launch Equipment Shop is equipped with four large, roll-up doors on the west, east and south sides of the building. Two doors are 10 feet wide, and two doors are 12 feet wide.

Processing Area:

Not applicable

Office Space:

The first floor is configured with about 3,050 square feet of office space. The second floor is configured with about 2,489 square feet of office space.

2.14 Launch Equipment Test Facility (LETF)

Description:

The Launch Equipment Test Facility (LETF) is a one-of-a-kind test facility that is used to test major launch pad systems to ensure that they react properly when exposed to dynamic loads and movements that would be experienced during a launch. The LETF also is used to load-test lifting and handling equipment up to 600 tons, and supports various ground support equipment (GSE) development and qualification testing. The 1,484-square-foot facility was built in 1976 and has a poured concrete floor, concrete block walls, a built-up roof, and is surrounded by a steel structure that serves as the test stand for space shuttle hardware.

A view of the front entrance to the Launch Equipment Test Facility office area.

The LETF can fabricate launch equipment prototypes, test whole systems or individual components, and simulate launch conditions with the new Vehicle Motion Simulator. The facility is used to calibrate launch components and present the data using state-of-the-art data acquisition systems with synced video that can be customized for analyzing data in real-time and for post-analysis.

Located within the complex are multiple labs and shops, including a machine shop, weld shop, pneumatics shop, cable fabrication shop, molding shop, electrical shop, data acquisition systems laboratory and a mechanical shop.

Major LETF test fixtures include a Vehicle Motion Simulator, Component Lift-off Simulator, 600-Ton Proof Load Test Fixture, Hold Down Post Test Fixture, Water Flow Test Loop, Cryogenic Component Test Area, Fluids Component Test Bench, Launch Simulation Towers, and ground support equipment (GSE) Integration Testbed. LETF capabilities include full-scale umbilical and GSE testing with vehicle motion and liftoff simulation; liquid nitrogen and liquid hydrogen flow to subject test articles to cryogenic temperatures and pressures that simulate launch processing conditions; and component testing using liquid nitrogen, liquid hydrogen, gaseous nitrogen, gaseous helium, water or hydraulic fluid. The LETF also can provide data acquisition for up to 352 channels with recording speeds to 60 million samples-per-second; rapid prototype development and testing; Programmable Logic Controllers and controls development; structural and proof load testing of lifting hardware and slings up to 600 tons; and instrumentation services (fixed and portable, pyrotechnics testing and test engineering). The LETF has leveraged these unique test capabilities to evolve into a versatile test and development area that supports Kennedy Space Center's entire spectrum of operational programs.

Testing apparatus at the Launch Equipment Test Facility Complex.

Ammonia Servicing:

Not available

Building Management System:

Not available

Chilled Water:

Not available

Clean Room:

Not available

LETF (Continued)

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air capabilities are available at the LETF. As of press time, specifications were not available. Specific technical information can be provided based upon customer requirements.

Gaseous Nitrogen:
Gaseous nitrogen capabilities are available at the LETF. As of press time, specifications were not available. Specific technical information can be provided based upon customer requirements.

Gaseous Helium:
Gaseous helium capabilities are available at the LETF. As of press time, specifications were not available. Specific technical information can be provided based upon customer requirements.

Control Rooms:
The LEFT control room supports hazardous testing and operations, including a video system, data acquisition system, hazardous gas detection system, Vehicle Motion Simulator (VMS) controls, liquid hydrogen and liquid nitrogen controls, pyrotechnic tests, and test team communication system (OIS-D).

Cranes:
One, 20-ton overhead bridge crane with a 41-foot hook height is available in the LETF high bay.

Relative Humidity:
The HVAC system conforms to industry standards for comfort air relative humidity for an office environment.

Temperature Range:
The HVAC system conforms to industry standards for comfort air temperature for an office environment.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
The facility is serviced by CCTV.

Floor Space:
7,745 square feet in the machine and weld shop.

Door Height:
Machine and weld shop doors are 18 feet high. The LETF high bay main door is 40 feet high.

Door Width:
The Machine and weld shop doors are 16 feet wide. The LETF high bay main door is 30 feet wide.

Processing Area:
Not applicable

Office Space:
7,000 square feet is currently configured as office space at the LETF complex.

2.15 Launch Pad A

Description:

Kennedy Space Center's Launch Pads A and B were built in the early 1960s for the huge Apollo/Saturn V rockets. Both pads are octagonally shaped and share identical features. Pad A is located 18,159 feet from the Vehicle Assembly Building (VAB), and Pad B is 22,400 feet from it.

Each pad covers about a quarter square mile of land and is contained within a high chain link fence. Launches are conducted from atop a concrete hardstand located at the center of the pad that measures 390 feet by 325 feet. Pads A and B hardstands are 48 feet, and 55 feet above sea level, respectively.

Both pads support the concept of mobile launcher platform (MLP) operations, where space vehicles are assembled and checked out on the MLP in the protected environment of the VAB, and then transported by crawler-transporter to the launch pad for final processing and launch.

Space shuttle Discovery sits atop its mobile launcher platform on Launch Pad 39A at Kennedy Space Center.

Space shuttle Discovery's external tank and solid rocket boosters are seen in this view of Launch Pad 39A at Kennedy Space Center. To the right is the fixed service structure and to the left is the rotating service structure.

Pad A is capable of supporting the test and checkout, payload installation, servicing and launch of the space shuttle. The pads are an integral part of the Launch Complex 39 integrate, transport and launch (ITL) concept for space shuttle processing and launch. Pad A is theoretically capable of supporting 10 launches per year. See K-SM-10.2.23 for detailed capabilities. Space shuttles launch from the top of the concrete hardstand in the center of the pad. The pad A stand is 48 feet above sea level at its top, while the upper surface at pad B is at an elevation of 53 feet. The flame trench divides the hardstand lengthwise from ground level to the pad surface. It is 490 feet long, 58 feet wide and 40 feet high. The top of each pad measures 390 feet by 325 feet. The two major items of equipment on pad A are the fixed service structure and the rotating service structure. The fixed service structure is located on the north side of the pad's hardstand. It is an open- framework structure about 40 feet square. A hammerhead crane on top provides hoisting services as required for pad operations. There are 12 work levels at 20-foot intervals. The height of the structure to the top of the tower is 247 feet, while the distance to the top of the hammerhead crane is 265 feet. The 80-foot fiberglass lightning mast tops off the fixed service structure at 347 feet. The fixed service structure has three service arms: the orbiter access arm, the external tank hydrogen vent line access arm and the external tank gaseous oxygen vent arm. The Rotating Service Structure provides protection for the orbiter and access to the cargo bay for installation and servicing of payloads at the pad. It pivots through one-third of a circle, to 120 degrees, from a retracted position well away from the shuttle, to where its payload changeout room doors meet and match the orbiter cargo bay doors. This structure rotates around a vertical hinge attached to one corner of the fixed service structure. The body of the rotating service structure begins at the 59-foot level and extends to 189 feet above the pad floor, providing orbiter access platforms at five levels. The hinge and a structural framework on the opposite end support the structure. This framework rests on two, eight-wheel, motor-driven trucks, which ride on

Launch Pad A (Continued)

rails installed within the pad surface. The rotating body is 102 feet long, 50 feet wide, and 130 feet high. The primary purpose of the rotating service structure is to receive space shuttle payloads while in the retracted position, rotate, and install them in the orbiter cargo bay. The propellant storage facilities are located at both pads. A 900,000-gallon tank situated at the northwest corner of each launch pad stores the liquid oxygen, which is used as an oxidizer by the orbiter's main engines. Two pumps, which supply 1,200 gallons of oxidizer per minute each, transfer the liquid oxygen from the storage tank to the orbiter's external tank. Similarly, an 850,000-gallon storage tank at the northeast corner of pad A stores the liquid hydrogen for the orbiter's main engines. Hypergolic propellants used by the orbiter's orbital maneuvering engines and attitude control thrusters also are stored at the pad in well-separated areas. A facility located on the southeast corner of each pad holds the fuel, monomethylhydrazine. A facility on the southwest corner stores the oxidizer, nitrogen tetroxide. These propellants feed by transfer lines to the fixed service structure and continue to the rotating service structure's hypergolic umbilical system, with its three pairs of umbilicals attached to the orbiter.

At Kennedy Space Center's Launch Pad 39A, space shuttle Discovery is visible following the retraction of the rotating service structure. The structure provides weather protection and access to the shuttle while it awaits liftoff on the pad.

Ammonia Servicing:
Not available

Building Management System:
Not available

Chilled Water:
Yes

Clean Room:
The payload changeout room (PCR) on the rotating service structure (RSS) is a clean work area. The airborne particulate cleanliness level is 1000 clean. The surface area other than the payload ground handling mechanism (PGHM) is visually clean.

Electrical Service:
This facility is outfitted with 480, volt three-phase power at 60 hertz, and is capable of being reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with federal government standard is available in this facility.

Compressed Air:
Each pad's compressed air system is used for hazardous purging, shop tools, Orbiter Weather Protection (OWP), Firex System controls, external tank vent cap controls and several other functions. Compressed air is supplied from a compressor facility at 750 cubic feet per minute (CFM) at the east base of each pad. The systems support processing operations 24 hours day, seven days a week. Off the pads, compressed air is provided by stand-alone compressors at 150 pounds per square inch (psi) for facility shop air and Firex/HVAC controls.

Gaseous Nitrogen:
A pipeline supplies high-pressure gaseous nitrogen (GN2) to the K7-468 Converter/Compressor Facility (CCF) located halfway between the pads and the VAB. At the CCF, the GN2 is filtered, monitored for oxygen, hydrocarbon, and moisture content, reduced to 5,660 psi, and distributed via pipeline to the pad HP Gas Storage Batteries and to the K7-853 VAB HP Gas Storage Battery. The SGS-SFOC GN2 interfaces are at the storage battery entrances. The C-2 console in room 1P9 in the Launch Control Center (LCC), can remotely close a shut-off valve if a line rupture occurs in the SGS distribution lines. The three storage batteries can support either pad by reconfiguration of distribution control valves. Each storage battery is located under the east side pad surface. GN2 is distributed at 50 to 6,000 psi pressure around the pad perimeter and up the FSS and RSS to numerous end users for purging

Launch Pad A (Continued)

and control applications. GN2 also is supplied to the VAB, the orbiter processing facilities , three Hypergol Maintenance Facilities (HMF) facilities, and to the solid rocket booster Assembly and Refurbishment Facility. At the pads, there are three GN2 Systems, high-pressure GN2 (6,000 psi, 3,000 psi, and 750 psi), low-pressure GN2 (150 psi), and purge (hazardous purge at 50 psi, camera lens purge at 750 psi).

Gaseous Helium:

Gaseous helium (GHe) is delivered by railcar to the CCF where it is transferred and pressurized for 6,000 psi distribution to pads A and B, and the VAB storage batteries. These three gaseous storage batteries can support launch at either pad by reconfiguration of distribution control valves. GHe also is supplied to the VAB, orbiter processing facilities, three Hypergolic Maintenance Facilities buildings, and used to process flight hardware.

Control Rooms:

Launch Pad 39A has a control room in the Pad Terminal Connection Room (PTCR) for monitoring, testing, and oversight of Environmental Control Systems (ECS) activities. The ECS control room is hardwired to the LCC. The ECS control room utilizes the Integrated Network Control System (INCS) and can has be upgraded or reconfigured.

Cranes:

Cranes and hoists available at pad A are as follows: 90-ton hoist/207-foot-level (drum location), elevation is 223 feet, 2 inches maximum and 47 feet minimum.

Electric hoist with a 10-ton capacity, 207-foot-level, 60 foot lift.

Electric hoist with a 5-ton PCR, 60-foot-lift (inside the PCR/top of PCR).

Electric hoist with a 2-ton hoist, 40-foot-lift (inside the PCR/level 4 or 5).

Specifications of pneumatic hoists can be provided based upon customer requirements.

Relative Humidity:

The HVAC system conforms to industry standards for comfort air relative humidity for an office environment.

Temperature Range:

The HVAC system conforms to industry standards for comfort air temperature for an office environment.

Uninterruptible Power Supply (UPS):

Pad A has six UPS located in the Pad Terminal Connection Room (PTCR).

Vacuum Chamber:

None

Video Camera/Recorders:

Operational TV (OTV) cameras are available at pad A.

Floor Space:

Not applicable

Door Height:

Not applicable

Door Width:

Not applicable

Processing Area:

Not applicable

Office Space:

There is about 17,000 square feet of usable space located at pad A.

Additional data:

Facility System Interfacing with MLP:

- Facility AC power
- Compressed air
- Chilled water
- Potable water
- Waste water
- Firex System and fire alarm

Fluids:

Liquid oxygen (LO2) system

Liquid hydrogen (LH2) system

Environmental Control System (ECS)

Gaseous nitrogen (GN2)

Gaseous helium (GH3)

Gaseous oxygen (GO2) - mobile tankers

Breathing air

Launch Pad A (Continued)

Mechanical:

MLP pedestals

Rotating service structure (RSS)

Command and Control:

Integrated Network Control System (INCS)

Communication:

LPE to provide power, purge gasses as needed, cable trays, space and weight for equipment

Operational Intercom System (OIS)

Timing and Countdown System (T&CD)

Paging and Area Warning System (PAWS)

Kennedy Network (KNET)

Kennedy Integrated Transmission System (KITS)

Telephone

Radios

Broadband Communication Distribution System (BCDS)

Operational Television (OTV)

Electrical/Instrumentation:

Hazardous Gas Leak Detection System (HGLDS)

Ground Special Power (GSP)

Sensor Data Acquisition System (SDAS)

Weather system lightning detection and measurements, meteorological data

Infrastructure:

Lightning Protection System

Pad A: Lightning mast on top of the RSS

Pad B: Three towers with catenary wires for protection to 456 feet high

Ignition overpressure water

Flame deflectors (main and side)

2.16 Launch Pad B

Description:

As of press time, Launch Pad 39B was being reconfigured to support a clean pad concept. This concept will allow rockets to be transported to the pad on their own launcher, increasing versatility and flexibility and allowing the center to support multiple types of launch systems. During the next update to this document, specific information regarding the capabilities of Launch Pad 39B in its reconfigured state will be provided.

A view of Launch Pad 39B before work began to reconfigured it to support a "clean pad" concept. This concept supports a versatile system capable of launching a number of vehicles.

The rotating service structure on Launch Pad 39B is being dismantled at Kennedy Space Center.

An artist's rendering of a shuttle-derived heavy-lift launch vehicle is shown on Launch Pad 39B as it is being readied for launch with a multipurpose crew vehicle. This is just one concept being evaluated for NASA's new space launch system.

2.17 Logistics Facility

Description:

The Logistics Facility, constructed in 1986, is a 292,711-square-foot general warehouse which currently is used to store more than 200,000 space shuttle flight hardware and ground support equipment (GSE) items. The facility supports warehousing, procurement, inventory management, logistics engineering, transportation, packaging, shipping and receiving. The building contains state-of- the- art warehousing material handling equipment, including an Automatic Parts Retrieval and Storage System. Of the 275,000 square feet of usable space, 64,200 square feet is air conditioned. Facility systems and equipment, cantilevered and palletized storage areas are part of the Automated Storage and Retrieval System. Bins are arranged vertically (45 trays high, 56 trays deep, 10 rows of 2,520 trays). Each tray can hold up to 300 pounds. There is air conditioned storage for smaller items. Three Crown Man-aboard vehicles and two Raymond Side Loaders are guided manually and by an in-floor wire system. Three automatic vehicles are guided by in-floor wire ceiling transmitters and internal navigation computers. There are five crane retrieval lanes and operator stations. The facility is utilized to store flight spares hardware, flight GSE spares hardware, facility GSE spares and general purpose launch material.

The facility provides the capability for the storage and retrieval of space shuttle flight hardware and ground systems component spares.

The Barrel Shed supports a number of activities associated with the Logistics Facility.

The Logistics Facility is located in Kennedy Space Center's Launch Complex 39 Area.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The Logistics Facility is equipped with a compressed air system capable of producing 125 psi at approximately 20 cubic feet per minute.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Logistics Facility (Continued)

Control Rooms:
Not available

Cranes:
The Vehicle Processing Storage Area (VPSA) of the Logistics Facility is serviced by one, 5-ton bridge crane with a 20-foot hook height. The packing and crating area is serviced by a 3.5-ton crane with a 20-foot hook height.

Relative Humidity:
The office areas are serviced by systems capable of maintaining a temperature range of 71 (+/- 6) degrees F, with a maximum relative humidity of 60 percent.

Temperature Range:
The office areas are serviced by systems capable of maintaining a temperature of 71 (+/- 6) degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
275,000 square feet

Door Height:
The Vehicle Processing Storage Area (VPSA) portion of the facility is equipped with a 15-foot-high door. The warehouse section of the facility is accessed by a 14-foot-high door.

Door Width:
The Vehicle Processing Storage Area (VPSA) portion of the facility is equipped with a 12-foot-wide door. The warehouse section of the facility is accessed by a 20-foot-wide door.

Processing Area:
Not applicable

Office Space:
Approximately 68,185 square feet of the Logistics Facility is currently configured as office space.

2.18 Mobile Launcher (ML) Construction Area

Description:
The Mobile Launcher Refurbishment Area is comprised of two locations available to park a mobile launcher. The two locations have historically been known as the East and West Park Sites. The East Site has been used extensively throughout the Space Shuttle Program for postlaunch mobile launcher platform (MLP) refurbishment. This park site contains six structural mount mechanisms that carry the structural load of the MLP, personnel access towers to the MLP, and extensive power, pneumatics, Firex, and other water systems commodity connections.

A new mobile launcher is built in the construction and refurbishment area at NASA's Kennedy Space Center in Florida.

Ammonia Servicing:
Not available

Building Management System:
There are cables located on the structure that transfer fire, smoke and Oxygen Deficient Monitoring System (ODMS) to the Launch Control Center control rooms.

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
The facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Shop air is regulated at 150 psig and is available for use in the construction area.

Gaseous Nitrogen:
Gaseous nitrogen is available at 6,000 psi

Gaseous Helium:
Gaseous helium is available at 6,000 psi

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
Not applicable

Temperature Range:
Not applicable

Uninterruptible Power Supply (UPS):
Not applicable

Vacuum Chamber:
None

In the construction and refurbishment area at Kennedy Space Center, support pedestals are used for mobile launcher servicing.

ML Construction Area (Continued)

Video Camera/Recorders:
Not available

Floor Space:
Not applicable

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Up to 25,000 square feet of outdoor construction area is available on the site.

Office Space:
Not applicable

2.19 Multi-Operation Support Building

Description:
The Multi-Operation Support Building (MOSB) contains control rooms for customer electrical ground support equipment, a Facility Control Room for controlling hazardous operations, the MIL-71 Deep Space Network Checkout Station and office space for spacecraft personnel. The Launch Services Program determines launch site facility assignments based on agency policy and the identified payload requirement.

A view of the Multi-Operations Support Building in Kennedy Space Center's Industrial Area.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The facility has a breathing air system.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
There are two customer control rooms used for payload processing. One payload control room is used to monitor activities related to hazardous processing.

Cranes:
Not available

Relative Humidity:
These systems can maintain a temperature range of 71 (+/- 6) degrees F with a maximum relative humidity of 60 percent.

Temperature Range:
These systems maintain temperatures of 71(+/- 6) degrees F.

Uninterruptible Power Supply (UPS):
There is a 300KVA UPS unit in the MOSB to supply power to the payload control rooms (116 and 117).

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
28,129 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
Approximately 10,000 square feet of the MOSB facility is used as office space.

2.20 Multi-Payload Processing Facility (MPPF)

Description:

The Multi-Payload Processing Facility (MPPF) complex includes three major structures. They are the MPPF, a 25,667-square-foot facility, which contains a high bay, low bay, equipment airlock, laboratory space and administrative offices; and two Payload Operation Control Centers (POCC). The MPPF high-bay area maintains class 100,000 clean room conditions with facilities for checkout, assembly and processing of payloads and is currently used to process nonhazardous payloads.

As darkness falls, the Orbital Sciences Pegasus XL launch vehicle arrives at the Multi-Payload Processing Facility (MPPF) at Kennedy Space Center in Florida.

A view of the Multi-Payload Processing Facility (MPPF) high bay door entrance.

A single-story flight data communications room is connected to the MPPF on the southeast wall of the high bay and provides fully equipped racks and wall-mounted equipment to support the following communications system: Administrative and Data Communications, Broadband Cable Distribution System, Operational Intercommunications System-Digital (OIS-D), Paging and Area Warning, Timing and Countdown, and Wideband/ Fiber Optics.

Other buildings are the Annex Building, which contains administrative offices, and a Multi-Operations Support Building (MOSB). The MOSB contains offices and payload control rooms. The MPPF is the main facility in the area, with a small fueling facility to the south, and a parking area to the north. The facility is surrounded by a security fence with three “crash-out” safety gates. The structure consists of a concrete foundation, steel frame and metal siding. The windows are single pane and the doors are steel. The flooring in the office area on the south side is carpet, and the flooring on the north side office areas and laboratory areas is vinyl tile. The flooring in the high bay area is concrete finished with a coating compatible with clean room environments.

Ammonia Servicing:

Not available

Building Management System:

Yes

Chilled Water:

Yes

Clean Room:

The MPPF high bay and low bay are rated as Level 4, Class 100,000 Clean Work Areas (CWA). The equipment air lock is rated as a Level 5, Class 300,000 Clean Work Area (CWA).

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

MPPF (Continued)

Compressed Air:
Compressed air is available within the facility at:
90 pounds per square inch gage (6.2 bars)
125 pounds per square inch gage (8.6 bars)
Breathing air is available.

Gaseous Nitrogen:
Gaseous nitrogen is available within the facility at:
750 pounds per square inch gage (51.7 bars)
3,000 pounds per square inch gage (206.7 bars) in high bay only.

Gaseous Helium:
Gaseous helium is available within the high bay only at:
750 pounds per square inch gage (51.7 bars)
3,000 pounds per square inch gage (206.7 bars)

Control Rooms:
Provisions exist within the Multi-Operations Support Building (MOSB) to provide control room operations to the MPPF.

Cranes:
The MPPF is serviced by one, 20-ton (18.1-metric-ton) bridge crane in the high bay that is capable of a 49-foot hook height.

Relative Humidity:
The HVAC systems within the MPPF can maintain a temperature of 71 (+/-6) degrees F (21.7 +/- 3.3 degrees C), with a maximum relative humidity of 55 percent.

Temperature Range:
Air enters the MPPF through High Efficiency Particle Air (HEPA) filters mounted in the ceilings of the high bay, low bay, equipment air lock, and TAIR station, and is guaranteed class 5,000 air at the filter discharge for the air conditioning and reheat systems. These systems maintain a temperature of 71 (+/-6) degrees F (21.7 +/- 3.3 degrees C), with a maximum relative humidity of 55 percent. Air is exchanged at a minimum of eight changes per hour and positive pressure is maintained at all times.

Uninterruptible Power Supply (UPS):
The south end wall of the MPPF high bay area contains several 120/208V and 100A receptacles that automatically switch over to uninterruptable power supply units during an AC power failure.

Vacuum Chamber:
None

Video Camera/Recorders:
The MPPF is equipped with a CCTV video system.

Floor Space:
25,667 square feet

Door Height:
High bay door, east side is 42 feet high
Low bay door is 15 feet high

Equipment air lock:
Roll-up door is 15 feet high
Vertical-lift door is 15 feet high

Door Width:
High bay door, east side, is 28 feet wide
Low bay door is 20 feet wide
Equipment Airlock:
Roll up door is 20 feet wide
Vertical lift door is 20 feet wide

Processing Area:
MPPF high bay: 132 feet long (40.2 m), 60 feet wide (18.9 m), with a ceiling height of 62 feet (18.9 m)

MPPF low bay: 34 feet long (10.4 m), 34 feet wide (10.4 m), with a ceiling height of 20 feet (6.1 m)

Equipment Air lock: 39 feet long (11.9 m), 28 feet wide (8.5 m), with a ceiling height of 20 feet (6.1 m)

Office Space:
Currently there is 6,875 square feet configured as office space within the MPPF.

2.21 Operations & Checkout (O&C) Building

Description:

The Operations & Checkout (O&C) Building, built in 1964, is located in Kennedy Space Center's Industrial Area, immediately east of KSC's Headquarters Building. The building's high bay area was used for assembly and test of the Apollo spacecraft during the Apollo Program and has since been modified for the space shuttle era. The five-story structure's roof and high bay were refurbished in 2009 and the power systems were updated to industry standards in 2009 as well.
The O&C Building contains 602,000 square feet (55,926 m^2) of offices, laboratories, astronaut quarters

A view of the Operations and Checkout building in Kennedy Space Center's Industrial Area.

and payload bay areas. The bay area is 650 feet long and a uniform 85 feet wide, except at the east end of the high bay where it is 38 feet, 5 inches wide. The bay is divided into a high bay area that is 175 feet long and 140 feet high, and a low bay area that is 475 feet long and 70 feet high. Attached to the bay area are three processing rooms, measuring about 13,800 square feet, with a 19-foot-high ceiling. The O&C is used as the horizontal processing facility for most pallet-type Spacelab module payloads, and some science (mid-deck) experiments. These payloads are processed through experiment-to-pallet/flight floor, pallet/module-to-complete payload, and payload-to-simulated orbiter integration and de-integration. The main payload processing area in the O&C is the bay area. The bay area contains work stands with mechanical and electrical services to support payload processing. Other payload support areas in the facility are laboratories, control and monitor areas, and shops. Rooms are also available to customers for processing their experiments. A two-level, clean work area is 36 feet long, by 36 feet wide, by 38 feet high. It is located at the west end of

In the Operations and Checkout Building at Kennedy Space Center, a Lockheed Martin-led crew begins path finding operations on a full-scale Orion spacecraft mock-up.

the bay area and can be maintained in accordance with class 50,000 clean work area conditions specified in KCI-HB-5340.1. This clean work area is serviced by a 1-ton bridge crane. Equipment enters the bay area through the 40-foot-wide and 80-foot-high vertical-lift doors at the east end, or through the shipping and receiving area, room 1469. Personnel enter the bay area on the north side from the first floor corridor near work stands 1, 1A and 4, through doors A1 and C7. Personnel also may enter between work stands 3 and 4 (door D-14) on the south side of the bay area. Emergency egress doors are on the south and north sides of the bay area and on the east vertical-lift door. The bay area is serviced by three, 27.5-ton bridge cranes; two of the cranes can traverse the length of the high and low bay area which is about 49,250 square feet. The O&C processes space shuttle horizontal payloads from buildup through final check out using the cargo integrated test equipment (CITE). The building contains one large clean room with four payload 100,000 class test standards. The O&C also contains labs for malfunction analysis of shuttle flight hardware components.

Ammonia Servicing:

Not available

Building Management System:

Yes

Chilled Water:

Yes

O&C Building (Continued)

Clean Room:
The high and low bay area provides a visually clean working area (CWA). Air quality is rated class 100,000 clean. The Apollo Telescope Mount Room (ATM) is rated as a Level 3 CWA although it can be maintained as a Level 2 CWA if stringent controls are adhered to. The test stands and specific work areas are level 4 CWA's. The assembly and test area and offline labs are level 4 to 5 CWA's.

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is provided within the facility at 125 pounds per square inch gage (8.6 bars).

Gaseous Nitrogen:
Gaseous nitrogen is available within the O&C at the various pressures indicated below:
390 pounds per square inch gage (27 bars)
1,200 pounds per square inch gage (83 bars)
3,000 pounds per square inch gage (207 bars)

Gaseous Helium:
Gaseous helium is available within the O&C at the various pressures indicated below:
725 pounds per square inch gage (50 bars)
3,625 pounds per square inch gage (250 bars)

Control Rooms:
Not available

Cranes:
High bay: 27.5-ton crane, 82 feet, 3.5 inches hook height

Low bay: 27.5-ton crane, 47 feet, 9.5 inches hook height

The low bay crane also services the high bay

Relative Humidity:
These systems maintain temperatures of 71 (+/- 6) degrees F (21.7 +/- 3.3 degrees C), with a maximum relative humidity of 60 percent.

The environment within the Baseline Data Collection Facility (BDCF) is maintained between 61 and 80 degrees F (between 17 and 27 degrees C). Relative humidity is maintained between 35 and 70 percent.

Temperature Range:
These systems maintain temperatures of 71 (+/- 6) degrees F (21.7 +/- 3.3 degrees C).

The environment within the BDCF is maintained between 61 and 80 degrees F (between 17 and 27 degrees C). Relative humidity is maintained between 35 and 70 percent.

Uninterruptible Power Supply (UPS):
UPS is available for the processing areas. Generator power available for emergency lighting only.

Vacuum Chamber:
Yes

Video Camera/Recorders:
OTV can provide video surveillance and recording of payload processing in all operational areas such as the Payload Hazardous Servicing Facility (PHSF) to the O&C Building. Although the camera mounts and cable are installed in the bay area, OTV is not available as a standard service. The shuttle customer must request OTV. Payload processing in the orbiter processing facilities, the rotating service structure (RSS), and at the launch pad can be observed through the OTV system. OTV distributors in these areas route the video by way of the payload television video system (PTVS) video routing switcher system (VRSS) to monitors in the O&C Building control and monitor rooms.

Floor Space:
602,000 square feet

Door Height:
The main door is 80 feet high.
The door from the high bay to the airlock is 15 feet by 20 feet.

O&C Building (Continued)

Door Width:

The main door is 40 feet wide.
The door from the high bay to the airlock is 15 feet by 20 feet.

Processing Area:

High bay – 175 feet long by 85 feet wide by 104 high (6,825 square feet).

Low bay – 475 feet long by 85 feet wide by 70 feet high (40,375 square feet).

Air lock – 37 feet long by 37 feet wide by 38 feet high (1,369 square feet).

Office Space:

160,000 square feet

2.22 Operations & Checkout (O&C) Vacuum/Altitude Chamber

Description:

The Operations and Checkout Building has an altitude chamber and a vacuum chamber. The altitude chamber provides the ability to leak check International Space Station pressurized flight modules in a near space vacuum environment. Although two chambers were originally constructed in 1964, only the west chamber is currently active. It was reactivated and refurbished in the last three years. The vacuum chamber is approximately 33 feet in diameter, 59 feet high, and is constructed of Type 304 stainless steel. The shell is one-half inch thick. The dome-shaped lid provides access to flight and test hardware, and is removed or placed using the facility overhead crane. Two additional personnel access doors enable egress into the chamber. A dedicated air conditioning system is used only during experiment setup and takedown. The chamber itself has no thermal capabilities, and was not designed for it.

In the Operations and Checkout Building's high bay, the Rotation Handling Fixture (RHF), with a simulated module attached, is viewed from above the altitude chamber into which it was lowered during a test.

The chamber can maintain a 0.1 torr (100 millitorr) vacuum level. This is based on the design parameters of the new pumps. Lower levels have been achieved. The 100 millitorr level can be maintained using one of the two pump trains. Two pump trains are initially operated in order to reach the vacuum level. Each pump train consists of two Stokes model 412-11 Microvac rotary oil-sealed pumps and a single blower assembly. The blowers are activated at a 2.5 torr level and remain online until the desired level is achieved. Historically, the 100 millitorr level of vacuum is achieved in less than six hours. The repressurization cycle is controlled by the user, and is throttled by the extent of valve modulation. An emergency repressurization cycle can also be used. Typically, a three-hour re-pressurization occurs when performing standard operations or maintenance.

Chamber operations are completely automated using software stationed in control room 2271. The operations are controlled via two Programmable Logic Controllers (PLCs). One is of active duty and the other provides full redundancy. The PLCs issue commands to start vacuum pumps, monitor chamber pressure, open and close valves and operate chamber safety systems. The altitude chamber is an optional payload service.

Ammonia Servicing:

Not available

Building Management System:

Yes

Chilled Water:

Not available

Clean Room:

The area inside of the O&C vacuum chamber is rated as a 100,000, Level 4 clean work area.

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Compressed air is provided at 125 pounds per square inch, at 100 cubic feet per minute.

Gaseous Nitrogen:

Not available

O&C Vacuum/Altitude Chamber (Continued)

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
The vacuum chamber is serviced by a 27.5-ton crane with an 82-foot, 3.5-inch hook height.

Relative Humidity:
The HVAC system can maintain a relative humidity of 60 percent.

Temperature Range:
The HVAC system can maintain a temperature range of 71 degrees F (+/- 6 degrees).

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
Yes

Video Camera/Recorders:
Not available

Floor Space:
Not applicable

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
50 feet tall by 33 feet wide

Office Space:
Not available

2.23 Orbiter Processing Facility (OPF) Bays 1 and 2

Description:

Orbiter Processing Facilities 1 and 2, built in 1979 to support the Space Shuttle Program, are located near the west side of the Vehicle Assembly Building (VAB) in the Launch Complex 39 area. The OPF has two identical bays that are each 197 feet long, 150 feet wide and 95 feet high, and have 29,000 square feet of area. A low bay separating the two bays is 233 feet long, 97 feet wide and 24.6 feet high. A 10,000-square-foot annex is located on the north side of the facility. Another 34,000-square-foot, three-story annex provides additional office space. In the high bays, a trench system

A view of Orbiter Processing Facilities 1 and 2. OPF 1 is in the foreground.

Workers at Kennedy Space Center look on as space shuttle Atlantis enters Orbiter Processing Facility-1.

under the floor contains electrical, electronic, communication, instrumentation and control cabling; hydraulic supply and return plumbing; gaseous nitrogen, oxygen and helium plumbing; and compressed air distribution plumbing. Gaseous nitrogen, helium and compressed air are supplied by the systems in the VAB. All of these systems are used to support processing and maintenance of the orbiters during ground turnaround operations. The two high bays have the ability to perform hypergol offloading and have emergency exhaust systems in case of hypergolic spills. The low bay houses areas for electronic equipment, a launch processing system interface, mechanical and electrical equipment shops and thermal protection system repair. The low bay also includes provisions for a communications room, offices and supervisory control rooms. Two large rolling bridges span the main access bridge to provide complete access to installed payloads, radiators, internal areas of the payload bay and external areas of the payload bay doors. Each of the rolling bridges supports two independently movable trucks with a personnel bucket at the bottom of each vertically telescoping arm. The buckets are manually rotatable around a full circle. The bridges, trucks and telescoping arms are electrically powered and controlled from the buckets or the catwalk. Flip-up work platforms parallel the payload bay area to provide access to radiators, the inside payload bay doors, payload bay door hinges and trunnion points. Other platforms provide access to other orbiter elements. The hinges of the payload bay doors are not designed to support the weight of the doors while they are open horizontally in the Earth's gravitational environment. A counterweight zero-gravity device supports the weight of the doors while they are open for processing in the OPF. Each OPF bay is theoretically capable of supporting 3.75 launches per year. This flight rate is reduced when the orbiter maintenance down period is included. Supporting facilities include an Environmental Control System Building (east) with 1,390 square feet of area, an Environmental Control System Building (west) with 1,390 square feet of area, a ground support equipment storage building with 4,031 square feet of area, a Hazardous Waste Staging Building with 145 square feet of area, and a Pump House with 3,201 square feet of area.

Ammonia Servicing:

All three OPFs have the ability to perform ammonia servicing. The current ground support equipment (GSE) can hold up to 50 gallons. This GSE "pushes" the ammonia into the orbiter at about 180 pounds per square inch gage(psig) with a flow rate of 1-gallon-per-minute. Following load it is pressurized to about 400 psig.

OPF Bays 1 and 2 (Continued)

Building Management System:
This system monitors the HVAC and hyper fan equipment.

Chilled Water:
Yes

Clean Room:
Level 5, Class 300,000 Clean Work Area

Electrical Service
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The high bay has 125 psi compressed air supply.

Gaseous Nitrogen:
Gaseous nitrogen is available at 5,600 psi.

Gaseous Helium:
Gaseous helium is available at 5,600 psi.

Control Rooms:
The high bays are connected to the Launch Control Center. Preflight checkout, testing and monitoring of the orbiter systems, are managed from operator-controlled consoles, which are clustered together based on the type of systems. Vehicle test and performance data can be stored and played back.

Cranes:
OPF 1 and 2 are serviced by two, 30-ton high bay bridge cranes, each with a 66-foot hook height.

Relative Humidity:
The HVAC system in the OPF can maintain a 50 percent relative humidity

Temperature Range:
The HVAC system in the OPF can maintain 70 to 78 degrees F.

Uninterruptible Power Supply (UPS):
OPF 1 and 2 are equipped with UPS, 80kva. The facilities do not have a generator, but are serviced by an emergency generator feeder in the event utility-provided power is lost.

Vacuum Chamber:
None

Video Camera/Recorders:
OPF 1 and 2 are equipped with a CCTV system.

Floor Space:
131,948 square feet

Door Height:
Main door is 35 feet high.
Equipment door is 30 feet high.

Door Width:
Main door is 95 feet wide.
Equipment door is 30 feet wide.

Processing Area:
Processing space is 197 feet long, 150 feet wide and 66 feet high, with 29,950 square feet of area.

Office Space:
OPF 1 and 2 are currently configured for about 27,552 square feet of office space.

2.24 Orbiter Processing Facility (OPF) Bay 3

Description:

Orbiter Processing Facility-3 (OPF-3) was built in 1987 to support the Space Shuttle Program. The 50,000 square foot facility is located northwest of the Vehicle Assembly Building (VAB) in the Launch Complex 39 area. The facility consists of a single high bay identical to Orbiter Processing Facilities 1 and 2. It also has a two-story low bay. The facility is 197 feet long, 150 feet wide and 95 feet high, has 29,000 square feet of area, and is equipped with two 30-ton bridge cranes with approximately 66 feet of hook height. In the high bay, a trench system under the floor contains electri-

A view of Orbiter Processing Facility-3.

cal, electronic, communication, instrumentation and control cabling; hydraulic supply and return plumbing; gaseous nitrogen, oxygen and helium plumbing; and compressed air distribution plumbing. Gaseous nitrogen, helium and compressed air are supplied by the systems in the VAB. All of these systems are used to support processing and maintenance of the orbiters during ground turnaround operations. Two large rolling bridges span the main access bridge to provide complete access to installed payloads, radiators, internal areas of the payload bay and external areas of the payload bay doors. Each of the rolling bridges supports two independently movable trucks with a personnel bucket at the bottom of each vertically telescoping arm. The buckets can be manually rotated around a full circle. The bridges, trucks and telescoping arms are electrically powered and controlled from the buckets or the catwalk. Flip-up work platforms parallel the payload bay area to provide access to radiators, the inside payload bay doors, payload bay door hinges and trunnion points. Several platforms provide access

A space shuttle main engine is secured on a Hyster forklift as it is moved from the Space Shuttle Main Engine Processing Facility to Orbiter Processing Facility-3 at Kennedy Space Center.

to other orbiter elements. The hinges of the payload bay doors are not designed to support the weight of the doors while they are opened horizontally in Earth's gravitational environment. A counterweight zero-gravity device supports the weight of the doors while they are open for processing in the facility. The processing facility is theoretically capable of supporting 3.75 launches per year. This flight rate is reduced when the orbiter maintenance down period is included.

Ammonia Servicing:

All three OPFs have the ability to perform ammonia servicing. The current ground support equipment (GSE) can hold up to 50 gallons. This GSE "pushes" the ammonia into the orbiter at about 180 pounds per square inch (psig) with a flow rate of 1-gallon-per-minute. Following load it is pressurized to about 400 psig.

Building Management System:

This system monitors the HVAC and hyper fan equipment.

Chilled Water:

Yes

Clean Room:

The entire high bay is a good housekeeping area and the area around the payload bay is Level 4, class 100,000 CWA.

OPF Bay 3 (Continued)

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
The high bay has 125 psi compressed air supply. Air is fed from the VAB.

Gaseous Nitrogen:
Gaseous nitrogen is available at 5,600 psi.

Gaseous Helium:
Gaseous helium is available at 5,600 psi.

Control Rooms:
The high bays are connected to the Launch Control Center. Preflight checkout, testing and monitoring of the orbiter systems, are managed from operator-controlled consoles, which are clustered together based on the type of systems. Vehicle test and performance data can be stored and played back.

Cranes:
OPF-3 is serviced by 30-ton high bay bridge cranes with a 66-foot-hook-height.

Relative Humidity:
The HVAC system in the OPF can maintain 50 percent relative humidity.

Temperature Range:
The HVAC system in the OPF can maintain 70 to 78 degrees F.

Uninterruptible Power Supply (UPS):
OPF-3 is equipped with UPS, 80 kva. The facility does not have a generator, but is serviced by an emergency generator feeder in the event utility-provided power is lost.

Vacuum Chamber:
None

Video Camera/Recorders:
OPF-3 is equipped with a CCTV system.

Floor Space:
148,470 square feet

Door Height:
The OPF-3 main door is 35 feet high.
The OPF-3 equipment door is 30 feet high.

Door Width:
The OPF 3 main door size is 9,535 feet wide.
The OPF 3 equipment door size is 30 feet wide

Processing Area:
Processing space is 197 feet long, 150 feet wide, and 66 feet high, a total of 29,950 square feet.

Office Space:
OPF-3 is currently configured for about 28,196 square feet of office space.

2.25 Parachute Refurbishment Facility

Description:

Keeping the space shuttle's solid rocket booster parachutes in good condition is the job of the Parachute Refurbishment Facility (PRF). Located two blocks south of the Operations and Checkout Building, the PRF was originally built in 1964 to process parachutes for Project Gemini. The facility was expanded to 35,758 square feet of area in 1977 and 1979. The PRF is used to clean, repair and repack parachutes used in support of spaceflight. After the chutes are returned to the PRF, a hanging monorail system is used to transport each parachute into a 30,000 gallon washer and then in a large dryer heated with 140 degree air, at 13,000 cubic feet per minute. Typically, each main canopy requires hundreds of repairs after each use. The smaller chutes and parachute deployment bags they are packed in also require repairs. To repair the chutes, industrial sewing machines are used that can stitch through several inches of material. After the chutes are cleaned and repaired they must be carefully packed into their bags so they will deploy correctly the next time they are used. It takes about one week to pack a main canopy.

The PRF receives, rinses, washes, dries, inspects, repairs as required, and repacks SRB spent parachutes for reuse and retrieval on the next space shuttle launch. When required, new parachutes are designed and fabricated. The main building is concrete block construction with concrete floor and roof deck. A monorail system that runs throughout the building is uniquely designed to transport the parachutes from one area to another. The PRF has 37,220 square feet of area; 24,890 square feet of that is air conditioned. The high bay area is 2,100 square feet. There is a 5,100-square-foot stand-alone metal building warehouse.

Ammonia Servicing:

Not available

Building Management System:

The building automation system is a Carrier ComfortView 3.0.

Chilled Water:

Yes

Clean Room:

Not available

A view of the Parachute Refurbishment Facility.

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Compressed air is available in the facility at 115 Pounds per square inch gage (psig) at 21 cubic feet per minute.

Gaseous Nitrogen:

Not available

Gaseous Helium:

Not available

Control Rooms:

Not available

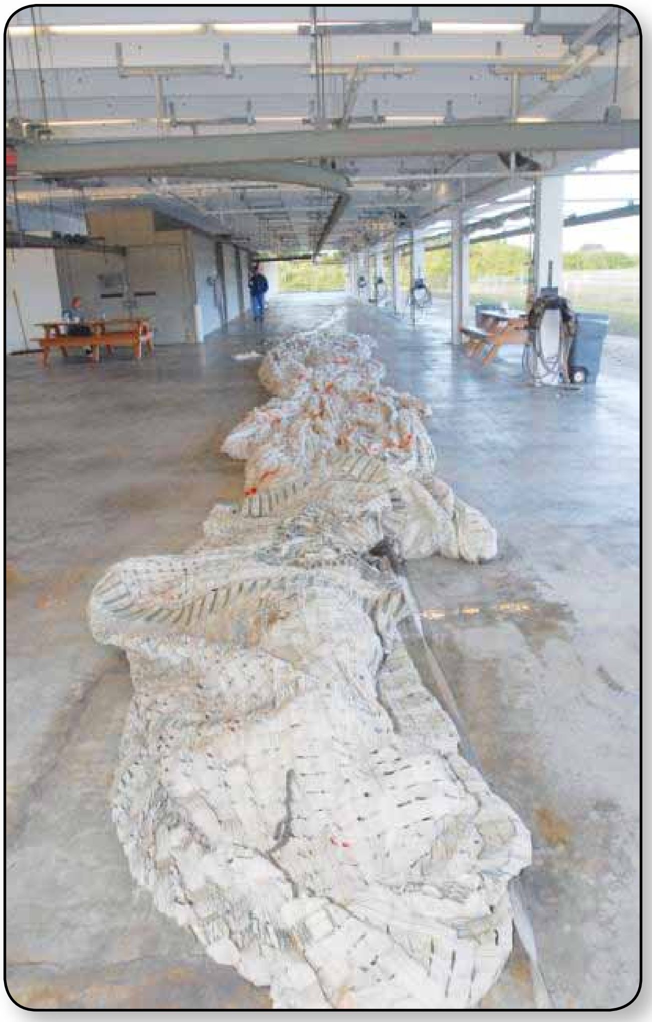
Cranes:

The facility is serviced by one, 5-ton crane with a maximum 18-foot hook height.

Relative Humidity:

The HVAC system within the Parachute Refurbishment Facility is capable of maintaining 55 percent relative humidity to the conditioned portion of the facility's space.

Parachute Refurbishment Facility (Continued)



Parachutes recovered from sea after the launch of space shuttle Endeavour on the STS-126 mission are stretched out at the Parachute Refurbishment Facility to detangle them.

Floor Space:
35,758 square feet

Door Height:
The door is 15 feet high.

Door Width:
The door is 16 feet wide.

Processing Area:
32,840 square feet (20,510 square feet of this is air conditioned .

Office Space:
2,025 square feet

In the Parachute Refurbishment Facility, workers repair the parachutes recovered from sea after the launch of space shuttle Endeavour on the STS-126 mission.

Temperature Range:
The HVAC system within the Parachute Refurbishment Facility is capable of maintaining a temperature range of 70 to 80 degrees F to the conditioned portion of the facility's space.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

2.26 Payload Hazardous Servicing Facility (PHSF)

Description:

The Payload Hazardous Servicing Facility (PHSF) was built in 1986. It is a Level 4, class 100,000 clean room that can be used as a Payload Processing Facility (PPF) and/or a Hazardous Processing Facility (HPF). When used as a PPF, the processing flow may include installation of solar panels, antennas and other items by the spacecraft builder. When used as an HPF, the processing flow may include propellants (e.g., hypergols); hazardous systems tests and checkout; build-up and mating of a payload to a solid propellant upper stage motor; propellant system leak tests; and other potentially explosive or hazardous operations. The facility can be used to process expendable launch vehicle payloads that have planetary protection cleanliness requirements or carry nuclear material.

The PHSF is an 18,813-square-foot metal structure with a built-up roof. It is used by Boeing to perform hazardous payload processing for the Checkout, Assembly and Payload Processing Services (CAPPS) contract on expendable launch vehicle (ELV) payloads. Sliding doors (owned and maintained by Boeing) on the east and west sides allow payload access to the facility high bay. When the facility is used for payload processing, 30 to 40 people occupy the building during operations and work from temporary offices inside the Multi-Operations Support Building (M7-1357).

A fuel vapor scrubber is shown outside the Payload Hazardous Servicing Facility.

An oxidizer vapor scrubber is shown outside the Payload Hazardous Servicing Facility.

The PHSF complex has three main structures: 1) the PHSF, which contains a hazardous operations service bay and airlocks; 2) the Multi-Operations Support Building (MOSB) M7-1357, which contains an office area, support rooms and payload control rooms for the PHSF and Multi-Payload Processing Facility (MPPF) customers; and 3) the transporter storage building. The complex also has a fuel transfer building and an oxidizer shed. The PHSF is a steel frame building covered with insulated metal siding which contains a hazardous operations service bay and air lock.

Ammonia Servicing:

Not available

Building Management System:

Yes

Chilled Water:

Yes

Clean Room:

The high Bay clean work area is classified as a Level 4, Class 100,000

The air lock clean work area is classified as a Level 5, Class 300,000

PHSF (Continued)

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Two air compressors supply regulated compressed air to the PHSF service bay and the air lock, the outlets are equipped with 5-micron filters.

Specifications:
90 pounds per square inch (6.2 bars) at 185 cubic feet per minute
150 pounds per square inch (10.3 bars) at 325 cubic feet per minute

PHE Breathing Air
Regulated breathing air for Propellant Handlers Ensemble (PHE) operations is available from four, 9.525 millimeter (3/8 inch) quick disconnect couplings on the west wall of the service bay.

Specifications:
65 pounds per square inch (4.5 bars)
120 pounds per square inch (8.3 bars)

Gaseous Nitrogen:
The Gaseous nitrogen (GN2) system is supplied from the unfiltered Industrial Area at 6,000 pounds per square inch (413.8 bars) A GN2 regulating panel, also located at the west end of the building, filters the GN2 to 10 microns and regulates the GN2. The GN2 (Grade B, MIL-P-27401C) is available in both the PHSF service bay and air lock.

Specifications:
50 pounds per square inch (3.4 bars)
750 pounds per square inch (51.7 bars)
3,000 pounds per square inch (206.9 bars)

Gaseous Helium:
A 500-cubic-foot (14.16 cubic meter) gaseous helium (GHe) storage tank and a GHe regulating panel supply filtered GHe. The GHe (procured to Grade A, MIL-P-27407A) is available through outlets in the PHSF service bay and air lock.

Specifications:
- 50 pounds per square inch (3/4 bars)
- 1,000 pounds per square inch (69.0 bars)
- 3,000 pounds per square inch (206.9 bars)
- 3,800 pounds per square inch (262 bars)

Control Rooms:
Control Rooms in the Mission Operations Support Building (MOSB) can be used to monitor activities in the PHSF.

Cranes:
The air lock has a 15-ton (13.6-metric-ton) bridge crane that operates on twin runway girder rails in an east-west direction. The effective east-west travel of the hoist (hook centerline to wall) is to a point 17 feet, 5 inches (5.5 meters) from the east wall, and 12 feet, 11 inches (3.9 meters) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 4 feet, 9.5 inches (1.5 meters) from the north wall and 4 feet, 5 inches (1.3 meters) from the south wall. The maximum hook height is 72.5 feet (22.9 meters).

The service bay has two, 50-ton (45.36 metric ton) bridge cranes which operate on twin runway girder rails in an east-west direction. The nominal hook height for each of the cranes is 74.5 feet (24.3 meters). Both crane hooks are outfitted with a debris shield to protect payloads from any possible overhead debris falling from the crane.

The effective east-west travel of the west crane hoist (hook centerline to wall) is to a point 31 feet, 5 inches (9.5 meters) from the east wall, and 13 feet, 9 inches (4.2 meters) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 6 feet, 5 inches (2 meters) from the north and south walls. The effective east-west travel of the east crane hoist (hook centerline to wall) is a point 11 feet, 2 inches (3.4 meters) from the east wall, and 34 feet, 3 inches (10.4 meters) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 11 feet (3.3 meters) from the north wall, and 9 feet, 10 inches (2.9 meters) from the south wall.

Relative Humidity:
These systems maintain temperatures of 71 (+/- 6) degrees F (21.7 +/- 3.3 degrees C), with a maximum relative humidity of 60 percent.

PHSF (Continued)

A view of the high bay door entrance into the Payload Hazard-ous Servicing Facility (PHSF).

Temperature Range:

Air enters the PHSF through High-Efficiency Particle Air (HEPA) filters mounted in the ceilings of the service bay, air lock and equipment air lock, and is guaranteed class 5,000 air at the filter discharge for the air conditioning and reheat systems. These systems maintain temperatures of 71 (+/- 6) degrees F (21.7 +/- 3.3 degrees C), with a maximum relative humidity of 60 percent. Volumetric air change is exchanged a minimum of four times per hour, with positive pressure maintained at all times.

Uninterruptible Power Supply (UPS):

There are two UPS units in the PHSF. An 80 KVA 480v system and a 100 KVA 120/208v system supply power to all the explosion-proof receptacles in the high bay and air lock.

Vacuum Chamber:

None

Video Camera/Recorders:

CCTV provides closed-circuit video surveillance of payload processing from operational areas (PHSF Rooms 116 and 117) to control and monitor areas in the payload control rooms and in the facility control room in the Mission Operation Support Building. Also, four monitors are located in the PHSF security room 110. There are eight pan-and-tilt CCTV cameras. Four are in the PHSF and two each (one portable and one fixed) are in the fuel transfer building and oxidizer shed. These cameras and pan-and-tilt units are hazard proof.

Floor Space:

18,813 square feet

Door Height:

The main door is 75 feet high.
The door from the high bay into the airlock is 75 feet high.

Door Width:

The main door is 35 feet wide.
The door from the high bay into the air lock is 35 feet wide.

Processing Area:

High bay is 107 feet by 60 feet by 95 feet (6,420 square feet)Air lock is 85 feet by 50 feet by 90 feet (4,250 square feet).

Office Space:

About 890 square feet of the facility is used for office space.

2.27 Processing Control Center (PCC)

Description:
The Processing Control Center (PCC) is a three-story, 240-foot by 135-foot building located west of the Vehicle Assembly Building in Kennedy Space Center's Launch Complex 39 area. The first floor consists of 31,920 square feet of area for the Intermediate Level Maintenance Facility (ILMF) which is occupied by personnel who perform maintenance on Checkout, Control and Monitor Subsystem (CCMS) Line Replaceable Units. The second floor is office area occupied by Launch Processing System Engineering and support personnel. The third floor contains two processing control rooms. PCC-1 contains CCMS hardware and software consoles linked to Orbiter Processing Facility bays 1, 2 and 3. These will be used during the CCMS I and CCMS II transition to control and monitor orbiter processing in support of a specific mission. PCC-1 also contains the Application Software Development Facility and photo console. PCC-2 provides the capability for CCMS software validation and will eventually contain the Software Production Facility. PCC-2 also contains the Tape Library.

The Processing Control Center (PCC) is located in the Launch Complex 39 area at Kennedy Space Center.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Not available

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Yes

Cranes:
Not available

Relative Humidity:
The HVAC system conforms to industry standards for comfort air relative humidity for an office environment.

Temperature Range:
The HVAC system conforms to industry standards for comfort air temperature for an office environment.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

PCC (Continued)

Floor Space:
99,000 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
31,920 square feet of office space is spread across three floors within the building.

2.28 Radioisotope Thermoelectric Generator Facility (RTGF)

Description:

The Radioisotope Thermoelectric Generator Facility (RTGF) provides storage, testing and monitoring of RTG's used in payload programs. The RTGF has five rooms, four of which are available for customer use. The facility is located just east of Kennedy Space Center's Industrial Area. Construction is poured, reinforced concrete with masonry block walls. The floor is poured conductive concrete covered with an epoxy stone-hard floor. A blowout roof and frangible wall sections provide overpressure relief to minimize damage to the storage area in the event of an explosion.

A view of the Radioisotope Thermoelectric Generator Facility (RTGF) at Kennedy Space Center.

Ammonia Servicing:

Not available

Building Management System:

Yes

Chilled Water:

Yes

Clean Room:

Not available

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Two air compressors are located in the mechanical room. Both compressors provide regulated air pressure to the pneumatically sealed roll-up door to a maximum of 15 pounds per square inch gage (psig) or 1.0 bar.

Gaseous Nitrogen:

Not available

Gaseous Helium:

Not available

Control Rooms:

Not available

Cranes:

Room 101 has an explosion-proof, double girder bridge crane with two hoists mounted on a single trolley. Each hoist is rated to lift 5 tons (4.5 metric tons) for a total crane lift capacity of 10 tons (9 metric tons). The hoists may be operated individually or simultaneously. Bridge travel is in an east and west direction. The hoists have a maximum hook height of 18 feet (5.5 m). There are two hook travel speeds in both horizontal and vertical directions: 2 feet (0.6 m) per minute, and 6 feet (1.8 m) per minute. Each hoist has a debris shield to minimize contamination. The bridge crane has been certified as a critical lift category crane.

Relative Humidity:

The facility air conditioning system is capable of maintaining a relative humidity of less than 50 percent.

Temperature Range:

The facility air conditioning system is capable of maintaining a temperature level of 71 (+/- 6) degrees F (22 +/- 1 degree C). A negative, rather than positive, atmospheric pressure is maintained in the building to contain release of radioactive material.

RTGF (Continued)

Uninterruptible Power Supply (UPS):

Provisions have been made for back-up power to be supplied by an auto-transfer switch or manually activated diesel generator located directly outside the facility. This generator provides power for the air conditioning and electrical systems.

Vacuum Chamber:

None

Video Camera/Recorders:

Currently, an explosion-proof portable CCTV camera provides video surveillance of activities within room 101. This unit, located on the floor at the center of the south wall, has pan, zoom and tilt capabilities, and can be controlled and viewed on monitors from within the guard shelter at the personnel entrance outside the building, in the office trailer, the parking lot, or outside the security fence.

Floor Space:

3,788 square feet

Door Height:

Door entry into the storage area is 10 feet high.

Door Width:

Door entry into the storage area is 13 feet, 10 inches wide.

Processing Area:

Room 101, the main RTG storage room, is 42 feet long by 61 feet wide by 25 feet high.

Office Space:

Not available

2.29 Reusable Launch Vehicle (RLV) Hangar

Description:

Space Florida's Reusable Launch Vehicle (RLV) Hangar is a multipurpose facility that was developed in partnership with NASA's Kennedy Space Center (KSC). Located near the south end of the Shuttle Landing Facility, the 50,000-square-foot hangar was completed in April 2000.

The RLV was established to support spaceport aviation activities. The facility was developed as part of a broader state of Florida and KSC initiative to expand the capability of the spaceport to support government and commercial research and technology development activities.

A view of the main hangar door of the Reusable Launch Vehicle Hangar.

A view of the north side and back of the Reusable Launch Vehicle Hangar.

Ammonia Servicing:

Not available

Building Management System:

Not available

Chilled Water:

Not available

Clean Room:

Not available

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Not available

Gaseous Nitrogen:

Not available

Gaseous Helium:

Not available

Control Rooms:

Not available

Cranes:

Not available

Relative Humidity:

There is no requirement to control humidity at this facility.

Temperature Range:

The air conditioning system is designed to maintain a temperature within 10 degrees F of the outside ambient air temperature.

Uninterruptible Power Supply (UPS):

Not available

RLV Hangar (Continued)

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
52,000 square feet

Door Height:
The main door into the RLV Hangar is 30 feet high.

Door Width:
The main door into the RLV Hangar is 185 feet wide.

Processing Area:
The high bay is 200 feet long, 239 feet wide and 66 feet high, with 47,800 square feet of area.

Office Space:
Not applicable

2.30 Rotation Processing and Surge Facility (RPSF)

Description:

The Rotation Processing Surge Facility (RPSF) is located north of the Vehicle Assembly Building (VAB) in the Launch Complex 39 area and comprises the following facilities: SRM Rotation and Processing Facility for processing; contractor support building for storage;, support building for offices; Surge Building No. 1 for SRM staging; Surge Building No. 2 for SRM staging; and shop and storage building. The RPSF was built in 1984 to receive solid rocket motor segments by railcar, and offload and inspect them prior to delivery to the VAB. Rail tracks within the building allow railroad cars containing the segments to be positioned directly under one of two, 200-ton overhead bridge cranes. A tug vehicle, capable of pulling and stopping a fully-loaded segment car, moves and positions railcars in the building. The facilities isolate hazardous operations associated with solid rocket motor rotation and processing that was once performed in High Bay No. 4 in the VAB, thereby averting impacts to VAB processing. The surge facilities are primarily large storage areas capable of holding up to eight solid rocket motor segments each. Two surge buildings allow a complete space shuttle flight set to be ready while processing another for the next flight.

The Rotation, Processing and Surge Facility (RPSF) is located in Kennedy Space Center's Launch Complex 39 Area.

The Rotation and Processing Building has an area of 18,800 square feet, and is used for solid motor receiving, rotation and inspection and supports aft booster buildup. Two surge buildings located nearby each contain 6,000 square feet of floor area to store eight

The locomotive and rail cars carrying solid rocket booster motor segments and two aft exit cone segments deliver their cargo to the Rotation, Processing and Surge Facility (RPSF) in Kennedy Space Center's Launch Complex 39 Area.

segments (one flight set). The buildings are 61 feet high in the aft segment storage area, and 43 feet high in the forward and center segment storage area. Paved roads between the processing facility, the two storage buildings, and the VAB allow transporters to transfer the segments and other hardware from one facility to another. Live solid rocket motor segments arrive at the processing faculty and are positioned under one of the cranes. Handling slings are then attached to the railcar cover, and it is removed. The segment is inspected while it remains in the horizontal position. Two overhead cranes hoist the segment, rotate it to the vertical position and place it on a fixed stand. The aft handling ring is then removed. The segment is hoisted again and lowered onto a transportation and storage pallet, and the forward handling ring is removed to allow inspections. The segment is then transported to one of the surge buildings and temporarily stored until it is needed for booster stacking in the VAB.

Ammonia Servicing:

Not available

Building Management System:

The facility is equipped with a building management system which monitors fire alarm and life safety systems.

Chilled Water:

Not available

RPSF (Continued)

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is available in the RPSF and provided at 175 pounds per square inches, at 33 cubic feet per minute.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
There are two, 200-ton capacity cranes, each with a hook height of 90 feet.

Relative Humidity:
The processing and surge facilities are not environmentally controlled (ambient temperature).

Temperature Range:
The processing and surge facilities are not environmentally controlled (ambient temperature).

Uninterruptible Rower Rupply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
CCTV video is available at the vehicle entry gate only.

Floor Space:
17,871 square feet in the RPSF Building (K6-0494)

Door Height:
In the RPSF building, the north door is 55 feet high, the east door is 20 feet high, and the two west doors are each 20 feet high.

Door Width:
In the RPSF building, the north door is 30 feet wide, the east door is 25 feet wide, and the two west doors are each 20 feet wide.

Processing Area:
SRM Rotation and Processing Facility – 18,800 square feet
Contractor Support Building - 986 square feet
Support Building – 2,865 square feet
Surge Building No. 1 – 5,704 square feet
Surge Building No. 2 – 5,704 square feet
Shop/Storage Building – 5,640 square feet

Office Space:
The Support Building (K6-0495) and the RPSF Operational Support Building (K6-0492) have a potential 3,000 square feet of office space available.

2.31 Shuttle Landing Facility (SLF)

Description:

The Shuttle Landing Facility (SLF) was built in 1976 to support the Space Shuttle Program. It is located in the Launch Complex 39 area, adjacent to the orbiter processing facilities. The SLF serves as NASA's primary runway for space shuttle landings, ferried landings of an orbiter atop the Shuttle Carrier Aircraft (SCA), or landings and takeoffs of other aircraft. A Mate-Demate Device (MDD) at the SLF is used to demate the orbiter from the SCA. The MDD is 150 feet long, 93 feet wide, and 105 feet high and can lift up to 230,000 pounds. Adjacent to the MDD is the Landing Aids Control Building, which houses equipment and the personnel who operate the SLF on a daily basis. The paved runway is 15,000 feet long, with a 1,000-foot-overrun on each end, 300 feet wide with 50-foot shoulders, and 16 inches thick. The SLF also includes a 550-foot by 490-foot parking apron, or ramp, on the southeastern end of the runway. The SLF has two runways, depending on the approach: from the northwest on Runway 15, or from the southeast on Runway 33. South of the midfield point, east of the runway is the SLF Air Traffic Control Tower. The orbiter recovery convoy team staging area, fire station and viewing area for the media and guests also are located at the midfield.

Space shuttle Discovery touches down on Runway 33 at the Shuttle Landing Facility at Kennedy Space Center, on April 20, 2010 at 9:08 a.m. EDT.

The SLF is equipped with NAV/landing aids-TACAN-MSBLS aim point-PAPI lights-ball/bar and distance-to-go markers. Ground and ground-to-air communications are available. Fire and crash and rescue and medical support are provided prior to space shuttle

Space shuttle Discovery's 40-foot-diameter drag chute extends with the aid of a mortar-deployed pilot chute.

launch and landing. In addition to the prime end of mission (EOM) site, the SLF serves as a return-to-launch-site, Abort-Once-Around (RTLS-AOA) and Eastern Launch Site (ELS).

Ammonia Servicing:
Not available

Building Management System:
Not applicable

Chilled Water:
Not available

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Not available

SLF (Continued)

The Alpha Magnetic Spectrometer (AMS) is offloaded from an Air Force C-5M aircraft on the Shuttle Landing Facility runway, after arriving at Kennedy Space Center from Europe.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
Not available

Temperature Range:
Not available

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Multiple outdoor cameras are positioned along the SLF to monitor activities occurring on the facility. These video streams can be transmitted to the center video facility.

Floor Space:
Not applicable

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
Not applicable

2.32 Hangar AF

Description:

The Solid Rocket Booster (SRB) Recovery Building facilities in Hangar AF in the Industrial Area at Cape Canaveral Air Force Station were built in 1963 and modified in 1978 to support the Space Shuttle Program. They are used for removing the SRB's from the water, inspecting, washing and disassembling them into the main segments, aft skirt, and forward skirt assemblies. The SRB's frustrums and parachutes are offloaded from the retrieval vessels at the dock in the Hangar AF area. Each SRB is lowered onto a rail dolly and driven through the First Wash Building for a cleaning and rinsing. Ordnance are removed from the forward skirt, and the Thrust Vector Control (TVC) system is depressurized. Hydrazine is removed in the Thrust Vector Control Deservicing Facility. From there, the SRB's are moved inside Hangar AF where the nozzles are removed and the four SRB segments are separated from each other, beginning with the forward skirt. The frustrums, forward skirt and aft skirt undergo hydrolasing (pressure cleaning) in the Robot Wash Building to remove the thermal protection system (TPS). They also undergo plastic media blasting in the Multi-Media Blast Facility to remove paint coatings, primer and sealants, stripping them down to bare metal. Following a water-break test and application of alodine, the components are taken to Hangar N, also in the Industrial Area of CCAFS for inspection and Non-Destructive Evaluation (NDE), including the inspection of welds.

A view of the front hangar door entrance to the Hangar AF facility at Cape Canaveral Air Force Station, in Florida.

At the Solid Rocket Booster Disassembly Facility at Hangar AF at Cape Canaveral Air Force Station, a mobile gantry crane lifts one of the solid rocket boosters used during space shuttle Atlantis' STS-132 launch.

Ammonia Servicing:

Not available

Building Management System:

Not available

Chilled Water:

Yes

Clean Room:

Not available

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

Compressed air is provided to the facility at 115 pounds per square inch gage (psig) at 800 cubic feet per minute. The facility also is served by a breathing air subsystem.

Gaseous Nitrogen:

Gaseous nitrogen is provided to the facility via a Tube Bank at 200 psig

Gaseous Helium:

Not available

Hangar AF (Continued)

Control Rooms:
Not available

Cranes:
The facility is serviced by two, 40-ton overhead cranes, each with a 40-foot hook height. Also, a mobile gantry straddle lift crane on the hoisting slip lift is capable of lifting 200 tons.

Relative Humidity:
These systems can maintain a relative humidity of 55 percent in office areas.

Temperature Range:
These systems can maintain a temperature range of 70 to 80 degrees F in the office areas.

Uninterruptible Power Supply (UPS):
10KVA output 208/120/3/60 27.8A

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
75,770 square feet

Door Height:
The door is 45 feet high.

Door Width:
The door is 101 feet wide.

Processing Area:
The size of the processing area is 250 feet by 107 feet (26,750 square feet).

Office Space:
20,000 square feet

2.33 Space Life Sciences Laboratory (SLSL)

Description:
The Space Life Sciences Laboratory (SLSL) is a 109,000-square-foot, world-class laboratory with all of the capabilities and systems necessary to host International Space Station (ISS) experiment processing, as well as associated biological and life sciences research. The 66 mixed-use laboratories and 14,000-square-foot vivarium offer a multitude of research opportunities to directly support the ISS.

A view of the Space Life Sciences Laboratory (SLSL) located within Exploration Park adjacent to Kennedy Space Center.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Yes

Clean Room:
The 14,000-square-foot Animal Care Facility within the SLSL is maintained at the 100,000 level CWA.

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

A view of the front entrance to the Space Life Sciences Laboratory (SLSL) located within Exploration Park adjacent to Kennedy Space Center.

Compressed Air:
The central station provides compressed air at 90 to 125 psi, at 132 cubic feet per minute.

Gaseous Nitrogen:
The facility's gaseous nitrogen system is provided via K bottles at 2,000 psi.

Gaseous Helium:
The facility's gaseous helium system is provided via K bottles at 4,000 psi.

Control Rooms:
Experimental Monitoring Area (EMA) control room for payload monitoring.

Cranes:
Not available

Relative Humidity:
The HVAC system can maintain a 40 to 80 percent relative humidity based upon ambient air conditions.

Temperature Range:
The HVAC system can maintain a 58 to 90 degree F temperature based upon ambient air conditions.

Uninterruptible Power Supply (UPS):
Various pieces of equipment have UPS, as well as a

Space Life Sciences Laboratory (SLSL) (Continued)

1,600 kilowatt CAT emergency generator for general facility emergency power generation.

Vacuum Chamber:
None

Video Camera/Recorders:
The facility has a CCTV video system.

Floor Space:
104,000 square feet

Door Height:
Main door is 14 feet high

Door Width:
Main door is 8 feet wide

Processing Area:
53 labs, each 20 feet by 25 feet

Office Space:
Currently within the SLSL there are 128 cubicles; each 67-square-foot area. There also are 18 offices; each 110 square feet, or about 10,556 square feet total.

2.34 Space Station Processing Facility (SSPF)

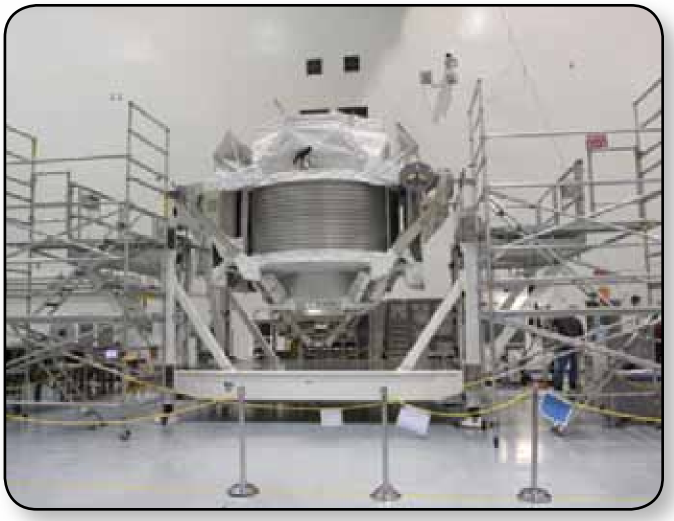
Description:

The Space Station Processing Facility (SSPF), built in 1992, consists of an administrative area, intermediate high bay (I-bay) area and high bay (HB) area. Currently, the I-bay and HB provide for nonhazardous, except anhydrous ammonia (NH3), processing of International Space Station and other space shuttle payloads.
The online processing areas are located in the high and intermediate bay areas of the SSPF. Each footprint in the SSPF high bay provides up to 480V/100A of power, facility ground, chilled water, gaseous nitrogen (GN2), gaseous helium (GHe), high and low pressure venting, Operational Intercommunication Systems-Digital (OIS-D) communications, and compressed air. The building also was designed to accommodate a set of changing requirements. New footprint capabilities can easily be added via the tunnels underneath the high bay.

A view of the front entrance to the Space Station Processing Facility in Kennedy Space Center's Industrial Area.

The offline processing areas are located near the office side of the SSPF building. They provide 20-foot- high ceilings and are capable of being a Clean Work Area, though they are rarely used as such. Offline processing areas provide similar features as the online areas, with the exception of cranes, chilled water, vents and fluids.

The SSPF contains areas that were originally designed to be datacenters. They have raised floors and are very easy to reconfigure with the necessary utilities for any type of activity to occur. The datacenter facilities typically have chilled water lines in them for low-profile air handlers to be readily installed. They also provide access to the facility uninterruptible power system (UPS).



In the Space Station Processing Facility at NASA's Kennedy Space Center in Florida, the Alpha Magnetic Spectrometer-2 (AMS) sits in its cargo element work stand, where more processing will take place.

Environmental counters are located in each footprint in the high bay and intermediate bay to monitor and track particle counts and relative humidity.
The high bay floor is capable of supporting very heavy loads. It also has sections which are seismically isolated, thus making it suitable for extremely precise measurements. The floor is very smooth in order to facilitate the use of air-bearing pallets which can enable very easy movement of large flight elements and stands. The floor is conductive, which helps to reduce the risk of inadvertent electrostatic discharge.

The air handling system in the online processing areas are capable of a minimum of four complete air changes in the high bay per hour, and can hold the temperature and humidity within strict specifications. The system runs at the capacity needed to keep the room at a 100,000 clean work area (CWA) specification.

The Vapor Containment Facility (VCF), located adjacent to the east end of the intermediate bay, contains equipment to service flight hardware with NH3. Ammonia lines are brought into the high and intermediate bays on the east end, and built-in and portable environmental monitoring equipment is available.

The SSPF has about 20 offline laboratories. A typical offline lab will provide all of the capabilities as the online areas. Biology labs provide deep freezers, fume hoods, and other laboratory equipment and support services.

SSPF (Continued)

The offline processing areas are located near the office side of the SSPF building. They have 20-foot- high ceilings and are capable of being a CWA, though they are rarely used as such. Offline processing areas provide similar features as the online areas, with the exception of cranes, chilled water, vents and fluids.
The SSPF has redundant connections to the power grid as well as a backup generator. Also, battery UPS is provided through a combination of built-in facility systems and portable UPS units. UPS units are used to power systems that are sensitive to fluctuations in power quality, and to ensure that tests are not interrupted.

In the Space Station Processing Facility at NASA's Kennedy Space Center in Florida, an overhead crane lifts the Alpha Magnetic Spectrometer, or AMS, so it can be lifted onto a work stand and processed for launch.

The SSPF functions as a processing facility for space station payloads. The SSPF is used primarily to support station operation, lift and reception of experiments, testing, and preparation of modules. Processing occurs for both preflight and postlanding activities of components and is available for all partners. This facility is suitable for nonhazardous processing and assembly of payloads and spacecraft. Without a waiver and additional controls the facility is not suitable for hazardous payload processing due to its proximity to existing inhabited buildings and the explosive and safety quantity distance requirements. The high bay is rated as a Class 1, Division 2, Groups C and D area.

Ammonia Servicing:

The facility is served by an ammonia plant to the east of the IB. The plant can handle 1,200 pounds flowing, with 6,000 pounds in storage.

Andover Monitor:

The environmental conditions are kept at 71 degrees F (+/- 6 degrees), and monitored continuously through the Andover control system.

Chilled Water:

Yes

Clean Room:

High bay: Level 4, Class 100,000 clean work area; Intermediate Bay: Level 4, Class 100,000 clean work area; Air lock: Level 5, Class 300,000 clean work area

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:

The SSPF can provide compressed air at 125 psi per square inch (8.6 bars).

Gaseous Nitrogen:

Gaseous Nitrogen (GN2) is provided to footprint mechanical panels H1 to H8 in the high bay, I1, I2 and I6 to I10, in the Intermediate bay, and G1 to G5 in the ground support equipment fluids area. There are control panels around the perimeter of the areas that isolate the gas. Pressures can be controlled through separate valves for 50, 750, 3,000 and 6,000 psi. The lines are 1 and ¼ inch by .049, 1 and 1/4 inch by .049, 1 inch by .095, and ½ inch by .072, respectively.

Gaseous Helium:

Gaseous helium is provided to footprint mechanical panels H1 to H8 in the high bay, I1, I2 and I6 to I10, in the intermediate bay, and G1 to G5 in the ground support equipment fluids area. There are control panels around the perimeter of the areas that isolate the gas. Pressures can be controlled through separate valves for 50, 750, 3,000 and 6,000 psi. The lines are 1 inch by .095, 1 inch by .095, ¾ inch by .065, and ½ inch by .072, respectively.

SSPF (Continued)

Control Rooms:
Environmental counters are located in each footprint in the high bay and intermediate bay to monitor and track particle counts and relative humidity.

Cranes:
High bay: two, 30-ton electrical bridge cranes, each with 50-foot maximum hook height, and two, 5-ton electrical bridge cranes, each with 25-foot maximum hook height.

One, 15-ton electrical bridge crane, with 50-foot, 7-inch maximum hook height.

The high bay has two, 30-ton cab-operated overhead cranes with a 50-foot hook height. The air lock has one pendant-operated 15-ton overhead crane with a 50-foot hook height. The hardware inspection area has a 5-ton pendant overhead crane with a 25-foot hook height, and the intermediate bay has two, 5-ton overhead pendant cranes with 25-foot hook height. The high bay door allows approximately a 50-foot clearance.

Relative Humidity:
55 percent max continuous; humidity in offline lab areas to be between 35 and 50 percent.

Temperature Range:
The environmental conditions are kept at 71 degrees F (+/- 6 degrees). Offline lab areas also are available with additional controls for air conditioning monitoring. The lab areas require the temperature to be 72 degrees F (+/- 2 degrees).

Uninterruptible Power Supply (UPS):
450 KVA , International Power Machines

Vacuum Chamber:
None

Video Camera/Recorders:
The CCTV system provides color, closed-circuit video surveillance and recording of payload processing activities from operational areas. Portable cameras are available for floor level monitoring. The cameras can be remotely-controlled from the control and user rooms. Interfaces are available at each high bay footprint for customer-provided cameras. Monitors are located in the user and control rooms and various other locations.

A tractor-trailer carrying the Alpha Magnetic Spectrometer, or AMS, arrives at the Space Station Processing Facility, where it will be processed for launch.

Floor Space:
522,313 square feet

Door Height:
High bay door is 49 feet, 6 inches high.

Door Width:
High bay door is 42 feet wide.

Processing Area:
High Bay: 105 feet wide by 362 feet long by 61 feet, 6 inches high; Intermediate Bay: 50 feet wide by 338 feet long by 30 feet high; Air lock: 46 feet wide by 108 feet long by 61 feet, 6 inches high. The air handling system in the online processing areas are capable of a minimum of four complete air changes in the high bay per hour, and can hold the temperature and humidity within strict specifications. It runs at the capacity needed to keep the room at a 100,000 CWA specification.

Office Space:
About 140,000 square feet for nearly 1,000 employees, 25 conference areas, 16 offline processing rooms, two chemical labs, two dark rooms, and nine control

SSPF (Continued)

rooms, located on raised floor areas. Also included are a Multi-Layer Insulation (MLI) sewing room; Vapor Containment Facility (VCF) to house anhydrous ammonia; Flight Crew room (final checkpoint for all flight crew equipment); foam cutting room (custom cut foam for hardware elements); food processing room (for storing and processing crew food packages); and a waste processing room (for processing of postflight waste containers).

Additional Data:

The VCF, located adjacent to the east end of the IB, contains equipment to service flight hardware with NH3. Ammonia lines are brought into the HB or IB on the east end, and built-in and portable environmental monitoring equipment is available. The HB floor is capable of supporting very heavy loads. It also has sections which are seismically isolated, thus making it suitable for extremely precise measurements. The floor is very smooth in order to facilitate the use of air-bearing pallets which can enable very easy movement of large flight elements and stands. The floor is conductive, which helps to reduce the risk of inadvertent electrostatic discharge (ESD). The SSPF has about 20 offline laboratories. A typical offline lab will provide all of the capabilities as in the online areas. The biology labs also provide deep freezers, fume hoods and other laboratory equipment and support services. The SSPF has areas that were originally designed to be datacenters; they have raised floors and are very easy to reconfigure with the necessary utilities for any type of activity to occur. The datacenter facilities typically have chilled water lines for low-profile air handlers to be readily installed. They also provide access to the facility UPS system.

2.35 Supply Warehouse No. 1

Description:
Supply Warehouse No.1 predominately supports International Space Station Processing and is used for flight and ground support equipment that needs a conditioned environment. The facility contains an Automated Guided Vehicle (AGV), which provides 60 percent space and storage efficiency compared to a conventional fixed aisle configuration.

The Central Supply Warehouse is a single-story warehouse facility with 92,688 square feet of space. Included in this total is 17,449 square feet of office space. The warehouse area includes two mezzanine storage areas totaling 3,499 square feet. Supply Warehouse No. 1 is a single-story warehouse facility with a total of 71,826 square feet of space. About 60 percent of this area (41,572 square feet) supports the central supply function, with 719 square feet of this total used for office space. Both of these areas are primarily tasked to support institutional projects. The remaining 30,254 square feet of Supply Warehouse No. 1 supports various supply functions. Supply Warehouse No. 2 is a single story warehouse facility with a small second floor area (148 square feet). The facility has 34,209 square feet of space, including 1,155 square feet of office space.

A view of the loading dock area of Supply Warehouse No. 1 at Kennedy Space Center in Florida.

Ammonia Servicing:
Not available

Building Management System:
Yes

Chilled Water:
Not available

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Not available

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
These systems can maintain a temperature range of 71 (+/- 6) degrees F with a maximum relative humidity of 55 percent (+/- 5 percent).

Temperature Range:
These systems maintain temperatures of 71 (+/- 6) degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Supply Warehouse No. 1 (Continued)

Floor Space:
71,826 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
71,107 square feet

Office Space:
Approximately 719 square feet of the facility is used as office space.

2.36 Thermal Protection System Facility (TPSF)

Description:
The Thermal Protection System Facility (TPSF), built in 1988, is a two-story, 44,000-square-foot building located across the street from the Orbiter Processing Facility and near the Vehicle Assembly Building in the Launch Complex 39 area. It provides a unique capability at KSC to manufacture thermal tiles for the space shuttle orbiter. The TPSF is used to assemble, manufacture and repair thermal protection tiles, gap fillers and insulation blankets that protect the exterior of each orbiter from the searing heat of launch and re-entry and the cold soak of space. These materials can sustain damage during a flight and must be inspected, repaired, or sometimes replaced for the next mission.

Ammonia Servicing:
Not available

Building Management System:
The Building Management System is a temperature monitoring system for the HVAC equipment that also monitors the security cipher locks on doors leading to the processing area.

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Compressed air is available in the TPSF at 120-pounds-per-square-inch, at 20-cubic-feet-per-minute.

Gaseous Nitrogen:
Gaseous nitrogen is available in the TPSF facility at 135 PSI, at 20 cubic feet per minute.

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
The air conditioning system is designed to maintain a relative humidity of about 55 percent.

Temperature Range:
The air conditioning system is designed to maintain a temperature range of 68 to 78 degrees F.

Uninterruptible Power Supply (UPS):
A UPS, rated at 50KVA, is available in the TPSF.

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
44,100 square feet

Door Height:
A 10-foot-high roll-up door provides access to the Machine Shop within the TPSF.

Door Width:
A 19.5-foot-wide roll-up door provides access to the Machine Shop within the TPSF.

Processing Area:
Usable area:
34,000 square feet on the first floor
10,000 square feet on the second floor

Office Space:
5,088 square feet is currently configured as office space within the TPSF.

The Thermal Protection System Facility is located in Kennedy Space Center's Launch Complex 39 Area.

2.37 Utility Shop

Description:
The Utility Shop, located in the LC-39 area, addresses a multitude of needs as they arise on center. Located within the facility are various individual shops that house personnel and equipment to address a multitude of tasks related to pneumatics, painting, assembly and repair, logistics, structures, water, heating, ventiltion and air conditioning (HVAC), and instrumentation. Utility Shop capabilities range in nature, from installing and modifying security fencing, to repairing, servicing and installing various sensors used to collect data on a wide variety of inputs to monitor and provide oversight of operational activities, tests and experiments occurring on center.

Ammonia Servicing:
Not available

Building Management System:
The building management system resident in the Utility Shop provides oversight of the HVAC system.

Chilled Water:
Yes

Clean Room:
Not available

Electrical Service:
This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Potable Water:
Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Compressed Air:
Dual 7.5 horsepower compressors provide 175 psi maximum pressure (125 psi nominal), at about 50 cubic feet per minute to the Utility Shop.

Gaseous Nitrogen:
Not available

Gaseous Helium:
Not available

Control Rooms:
Not available

Cranes:
Not available

Relative Humidity:
The HVAC system within the Utility Shop is capable of maintaining 50 percent relative humidity.

Temperature Range:
The HVAC system within the Utility Shop is capable of maintaining a temperature range of 68 to 78 degrees F.

Uninterruptible Power Supply (UPS):
Not available

Vacuum Chamber:
None

Video Camera/Recorders:
Not available

Floor Space:
25,013 square feet

Door Height:
Not applicable

Door Width:
Not applicable

Processing Area:
Not applicable

Office Space:
The Utility Shop has about 6,683 square feet of office space.

A view of the Utility Shop Facility located in Kennedy Space Center's Launch Complex 39 Area.

2.38 Vehicle Assembly Building (VAB)

Description:

The Vehicle Assembly Building (VAB) is one of the largest and most-recognizable buildings in the world. It was built in 1965 to support assembly of Apollo/Saturn vehicles, and was later modified to support the Space Shuttle Program. The VAB covers eight acres and is 525 feet tall, 716 feet long, and 518 feet wide.

The VAB is a 1,831,549-square-foot facility used to assemble and mate solid rocket boosters (SRB) and an external fuel tank (ET) on a mobile launch platform (MLP) to an orbiter. United Space Alliance (USA) is the prime contractor for the Space Flight Operations Contract (SFOC), and has primary responsibility for shuttle launch preparation operations and launch equipment maintenance and engineering. ISC is responsible for maintenance and engineering of certain VAB support systems, including structural and roof systems, protective systems, high voltage power supply, facility grounding and lightning protection, water and wastewater, utilities, and roads and grounds. The VAB is split into high bay and low bay sections. The 525-foot-tall high bay contains four vehicle assembly and checkout cells (HB 1-4). Bays 2 and 4 face west and bays 1 and 3 face east located between six, 41-story towers (A-F) and a transfer aisle. HB-1 and HB-3 are used for integration and stacking of the space shuttle, ET and SRBs on top of an MLP. HB-2 is used for ET checkout and storage and as a contingency storage area for orbiters. HB-4 is used for ET checkout and storage, as well as for payload canister operations and SRB contingency handling. The 210-foot-tall low bay is divided by the south end of the transfer aisle and contains eight works cells and four, six-story towers (K-N). The work cells are used by space shuttle main engine maintenance and overhaul shops and serve as a holding area for SRB forward assemblies and aft skirts. All towers in the VAB contain operations and maintenance shops, general offices and materials storage space and equipment rooms. A walkway between the Launch Control Center and VAB is located at the southeast corner of the building (fourth floor of Tower D). The facility is constructed of carbon structural steel framework, aluminum siding and luminous plastic exterior wall panels, concrete floors and foundation, and a combination of built-up and membrane roofing. The roof was replaced, and panels and vertical doors were refurbished between 2006 and 2009.

Two large fold up doors are located at the east and west sides of the building and provide access to the high bay work cells. Large sliding doors located on the north and south ends of the building provide orbiter and large equipment access to the transfer aisle. Numerous powered, coiling, roll-up doors, used for ancillary functions by USA operations, maintenance and logistics shops, are located throughout the building and are maintained by USA. A total of 71 cranes (maintained by USA) are located throughout the building, including two, 250-ton bridge cranes in the transfer aisle.

The massive Vehicle Assembly Building is located in Kennedy Space Center's Launch Complex 39 Area.

Ammonia Servicing:

Not available

Building Management System:

The VAB is equipped with a remote command and control which is operational 24-hours-per-day, seven-days-a-week, and monitors HVAC, power, water, elevator and pneumatics systems inside the facility.

Chilled Water:

Yes

Clean Room:

The VAB is equipped with two clean rooms. The first is the Extended Duration Orbiter (EDO), the second is the Robotic Manipulation System (RMS) Lab. Each is rated as a 100,000 clean work area (CWA).

Electrical Service:

This facility is outfitted with 480 volt, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements

.

Potable Water:

Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

VAB (Continued)

Compressed Air:
The Utility Annex compressor system feeds the VAB and the orbiter processing facilities. The two on-line compressors are each capable of producing 150 horsepower. The operating pressure is 125 pounds per square inch, with a capable output of 650 cubic feet per minute.

Gaseous Nitrogen:
The maximum gaseous nitrogen (GN2) pressure is 5,600 pounds per square inch gage (psig). The water volume is 4,800 cubic feet so that at maximum pressure there is 1,468,800 cubic feet of nitrogen stored in the GN2 battery.

Gaseous Helium:
The maximum gaseous helium (GHe) pressure provided to the VAB storage battery is 5,660 psig. The volume of the VAB storage battery is 5,200 cubic feet of water volume So that at maximum pressure there is 1,679,600 cubic feet of helium stored in the battery.

Control Rooms:
Not available

Cranes:
The VAB is serviced by two, 250-ton, and one, 325-ton bridge cranes (east - west), with a 462.5-foot hook height.

The VAB also is serviced by one, 175-ton bridge crane running along the transfer isle (north - south), with a 156-foot hook height.

Relative Humidity:
The VAB does not have HVAC support for the entire facility. Some areas that have HVAC are the towers, labs, and other miscellaneous areas. Extended Duration Orbiter (EDO) Room A/C was designed for 65 gallons per minute at 42 degrees to maintain 75 (+/- 5) degrees F and 40 to 55 percent relative humidity. The Robotic Manipulation System (RMS) Room A/C was designed for 36 gallons per minute at 42 degrees to maintain 75 (+/- 5) degrees F and 30 to 55 percent relative humidity.

Temperature Range:
See relative humidity specifications for temperature range information.

The drifting smoke plumes from the launch of space shuttle Atlantis seem to swirl above the Vehicle Assembly Building (right) and NASA News Center (left) near sunset at Kennedy Space Center.

Uninterruptible Power Supply (UPS):
The VAB is equipped with both UPSs and backup generator power. The specific capabilities and their availability throughout different portions of the VAB facility will be addressed based upon the customer's specific requirements.

Vacuum Chamber:
None

Video Camera/Recorders:
The VAB is equipped with a closed circuit TV monitoring system.

Floor Space:
1,831,549 square feet

Door Height:
High bay doors are 456 feet high, and are comprised of a lower door that is 114 feet high and an upper door that is 342 feet high. Low bay door is 53 feet high.

Door Width:
High bay doors are comprised of a lower door that is 192 feet wide and an upper door that is 76 feet wide. Low bay door is 56 feet wide.

Processing Area:
The VAB has about five acres of high bay space available for many aspects of processing activities.

Office Space:
Due to rules governing the storage and use of ordnance within close proximity to office space, the office space within the VAB currently is used for storage.

Appendix A. Capability Cross-reference

KSC's numerous technical capabilities, facilities, labs and shops are highly relational. To provide information on relationships between technical capabilities, facilities, labs and shops, a cross-reference is included in Appendix B that identifies which technical capabilities are associated with each facility, shop and lab.

Capabilities / Facilities	Assembly and Refurbishment Facility (ARF)	Hangar AE	Hypergolic Maintenance Facility (HMF)	Launch Complex 39 Turn Basin and Dockage	Launch Control Center (LCC)	Launch Equipment Shop (LES)	Launch Equipment Test Facility (LETF)	Launch Pad 39A	Launch Pad 39B	Logistics Facility	Mobile Launcher (ML) Construction Area	Multi-Payload Processing Facility (MPPF)	Operations and Checkout (O&C) Building	Orbiter Processing Facility (OPF) Bay 3	Orbiter Processing Facility (OPF) Bays 1 and 2	Parachute Refurbishment Facility	Payload Hazardous Servicing Facility (PHSF)	Processing Control Center (PCC)	Reusable Launch Vehicle (RLV) Hangar	Rotation Processing and Surge Facility (RPSF)	Shuttle Landing Facility (SLF)	Solid Rocket Booster (SRB) Recovery Building (Hangar AF)	Space Station Processing Facility (SSPF)	Supply Warehouse No. 1	Thermal Protection System Facility (TPSF)	Vehicle Assembly Building (VAB)
Advanced Leak Detection Capabilities							•																			
Advisory Systems					•																					
Anomalous Weather Management					•																					
Biological Research and On-Orbit Planning																							•			
Corrosion													•													
Crew Support Systems								•	•					•	•								•			
Critical Sensors and Transducers (Cryogens and Hydrogen)					•		•	•	•																	
Cryogen Storage, Handling, and Servicing /De-servicing				•			•	•	•																	
Design of Avionics Systems														•												•
Design of Fluids and Propulsion Systems							•																			
Design of Mechanical Systems							•																			
Design of Pyrotechnics Systems							•																			
Design Visualization															•								•			
Development of Flight Hardware Concept of Operations																						•				
Electronic Equipment and Cable Fabrication and Repair						•																				
Emergency Management					•																					
Extreme Temperatures and Low Flammability							•						•													
Flight and Ground Hardware Technical Training and Certification																							•			
Flight Systems Design					•	•		•	•		•															
Ground Command and Control Systems					•																					

Capabilities \ Facilities	Assembly and Refurbishment Facility (ARF)	Hangar AE	Hypergolic Maintenance Facility (HMF)	Launch Complex 39 Turn Basin and Dockage	Launch Control Center (LCC)	Launch Equipment Shop (LES)	Launch Equipment Test Facility (LETF)	Launch Pad 39A	Launch Pad 39B	Logistics Facility	Mobile Launcher (ML) Construction Area	Multi-Payload Processing Facility (MPPF)	Operations and Checkout (O&C) Building	Orbiter Processing Facility (OPF) Bay 3	Orbiter Processing Facility (OPF) Bays 1 and 2	Parachute Refurbishment Facility	Payload Hazardous Servicing Facility (PHSF)	Processing Control Center (PCC)	Reusable Launch Vehicle (RLV) Hangar	Rotation Processing and Surge Facility (RPSF)	Shuttle Landing Facility (SLF)	Solid Rocket Booster (SRB) Recovery Building (Hangar AF)	Space Station Processing Facility (SSPF)	Supply Warehouse No. 1	Thermal Protection System Facility (TPSF)	Vehicle Assembly Building (VAB)
Hazardous Gas Detection					•		•	•	•																	
Hypergol Storage, Handling, and Servicing /De-servicing			•											•	•											
Institutional Maintenance						•																				
Integrated Command, Control, and Monitor					•													•								
Integrated Launch Vehicle Technical Management					•																					
Integration of Spacecraft Requirements and Ground System Services																	•									
Launch Commit Criteria																							•			
Launch Countdown Simulation and Launch Team Training					•													•								
Launch Image Analysis					•			•	•									•								•
Launch Pad Processing					•			•	•																	
Launch Radar Tracking																						•				•
Launch Vehicle Element Processing	•													•	•				•	•		•				•
Launch Vehicle Thermal Analysis		•				•																			•	
Logistics Warehousing										•														•		
Machining						•																				
Mission Processing Team					•																		•			
Offline Laboratory Test and Checkout														•									•			•
Payload Checkout Systems																							•			
Payload Integration								•						•	•											

Facilities

Capabilities	Assembly and Refurbishment Facility (ARF)	Hangar AE	Hypergolic Maintenance Facility (HMF)	Launch Complex 39 Turn Basin and Dockage	Launch Control Center (LCC)	Launch Equipment Shop (LES)	Launch Equipment Test Facility (LETF)	Launch Pad 39A	Launch Pad 39B	Logistics Facility	Mobile Launcher (ML) Construction Area	Multi-Payload Processing Facility (MPPF)	Operations and Checkout (O&C) Building	Orbiter Processing Facility (OPF) Bay 3	Orbiter Processing Facility (OPF) Bays 1 and 2	Parachute Refurbishment Facility	Payload Hazardous Servicing Facility (PHSF)	Processing Control Center (PCC)	Reusable Launch Vehicle (RLV) Hangar	Rotation Processing and Surge Facility (RPSF)	Shuttle Landing Facility (SLF)	Solid Rocket Booster (SRB) Recovery Building (Hangar AF)	Space Station Processing Facility (SSPF)	Supply Warehouse No. 1	Thermal Protection System Facility (TPSF)	Vehicle Assembly Building (VAB)
Payload, Spacecraft and Launch Vehicle Fluids Storage, Handling, and Servicing / De-servicing								•	•			•		•	•		•						•			
Payload/Element/Orbital Replacement Unit Testing					•																		•			
Pneumatics Fabrication						•																				
Post Launch Recovery and Retrieval	•													•	•	•					•	•				
Real Time Field Test and Checkout					•									•									•			•
Reusable Spacecraft Processing														•	•	•					•				•	•
Rocket Plume Blast Effects							•																			
Smart and Self-Healing Materials and Composites for Detection and Repair Systems							•						•													
Software Independent Verification and Validation Integration						•																				
Telemetry Data Analysis, Output and Storage					•																					
Telemetry Data Management					•																					
Thermal Protections System Manufacture and Repair																									•	
Umbilical System Design and Development							•																			
Welding						•																				

Capabilities / Laboratories	Advanced Electronics and Technology Development Laboratory	Advanced Range and Systems Health Laboratory	Animal Care Facility	Applied Chemistry Laboratory	Applied Meteorology Unit	Chemical Analysis and Sampling Laboratory	Chemical Test and Analysis Laboratory	Controlled Environment Laboratory	Controls Laboratory	Corrosion Technology Laboratory	Cryogenics Test Laboratory	Design Visualization Laboratory	Earth Systems Modeling and Data Management Laboratory	Electrical/Electronics Failure Analysis Laboratory	Electromagnetic Effects Laboratory	Electronic Development and Test Laboratory	Electrostatics and Surface Physics Laboratory	Environmental Microbiology Laboratory	Experiment Support Laboratories	Flight Experiment Development Laboratory	Granular Materials and Regolith Operations Laboratory	Instrumentation Systems Development Laboratory	Information Technology System Services Laboratory	Materials Failure Analysis Laboratory	Mechanical, Structural and Controls Development Laboratory	Metrology Laboratory	Nondestructive Evaluation Laboratory	Physical Test and Analysis Laboratory	Polymer Science and Technology Laboratory	Power Systems Laboratory	Prototype Development Laboratory	Standards and Calibration Laboratory	Telescience and Internet Systems Laboratory
50 Megahertz Doppler Radar Wind Profiler					•																												
Advanced Leak Detection Capabilities				•			•																										
Aerogels for Unique Ground Heat Leak Applications											•																						
Air and Water Purification						•	•											•															
Application Development Services																							•										
Avionics	•	•							•					•		•						•								•			
Bioinstrumentation Checkout of Space Vehicles																																	
Biological Research and On-Orbit Planning			•					•											•														
Calibration Engineering and Measurement Analysis																										•						•	
Closed Environment Plant Production Research																		•															
Contamination Control							•			•				•												•	•	•					
Corrosion										•														•									
Corrosion Control										•																							
Corrosion Control							•			•				•												•	•	•					
Crew Support Systems						•																				•	•					•	
Critical Sensors and Transducers (Cryogens and Hydrogen)							•				•			•	•	•																	
Cryogen Storage, Handling, and Servicing /De-servicing						•					•													•			•				•	•	
Design and Assurance of Electrical and Electromagnetic Systems															•	•																	

Capabilities / Laboratories	Advanced Electronics and Technology Development Laboratory	Advanced Range and Systems Health Laboratory	Animal Care Facility	Applied Chemistry Laboratory	Applied Meteorology Unit	Chemical Analysis and Sampling Laboratory	Chemical Test and Analysis Laboratory	Controlled Environment Laboratory	Controls Laboratory	Corrosion Technology Laboratory	Cryogenics Test Laboratory	Design Visualization Laboratory	Earth Systems Modeling and Data Management Laboratory	Electrical/Electronics Failure Analysis Laboratory	Electromagnetic Effects Laboratory	Electronic Development and Test Laboratory	Electrostatics and Surface Physics Laboratory	Environmental Microbiology Laboratory	Experiment Support Laboratories	Flight Experiment Development Laboratory	Granular Materials and Regolith Operations Laboratory	Instrumentation Systems Development Laboratory	Information Technology System Services Laboratory	Materials Failure Analysis Laboratory	Mechanical, Structural and Controls Development Laboratory	Metrology Laboratory	Nondestructive Evaluation Laboratory	Physical Test and Analysis Laboratory	Polymer Science and Technology Laboratory	Power Systems Laboratory	Prototype Development Laboratory	Standards and Calibration Laboratory	Telescience and Internet Systems Laboratory
Design of Avionics Systems							•							•																		•	
Design of Fluids and Propulsion Systems							•			•	•																•	•					
Design of Mechanical Systems																									•						•		
Design Visualization Research												•																					
Distributed Simulation												•																					
Documentation and Process Management								•											•	•													
Electronic Equipment and Cable Fabrication and Repair															•																	•	
Extreme Temperatures and Low Flammability											•																	•	•				
Fabrication and Rapid Prototyping																															•		
Failure Analysis							•			•				•												•	•	•					
Far Field Antenna Testing															•																		
Ground Systems Logistics Support Planning and Analysis												•																					
Hazardous Gas Detection							•							•	•	•																	
Hypergol Storage, Handling, and Servicing /De-servicing						•	•																	•			•					•	
Launch Vehicle Electromagnetic Environments															•																		
Launch Vehicle Thermal Analysis											•																						
Lightning Measurement	•				•										•																		
Materials Selection							•			•				•												•	•	•					
Materials Testing and Analysis							•			•				•												•	•	•					

Capabilities / Laboratories	Advanced Electronics and Technology Development Laboratory	Advanced Range and Systems Health Laboratory	Animal Care Facility	Applied Chemistry Laboratory	Applied Meteorology Unit	Chemical Analysis and Sampling Laboratory	Chemical Test and Analysis Laboratory	Controlled Environment Laboratory	Controls Laboratory	Corrosion Technology Laboratory	Cryogenics Test Laboratory	Design Visualization Laboratory	Earth Systems Modeling and Data Management Laboratory	Electrical/Electronics Failure Analysis Laboratory	Electromagnetic Effects Laboratory	Electronic Development and Test Laboratory	Electrostatics and Surface Physics Laboratory	Environmental Microbiology Laboratory	Experiment Support Laboratories	Flight Experiment Development Laboratory	Granular Materials and Regolith Operations Laboratory	Instrumentation Systems Development Laboratory	Information Technology System Services Laboratory	Materials Failure Analysis Laboratory	Mechanical, Structural and Controls Development Laboratory	Metrology Laboratory	Nondestructive Evaluation Laboratory	Physical Test and Analysis Laboratory	Polymer Science and Technology Laboratory	Power Systems Laboratory	Prototype Development Laboratory	Standards and Calibration Laboratory	Telescience and Internet Systems Laboratory
Mission Processing Team												•			•																		
Multi-Layer Insulation Systems											•																						
Nondestructive Evaluation (NDE)							•			•				•												•	•	•					
Offline Laboratory Test and Checkout						•								•																		•	
Payload, Spacecraft and Launch Vehicle Fluids Storage, Handling, and Servicing/De-servicing						•	•																	•		•	•					•	
Payload/Element/Orbital Replacement Unit Testing															•																		
Precision Measurement and Dimensional Analysis																										•							
Radio Frequency and Electromagnetic Interference Analysis															•																		
Real Time Field Test and Checkout						•								•																		•	
Regolith Excavation and Handling																					•												•
Remote Operations and Telescience Support																																	•
Reverse Engineering												•																					
Risk Management																																	
Roads, Bridges and Parking																																	
Rocket Plume Blast Effects																					•												
Simulation Based Human Factors												•																					
Smart and Self-Healing Materials and Composites for Detection and Repair Systems										•																	•	•					
Static Electricity and Dust Mitigation																•																	

Capabilities \ Laboratories	Advanced Electronics and Technology Development Laboratory	Advanced Range and Systems Health Laboratory	Animal Care Facility	Applied Chemistry Laboratory	Applied Meteorology Unit	Chemical Analysis and Sampling Laboratory	Chemical Test and Analysis Laboratory	Controlled Environment Laboratory	Controls Laboratory	Corrosion Technology Laboratory	Cryogenics Test Laboratory	Design Visualization Laboratory	Earth Systems Modeling and Data Management Laboratory	Electrical/Electronics Failure Analysis Laboratory	Electromagnetic Effects Laboratory	Electronic Development and Test Laboratory	Electrostatics and Surface Physics Laboratory	Environmental Microbiology Laboratory	Experiment Support Laboratories	Flight Experiment Development Laboratory	Granular Materials and Regolith Operations Laboratory	Instrumentation Systems Development Laboratory	Information Technology System Services Laboratory	Materials Failure Analysis Laboratory	Mechanical, Structural and Controls Development Laboratory	Metrology Laboratory	Nondestructive Evaluation Laboratory	Physical Test and Analysis Laboratory	Polymer Science and Technology Laboratory	Power Systems Laboratory	Prototype Development Laboratory	Standards and Calibration Laboratory	Telescience and Internet Systems Laboratory
Supply Chain and Discrete Event Simulation											•																						
Tele-robotics																				•												•	
Thermodynamic Measurement, Weather Sensor Development and Winds Research				•																													
Umbilical System Design and Development																														•			
Zero Loss Cryogenic Propellant Servicing										•																							

Appendix B. Core Technical Capabilities Catalog Link

KSC boasts numerous shops and labs available for everything from fabrication, cleaning, analysis, and repair of numerous products, components, and materials, to life sciences, electrical, prototyping and material property laboratories. If finding technical solutions to processing, launch and spaceflight problems, or research and technology development is of interest, explore the laboratories and shops that KSC has to offer. A detailed description of the various laboratories and shops are in the Core Technical Capabilities Catalog, which can be found at this link:

http://kscpartnerships.ksc.nasa.gov/documents/2008_CTC_Catalog.pdf

Appendix C. Gems (To be included at a later date.)

Of all of the resources, facilities, services and expertise that KSC has to offer, there are a number of capabilities that should be distinguished as above the rest. KSC refers to these special capabilities as Gems. Appendix A provides high level summaries of the many Gems that KSC wants to showcase due to their world-class nature, uniqueness and/or potential to significantly enable space industry and associated technology development.

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

www.nasa.gov

SP-2010-10-194-KSC