



Launch Equipment Test Facility (LETF) Capabilities

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KSC Launch Equipment Test Facility

- The Launch Equipment Test Facility (LETF) was originally established in the 1970's to allow full-scale qualification of Space Shuttle umbilicals and T-0 release mechanisms.
- The facility test fixtures and supporting systems have been upgraded to support SLS umbilical and component qualification testing.
- The LETF has the capability to simulate virtually any type of launch vehicle and can perform unique testing for systems, components and hardware to customer specifications with complete instrumentation & data acquisition services.
- In addition, the facility also has multiple fabrication shops capable of performing rapid prototyping and precise manufacturing.



**Vehicle Motion
Simulator**



**Cryogenic
Component Testing**



**Rapid Manufacturing
/ Prototyping**



LETF Program Support

Space Shuttle

- ◆ LO2 TSM Testing
- ◆ LH2 TSM Testing
- ◆ ET Vent Testing
- ◆ GOX Vent Arm Testing
- ◆ Hold Down Post Calibration
- ◆ Load Testing of SRM Beams
- ◆ Composite Nose Cone Testing
- ◆ Orbiter Access Arm Test
- ◆ ET Vent QD Shroud Testing
- ◆ BSM Aero Heat Shield Testing
- ◆ Crawler Shoe Testing
- ◆ LOX Pump Testing
- ◆ Blast Debris Containment Device
- ◆ Payload Ground Handling Mechanism
- ◆ OAA Actuator Testing
- ◆ ETV Energy Absorber Test
- ◆ Failsafe Jackscrew Test
- ◆ Payload Transporter
- ◆ 2-inch Cryo Replenish Valve Testing
- ◆ Fluid/Valve Component Qualification
- ◆ HDP Alternate Shim Material Testing
- ◆ Special Power Supply Development for the MLP
- ◆ 17 Inch Disconnect Hydrogen Leak Dispersion Test Program
- ◆ ET Vent TO Lock Testing
- ◆ SRB Joint Heater Umbilical Testing
- ◆ Centaur Rolling Beam Testing

Space Shuttle

- ◆ Payload Ground Handling Mechanism (PGHM) Qualification Testing
- ◆ PGHM Automation Development and Testing
- ◆ Circularity Measurement Tool (CMT) Development and Testing

Space Station

- ◆ SSPF NH3 Servicer Qualification
- ◆ MPLM Cooling Servicer System Prototype Development
- ◆ MPLM Access Certification Equipment (MACE) Test Stand Fabrication and Checkout
- ◆ Rack Insertion Device (RID) Fabrication and Testing
- ◆ Cable Fabrication

LSP

- ◆ Delta IV Swing Arm Testing
- ◆ Delta IV Disconnect Testing
- ◆ Delta IV Hydrogen Entrapment Testing
- ◆ Atlas V Autocoupler Testing
- ◆ Titan H/W Proof Loading
- ◆ ELV Payload Fairing Testing
- ◆ Glory Spacecraft Payload Mockup Fabrication

Space Launch Services

- ◆ SLS Mobile Launcher 1 and 2 Umbilical Testing
- ◆ Mobile Launcher Instrumentation Support During Move to Pad B
- ◆ Mast Climber Testing
- ◆ VAB Platform Testing
- ◆ Telescoping Man-Lift Testing
- ◆ LETF Upgrades and Facility Refurb
- ◆ Weather System Fabrications
- ◆ Crawler Shoe Testing
- ◆ S-DAS Cable Fabrication
- ◆ SLS Fluid Component Testing

Miscellaneous / Commercial

- ◆ Blue Origin New Glenn Umbilical Testing
- ◆ Lockheed Martin Nose Cone Testing
- ◆ NESC Pyrotechnic Valve Testing
- ◆ NESC Stud Hang-up Testing
- ◆ Magnetically-Coupled Cryogenic Pump Testing
- ◆ APCI Linear Cryogenic Pump Testing
- ◆ TUUA Fabrication and Testing
- ◆ VSDS Testing
- ◆ FSFSU Testing
- ◆ Wire Rope Pull Testing
- ◆ Stack 5 Lifting Hardware Fabrication,
- ◆ SpaceX Compression Bridge Proof-Load



LETF Testing – Core Stage Inter-Tank Umbilical (CSITU)

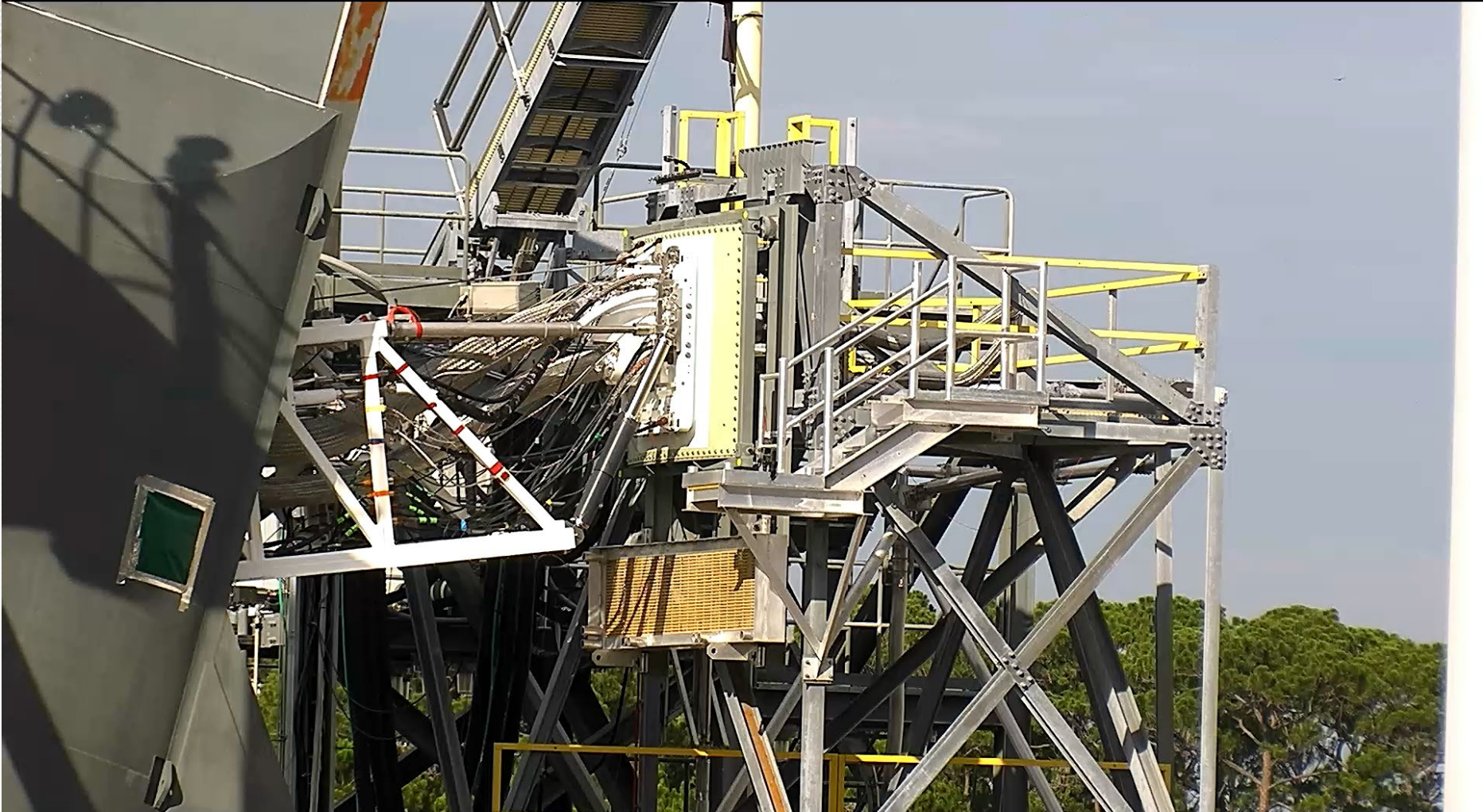
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LETF Testing – Liquid Hydrogen Tail Service Mast Umbilical (LH2 TSMU)

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LETF Testing – Interim Cryogenic Propulsion Stage Umbilical (ICPSU)





Launch Equipment Test Facility Overview

Capabilities

- Full-scale umbilical and GSE testing with vehicle motion and lift-off simulation.
- LN2 and LH2 flow to subject test articles to cryogenic temperatures and pressures that simulate launch processing conditions
- Component testing using LN2, LH2, GN2, GHe, Water, or hydraulic fluid
- Data acquisition up to 352 channels with recording speeds to 60 million samples per second
- Rapid prototype development and testing
- PLC / Controls development
- Structural testing/proof load testing of lifting hardware, slings, etc., up to 600 tons
- Instrumentation services (fixed and portable)
- Pyrotechnics testing
- Test Engineering

Development Shops & Labs

- Machine Shop
- Weld Shop
- Pneumatics Shop
- Cable Fabrication & Molding Shop
- Electrical Shop
- Data Acquisition Systems Laboratory
- LETF High Bay & Mechanical Shop

Test Fixtures

- Vehicle Motion Simulator (2 each)
- 600 Ton Proof Load Test Fixture
- Vehicle Support Post Test Fixture
- Vehicle Stabilizer Test Fixture
- Water Flow Test Loop
- Cryogenic Component Test Area
- Fluids Component Test Bench
- Launch Simulation Towers
- GSE Integration Test Bed

Support Systems

- Control Room
- Cryogenic System (LN2 & LH2)
- Pneumatics System (GN2 & GHe)
- Data Acquisition System
- Video System (high/low speed/thermal)
- Hazardous Gas Detection System
- Area Warning Light System
- Paging & Area Warning
- Operational Audio Com System
- AC Power
- DC Power

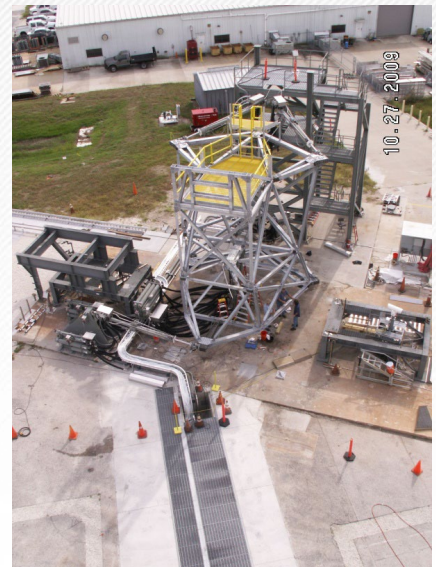


Vehicle Motion Simulators

The Vehicle Motion Simulator (VMS) simulates all the motions that a launch vehicle will experience from the time of its roll-out to the launch pad, through roughly the first $\frac{1}{2}$ second of launch. The VMS enables the development and qualification testing of umbilical systems in both pre-launch and launch environments and launch vehicle access arms in a pre-launch environment. The VMS is also used to verify operations procedures, clearances, disconnect systems performance & margins, and vehicle loads through processing flow motion excursions.

Capabilities:

- Vertical acceleration for umbilical tests are constant, net 1.2g through 48 inches
- Horizontal acceleration up to 2 Hz for small amplitudes (± 2 inches) and 0.5 Hz for amplitudes up to approximately ± 30 inches
- Angular motion will not exceed 0.2 degrees in any axis during normal umbilical tests and 5 degrees in any axis during an emergency stop
- Emergency stop, total movement of the test article in the Cartesian axes will not exceed a vector length of 6 inches beyond the test-article-specific motion boundaries.
- Umbilical loads 5,000 lbm, Access arm loads 10,000 lbm





600 Ton Load Test Fixture

The 600 Ton Test Fixture is a multi-purpose proof-loading apparatus. Test articles can be tested in either the vertical or horizontal direction. They can also be tested in either tension or compression. The versatility of the test fixture makes it possible to test a wide variety of large scale GSE components that require periodic proof-loading to remain in service including slings and lifting beams. It can also be used to test objects to failure to better understand their performance. The test fixture has a long history of providing support to the Shuttle program and other customers at KSC.

Capabilities:

- The 600 Ton Test fixture is capable of testing hardware vertically up to 23' tall, 20'-9" wide at a capacity of 600 tons (tension and compression).
- The fixture is capable of testing hardware horizontally up to 66' long, 20'-9" wide at a capacity of 400 tons (tension and compression).





Launch Simulation Towers

There are a total of four mobile launcher tower simulators in the facility that allow the structural attachment of umbilical and access arms to perform qualification testing with the Vehicle Motion Simulators.

Features:

- Personnel lighting
- Area flood lighting
- AC Power
- Fiber and Ethernet connections
- Video connections and camera mounting
- DAS Terminal Distributors
- Haz Gas connections
- Fire Detector mounting
- Cryo and pneumatics available





Facility Cryogenic System

The LETF Cryogenic System provides both LN2 and LH2 to the VMS, Simulator Towers, and to the component test area to support GSE, component, and umbilical development and qualification testing. The Cryogenic System consists of liquid Nitrogen storage, connections for tanker delivery of liquid Hydrogen, piping, valving and control devices.

- Capabilities:
- Remote operation from the LETF Control Room
- LN2 system is comprised of two (2) 15,000-gallon cryogenic dewars, a fifty gallon-per-minute centrifugal pump, and vacuum jacketed supply and return piping with recirculation capability for long duration testing greater than 24 hours
- Test area has provisions for both 2" diameter and 8" diameter pipe spool for testing multiple sizes of components
- LETF sited for 13,000 gallons of LH2 delivered by tanker



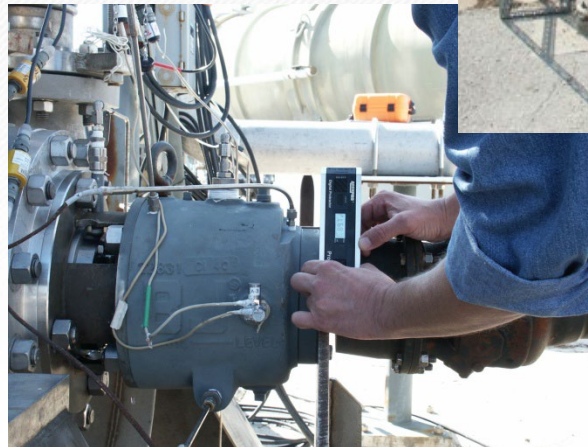
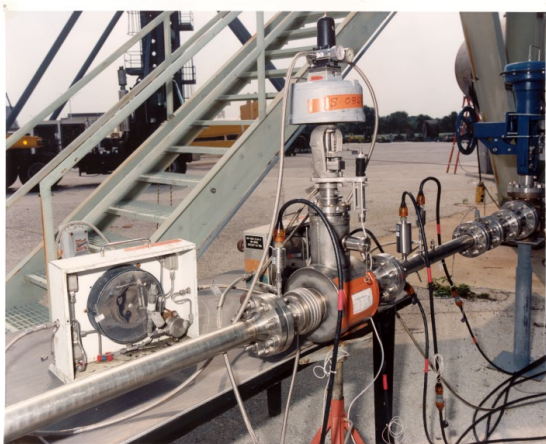


Water Flow Test Loop

The Water Flow Test Loop is used to verify performance of various fluid components including valves, pumps, and flow meters. Water Flow Test Loop is a set of closed, independently operated, concentric flow loops which are supplied from a pair of stainless-steel tanks. Each loop consists of a large main line and a smaller bypass line. The loops are supplied through a common feed line and return through a common return line. Flow is induced by means of Variable Frequency Driven pumps.

Capabilities:

- Tank Capacity: 5200 Gallons Each (Total 10,400)
- Maximum Tank Pressure: 125 psig
- Maximum Ullage Pressure: 110 psig
- Large Pump Maximum Flow Rate: 1700 GPM
- Small Pump Maximum Flow Rate: 400 GPM
- Large Pump Maximum Discharge Pressure: 300 psig
- Small Pump Maximum Discharge Pressure: 130 psig
- Large Pump Maximum RPM: 3450
- Small Pump Maximum RPM: 3350
- Currently out of service





Vehicle Stabilizer Test Fixture

The Vehicle Stabilizer Test Fixture is used to simulate swaying of a flight vehicle and sits approximately 38 feet above ground level, providing 7 inches or more of planar motion in the Y and Z axis, and creating a tangential load of 130,000 lbs and a radial load of 38,000 lbs.

This test fixture was specifically developed for the purpose of testing the stabilizer that will be used for the SLS vehicle, but modifications can be made to the fixture and drop tower to allow use by other programs.

This test fixture will be used during ML-2 Vehicle Damper System (VDS) Testing





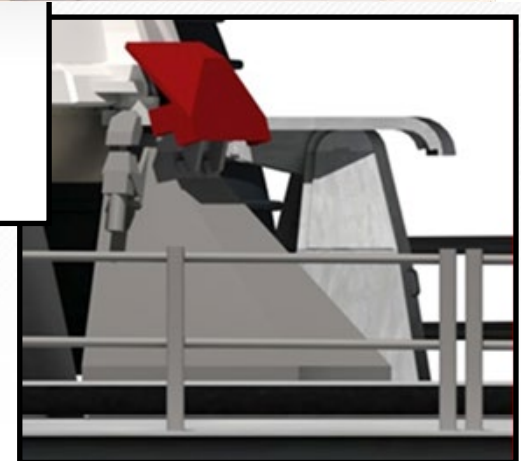
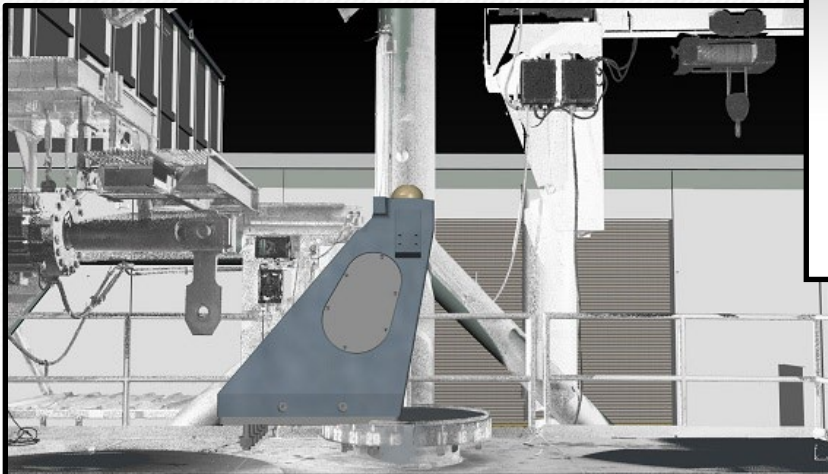
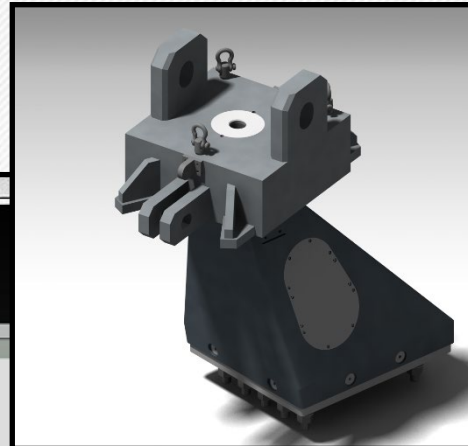
Vehicle Support Post Test Fixture

The Vehicle Support Post Test Fixture (VSPTF) is a static test structure used to simulate loading conditions on the SLS support post for calibration of its numerous strain gages.

Capabilities:

The test fixture combined loading capacities are as follows:

- Combination I - Vertical compression max load of 2000 kips while applying a horizontal tension max load of 1000 kips.
- Combination II - Vertical tension max load of 875 kips while applying a horizontal tension max load of 300 kips.
- Moment Load - Max 250 kips horizontal tension applied independently.





LETF Data Acquisition System

The Data Acquisition System (DAS) conditions, acquires, and archives transducer signals (i.e., temperature, pressure, strain, displacement, vibration) from program specific test articles and LETF test fixtures during testing efforts. Signal are routed to the Control Room via terminal distributors and PLCs located throughout the LETF and displayed and recorded utilizing National Instrument's LabView software.

Capabilities:

- 352 input channels
- 160 Channels of Signal Conditioning Amplifiers
- 240 channels of low-speed sensor channels (PXI 6133, 14 Bit, 3 MS/s max, 32M/ buffer) approximately 10 seconds of recording at full sample rate.
- 48 high-speed channels (PXI 5105, 12 Bit, 60 MS/s max, 128M/ buffer) approximately 2 seconds of recording at full sample rate.
- 64 discrete inputs (PXI 6534, 20MS/s max, 32M/ buffer) approximately 2 seconds of recording at full sample rate.
- Supports inputs from: low level bridge type (delta R), low level voltage (delta V), low level current (delta I), and ICP Pressure/Accelerometer/Force sensors.
- Software programmable gain (max 10K), excitation (0-15 & 28 VDC), filter (8 steps from 10HZ to wideband), cal steps (4 total), bridge balance, etc
- 100KHz bandwidth (at gains up to 1000)
- Constant voltage & current excitation
- Cable plant consisting of 604 cables (expandable to 944)





Mobile Instrumentation and Data Acquisition System



The Mobile Instrumentation and Data Acquisition System (MIDAS) trailer is a self-contained control room with an independent data acquisition system, similar to the LETF Control Room DAS. This trailer can easily be moved to virtually any location to be used to monitor and record measurement data.

Capabilities:

- Maximum of 96 channels
- 60 low level (Signal Conditioned) inputs and 36 direct inputs
- Sample rates from 1 to 3 Mega Samples/second simultaneous
- National Instruments PXI based Data Acquisition System
- Operates off facility power or generator power



LETF Control Room



The Control Room is the hub of the LETF. Virtually all systems are operated, monitored, or recorded from this command center. Integrated testing operations are executed from the Control Room led by an LETF Test Conductor and supported by engineers and technicians at various control consoles.

Features:

- Video System
- Data Acquisition System
- Hazardous Gas Detection System
- VMS controls
- Cryogenic System controls
- Test Team Communication System (OIS-D)
- GPS Timing
- Area Warning Light System controls
- Configurable system control consoles
- Large configurable video display



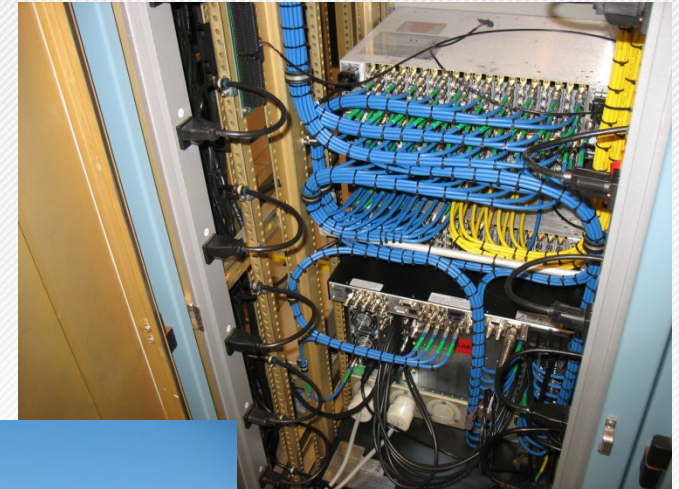


LETF Video System

The LETF Video System provides remote controlled surveillance and monitoring of test operations at various locations throughout the LETF. The system is compatible with current NASA and KSC digital video standards and systems. A multi-image display system allows simultaneous display of all video images on two large screens in the LETF Control Room. Video can also be displayed on all Control Room console monitors.

Capabilities:

- Remote operation from the LETF Control Room
- System can record and archive test images
- Multiple High Definition fixed and portable cameras
- Phantom High Speed cameras (100K frames per second)





Hazard and Gas Detection System

The LETF Hazard and Gas Detection System is comprised of two subsystems, the Hydrogen Fire Detection Subsystem (HFDS) and the Ground Hydrogen Leak Detection Subsystem (GHLDS). Both subsystems are mandatory for LH2 flow. Sensors are strategically located throughout the testing area to provide hydrogen fire and leak detection during hydrogen testing. These systems are mod common with those being developed for use at KSC launch pads and mobile launchers. This allows for system testing and troubleshooting to be performed at the LETF prior to implementation or changes to other KSC systems.

- Capabilities:
- Remote operation from the LETF Control Room
- 6 fire detectors with relocation/reorientation capability
- Fire detectors have +/- 45 degree field-of-view with a 100-foot radius arch
- 9 leak detectors are mobile and can be relocated for each test depending on identified possible leak areas





Instrumentation & Data Acquisition System Laboratory

The LETF Data Acquisition Systems (DAS) Laboratory is located in rooms 1307 and 1313 of building M7-505. This lab is utilized to develop, install, and maintain measurements and associated data acquisition systems required to record data for testing at the LETF. DAS Lab personnel are responsible for maintenance of the LETF Control Room, the LETF cable plant, LETF portable data acquisition systems (PDAS), and measurement and equipment calibrations. The lab is also utilized for electronic circuitry development and computer support.

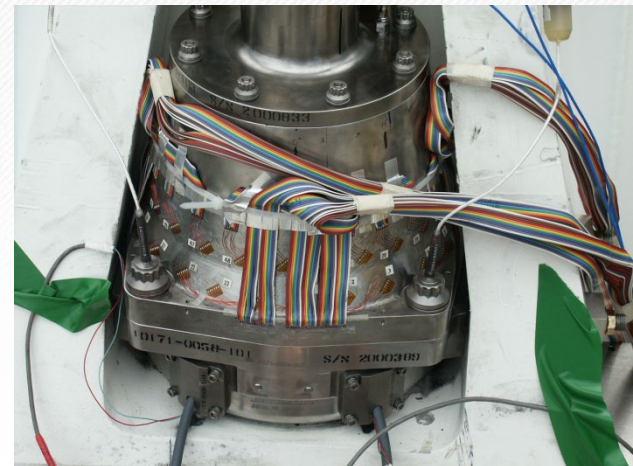
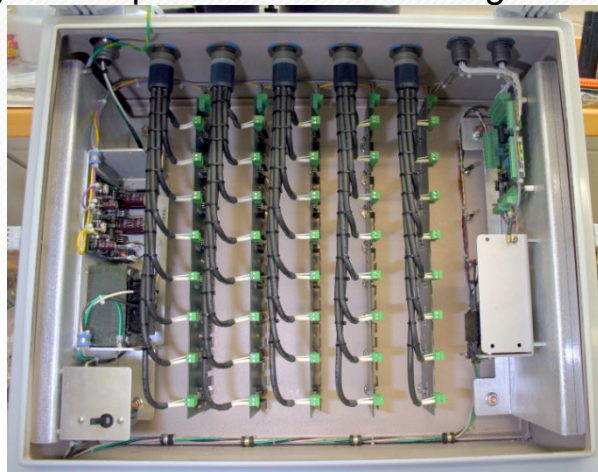
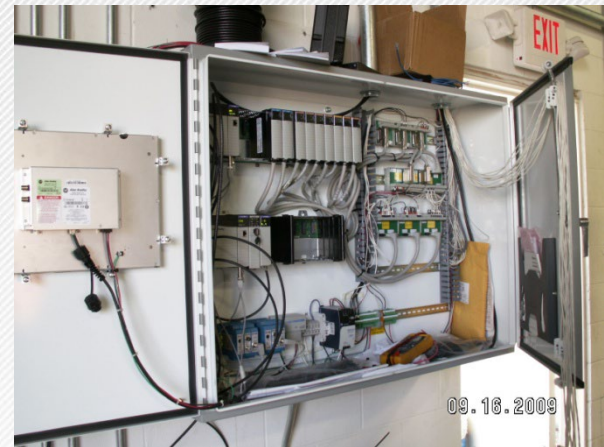
Capabilities:

Complete instrumentation facilities, including:

- Surface mount soldering
- Regular through-hole soldering
- Electric prototyping
- National Institute of Standards (NIST) traceable instrumentation
- Shop air and vacuum available

Selection & assembly of computers for the following:

- Testing
- Development
- Support





Ground Support Equipment Integration Testbed (GSEITB)

The GSE Integration Testbed provides a fiber optic ControlNet and Ethernet communication path between the EDL and LETF to perform end-to-end testing of Command-and-Control software. The GSE Integration Testbed can interface with virtually any size GSE component or end item to allow for software/hardware qualification testing. The GSE Integration Testbed can also simulate hardware to allow for software testing.

Capabilities:

- Provide GSE end item emulation/simulation for up to 300 inputs/outputs
- Provide data logging and analysis of test results
- Utilizes LabView software to simulate components and provide high speed data acquisition
- Performs LETF equipment simulations for training test conductors, test teams, and system operators



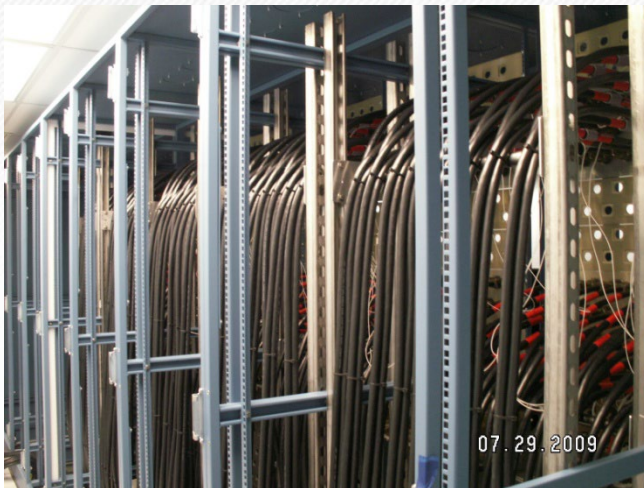


Cable Fabrication and Mold Shop

The LETF Cable Fabrication and Molding Shop is located in the Northeast corner of building M7-505. This shop is utilized to fabricate KSC and Military specified electrical and instrumentation cables for the LETF, KSC, other NASA and Government facilities, and for commercial industry.

Capabilities:

- 7-Ovens for Potting & Molding
- Fabrication of all types & grade of cables
- Installation of Crimps
- Soldering
- Installation of harnesses
- Fabrication from fiber optic to power cables
- Multiple 100psi compressed air drops throughout cable shop



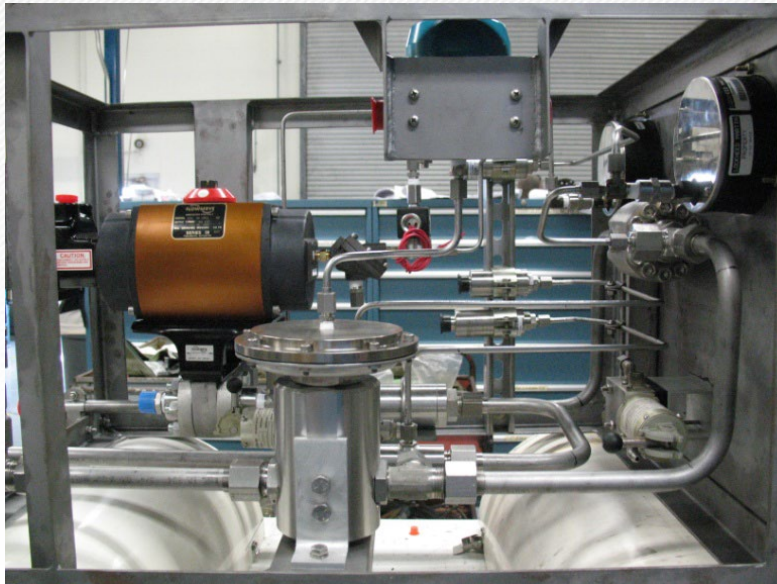


Pneumatics Shop

The LETF Pneumatics Shop is located in room 1140 of building M7-505. This area is utilized to fabricate, install and maintain pneumatic and hydraulic systems for the LETF, KSC and other Government facilities. The lab personnel also fabricate, install and maintain gas pressure control panels, calibrate pressure gages and hydrostat high pressure lines and systems.

Capabilities:

- Automated valve qualification testing (relief, check and shut off valves up to 6") utilizing the Fluids Component Test Bench
- Calibration of hydraulic and pneumatic systems up to 10,000 psig
- Tubing and flex hose fabrication to KSC specifications
- 1/4" – 2" tube flaring
- The ability to rebuild valves & cryogenic systems
- Hydrostat systems up to 10,000 psi



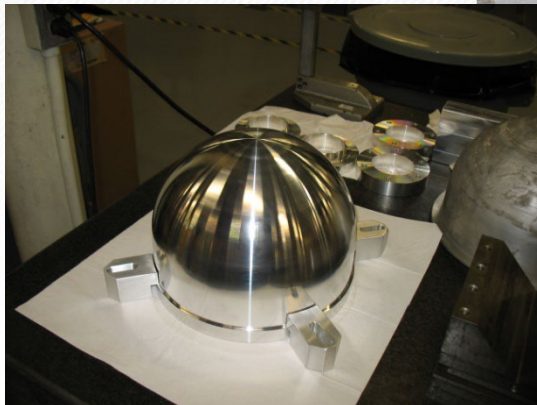


Machine and Weld Shop

LETF capabilities include complete machining and fabrication facilities, including computer numerically controlled (CNC) vertical mills, lathes and 5-axis wire EDM, tube bending, flaring and orbital welding up to 2" diameter. Welding capabilities include sheet metal, structural and piping, most materials and processes. The shop can take CAD files and generate tool profiles allowing rapid prototyping.

Capabilities:

- Computer numerically controlled (CNC) vertical mills
- Lathes
- 5-axis wire Electrical Discharge Machining (EDM)
- Punch Press
- 3 Axis Mills
- Plasma Cutter
- Orbital welding up to 2" diameter
- Tig and Mig welding
- Aluminum welding
- Sheet metal welding
- Structural and piping welding
- Pipe fitting





LETF High Bay

Description:

The LETF High bay is a general-purpose test and development area located on the southeast corner of building M7-505. The High bay is also utilized to assemble and stage GSE equipment to be tested in the LETF. The High bay has been partitioned off into 8 work foot-prints. The High bay is outfitted with an overhead crane, multiple access doors, multiple AC power availability, and shop air and storage areas. The High bay is also an environmentally controlled area.

Capabilities:

- 100ft x 60ft x 40ft (6000 sq ft of floor space)
- 20-ton overhead bridge crane (41'-11" span)
- East and West Main doors - 40 ft high X 30 ft wide
- South roll-up door 16 ft x 18 ft
- Footprints 1-4 offer standard single phase 115v AC 20amp power source along with filtered and regulated shop air.
- Footprints 6-8 offer 3phase 208 and 480v AC disconnects serviceable to 100Amp service in addition to single phase 115Vac 20amp power receptacles and shop air.
- 2 Mezzanine's approximately 400sq ft each.
(Storage capabilities 250 lbs/sq ft)





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