SAND2015-9852PE

Exceptional service in the national interest

Sandia National Laboratories

Major Environmental Testing Facilities and Capabilities

Validation and Qualification Sciences Experimental Complex

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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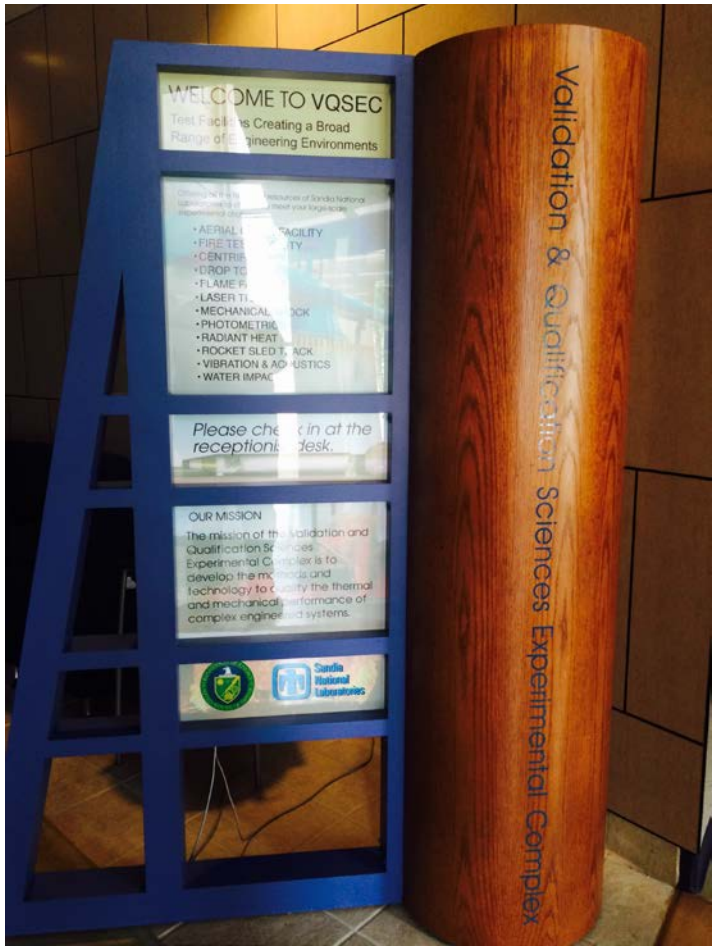
Major Environmental Test Facilities…

Validation & Qualification Sciences Experimental Complex

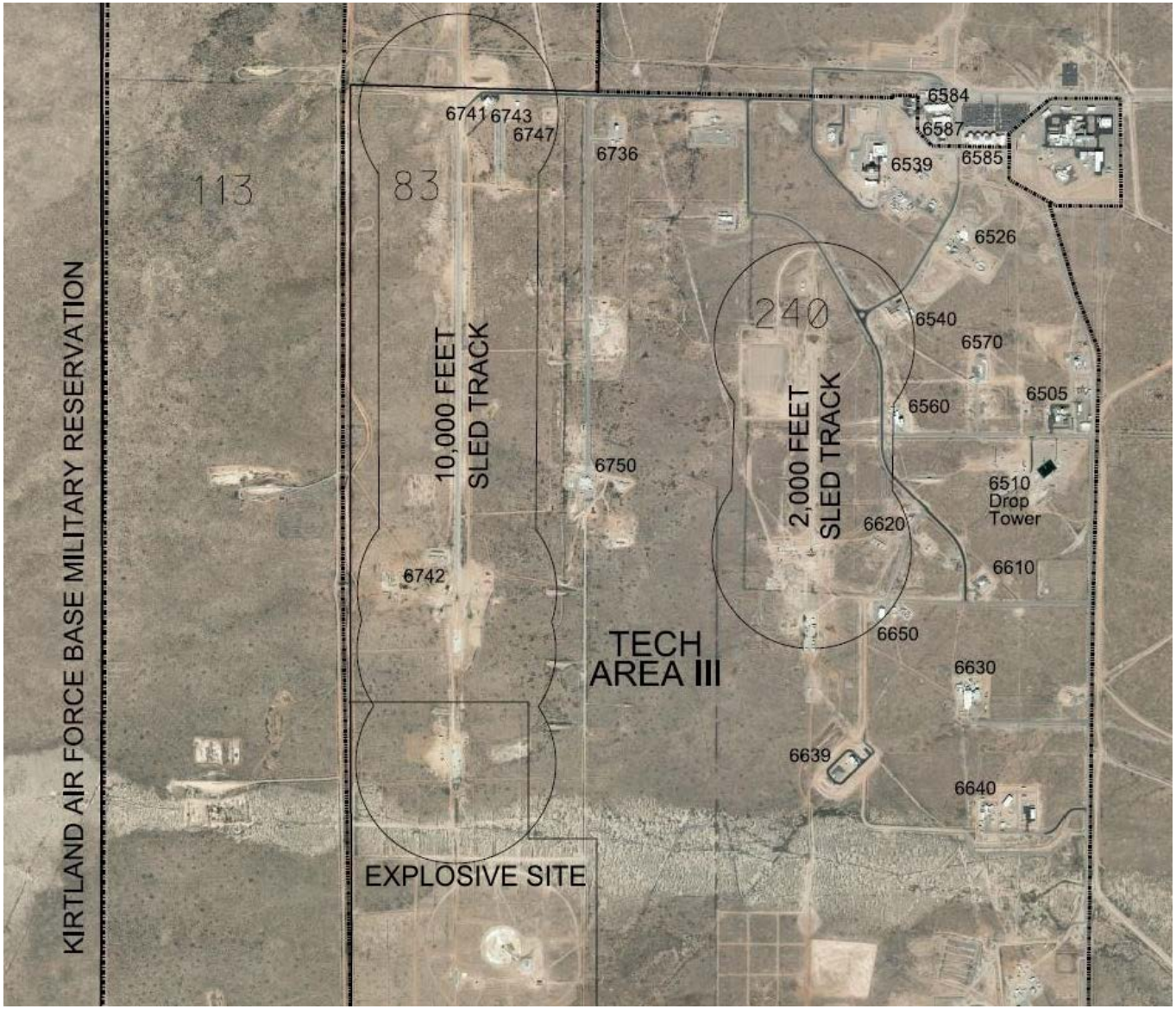
Large-scale thermal and mechanical test facilities are located in Technical Area III and Coyote Canyon

Validation & Qualification Sciences Experimental Complex (VQSEC)



- **The mission of the Validation and Qualification Sciences Experimental Complex is to develop the methods and technology to qualify the thermal and mechanical performance of complex engineered systems.**

Tech Area III Facilities



- 6584: Offices
- 6510: Water Impact Facility & Drop Tower
- 6526: Centrifuge Complex
- 6539: Thermal Test Complex
- 6560: Vibration & Acoustics
- 6570: Mechanical Shock & Gas Gun
- 6610: Vibration

Large Scale Thermal Environments

- **TAIII Thermal Test Complex**
  - **Radiant Heat Test Facility**
  - **FLAME Facility**
  - **Crosswind Test Facility (XTF)**

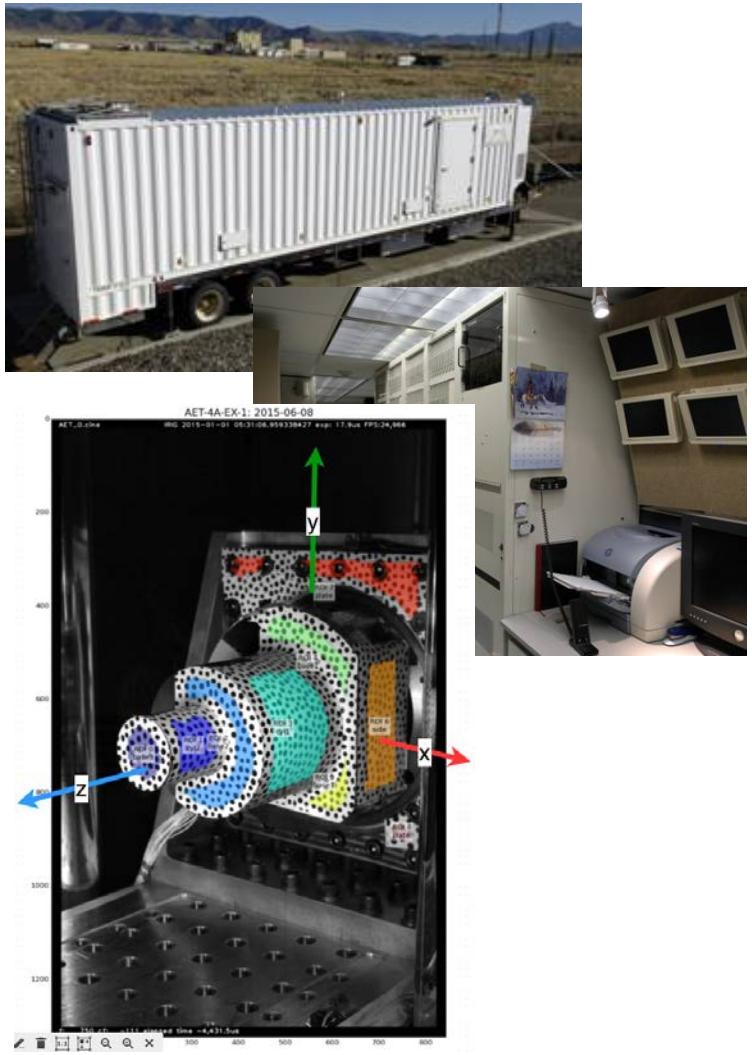
- **Lurance Canyon Burn Site**

Large Scale Mechanical Test Facilities

- **Sandia Tech Area III:**
  - Rocket Sled Track Complex
    - 2,000 ft & 10,000 ft sled tracks, Impact Target, Shock Tube, Rocket Rail
    - Explosive Test sites
  - Centrifuge Complex
    - 29 ft & 35 ft
  - Mechanical Shock Facility
    - 20” Linear Actuator, 6” Gas Gun
  - Water Impact/Drop Tower Facility
    - 300’ and 185’ towers, 80’ deep pool
  - Vibration
  - Mass Properties
  - Non-Destructive Test/Radiography
  - Light Initiated High Explosive
- **Sol se Mete Canyon**
  - Aerial Cable Facility
    - Four 5000 ‘ x 1000’ cables, Impact Target, Rocket Rail

Measurement Sciences & Engineering

- Component and system level measurement capabilities
- Mechanical, thermal, spatial and spectral information
- Specializing in high speed and destructive events
- Measurement uncertainty
- Explosive event projectile tracking
- Fireball/plume evolution
- Time synced data products
- We work closely with modelers to provide useful and actionable data products



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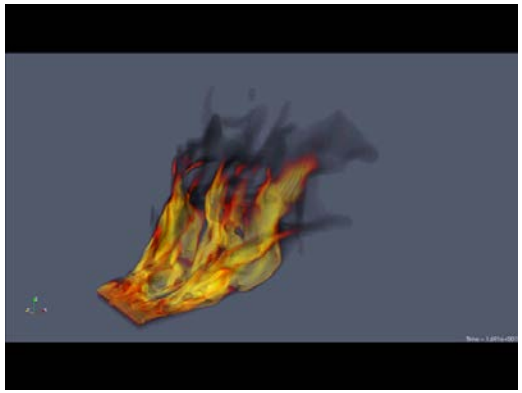
FIRE SCIENCE AND ENGINEERING

THERMAL TEST COMPLEX
LURANCE CANYON BURNSITE

Fire Science and Engineering Competencies

- **Advanced Computing, Fire modeling and CFD**
  - **Fuego, Fluent, FDS codes**
  - **Pretest fire simulations and DoE**
- **Large-scale fire and thermal environments design and test**
- **Thermal test diagnostics and control systems**
  - **Temperature profiles**
  - **Heat Flux, emissivity**
  - **Photometrics**
  - **Integrated control (Process Equipment Control System)**
  - **Particle Image Velocimetry, Coherent Anti-stokes Raman Scattering, IR spectroscopy, CARS, Laser-Induced Incandescence**

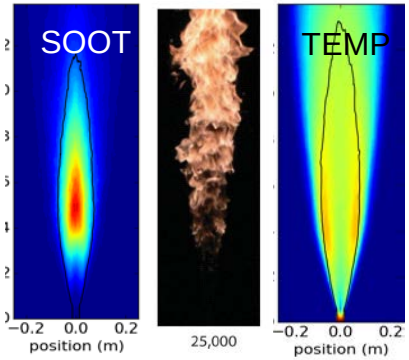


Fire/Thermal Experimental Thrusts

- **Thermal Qualification and Model Validation of Nuclear Weapon Systems, Subsystems, and Components**
- **Thermal/Mechanical Failure**
  - **Pressurization and breach**
- **Organic Material Decomposition**
- **Carbon Composite Fire**
- **Rocket Propellant Fires (metal particle combustion)**
- **Fire Dynamics and Jet Flame turbulence/soot model development and validation**
- **LNG, LPG, crude oil dispersion and fire**

Propellant Fire

Phoenix Series
LNG fire on water



Data sets for soot –turbulence models and model validation

Composite Fire Test

Thermal-mechanical failure of a unit at Temp and Pressure

Experimental Fire Science Capability: Thermal Test Complex

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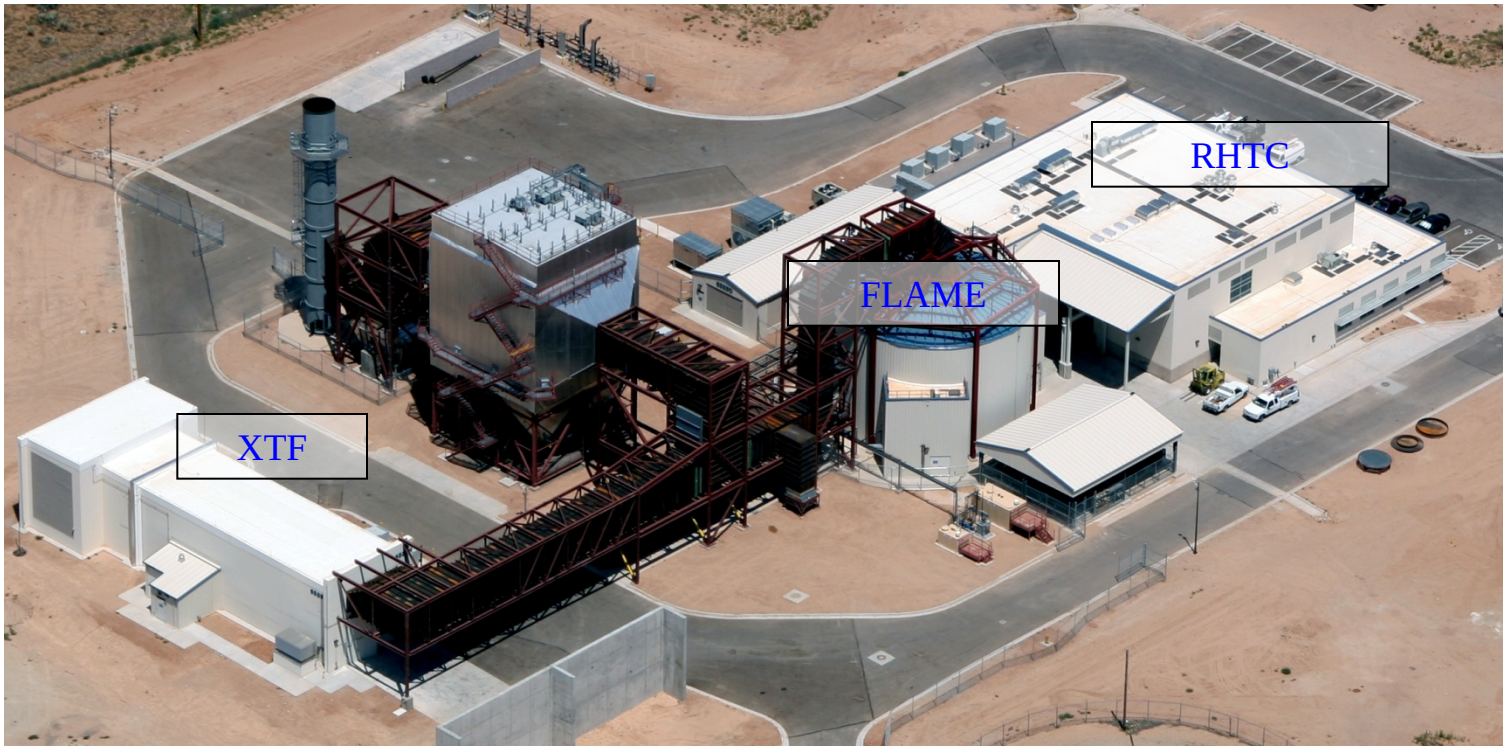
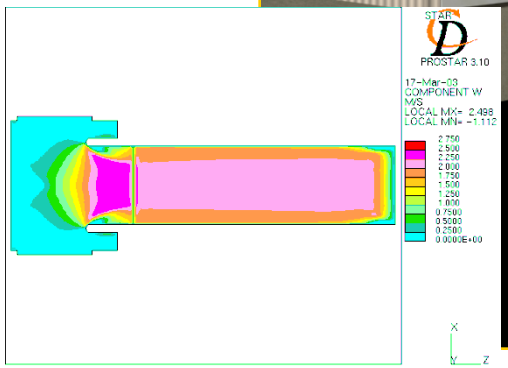
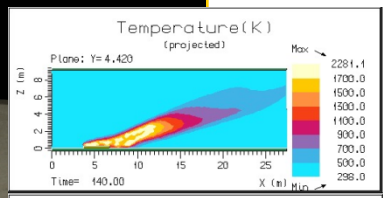


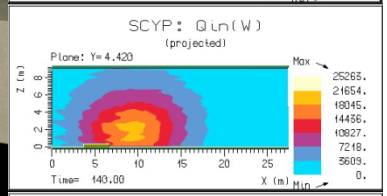
- XTF – Horizontal Wind Tunnel for Fires in Cross Wind
- FLAME – Vertical Wind Tunnel for Fires in Calm Conditions
- RHTC – Full Scale Radiant Heat (Fire Loading Simulator) Lab
- Lurance Canyon Burnsite – Outdoor Facility for Large-Scale Fire Tests

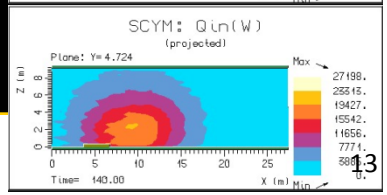
XTF – Crosswind Test Facility

Designed with
Computational Fluid Dynamics



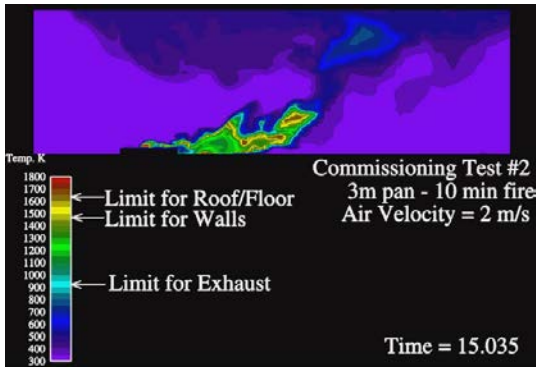






XTF Capabilities -- up to 20 MW Fire in a 8 m/s Cross Wind

- Test Cell Dimensions
  - 7.6 m x 7.6 m by 25 m long
- Fuel Sources
  - Liquid
    - JP-8 – 10 ft dia. (20 MW)
  - Gas source easily added
- Heat Sources
  - Radiant Heat Panels
    - 2.88 MW
- Air Sources
  - Full Cross Section
    - 8 ft/sec (2.4 m/s)
  - Limited Cross Section (~1/4)
    - 34 ft/sec (10 m/s)
- Explosives
  - <106 lbs (damage/no-injury)



- Pretest Simulations

FLAME – Fire Laboratory for Accreditation of Models and Experiments

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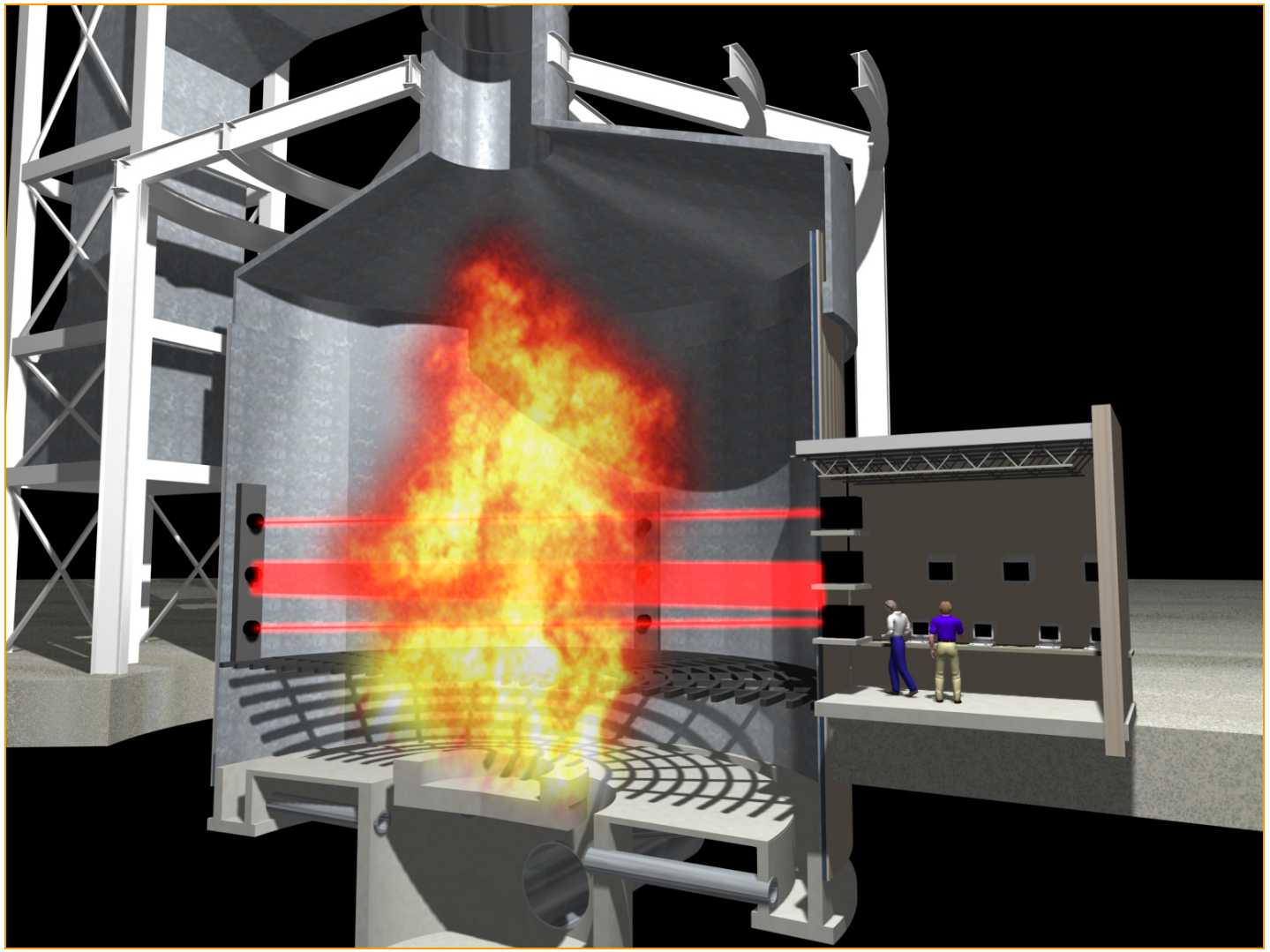
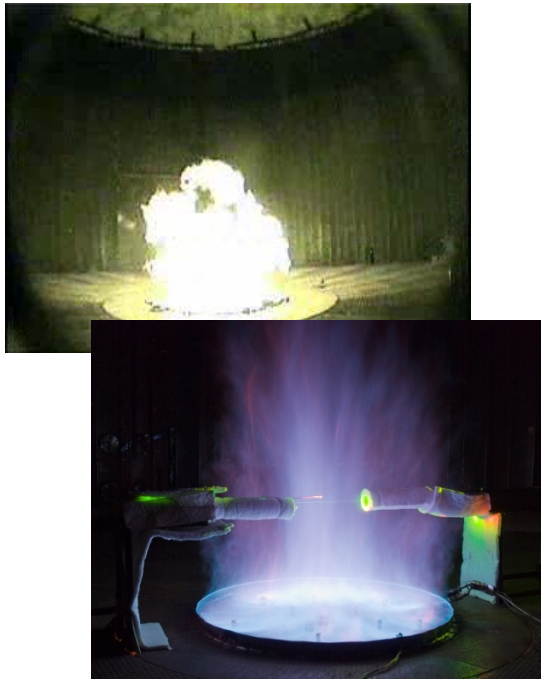
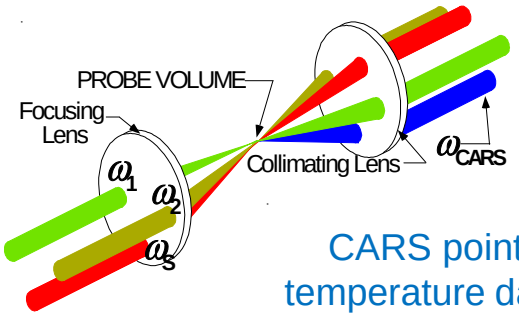


FLAME Capabilities – Fires in calm (no wind) environment

- **Test Cell Dimensions**
  - **18.3 m dia. x 12.2 m high**
- **Fuel Sources**
  - **Liquid**
    - **JP-8/Ethanol**
    - **3 m dia. (20 MW)**
  - **Gas**
    - **$CH_4/H_2/N_2$**
    - **3 m dia. (20 MW)**
- **Heat Sources**
  - **Radiant Heat Panels**
    - **5.2 MW**
- **Air Sources**
  - **Push/Pull Fan Arrangement**
    - **150,000 cfm**
    - **Annular/Central flow**
- **Walls**
  - **Water Cooled (infinite boundary layer)**





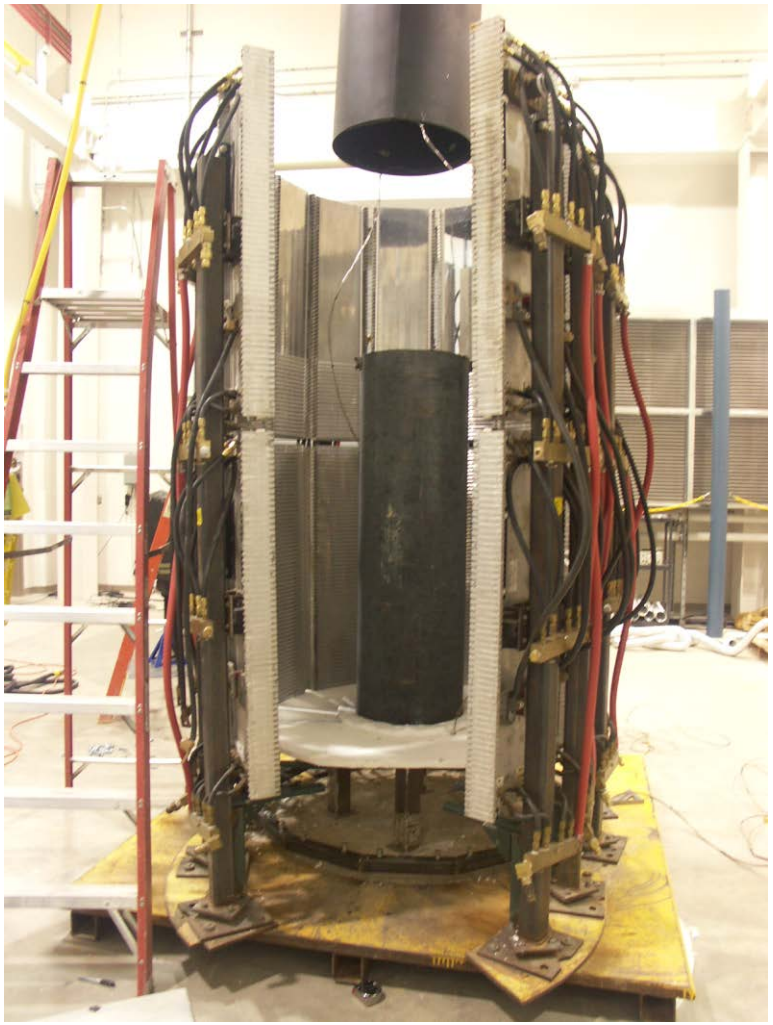
CARS point temperature data

- Simulation capability exists for design of experiments
- Optics-based diagnostic capability includes
  - Particle Image Velocimetry
  - Coherent Anti-stokes Raman Scattering CARS (temperature)
  - IR spectroscopy
  - Laser Induced Incandescence (soot)

RHTC – Radiant Heat Test Cell

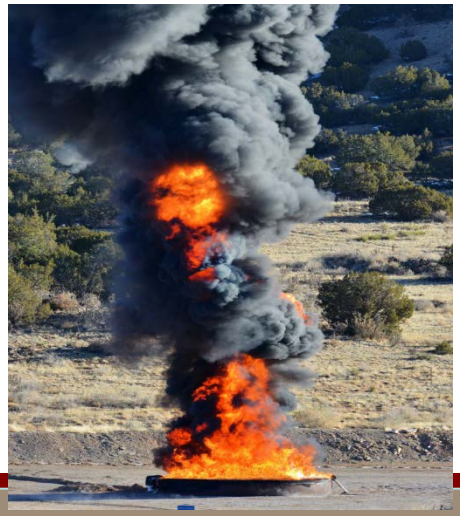
(Fire simulation)

- **Test Cell Dimensions**
  - **12.2 m x 12.2 m x 7.6 m high**
- **Heat Source**
  - **Radiant Heat Panels**
    - **5.2 MW**
    - **Feedback controlled heat fluxes up to 500 kW/m^2.**
    - **Spatial and time variations in flux delivered to an object are programmable.**
- **Hoods for Exhaust**



Lurance Canyon Burnsite

- Old-FLAME
  - Indoor facility for small-scale controlled burns
  - 6m x 6m with forced draft ventilation
  - Propellant and liquid hydrocarbon fuels
- Above ground pools
  - Intermediate- and large-scale liquid hydrocarbon fuel fire
  - Crib fires
  - 3m and 8m diameter
- Below ground pool
  - 10m x 30m
- Igloo/bunker
  - Simulated weapon storage environment



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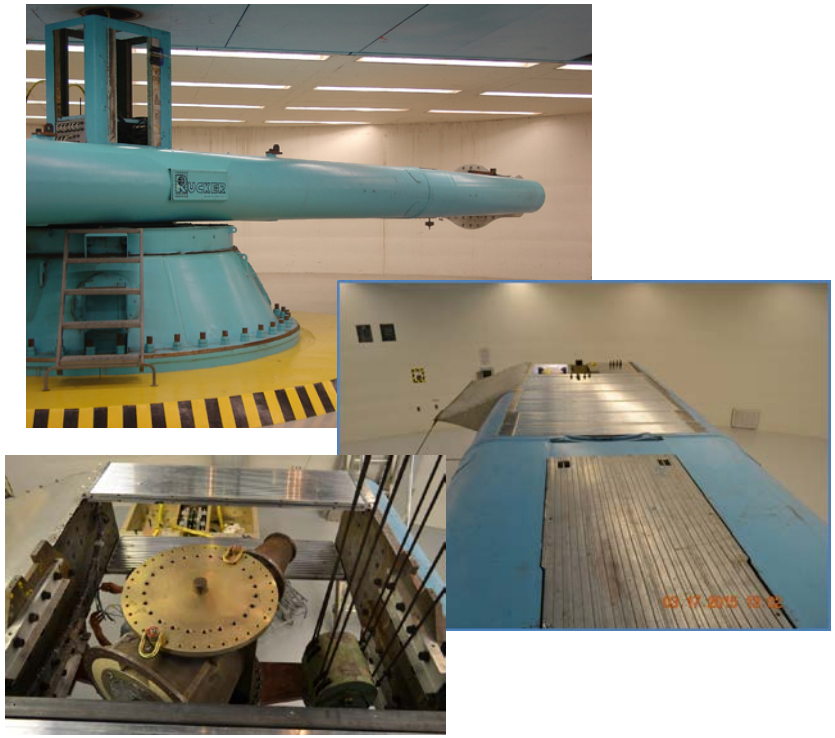
Superfuge Complex

29-Foot Indoor Superfuge

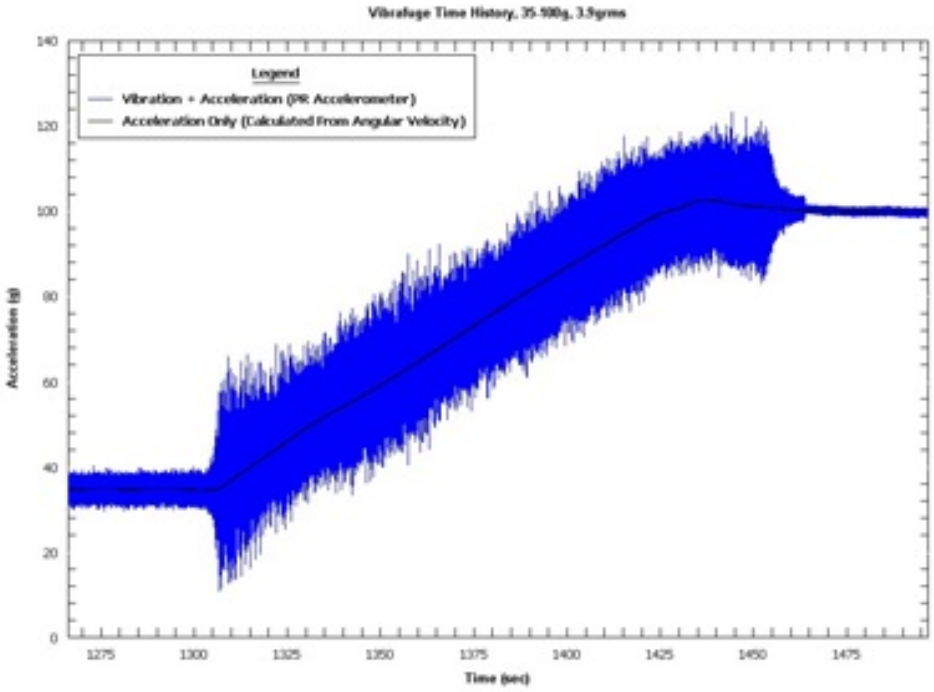
- **Provides a temperature controlled environment for acceleration testing.**
- **USE: Reentry vehicles; weapon components**
- **"Superfuge": centrifuge acceleration + vibration + secondary axis spin.**

Max Dimension	**73" W x 96" L x 120" H**
Specimen Weight, max	16000 lb @ 100g, 5333 lb @ 300g
Specimen Radius of rotation	From 21-35 ft
Time to full speed	6-10 minutes
Acceleration Range	0.1 – 300g
Dynamic load capacity	1600000 g-lb



Vibrafuge Technology

- **Purpose: Apply vibration and acceleration simultaneously during single centrifuge test.**
  - **More realistic flight environments**
  - **50lb Payload, 120g, 15grms***
  - **400lb Payload, 100g, 12grms***
- **Readiness state: Operational but not yet turnkey. Most applications require custom hardware design & fabrication.**
- **US Patent No. 8408066**
  - **issued 04/02/2013**



*grms is an average acceleration magnitude achieved during vibration testing. g = acceleration; rms = root mean square

35-Foot Outdoor Centrifuge

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- **Primarily used for hazardous tests**
  - **Test items include Explosives, oversized items, impact released items, Rocket motors for ignition testing.**
- **Rarely used – long lead time to ensure readiness.**

Specimen Dimensions, max	**73” W x 96” L x 120” H**
Specimen Weight, max	10000 lb @ 45g, 1875 lb @ 240g, …
Specimen Radius of rotation	From 27-45 ft
Time to full speed	5-10 minutes
Acceleration Range	0.1 – 245g
Dynamic load capacity	450000 g-lb

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MECHANICAL SHOCK COMPLEX: 20” ACTUATOR AND 6” GAS GUN

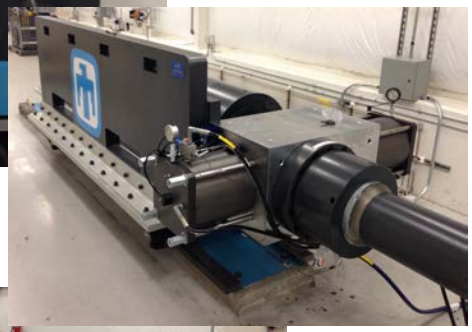
20” Linear Actuator

- **Purpose: Provide high levels of mechanical shock to components**
  - **Shock Impulse**
  - **Crush Tests**
- **Max Acceleration: 10,000 g***
- **Max Velocity Change: ~285 ft/s**
- **Max Fire Pressure: 6,000 psi**
- **Sled Weight: 1000 lbs**
- **Max Load Weight: 20,000 lbs***
- **Provides 10,000G’s for 1.25 milliseconds*.**
- **Track Length: 120 ft.**

***Note: These maxima cannot be applied simultaneously and they depend largely on supporting hardware and not just on the actuator energy**

6” Gas Gun

- **Technical Specifications:**
  - Total Weight: ~ 10,000 lbf (floor mounted permanently in Bldg 6570)
  - Bore diameter: 6”
  - Speed: 100 lbf projectile 1,000 ft/s*
  - Pressurized with Nitrogen gas up to 5,000 psi
  - Projectiles up to 6 feet in length
  - Variable volume fire chamber (500 in^3 - 13,500 in^3)
  - Barrel sections 20 feet long each (4 available barrel sections)
- **Intended Uses:**
  - Shock, penetration, or fragmentation tests
  - Open muzzle, closed muzzle (1 or 2 projectiles)
  - Open muzzle = 60 ft barrel, contained muzzle = 80 ft barrel
  - Free-flight between muzzle and target allows for full real-time and high-speed video coverage of entire test event



* Velocity to be validated during initial open muzzle testing

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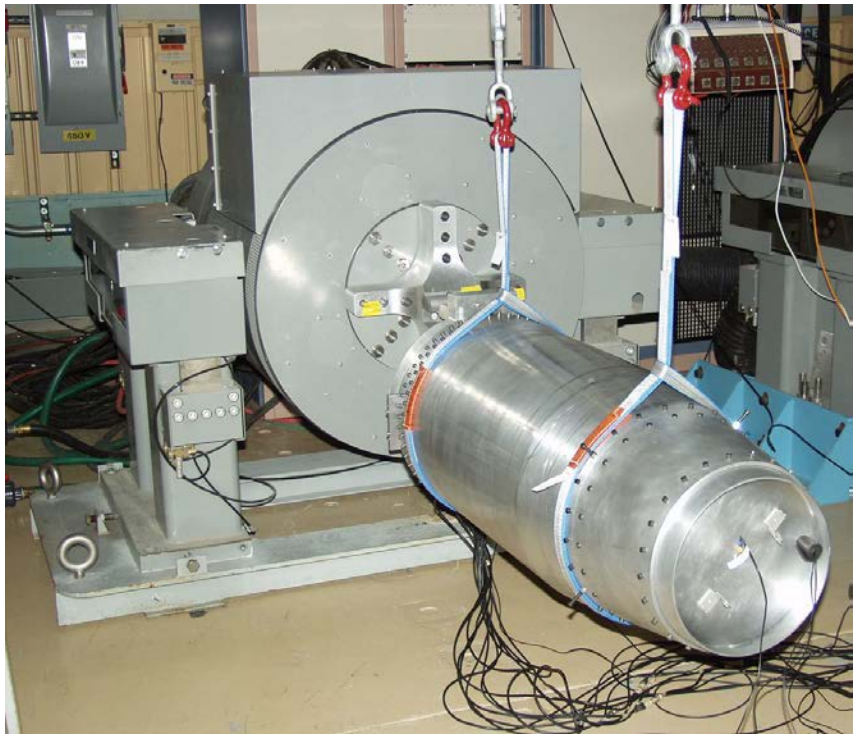
VIBRO-ACOUSTICS

6560 Vibration Laboratory T-4000 Shaker

Electrodynamic Shaker (Unholtz DIckie T4000)	
Force Limit	+40,000 lbs
Velocity Limit	95 in/sec
Displacement Limit	+/- 1.5 in
Slip Table Size	4’ x 6’
Vertical Expander Head Size	4’ x 5’
Power Amplifier	480 kVA
Frequency Range	10 - 2kHz (max force) 3 - 7kHz (operational limits)
Two 6 ton bridge cranes	
Hook height to top of vertical shaker	17’ 5”
Hook height to top of slip table	19’ 6”

6560 Vibration Laboratory T-1000 Shaker

Electrodynamic Shakers (Both Unholtz Dickie T1000)	
Force Limit	+12,000 lbs
Velocity Limit	70 in/sec
Displacement Limit	+/- 0.5 in
Slip Table Size	3’ x 3’
Vertical Expander Head Size	3’ Diameter
Power Amplifiers	100 kVA
Frequency Range	10 - 2kHz (max force) 3 - 7kHz (operational limits)
Two 6 ton bridge cranes	
Shakers can be run in a MIMO configuration if needed	



6560 Vibration Laboratory
6-DOF Vibration Test System

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Features:

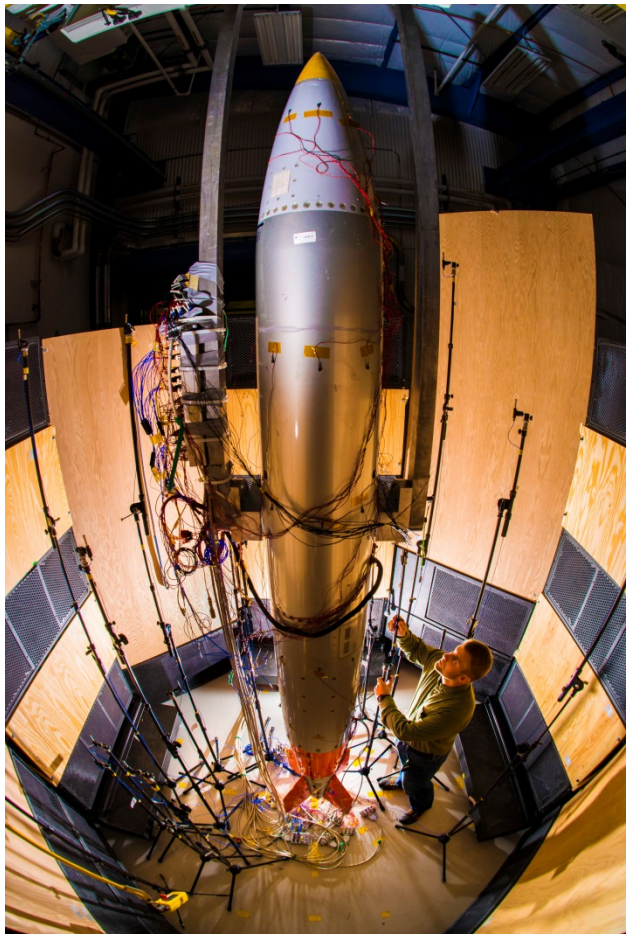
- Simultaneous or sequential excitation of X, Y, and/or Z axes
- Complete control of rotations around all axes
- Bandwidth from 10 to 2 kHz
- 30” square vibration table

Applications:

- Accurate replication of true, real-world vibration environments in 6DoF
- Model Validation
- Rapid screening of electrical components and modules
- **Addresses new multi-axis testing protocol in MIL STD 810(G)**

6560 Vibration Laboratory Acoustic Chamber

- Use loudspeakers, microphones, and closed-loop control system to generate desired acoustic fields.
- Acoustic testing desired for systems with acoustic loading as primary excitation in the field.
  - Multi-Input Multi-Output Control System: provides coherent, incoherent, or shaped acoustic fields.
  - Speakers: twelve VT-99 speaker cabinets (low-mid-high frequencies), six VS-Q subs (low-frequency), and six control circuits.
  - Reverberation chamber: 16,000 ft^3
  - Direct-field testing performed in high-bay.
  - 25Hz-10kHz, 146.7 dB OASPL*



Direct-field Acoustic Test

*Overall Sound Pressure Level

6610 Vibration Laboratory

- Remote Testing of Explosive Test Items (5 lbs local, 110 lbs remote)
- Combined Temperature and Vibration Testing
  - -165F to 250F
- Off-hours storage of classified materials
  - Facility classified as a Closed Area (VTR)

6610 Vibration Laboratory

Electrodynamic Shakers (2ea UD T4000)	
Force Limit	+40,000 lbs
Velocity Limit	90 in/sec
Displacement Limit	
T4000 #1 T4000 #2	+/- 1.0 in +/- 1.5 in
Slip Table Size (Split Table Design)	4’ x 8’ or 4’ x 4’
Vertical Expander Head Size	4’ x 5’
Power Amplifier	480 kVA
Frequency Range	10 - 2kHz (max force) 3 - 7kHz (operational limits)
Two 3 ton bridge cranes	
Hook height to top of vertical shaker	11’ 9”
Hook height to top of slip table	12’ 8”

Sandia National Laboratories

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WATER IMPACT & DROP TOWER COMPLEX

Drop Tower Facility

- **Vertical Guide System Drop Tests:**
  - **Shipping container certification, Simulated transportation accidents, Weapon ejection, and Moderate gravity velocity impact**
- **185 Foot Drop Tower**
  - **Guided Trolley for Vertical Drop Testing**
    - **Test unit weight limited to 2,500 lbs**
    - **30,000 lb steel or concrete target**
  - **Main Cable Trolley Vertical and Angled Drop Testing**
    - **Test unit weight limited to 12,000 lbs**
    - **Available Impact targets:**
      - **Dirt, concrete and steel**

Water Impact Facility

- **Purpose: Water Impact Testing**
- **300-foot drop tower**
  - **120-ft (W) x 188-ft (L) x 50-ft (Deep) pool**
  - **Total depth of 80 feet for underwater testing is provided via a 6-foot-diameter, 30-foot-long pipe at the bottom of the pool.**
  - **Objects weighing up to 3,000 pounds can be subjected to free-fall drops or other type of assisted energetic (rocket motors) pulldowns.**

- **Points of Contact:**
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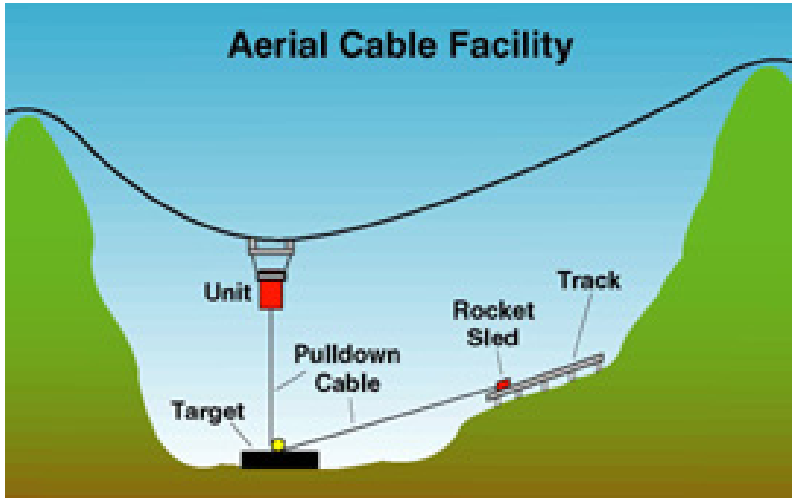
AERIAL CABLE FACILITY

Drop and Pull-down Testing

- **Purpose:**
  - Impact testing can include guided drops, rocket-assisted pull downs, or free falls to simulate high altitude drops at impact velocity.
  - The cable system facilitates pull down and drop tests with impacts on a level test bed located in the canyon bottom.
- **Technical Specifications:**
  - The facility can conduct rocket-assisted impact tests with impact speeds up to 1,000 feet per second.
  - Target impact angles of 30 to 90 degrees can be achieved and the angle of attack can be tightly controlled and measured.



Drop and Pull down Testing

- **Items as heavy as 67,000 pounds can be lifted and dropped from about 100 feet, while smaller items can be raised to almost 700 feet. The facility can perform impact testing that offers:**
  - **High or low velocity**
  - **Guided drop testing**
  - **Hard or soft targets**
  - **Penetration events**

Rocket Rail Testing

- **Purpose: Rocket rail testing is primarily used to determine terminal dynamics of test articles/units.**
- **A second rocket rail is located at the South end of the 10K sled track in Area III.**
- **The rocket rail is constructed from a steel wide flange structural I-beam approximately 60 feet long which is connected to a four leg trunnion at one end.**

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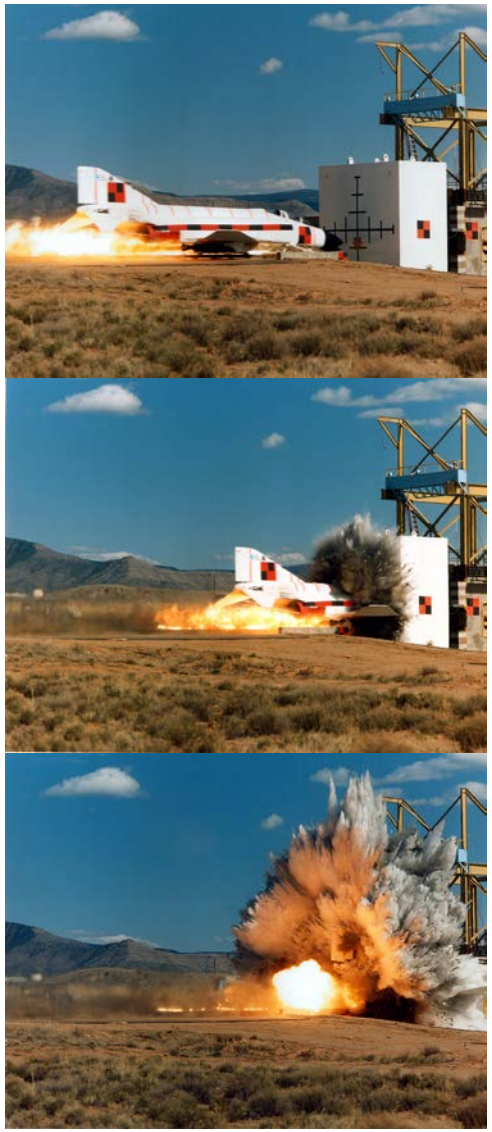
ROCKET SLED TRACK FACILITY

2,000 and 10,000 Foot Sled Track

- **Intended Usage:**
  - Reverse ballistic tests, high speed impact testing, parachute tests, free flight rocket motor testing, acceleration testing, liquid dispersion upon impact, and aerodynamics testing.
  - Some explosive targets
- **2000 foot:**
  - Wide gauge track typically used for heavy test articles at slower speeds.
  - 'Rigid' target
- **10,000 foot**
  - Narrow gauge track typically used for lighter payloads at higher speeds.



Shock Tube

- **Usage/Simulation**
  - Head-on & Side-on Pressures
  - Planar Shock Fronts
  - Pressure, Temperature and Velocity
  - Blast Overpressure for Re-Entry Vehicles
  - Model Validation

- **Specifications**
  - This full-scale hostile blast testing involves six to twelve foot diameter tubes located near the south end of the 10,000-foot track. It is sited for 250-pound HE detonation.

Sandia National Laboratories

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EXPLOSIVE OPERATIONS

Sandia National Laboratories

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MEASUREMENT SCIENCES & ENGINEERING

Measurement Sciences & Engineering

- Component and system level measurement capabilities
- Mechanical, thermal, spatial and spectral information
- Specializing in high speed and destructive events
- Time synced data products
- Measurement uncertainty
- Explosive event projectile tracking
- Fireball/plume evolution
- Production (KCP) automated optical test development with pass/fail criteria.
- We work closely with customers, modelers and stakeholders to provide useful and actionable data products