U.S. ARMY

DEVCOM GROUND VEHICLE SYSTEMS CENTER

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND GROUND VEHICLE SYSTEMS CENTER

Ground System Power and Energy Laboratory (GSPEL) Capabilities Overview

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Ground Vehicle Power & Mobility Test & Integration

Always Moving

Building 212A & 212B
Detroit Arsenal

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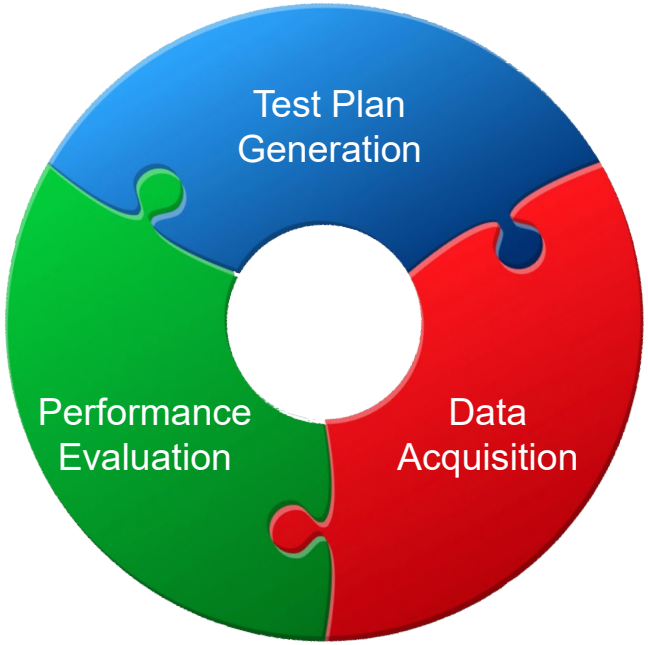
Test & Integration Support

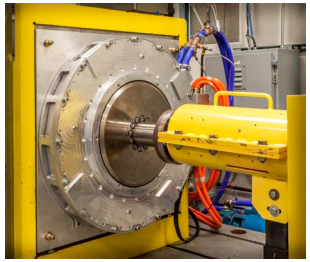
Purpose: Manage, develop, and support integrated life cycle Test and Integration (T&I) services. Provide strategy to innovatively test for performance and reliability of ground systems, and mitigate risks associated with the deployment of ground systems while ensuring timely focus on reliability and maintainability requirements.

- **TRL Maturation**
- **Requirements Testability**
- **Subsystem Integration**
- **Developmental/Operational Test Management**
- **Engineering Change Validation**
- **T&I Efficiencies**



Technology Maturation → ***Subsystem Integration*** (A) → ***System Level DT*** (B) → ***System Level OT*** (C) → ***Engineering Changes***

Best Practices
Similar System Analysis
Efficient / Effective Testing



Increased Utilization of available data (HWIL, M&S, Physical Simulation, Proving Ground)

DEVCOM GROUND VEHICLE SYSTEMS CENTER

GSPEL

Ground Systems Power and Energy Laboratory

The Future of Testing is in GSPEL

Building 212B
Detroit Arsenal

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Ground Systems Power and Energy Laboratory (GSPEL)

The GSPEL is the Army' Centerpiece Laboratory for full vehicle environmental mobility testing, power and energy research and development, integration, and component testing. The GSPEL is composed of five laboratories that provide one-of-a-kind test support to current and emerging classes of ground military and commercial vehicles, wheeled and tracked, manned and unmanned.

- **Air Flow Laboratory - Air Filtration Benches**
  - The Air Flow Laboratory (AFL) - Filtration Benches provide dust testing of air filtration devices to demonstrate and validate new or legacy system capabilities in a controlled environment.
- **Air Flow Laboratory – Calorimeter**
  - The Air Flow Laboratory (AFL) – Calorimeter provides testing of military vehicle heat exchangers to evaluate their cooling capacity, air restriction, and coolant restriction as well as military vehicle ballistic grilles to evaluate their air restriction in a repeatable, controlled environment.
- **Electrical Components Laboratory**
  - The Electrical Components Laboratory (ECL) tests high-voltage/power components for vehicle electrification and hybrid electric power technology integration..
- **Energy Storage Laboratory**
  - The Energy Storage Laboratory (ESL) provides testing for production qualification of batteries and electrochemical technology testing at cell, module and battery pack levels.
- **Power & Energy Vehicle Environmental Laboratory**
  - The Power & Energy Vehicle Environmental Laboratory (PEVEL) tests multi-wheel or tracked military vehicles with road-load simulation under extreme environmental conditions.

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Air Flow Laboratory

Air Flow Laboratory (AFL) an ISO/IEC 17025 accredited laboratory, supports the execution of component level testing on several critical mobility systems in a variety of military vehicles by use of Calorimeter and Air Filtration Testing Systems.

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Air Flow Laboratory

Calorimeter Testing

Benefits

- Evaluate new heat exchangers and ballistic grilles
- Repeatably simulate field environmental conditions
- Test up to three heat exchangers as a pack
- Unique Army testing capability
- Unbiased first-article test and production quality surveillance
- Expedites the development process for vehicle engine and transmission cooling systems

Components and Testing Standards:

- Radiators (MIL-PRF-62259)
- Oil Coolers (MIL-DTL-62006C)
- Charge Air Coolers
- Ballistic Grilles

AFL Calorimeter Test

Air Filtration Testing

Benefits

- Evaluate new air cleaner systems
- Troubleshoot currently fielded systems & failures
- Assess impact of add-on parts to air cleaner systems
- Evaluates proposed vehicle maintenance efficiencies
- Unbiased first-article dust test and production quality surveillance
- Provides first-article dust testing before vehicle implementation.

Components and Testing Standards:

- Air Filters (MIL-PRF-46736F / MIL-PRF-62048C)
- Air Cleaner Assemblies (MIL-PRF-62565)
- Add-on components to air cleaner systems

AFL Filtration Test

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Air Flow Laboratory

Calorimeter Capabilities

Cooling Air

- Air Flow Rate: 800 to 60000 CFM
- Air Flow Velocity: 3000 to 7000 ft/min
- Inlet Air Temperatures: up to 250 °F

Radiator Loop

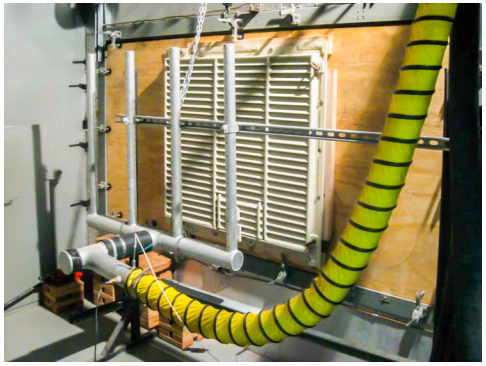
- Coolant Flow Rate: 10 to 300 gal/min
- Coolant Inlet Temperature: 125 to 350 °F
- Coolant Inlet Pressure: 0 to 125 psig

Oil Cooler Loop

- Oil Flow Rate: 10 to 150 gal/min
- Oil Inlet Temperature: 175 to 350 °F
- Oil Inlet Pressure: 0 to 300 psig

Charge Air Cooler Loop

- Charge Air Flow Rate: 30 to 150 lbs/min
- Charge Air Temperature: 150 to 650 °F
- Charge Air Inlet Pressure: 15 to 90 psig



Air Filtration Capabilities

Ambient air conditions are controlled in the Air Filtration laboratory. In addition to controlling temperature, the relative humidity can be set to the desired level.

250 CFM Bench

- Air Flow Rate: 8 to 250 SCFM

2000 CFM Bench

- Air Flow Rate: 80 to 2000 SCFM

5000 CFM Bench

- Air Flow Rate: 320 to 5000 SCFM

12000 CFM Bench

- Air Flow Rate: 800 to 12000 SCFM

Electrical Components Laboratory

The Electric Components Laboratory (ECL), an ISO/IEC 17025 accredited laboratory, supports research, development, characterization and testing of high-voltage, high-power components necessary for military vehicle electrification and hybrid-electric technology. This lab's research extends to a testing cell in the Propulsion Laboratory that has programmable power absorption and supply capabilities with voltage, current and power control, and a 350-horsepower AC dynamometer. Component testing on vehicle is also available. The ECL provides temperature and humidity-controlled environments, as well as 346kW and 373kW AC dynamometers to fully test various components.

ECL - Cell 10

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Electrical Components Laboratory

Components Tested

The ECL can test multiple types of components:

- Advanced Electric Machines
- High Voltage Alternators
- Motor controllers
- Power Inverters
- DC/DC Converters

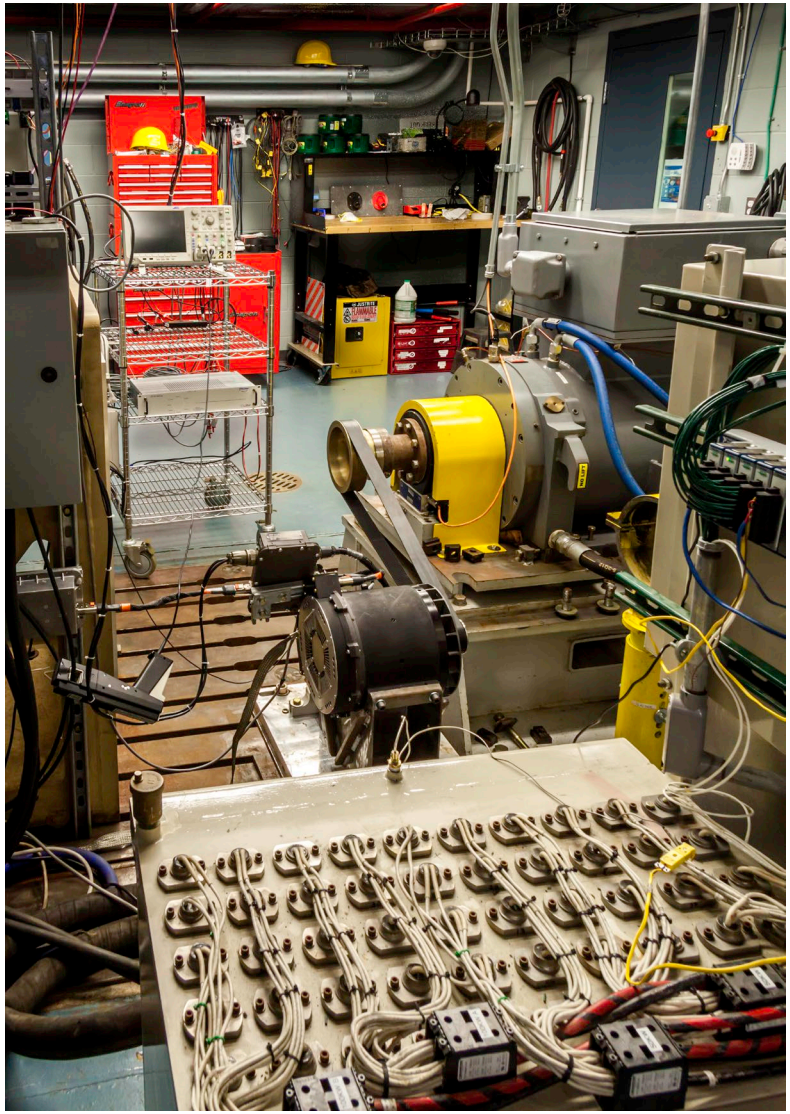
Benefits

- Certified and accredited testing to ISO17025 Standards
- Testing of high voltage, high power components
- Analysis of future electrical power generation and control technologies for the Army
- Provides power quality, transients, and harmonic distortion testing
- Variable coolant temperature and flow rate over a large range
- Thermal chamber for component level testing
- Resistive and Capacitive load banks to simulate a wide variety of load types
- Pressure testing of coolant cooled components using high sensitivity pressure transducers

Testing Standards

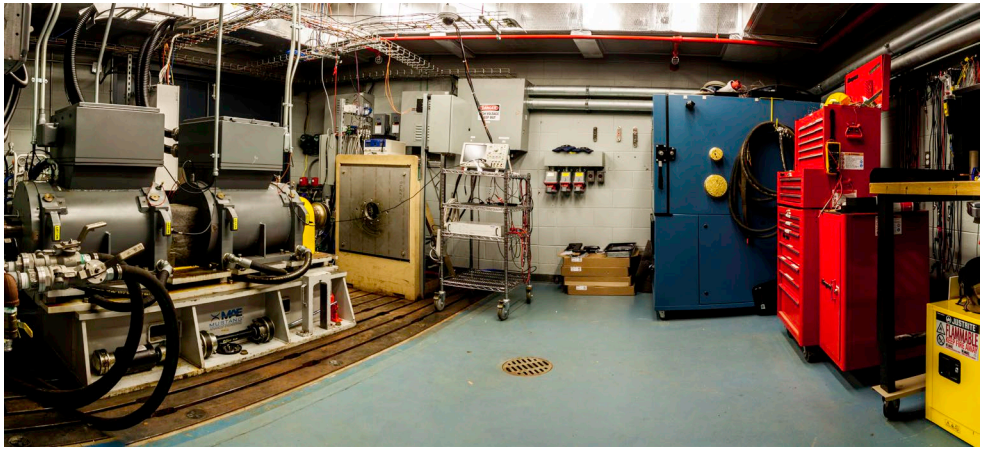
The ECL tests to the following standards / Qualifications / TOPs:

- MIL-PRF-GCS600



Niehoff Alternator 600VDC

Electrical Components Laboratory



ECL Main Laboratory

Acquisition of mechanical and electrical parameters

- Phase to Phase measurements
- Active, apparent and reactive power
- Mechanical power
- Power factor and efficiency
- Fundamental frequency
- Total Harmonic Distortion
- Voltage & Current Transients
- Cooling characteristics; Thermal, pressure, flow rate

ECL Dynamometer

- 373 kW Four Quadrant AC Dynamometer
- 3,321 Nm torque from 0-1000 rpm
- 0 – 12,000 rpm speed range

CELL 10 Dynamometer

- 346 kW Four Quadrant AC Dynamometer
- 1,245 Nm torque from 0-2000 rpm
- 0 – 12,000 rpm speed range

Thermal Chamber

- Temperature range of -30°C to +177°C
- Humidity range of 10% to 95% RH, 85°C Max temp and 4°C minimum dewpoint
- 439 Liter capacity

AV-900 250kW Dual Power Supply

- Voltage: 8 to 900 VDC
- Current: +/- 1000 ADC
- Power: +/- 250 kW

AC and DC Load Banks

- Up to 250 kW power absorption

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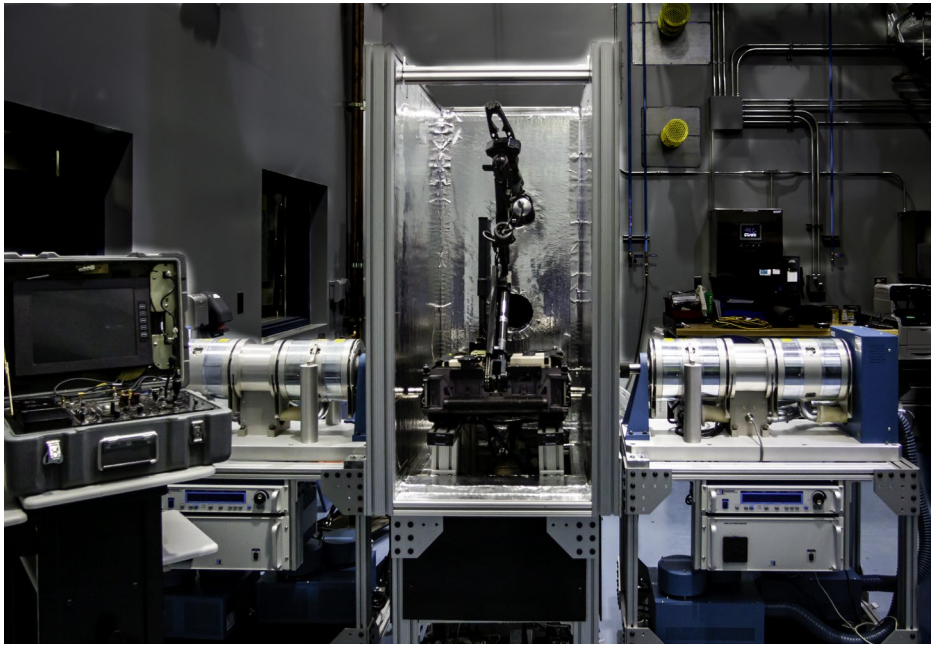
Electrical Components Laboratory

In addition to testing High Voltage and High-Power devices and hybrid-electric components, the ECL tests and evaluates robotic systems using the Robotic – Power and Energy Vehicle Environmental Laboratory, the R-PEVEL. This capability, while new, is already set up to test the QinetiQ TALON series of robots in support of PdM Unmanned Ground Vehicles and GVSC Ground Vehicle Robotics. This testing and evaluation capability also includes environmental control of the test asset.



R-PEVEL V. 1.0

R-PEVEL Dynamometer

- 14 kW Two Quadrant Hysteresis Dynamometer (x2)
- 56.5 Nm torque from 0 – 8,000 rpm
- 0 – 8,000 rpm speed range

Data Collection

- National Instruments cDAQ chassis
- SMBus collection and sampling
- National Instruments LabView

Acquisition of mechanical and electrical parameters

- Phase and DC electrical characteristics
- Active, apparent and reactive power
- Mechanical power
- Power factor and efficiency
- Fundamental frequency
- Total Harmonic Distortion
- Voltage & Current Transients
- Cooling characteristics: Thermal

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Energy Storage Laboratory

The Energy Storage Laboratory (ESL), an ISO/IEC 17025 accredited laboratory, is a specialized research and testing facility dedicated to the advancement of energy storage technologies, with a focus on batteries across multiple levels of integration, including cells, modules, and full battery packs and systems. The ESL provides comprehensive support for the research, development, characterization, validation, and qualification of a wide range of electro-chemical energy storage technologies.

ESL - Control Room

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Energy Storage Laboratory

Capabilities/Benefits

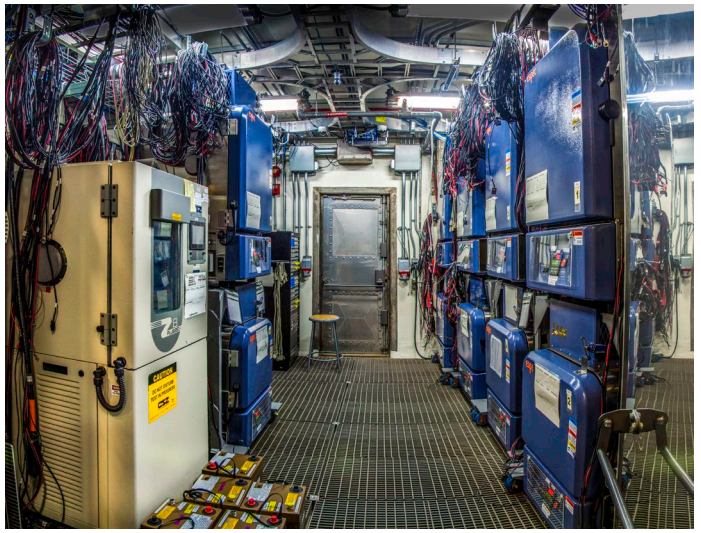
The ESL is comprised of Three (3) Large Battery Test Rooms, two (2) Pack Test Chambers and Battery Storage Rooms.

Multiple cell/battery cyclers on a centralized control system, thermal ovens and temperature-controlled water baths support a variety of electrochemical tests.

Cradle-to-grave R&D and testing support for all DoD ground vehicle energy storage systems, including new technologies and chemistries.

- Performance to specification
- Life Cycle to Failure (Service Life)
- Cold Cranking
- Deep Cycle / High Temperature Deep Cycle
- Reserve Capacity
- Full Charge Capacity
- Hybrid Pulse Power Characterization (HPPC)
- Charge/Discharge Characterizations
- Impact Test

ESL - Cell 103



ESL - Cell 105

Testing Standards

The ESL tests to the following standards / Qualifications / TOPs:

- MIL-PRF-32143
- MIL-PRF-32565
- MIL-B-11188
- GPMH24000-TOP-6T-Lithium-Ion Qualification
- GPMH25000-TOP-6T-VLRA Qualification

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Energy Storage Laboratory

Battery Cyclers

Brand	Model	Quantity of units	# of Channels per unit*	# Thermocouples Channels per unit	Voltage		Current		Temperature	
					Range	Tolerance	Range	Tolerance	Range	Tolerance
Bitrode	LCV3-100-36	1	3	7	±54VDC	±.05VDC	±100ADC	±.1ADC	-40 to 190ºC	±2.5ºC
Bitrode	MCV48-50-5	2	48	48	±5VDC	±.005VDC	±50ADC	±.05ADC	-40 to 190ºC	±2.5ºC
Bitrode	LCV12-50-24	2	12	16	±32VDC	±.036VDC	±50ADC	±.05ADC	-40 to 190ºC	±2.5ºC
Bitrode	LCV4-100-36	1	4	8	±54VDC	±.05VDC	±100ADC	±.1ADC	-40 to 190ºC	±2.5ºC
Bitrode	LCV4-100-60	7	4	8	±60VDC	±.06VDC	±100ADC	±.1ADC	-40 to 190ºC	±2.5ºC
Bitrode	DTV1-2000-24**	1	1	1	-24VDC	±.024VDC	-2000ADC	±2.0ADC	-40 to 190ºC	±2.5ºC
Bitrode	LCV8-100-60	3	8	12	±60VDC	±.06VDC	±100ADC	±.1ADC	-40 to 190ºC	±2.5ºC
Bitrode	LCV2-1000-48	1	2	4	±72VDC	±.07VDC	±1000ADC	±1.0ADC	-40 to 190ºC	±2.5ºC
Aero-Vironment	AV900	3	2	-	±900VDC	±1.35VDC	±300A	±1.13ADC	-	-

*Channels within unit may be placed in parallel for higher currents / **Discharge only

Temperature Conditioners

Brand	Model	Quantity of units	Temperature		Internal Volume	Cooling Change Rate	Heating Change Rate
			Range	Tolerance			
ESPEC	BTZ-175	5	-65 to 150ºC	±.5ºC	1.5 ft^3	5ºC/min	5ºC/min
ESPEC	BTZ-475	5	-65 to 150ºC	±.5ºC	4 ft^3	2.5ºC/min	2.75ºC/min
Cincinnati Sub-Zero	ZPHS-8-1.5-1-H/AC	1	-65 to 150ºC	±.5ºC	8 ft^3	14ºC/min	17ºC/min
Tenney	T10RC-1.5	3	-65 to 150ºC	±.3ºC	10 ft^3	4ºC/min	5.5ºC/min
Russells	GD-64-5-5-AC-EP	1	-65 to 150ºC	±1ºC	64 ft^3	3ºC/min	3.8ºC/min
Thermotron	SE-2000-6-6	1	-65 to 150ºC	±.7ºC	69.3 ft^3	3.4ºC/min	5.3ºC/min
Water bath	-	2	15 to 70ºC	±1ºC	up to 15.7 ft^{3*}	≈.2ºC/min	≈.25ºC/min

*Depth of water can vary from 4 to 17"

ESL - Outdoor Battery Chambers

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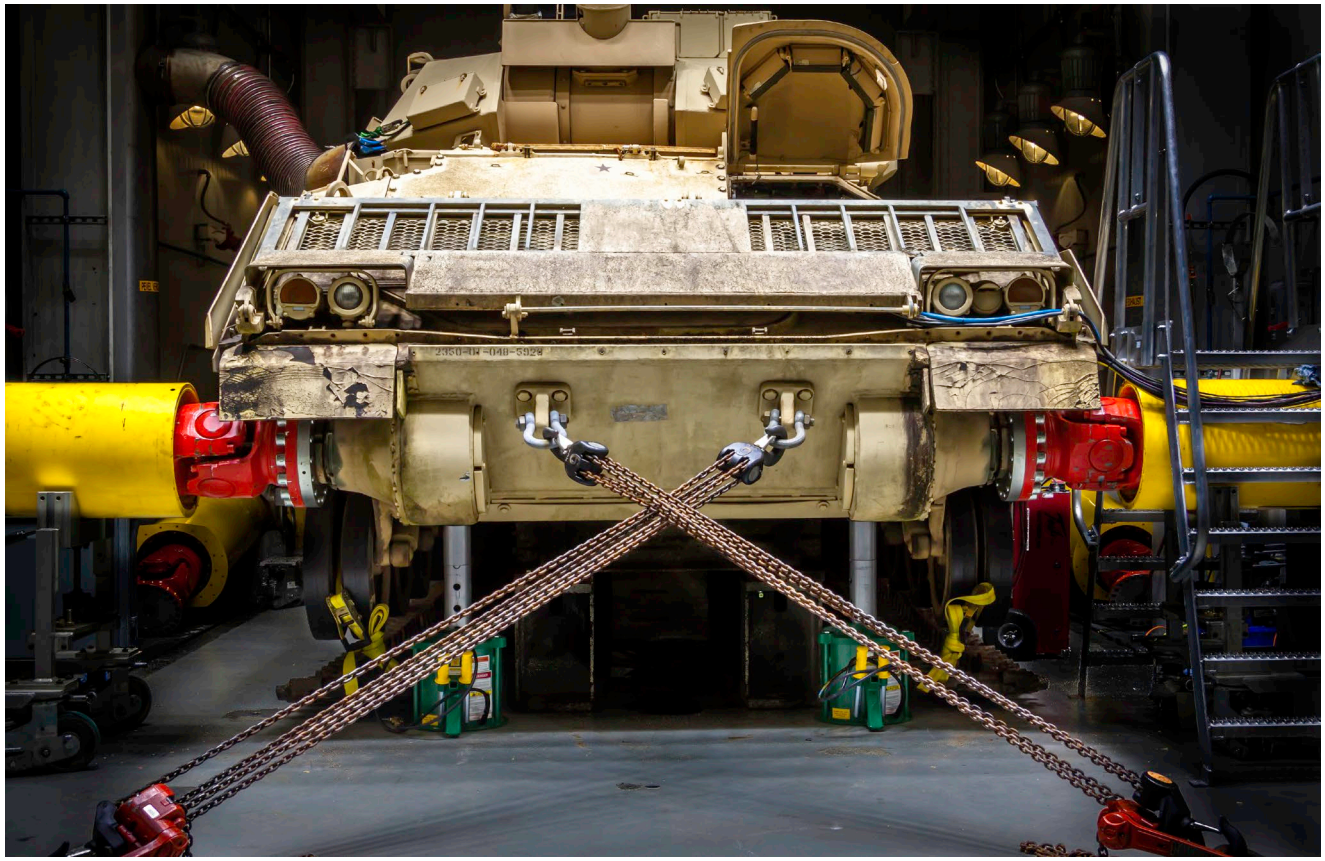
Power and Energy Vehicle Environmental Lab

The Power and Energy Vehicle Environmental Laboratory (PEVEL), an ISO/IEC 17025 accredited laboratory, offers tools for vehicle powertrain assessment. Equipped with multiple dynamometers, the PEVEL provides the tools required for full vehicle powertrain testing, evaluation and assessment of both wheeled and tracked vehicles through external load control and data collection. PEOs/PMs, OEMs, manufacturers, academics and researchers can use these tools to create, assess and validate vehicle design, functionality and utility in a fully controlled and repeatable environment.



PEVEL - Bradley

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Power and Energy Vehicle Environmental Lab

Capabilities

The PEVEL chamber enables testing at temperatures from -60°F to 160°F and humidity levels from 5 to 95% relative humidity. This environmental control makes it possible to produce, repeatable, real-world vehicle performance and capability comparisons. Simulation of wind speed up to 60 mph and solar load up to 1,200 watts/per square meter (W/m^2). Vehicle drivetrain loads of wheeled vehicle with torque up to 34,000 pound-foot (lbf-ft.) and of tracked vehicle torque up to 42,000 lbf-ft. can be provided.). Additionally, vehicle electrical power loads up to 800 kW can be simulated. Compatible fuels for testing in the PEVEL include hydrogen, Diesel, JP-8, F-24, bio-diesel and synthetic blends.

PEVEL - M109A7

Testing Standards

The PEVEL tests to the following Standards / Qualifications / TOPs:

- Transient Road-Load Profiles (TOP 01-01-030 / TOP 01-2-502)
- Vehicle Acceleration (TOP 02-2-602A)
- Fuel Economy (TOP 02-2-603A)
- Full-Load Cooling (TOP 02-2-607)
- Speed on Grade (TOP 02-2-610A)
- HVAC Validation (TOP 02-2-708 / TOP 02-2-816)
- Engine Cold-Start Evaluation (TOP 02-2-650)
- Alternator Load Testing (TOP 02-2-601)

Benefits

- Functions as a test-bed to evaluate vehicle system performance in any operational environment.
- Allows for testing in extreme climates under various loads.
- Performs repeatable tests on components or vehicles, producing real-world vehicle and component performance/capability comparisons.
- Functions as a systems integration laboratory (SIL); fully supports hardware-in-the-loop simulation.
- Addresses the testing gap for multi-axle wheeled vehicles and provides additional evaluation capabilities for vehicle on-road performance.

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Power and Energy Vehicle Environmental Lab

Powertrain Specifications

Wheeled Vehicle Dynamometers

- Speed: 0 - 1,000 RPM
- Torque: 0 - 34,000 lbf-ft. (per wheel)
- Power: 0 - 160 HP (per wheel)
- Wheel Stations: up to 10 wheels (5 axle)

Tracked Vehicle Dynamometers

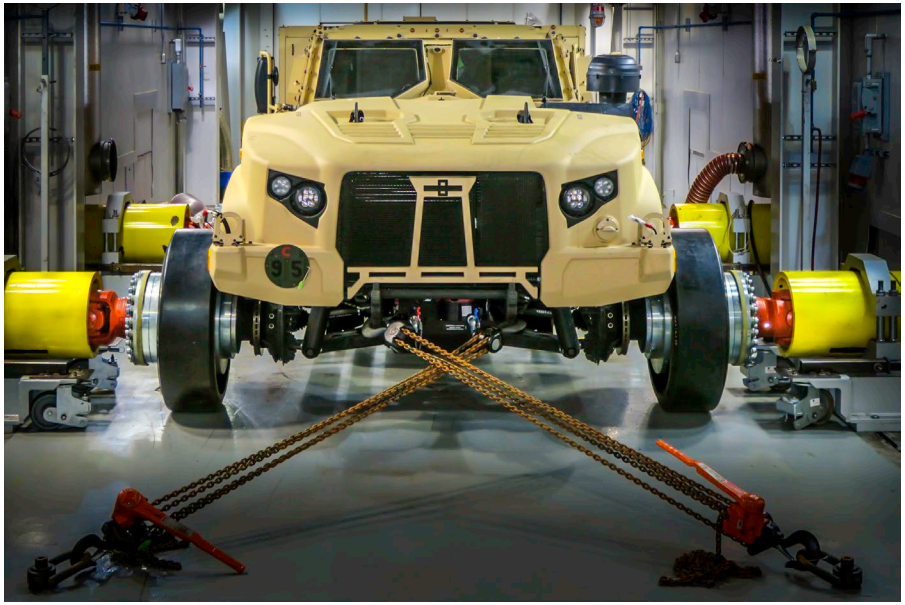
- Speed: 0 - 1250 RPM
- Torque: 0 - 42,000 lbf-ft. (per side)
- Power: 0 - 800 HP (per side)

Environmental Control

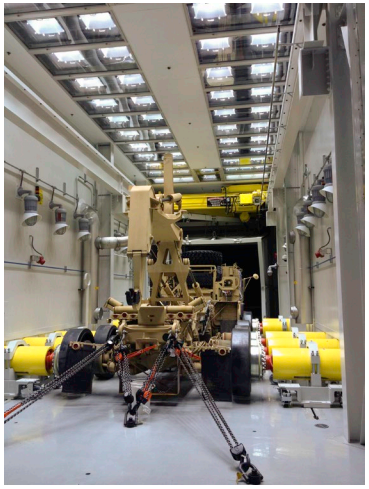
- Temperature: -60°F to 160°F
- Wind: 0 to 60 mph
- Solar: 0 to 1,200 W/m^2
- Humidity: up to 95% RH

General Information

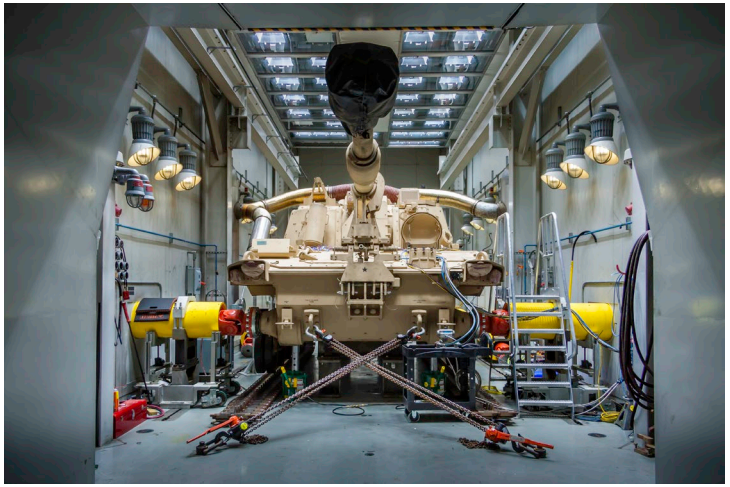
- Chamber Door: 14 ft. (W) x 14 ft. (T)
- Dimensions: 20 ft. (W) x 20 ft. (T) x 75 ft. (L)
- Wheelbases up to 320 in.
- Track Widths up to 120 in.
- Floor Capacity: up to 100 tons
- Crane: 25 tons
- Multiple Vehicle Build-up Bays



PEVEL - JLTV



PEVEL - PLS



PEVEL - M109A7

GSPEL

FOR FURTHER INFORMATION:

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GVPM Testing and Integration Website:
https://gvsc.devcom.army.mil/gvpm/

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