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CAPABILITY BROCHURE

http://www.uah.edu/rfal/capabilities/capabilities-brochure

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INTRODUCTION

The University of Alabama in Huntsville (UAH) Reliability and Failure Analysis Laboratory (RFAL) is located in the Von Braun Research Building on the Campus, at 301 Sparkman Drive Huntsville, AL 35899. RFAL is an independent research organization within the UAH Rotorcraft Systems Engineering and Simulation Center (RSESC). RSESC is under the direction of Mr. Dave Arterburn. Mr. Mark Gauldin is the Associate Director for RFAL and leads the team on a daily basis.

The capability of RFAL extends beyond their staff to the entire campus staff and faculty. The ability to reach out to the UAH staff and faculty provides RFAL areas of expertise across many disciplines. This ability is reflected in the quality product that is provided to our customers. This brochure will describe the objectives and capabilities of the RFAL including the technical features of the major equipment available in the Lab.

The information and the material contained herein is intended not only for UAH personnel but also for current and potential customers.

Updates to the information contained herein can also be located on our website at:

http://www.uah.edu/RFAL/capabilities/capabilities-brochure
WHAT IS RSESC

The Rotorcraft Systems Engineering and Simulation Center (RSESC) is a multifaceted research center focused on applied engineering and systems engineering techniques to enhance success for government and industry rotocraft partners. RSESC brings proven, unparalleled capabilities in systems engineering, design and system analysis, rapid prototyping, integration and fabrication. RSESC skills include: system design and development, analysis in CFD and mechanical fields, reverse engineering, data analysis, trade studies, systems engineering, systems integration, material science, non-destructive testing, independent verification, analysis and review and manual development for Government systems. RSESC personnel have proven experience with retrofits, upgrades, reverse engineering and miniaturizations to improve systems to meet emerging requirements, address obsolescence or save on overall lifecycle costs.

In addition to rotocraft, RSESC personnel have a long track record of supporting industry and Government organizations in space mission analysis and the design, qualification and fabrication of space and aircraft mounted payload systems. RSESC supports the Boeing Huntsville Design Center with part-time student engineering support and is a core member of the FAA UAS Center of Excellence supporting integration of UAS in the National Airspace System.

Mission

RSESC operates under the Office of Research at UAH. The center is self-sustaining by providing professional integration and engineering solutions to DoD, NASA, and industry. A unique workforce comprised of engineers, project managers, technicians, subject matter experts and students is available to the center. Professors or research staff from other departments and centers can be engaged when specialized areas of expertise or analysis are required. Employing students fulfills a prime component of the center’s mission; the mentoring of students and providing on-the-job experience for the future workforce.

Research

The center specializes in hardware and software systems engineering and integration to solve the problems presented by today’s advanced technology and mission requirements for rotocraft ground and airborne systems, unmanned aerial systems, and space and airborne payloads. The RSESC concentrates on conducting design and airworthiness analysis, integrating individual equipment packages, including defining requirements and going through conducting trade studies, value engineering studies, designing or modifying design, developing software, prototyping and testing. Center personnel have proven experience with model based system engineering, system engineering processes in support of acquisition processes, retrofits, upgrades, reverse engineering and miniaturizations to improve systems to meet emerging requirements, to address obsolescence or save on overall lifecycle costs.

The RSESC multi-disciplined team of professionals has decades of combined experience in understanding requirements, clearly defining problems and developing system-centric integrated solutions. The RSESC team is lean, flexible, efficient and responsive and understands mission requirements and the hardware and software used to meet them. From defining requirements to handover of prototypes, RSESC provides solutions that smoothly integrate mechanical, electrical, and software systems, ensuring that no other system is adversely affected. RSESC management works closely with the funding agency’s technical point of contact to ensure that all aspects of the design have been addressed and expectations are met. Solving problems of complex systems is understood to be iterative. Final deliverables may consist of software, reports, government mandated documentation (including production-ready drawings, systems engineering plans, test plans, etc.), and working software and hardware prototypes.
WHO IS RFAL

RFAL is a research organization within RSESC which works closely with other departments within the university and other research centers.

The RFAL focuses on expanding the body of knowledge in the reliability engineering discipline to obtain an overall system reliability understanding. The following is the RFAL Process that is used:

- The lab investigates possible failure mechanisms acting on a part through math modeling and physical testing.
- By looking at the Physics of Failure, the lab is able to develop FMEA, FMECA, and FRACAS to aid in the risk assessment of components.

Much of our commercial customer’s focus has been on verifying that their delivered products meet or exceed the stated standards for reliability and maintainability. The impact of our analysis has a positive impact on their designs resulting in cost effective design changes and optimization of vendor selection.
LAB RESEARCH FOCUS

➢ Our lab is focused on providing our customers with a full range of capabilities grounded in the Reliability Engineering Discipline.
➢ We offer capabilities that span the life cycle of a product from Design for Reliability to After Market Testing, aka… “Cradle to Grave”

➢ Our services include:

- Design for Reliability and Maintainability
- Reliability Centered Maintenance (RCM)
- Condition Based Maintenance (CBM)
- Reliability Modeling and Model Based Engineering
- Failure Mode and Effects Analysis (FMEA)
- Failure Mode, Effects, and Critically Analysis (FMECA)
- Probability Risk Assessment (PRA)
- Testing to determine design and destruct limits
- Physics of Failure / Root Cause Analysis
- UID Parts Marking Policy
- Design of Experiments
- Materials Research, Analysis and Development
- Analysis of HUMS Data through Probabilistic Methods
- Prognostics of Dynamic Components using Sensor Data
- Effective Conditioned-Based Maintenance (CBM) from HUMS Data
- Complex Modeling and Simulation
- Component Level Reliability Testing
- Product Development, Optimization, and Validation
- Environmental Simulation Testing
- Integrated Microgrid Compatibility Testing
- Flight Payload Development
- Propulsion Design
- Space Mission Analysis, Design, and Fabrication
- Statistical Analysis and Design
- Systems Engineering
- Flight Qualification and Acceptance Testing
- Structural Dynamics Analysis
BACKGROUND EXAMPLES

The following is a small list of examples of the type of work performed by RFAL:

- RFAL team includes a Chairman of the Failure Review Board (FRB) for Missile Defense Agency (MDA) missile test from various launch sites. The FRB performs an independent root cause analyses and assessments required to determine recommended corrective actions to the Director, MDA. Team members include government and contractor SME’s working with the OEMs of both target, command and control, radar, and missile.
- Worked with General Atomics constructing the Reliability Block Diagrams (RBD) of the Sky Warrior for a government System Safety Assessment.
- Developed a Machine Learning Maintenance Tool that uses sensor data collected from Dynamic Components. The Maintenance Tool has resulted in a drastic reduction of unscheduled maintenance actions and provided a means to optimize system scheduled maintenance.
- FMEACA on the Kiowa Warrior (OH-58) Helicopter.
- Corrosion Analysis for several commercial companies. Results ranged from production process control implementation issues to initial product design issues.
- Corrosion testing and analysis on Aircraft Engine Turbine Blades. RFAL acted as a 3rd Party Validation for the DoD.
- Provide Team Training for both Commercial and DoD in the Reliability Subject Discipline.
- Conducted an Environmental Analysis for the Army Primary Standards Lab (APSL) to determine the stresses from the time of shipment until equipment being setup in the different lab locations worldwide. These conditions were then simulated using RFAL equipment on various products tested at the APSL. Examples of this testing was Altitude exposure at temperature extremes, temperature and humidity exposure, and Package Drop/Shipment testing.
- ISTA-2A package validation testing.
- Numerous Composite Material structure analysis. RFAL has an SME that has recommended changes to the materials or the processes to make the structures.
ENVIRONMENTAL LAB EQUIPMENT

HALT CHAMBER

Manufacturer: Hanse
Type/Model: VTC-9
Table Size: 36” x 36”
Internal Dimensions: 42”W x 42”D x 38”H0
Max Load (lbs): 700
Vibration Output: Tri-Axial (6DoF) 10-10,000 Hz up to 100 GRMS
Temperature Range: -100° C /+200° C
Product Change Rate: 70° C/min
Humidity: 10-85 % RH from 25°-65° C

The HALT “Highly Accelerated Life Testing” chamber is used to test the robustness of system components. The chamber allows test specimens to be subjected to vibration in 6 degrees of freedom and up to 100g(rms) (root mean square). The system can simultaneously be subjected to thermal shock and vibration. When you want to determine the capability of systems components to withstand harsh conditions the HALT chamber will meet your needs. The HALT chamber has been applied to test electronics, but is able to subject system dynamic components to levels of vibration and thermal loading with chamber adaptations. Using the HALT capability many engineers and scientist believe that in as little as 24 hours you can stress the object being tested to the extremes that it will see in the life of the object.
DYNAMIC VIBRATION SYSTEM

Manufacturer: ETS Solutions

Type/Model: MPA404-LS232A

Sine/Random Force: 3,300 lbf

Shock Force: 6,600 lbf

Frequency Range: DC to 2,700 Hz

Continuous Displacement: 3.5 inches

Shock Displacement: 4.0 inches

Max Velocity: 5.9 ft/s

Max Acceleration (sine): 70 g

Max Static Payload: 660 lb

The dynamic vibration system is designed to simulate vibration or shock that an item will be subjected when in its normal application. The system can perform random vibration, sine vibration, sine on random vibration, sine on sine vibration, and all varieties of mechanical shock. The controller has the capability to interface with the output of a recording device permitting testing under the actual vibration profile of the target component under use.
THERMAL SHOCK

Manufacturer: ESPEC

Type/Model: TSD-100

Interior Volume: 3.5 cu ft / 100 Liters

Interior Dimensions: 28”W x 16”D x 13.5”H

Temperature Range: -65 to 200 °C / -94 to 392°F

Transfer Rate: <11 seconds between zones

Cooling Method: Air Cooled

The thermal shock chamber has the capability of taking a system component and subjecting it to a rapid thermal shock load. The chamber uses a basket as an elevator that moves a part from one zone to another hot/cold – cold/hot in under 11(s). This can be an important tool when investigating the effects of thermal cycling on system components that encounter various thermal gradients during operation. In electronics this thermal cycling can prove useful in finding components that have solder stress fractures or problems with the components breaking under the temperature cycling.
The Cyclic Corrosion chamber has the capability of applying a corrosive spray, mist, or fog to a material with adjustable mixtures. This chamber can simulate and accelerate natural corrosive agent’s effects on materials. Corrosion testing is vital for components that will be subjected to harsh abrasive/salty environments. The key advantage of the chamber is accelerating the corrosive effects on a material to shorten test time. Flow rate of the corrosive agent can be adjusted to meet specific test standards or RFAL has the capability of implementing a custom test. Upon the completion of a test RFAL has the microscopic capability to examine the effects that the corrosion test had on the object.
AXIAL/TENSION/COMPRESSION FATIGUE TESTING SYSTEM - INSTRON

Manufacturer: Instron

Type/Model: 8801

Axial force: +/-100 kN (+/- 22Kip) (22,500 lbf)

The Instron is a servo-hydraulic tension/compression/fatigue test machine. It uses a hydraulic pump and a series of computer controlled valves to control the force of an actuator. It has the capability to test a variety of materials up to loads of 22,500lbs. The machine can be used for experiments to define the properties of various materials. UAH has two types of grips used in separate applications. For room temperature, hydraulic grips are used, and for elevated temperatures mechanical grips are used to hold test specimens. RFAL can provide custom test fixtures and testing/characterization of materials. While in test RFAL has the ability to take strain gauge measurements for a detailed result of the stress.

Examples:
- Static tensile testing of unidirectional E-glass composite with fiber waviness.
- Static tensile testing under a -200 °C steady state of IM7 carbon fiber composite.
- Static tensile/compression/temp testing of Omni directional carbon fiber weaves.

ADDITIONAL ADAPTERS

Test Oven: ATS

Type/Model: 3710 Series

Service Temperature: -100° to +315° C (-150° to +600° F)

Internal Dimensions: 14” W x 14” D x 26” H

Cooling Method: LN2

The oven adapter for the Instron 8801 has the capability of subjecting test coupons to thermal loads of -100°C to 315°C. This testing capability is important for understanding the thermal effects on a material under stress. RFAL has the capability to perform data capture and analysis for elevated temperature.

Examples:
- Thermal testing of omnidirectional weave carbon fiber composites @ -65°C & 135°C
Furnace
Manufacturer: ATS
Type/Model: 3210
Max Temperature: 1100° C
Dimensions: 3-3/4” ID x 12” OD x 16” long
Heated Length: 12” long

The split tube furnace has the ability to mount to the Instron 8801 and is used for studying elevated temperature effects on materials under stress.
AXIAL/TENSION/COMPRESSION TESTING SYSTEM - MTS
Manufacturer: MTS
Type/Model: Insight 50
Axial force: +/-50 kN (+/- 11Kip) (11,250 lbf)
Vertical Test Space: 1050mm/43inches
Maximum Test Speed: 500 mm/minute (20 inches/minute)
Minimum Test Speed: 0.001 mm/minute (0.0004 inches/minute)
Space Between Columns: 835mm/33inches

The MTS Insight system is a leading edge electromechanical load frame. The MTS Insight 50 kN system features a large column spacing to accommodate testing of oversized test samples. This additional column allows up to 5 samples, to be simultaneously tested.

AXIAL/TENSION/COMPRESSION/TORSION SYSTEM - BOSE
Manufacturer: Bose
Type/Model: ElectroForce 3330
Axial force: +/-3 kN

The ElectroForce® Series II 3330 test instrument is well-suited for a variety of tests that include ASTM and ISO standards tests for medical devices, materials characterization, and long-term durability studies. The 3330 system provides static to 100 Hz performance with a load envelope of ±3000 N, allowing versatile performance for a variety of test applications such as durability testing of orthopaedic implant devices and dynamic characterization of engineered materials and components.

ElectroForce® multi-specimen fatigue test systems are designed to provide tension-tension, or compression-compression displacement controlled loading for small soft structures and devices, such as stents, stent structures, stented grafts, vena cava filters, septal patch structures or other similar devices.
SHEAROGRAPHY SYSTEM (Non Destructive Testing – NDT)

Manufacturer: Dantec Dynamics
Type/Model: SHS33

Shearography is an optical Non Destructive Testing (NDT) method that provides information on the surface of materials. The Technique is non-contact and full-field with the main applications related to Quality Inspection of composites and other materials. Shearography is being extensively used in production and development within the aerospace, automotive, wind energy, and marine industries as well as for material research. Unique advantages are that Shearography is non-contact and has a high rate of coverage (~1 m²/minute).

Shearography - NDT Measurement Systems | Shearography - NDT Systems for Flaw Detection in Composite Materials - Dantec Dynamics Typical flaws detectable in Composite Materials with Shearography are:

- Disbonds
- Delamination
- Wrinkles
- Porosity
- Foreign objects
- Impact damage

The Shearography System can be used on any of our fatigue test systems.
AUTOCLAVE

Manufacturer: American Autoclave
Type/Model: R-30-40-150-650-ELE
Working Envelope: 24” Diameter x 40” Depth
Operating Pressure: 150 Psi
Operating Temperature: 650°F/343°C

- 10°F per minute ramp rate based on a 100 lb steel and composite load
- Vacuum Pump – 10CFM / 28” Hg (2 Ports)

RFAL has the capability of processing a variety of thermosetting composites for material testing with the use of the Autoclave. An autoclave applies a controlled schedule of pressure and heat to fit the manufacturing requirements for a variety of composite materials. The internal chamber uses inert nitrogen gas feed by a liquid-gas converting nitrogen Dewar. Convective water cooled heat exchanger coil, inside the autoclave vessel, allows the chamber to trim the temperature during thermal ramps and dwells. RFAL has the capability to adapt tooling and cure profiles for varying geometries/thicknesses.

Examples:
- E-glass/epoxy 250°F (max temp) 90Psi (modified cure for thick lay-ups)
- IM7/epoxy 350°F (max temp) 90psi
INDUSTRIAL OVEN

Manufacturer: Thermcraft
Type/Model: OBR
Working Envelope: 24” W x 24” D x 24” H (8 Cu Ft)
Operating Temperature: 1250°F/677°C

- 88°F per minute ramp rate

The industrial oven’s main use is for thermally stressing materials-system components to study the effects of elevated temperature environments. The oven is also used for heat treatment of adhesive materials for composites. The oven has the ability to capture temperature readings via USB port located on the control tower of the oven.

-Tab curing for tensile samples
ALTITUDE CHAMBER

Manufacturer: Espec

Type/Model: EVTH8-CWA

Working Envelope: 24” W x 24” D x 24” H (8 Cu Ft)

Operating Temperature: -40°C to 100°C (-40°F to 212°F)

Altitude Range: Sea Level to 70,000 feet

Humidity Range: 20%RH to 95%RH +/-5% (Non Altitude Mode); Greater than 20% uncontrollable in Altitude Mode below 5,000 feet

Change Rates:

- 2°C per minute
- 1,000 feet per minute to 37,000 feet

The altitude chamber’s main use is for testing samples at different altitudes as well as being able to control the temperature. The chamber also has a humidity mode of operation where you can subject the samples to different humidity and temperature ranges. While in altitude mode if you have sensitive electronic equipment the chamber can keep greater than 20% RH while testing at or below 5,000 feet. This will allow you to safely turn on sensitive electronics and not cause static arcing or discharge.

-Altitude stress and effects on electronic equipment
ENVIRONMENTAL CHAMBER – 8 Cubic Foot

Manufacturer: Thermotron

Type/Model: SM8-8200

Working Envelope: 24” W x 24” D x 24” H (8 Cu Ft)

Operating Temperature: -68°C to 177°C (-90°F to 350°F)

Humidity Range: 10%RH to 98%RH

The environmental chamber is used to speed the aging process for lifetime testing. It can also be used for exposure testing to verify operation at given environmental conditions. This chamber can be used for material properties testing or on electronic devices that require exposure. By using the environmental chamber you can inject different failure mechanisms into the device or item being tested. This could be an extreme temperature on an electronic device or advanced material. By performing this type of testing during the design phase of a program, the weak points of the design can be located.

ENVIRONMENTAL CHAMBER – Oversized 8 Cubic Foot

Manufacturer: Thermotron

Type/Model: SE-200-2-2

Working Envelope: 24” W x 27” D x 27” H (8 Cu Ft)

Operating Temperature: -68°C to 177°C (-90°F to 350°F)

Humidity Range: 10%RH to 98%RH

We have 5 of these chambers in our lab.
DROP TESTER

Manufacturer: LAB
Type/Model: AD125
Payload Capacity: 125 lbs (56 kg)
Drop Height: 8” – 84”

Specifications / Standards:
- ISTA
- ASTM
- ISO

The drop tester is an important tool to verify impact shock resistance. Shipping standards can be verified using the drop tester to ensure that your packaging designs meet the standard. With remote shock sensors applied to the test specimen and to the external surface of the shipping container we can determine the dampening effects of the packaging material. This is important when shipping sensitive electronics to make sure they can survive the shipping standard, either custom or published.
CARBONIZING FURNANCE

Manufacturer: Sentro Tech Corporation
Type/Model: STT-1500C-2.5-18
Operating Temperature: 1500C with 30 Temperature Segment programming
Heating Zone: 18” Tube for uniform heating

The Carbonizing Furnace uses an inert atmosphere to subject the test sample to extreme heat during the carbonization process. Currently this equipment is part of the work involved in producing aerospace grade carbon fiber.

MICROWAVE DIGESTION LABSTATION

Manufacturer: Milestone
Type/Model: ETHOS D

The Microwave Digestion Labstation is designed to prepare samples for AAS, ICR and ICP-MS. One of the reasons is the time saved with using a microwave technology compared to other heating block techniques. Using the Microwave will decrease digestion time from hours to minutes. The application in our lab facility consists of using the microwave for uniform heating of Ionic Liquid mixtures. Having the ability to monitor the heat of the liquid using the temperature probe guarantees that the solution is at the proper temperature and by using the microwave we have consistent heating throughout the solution.
ASHING FURNACE

Manufacturer: Milestone
Type/Model: PYRO XL

The determination of ash content is a valuable test in determining material properties. The special microwave-transparent muffle allows the radiation to pass through and rapidly raise the temperature of a high-absorber material plate. The test sample is placed in a crucible which is weighed pre and post ashing and recorded in the controller. We have the ability to use our Mass-spectrometer to analyze the vapor from the ashing process.

VACUUM OVEN

Manufacturer: Thermo Electron Corporation
Type/Model: Lindberg / Blue M V01218A
Working Envelope: 12” W x 18” D x 12” H
Operating Temperature: 6°C Above Ambient to 260°C
Vacuum Capability: 1 x 10⁻² torr (10 Microns)
Atmosphere: Inert gases

The oven is designed for drying, curing, outgassing, ageing, process control, and other applications which require elevated temperature in a reduced atmosphere or vacuum. An inter atmosphere is capable when using the oven.
THERMOGRAVIMETRIC ANALYZER (TGA)

**Manufacturer:** TA Instruments  
**Type/Model:** TGA Q5000  
**Weight Range:** 0.1 g (nominal)  
**Weighing Accuracy:** +/- 0.1%  
**Temperature Range:** 5°C to 85°C  
**Humidity Range:** 0 to 98% RH

In thermogravimetry weight changes of a substance which occur during a controlled temperature program and in a defined gas atmosphere are measured. In the Difference Thermal Analysis (DTA), temperature changes of a substance compared to a reference temperature which occur during a controlled temperature program in a defined gas atmosphere are measured. This system is capable of performing both of these measurements. In our lab we are measuring the weight loss of rayon fibers as they are being carbonized to help in understanding the characteristic changes of the fiber. This is done using LN2 for the inert atmosphere to control the carbonization.

MASS SPECTROMETER

**Manufacturer:** Pfeiffer Vacuum  
**Type/Model:** Thermostar GSD320  
**Analyzer:** QMG-220

Mass Spectrometry is a technique that produces a singular spectrum of the masses of atoms of a sample material. This analysis is used to determine the isotropic signature of the sample. This equipment can be used with the TGA, the Ashing Furnace, or any other device to obtain the isotropic signature of the exhaust or atmosphere.
DYNAMIC MECHANICAL THERMAL ANALYSIS (DMTA)

Manufacturer: Rheometric Scientific
Type/Model: DMTA V
Temperature Range: Ambient to 500°C (without LN2) / -150°C to 500°C (with)
Frequency Range: 1.0 x 10⁻⁶ to 200 Hz
Displacement: +/- 2.5E⁻⁴ to +/- 0.128 mm with a total force of 15N

The DMTA V will test solid and semi-solid materials, determining properties related to use and wear modulus, temperature-dependent behavior, and frequency dependent behavior. The DMTA is a mechanical spectrometer that measures the stress/strain relationship of the material being tested. The DMTA can be used to test curing cycles and efficiency for thermosets and elastomers. It can be used for quality control of plastics and molded parts, coatings, paint, ink on substrates, thin films, and fiber testing. Current use is to test the properties of carbon fiber.

DIFFERENTIAL SCANNING CALORIMETRY-THERMOGRAVIMETRIC ANALYZER (DSC-TGA)

Manufacturer: TA Instruments
Type/Model: SDT Q600
Temperature Range: Ambient to 1500°C
Calorimetric Accuracy: +/- 2% (Based upon standard metals)
DTA Sensitivity: 0.001°C
Vacuum: To 7 Pa 10.05 torr

Simultaneous Thermal Analyzers measure both heat flow and weight changes in a material as a function of temperature (or time) under a controlled atmosphere. The simultaneous DSC-TGA can be used in phases of research, manufacturing operations, and quality control. The SDT Q600 can take measurements from ambient lab conditions to 1500°C. The thermobalance uses an accurate and reliable horizontal dual-balance to detect the weight change. The temperature control and the measurements are made using Platinum and Platinum-Rhodium thermocouples. The SDT Q600 has superior accuracy to a single-beam system. Current use is on carbon fiber analysis.
THERMAL CONSTANTS ANALYZER

Manufacturer: HotDisk

Type/Model: TPS 2500 S

Thermal Conductivity: 0.005 to 1200 W/mK

Thermal Diffusivity: 0.1 to 700 mm²/s

Measurement Time: 1 to 1280 seconds

Reproducibility: Typically better than 1%

Accuracy: Better than 5%

Temperature Range: -253°C to 1000°C

Additional Software Module: Anisotropic

The Thermal Constants Analyzer is a non-destructive precision analysis of thermal transport properties including thermal conductivity, thermal diffusivity, and specific heat capacity. The analyzer operates on a wide variety of sensors with radius from 0.5 mm to 30 mm. The test machine operates by pulsing energy into a circular disk sensor and reading a difference in resistivity values over time. These values change as heat is introduced to the material under test. There are two main differentiations between material types. Those that are Isotropic: meaning (the properties are the same in all directions i.e. metals) or Anisotropic: meaning (properties are not the same in all directions i.e. carbon fiber composites). The software for this machine allows RFAL to determine properties for both Isotropic and Anisotropic materials.

Advantages:

- Contact resistance between sensor and sample does not influence measurement results
- Porous and transparent samples are easy to test without modification
- Surface roughness or color does not influence measurement results
- Minimum or no sample preparation time
- Double-sided testing for maximum accuracy
- Three thermal transport properties testing in a single transient
- No calibration or reference sample required
VARIABLE SPEED GRINDER-POLISHER

Manufacturer: Buehler

Type/Model: AutoMet 3000

Memory: Automatic method memory

Memory Capacity: Nonvolatile 99 methods

Sample Capacity: 1 to 10 samples

The Ecomet 3000 is a variable speed grinder/polisher. It is a low profile along with a 203 mm (8”) aluminum platen and a universal mount. The platen speed ranges from 10 to 500 rpm. A pop-up water dispensing arm can be positioned over the platen and the amount of water dispensed can be regulated by the flow control valve. It is particularly used in getting material samples to 10 or less microns.
PRECISION WAFERING SAW

Manufacturer: Pace Technologies

Type/Model: PICO 155

Cutting Capacity: Max diameter 50mm / 2”

Variable Speed: 0-1500 rpm (Adjustable)

Cutting Load: 0-1000 gram

Micrometer Feed: 0-25 mm / 0-1”

The PICO 155 is a precision wafering saw with touch controls. It has variable cutting speed from 50-1500 rpm with a digital speed readout, precision micrometer, counterbalanced sliding load system, automatic cut-off switch, with coolant system, magnetic safety switch for the hood, and emergency stop button.

ROCKWELL HARDNESS TESTER

Manufacturer: Wilson

Type/Model: Zerominder
PORTABLE ROCKWELL HARDNESS TESTER

Manufacturer: Wilson
Type/Model: M200B
Measurement Type: HL, HV, HRB, HRC, and HS

The Wilson M200B is a Hand-Held Hardness Tester. It is an impact tester that incorporates the Leeb principle of measurement. The M200B is packaged in a rugged carry case and can be used as a portable measurement device. When you cannot bring the material to the lab you can bring this device to the material.
SURFACE PROFILER - PROFILOMETER

Manufacturer: KLA Tencor
Type/Model: P10
Wafer Size: 200 mm / 8"

The KLA Tencor P10 is used for measuring step heights to determine the thickness of etched features or film thickness. The system has the ability to measure in steps as small as 10 nm. It has the ability to measure micro-roughness with up to a 0.5A (0.002 min) resolution over short distances as well as waviness over a full 60 mm scan.
ACCELEROMETER CALIBRATION STATION
Manufacturer: The Modal Shop
Type/Model: 9155C
Frequency Range: 5Hz – 10kHz

Typical Measurement Uncertainty:
- 2.2% (5-10 Hz)
- 1.2% (10-100 Hz)
- 0.7% (100 Hz)
- 1.0% (100-1,000 Hz)
- 1.4% (1,000-5,000 Hz)
- 1.9% (5,000-10,000 Hz)

Calibration Method: Back-to-back comparison per ISO 16063-21
Measurements: Sensitivity, Amplitude, Phase, Bias, Resonance, Linearity,
Shock, DC Offset, Bridge Resistance, DC Sensitivity

Accelerometers Supported: ICP®, Charge, Voltage, Capacitive, Piezoresistive, CVLD
Sensors Supported: Acceleration, Velocity
TEDS Sensor Support: IEEE 1451.4, IEEE P1451.4
Excitation Type: Stepped Sine, Multi-sine
Acceleration Levels: 0.1 to 10 gpk

The accelerometer calibration station is an important tool used to verify the accuracy of piezoelectric accelerometers. Piezoelectric transducers create a voltage output when stress is applied to the material. The voltage output is read and filtered by a computer to translate accelerometer output into a component of acceleration. Proper accuracy of accelerometers will provide reliable test data for experiments which analyze the frequency of structures. The Accelerometer calibration system vibrates the accelerometers at a known frequency/magnitude. The system compares the output of the accelerometer to these known values and determines if the output meets its accuracy parameters.
SCANNING ELECTRON MICROSCOPE (SEM)

Manufacturer: FEI/Philips
Type/Model: XL30 ESEM
SEM: Tungsten thermal
Detectors: SE and BSE
Resolution: 3.5 nm @ 30KV (High and Low Vac)
<15nm @ 3KV (Low Vac)
Stage: 4-Axis motorized eucentric
50x50 mm full travel
-15 to 75 degree manual tilt
Vacuum: Turbo pump with dual mechanical RP
Low Vacuum capable

The XL-30 ESEM combines a high-brightness FEG source with a conventional electron column. Unlike conventional SEMs which require high vacuum in the specimen chamber, the microscope can be run in a “high-pressure” environmental mode allowing the examination of hydrated or insulating samples. This machine is capable of imaging almost any sample, with the only exceptions being volatile liquids, gases and samples that are too large. It is possible to image water and many other liquids by cooling them to a temperature where their vapor pressure becomes low enough to prevent unwanted evaporation at the chosen pressure of operation. (Liquids are seen as dark opaque shapes because the electrons do not penetrate through the liquid as light waves do through water.)

The unique conditions available with an ESEM make them useful for a large variety of experiments, not usually possible in an SEM. Imaging wet materials such as geological or biological material and non-conducting materials such as polymers and ceramics is possible. In addition, it is possible to heat it as high as 1500 C. Special stages can be constructed so that samples can be subjected to failure analysis; for example by using a strain stage to fracture materials. Such events can conveniently be recorded for repeated viewing and for timing purposes.

Because the water vapor acts to neutralize any charge buildup on the surface of the sample, almost no preparation is required. Thus it is possible to image corroded surfaces, paints and other synthetic finishes, glasses, ceramics, rocks, minerals, polymers and any other materials with low electrical conductivity, all without having to coat the samples with a conductive layer of gold or carbon. This means that everything is seen in its natural state.
Additionally this machine has a TSL electron backscatter pattern (EBSP) and phase identification system for determining the orientation of crystalline grains in a sample. The results from automatic stage or beam scanning are stored and may be displayed in a variety of different ways including colored maps and pole figures.

**X-RAY INSPECTION SYSTEM**

**Manufacturer:** Glenbrook Technologies

**Type/Model:** JewelBox 70T

**Anode Voltage:** 80 kV (Adjustable)

**Anode Current:** 100 microamps (Adjustable)

**Magnification:** 7X to 2000X

**Manipulator:** 5-Axis Joystick

The JewelBox 70T offers excellent resolution and sensitivity for laboratory and failure analysis inspections. The system has a high-resolution x-ray camera and a 10-micron x-ray source to provide magnification from 7X to 2000X, with a resolution of 100 line pairs/mm. Current use for this system is to perform solderability analysis on PCB assemblies.
COMMERCIAL DIESEL GENERATOR

Manufacturer: Kubota
Type/Model: GL7000-USA
Frequency: 60 Hz
Voltage: 120/240

Standby Output: 7.0 kVA / 7.0 kW
Prime Output: 6.5 kVA / 6.5 kW

This generator can output up to 7kW power and is custom modified with a graduated fuel chamber (0-1000 ml) to provide precise fuel consumption data for testing. The generator has 120V/240V single-phase and has a maximum output of 26A. This liquid-cooled diesel generator is suitable for use in microgrid and hybrid power system testing. It’s 7.4 gallon fuel tank permits continuous operation for 16.5 hours.
Military Tactical Quiet Generator (TQG)

Manufacturer: DRS Fermont for the U.S. Marine Corps

Type/Model: MEP-803A

Frequency: 50/60 Hz

Voltage: 120/208/240

Speed (RPM): 1800

Phase: Single and 3-Phase

Output: 10.0 kW @ 60 Hz

The 10kW TQG Generator Set, MEP-803A, is a fully enclosed, self-contained, skid-mounted, portable unit. It is equipped with all controls, instruments and accessories necessary for operation. The generator set consists of a diesel engine, brushless generator, excitation system, speed governing system, fuel system, 24VDC starting system, control system and fault system. The generator set is designed to be used with any equipment requiring a small source of AC power and operates in a “Hot and Basic” climatic condition range of -25°F to +120°F. This generator is suitable for use in microgrid and hybrid power system testing. Outputs include 120V single-phase 2-wire, 120V/240V single-phase 3-wire and 120V/208V 3-phase 4-wire configurations.
PHOTOVOLTAIC SOLAR ARRAY

Manufacturer: TenKSolar

Type/Model: Reflect System

The patented TenKSolar technology employs a unique parallel configuration to improve reliability by eliminating single-point failures. The loss of individual cells on a panel does not cause the entire panel to fail, and without serial strings the loss of an entire panel does not cause a string to fail. The parallel configuration also results in a low voltage system, improving safety and eliminating high voltage arcing failures. The reflectors direct additional sunlight onto the photovoltaic modules to improve the overall system performance by 20%.
GRID-TIE/OFFGRID SOLAR INVERTER

Manufacturer: Schneider Electric

Type/Model: Xantrex XW6048

Voltage: 120/240 – Single Phase

Frequency: 60 Hz – True Sine Wave

Wattage: 6000 W @ 120V

5752W @ 240V

Input Voltage: 50.4 VDC @ 130 ADC

Quantity: 4 each

This MPPT hybrid inverter/charger is a sine wave 120/240V AC, split-phase inverter charger. This item forms the basis of the lab’s solar/battery hybrid power configuration. One unit is grid-tied in standalone configuration, ready to connect to solar photovoltaic and generator power, and to charge a variety of battery systems. The other three units are in a self-contained a hybrid power containerized system in 3-phase configuration ready to accept both photovoltaic and generator inputs, and to charge the self-contained battery system.
GRID-TIE INVERTER
Manufacturer: Kaco
Type/Model: BluePlanet 3502xi
Voltage: 208/240
Frequency: 60 Hz – True Sine Wave
Wattage: 3500 W
Max Input Voltage: 600 VDC
Input Voltage Range: 200-550 VDC

This MPPT inverter is a sine wave 240/208V AC unit known for its high efficiency performance, >95.5%. Input voltage is 550-600VDC with 18.5V nominal. 3500W output is 240V/16A and 208V/17A.

BATTERY BANK – 1
Manufacturer: Exide
Type/Model: RoadForce AGM 200
Voltage: 12V
Quantity: 20

The RoadForce AGM 200 is a 12V absorbed glass mat (AGM) sealed lead acid battery designed for deep discharge applications. It provides a 20-hour discharge capacity at a 5A discharge rate. The lab is outfitted with 20 of these batteries configured for 48V. This is achieved by having four serial strings of batteries, with 5 batteries in parallel in each string.
BATTERY BANK – 2

Manufacturer: Enersys

Type/Model: PowerSafe SBS 190F

Voltage: 12V

Quantity: 4

The PowerSafe SBS 190F is a 12V Valve Regulated Lead Acid (VRLA) battery utilizing ultra-high purity lead and other materials. The Enersys batteries are designed to provide a high number of charge/discharge cycles, with application specifically targeted to hybrid power system operation. The nominal useful charge capacity for each battery is 190Ahr.

LOAD BANK

Manufacturer: Simplex

Type/Model: Swift-E 10 kW

The Swift-e is a light, portable resistance load bank capable of supporting 120/240V power sources. The resistance elements are nichrome wire in an incolloy sheath. The unit is designed to be rust-, vibration- and shock-proof. The panel mounted toggle switches provide 250W resistance increments, with load settings displayed on a digital power meter read-out. The connection cable is a four-cable bundle, ten feet long, with ring lug terminations.
2-AXIS SUN TRACKER

Manufacturer: Fina

This sun tracker provides solar pointing with an accuracy of up to 0.1°. Total available surface area is 60m².

HYBRID ADVANCED MICROGRID POWER SYSTEM (HAMPS)

Provider: U.S. Army Aviation & Missile Research, Development & Engineering Center (AMRDEC)

HAMPS is a microgrid power system developed for the Army by Radiance Technologies and South Dakota State University. The system contains batteries for back-up power and accommodates a 10kW generator input for recharging the batteries and running loads. It also contains a smart power controller to reduce fuel consumption during standard operation and is skid-mounted for easy tactical use.