

Autonomous Aerospace Research



<http://www.uah.edu/rfal>

CAPABILITY BROCHURE

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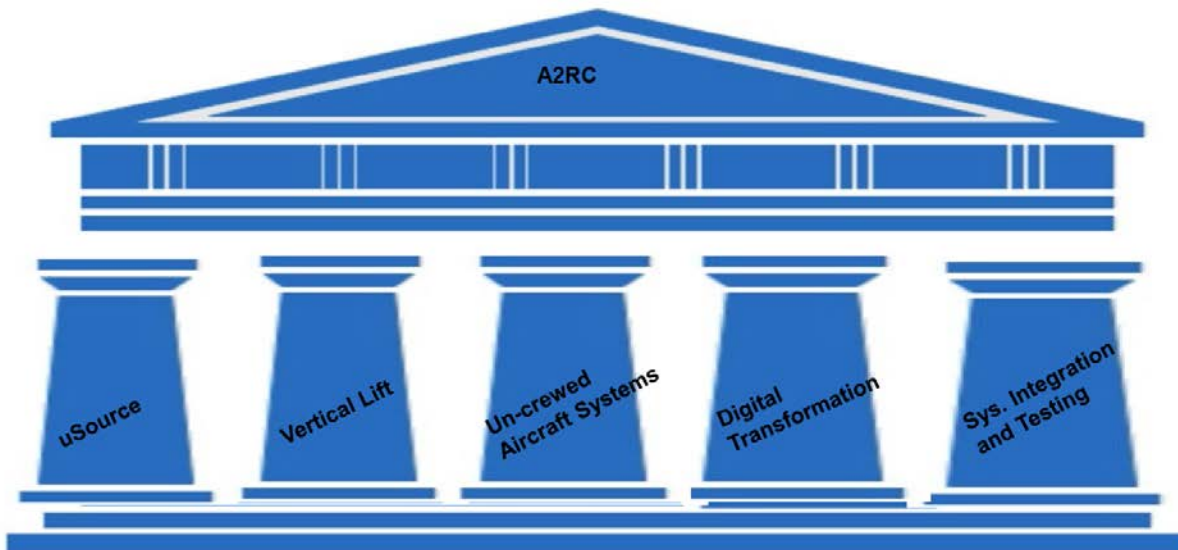
WHO IS UAH

- Tier 1 National Research University
- 1st in Alabama Universities for Math and Science
- 6th Nationally for federally financed Aeronautical and Aerospace Research, 9th in Computer Science
- Leading member of the FAA UAS Center of Excellence for Unmanned Aircraft Systems (UAS) Research – UAS in Disasters / Resiliency
- Leader in the FAA UAS Detections at Airports Program, DOJ training
- Leading Subcontractor supporting a large US Army UAS Program
- James P. Cogswell Superior Rating for Security Excellence with clearances at all levels

WHY UAH

- Access to DoD, FAA, NASA, and DOJ customer sets and support organizations, honest broker
- Access to SME's, students, and PhD's in niche aerospace engineering fields
- Controlled Unclassified Information (CUI) compliant facilities with cleared staff
- Access to advanced academic research (6.1, 6.2, and 6.3)
- Ability to influence future research
- Provision of future talent – Student worker program

WHAT IS A2R



The Autonomous Aerospace Research (A2R) is under the leadership of Mr. Jerry Hendrix. Jerry also is the Director of UAS Programs within A2R. A2R is a multifaceted research center focused on applied engineering and systems engineering techniques to enhance success for government and industry rotorcraft partners. A2R brings proven, unparalleled capabilities in systems engineering, design and system analysis, rapid prototyping, integration and fabrication. A2R 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. A2R 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 rotorcraft, A2R 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. A2R 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

A2R 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 are 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 rotorcraft ground and airborne systems, unmanned aerial systems, and space and airborne payloads. The A2R concentrates on conducting design and airworthiness analysis, integrating individual equipment packages, including defining requirements including research using 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 A2R multi-disciplined team of professionals has decades of combined experience in understanding requirements, clearly defining problems and developing system-centric integrated solutions. The A2R 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, A2R provides solutions that smoothly integrate mechanical, electrical, and software systems, ensuring that no other system is adversely affected. A2R 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.

FOCUS AREAS

- Aerospace System Engineering and Subject Matter Expert Support
- Model Based System Engineering Support for DoD, NASA and Industry Customers
- Unmanned Aerial Systems – FAA ASSURE UAS COE, Customer Support and Counter UAS
- NASA Support – System Development for Research, Space and Environmental Systems
- CAD and Structural Analysis Support for New and Existing Systems (SLS, UH-60 MEDEVAC)
- Aviation Airworthiness support for New and Existing Systems
- Logistics Support for New Systems
- Reliability Analysis and Qualification Testing

CENTER CAPABILITIES

➤ Services:

- ❖ Model Based Engineering
- ❖ Materials Research and Development
- ❖ Product Development and Optimization
- ❖ Propulsion Design
- ❖ Space Mission Analysis, Design and Fabrication
- ❖ Statistical Analysis / Design Analysis
- ❖ System and Payloads Safety Analysis
- ❖ System Engineering
- ❖ Design and Analysis
- ❖ Destruction and Non-Destructive Testing and Evaluation
- ❖ Electrical Design
- ❖ Fabrication, Assembly, and Integration
- ❖ Fatigue and Fracture Analysis
- ❖ Flight Qualification and Acceptance Testing
- ❖ Mechanical Design
- ❖ Rapid Prototype Development
- ❖ Reliability, Availability, and Maintainability Analysis
- ❖ Software Development
- ❖ Structural / Dynamics Analysis
- ❖ Thermal Analysis
- ❖ Computational Fluid Dynamics Analysis
- ❖ Flight Payload Development

➤ Labs:

- ❖ Composite Fabrication Lab
- ❖ Electrical and Mechanical Design and Manufacturing Lab with a Machine Shop
- ❖ Materials Research Lab
- ❖ Systems Engineering Lab
- ❖ Systems Design and Testing Lab
- ❖ UAS Integration Lab
- ❖ Complex Systems Integration Lab (CSIL)
 - Unclassified for Students
 - Restricted Computing Environment (RCE)
- ❖ 3D Scanner and 3D Printing

COMPLEX SYSTEMS INTEGRATION LAB (CSIL)

- ISEEM faculty, GRA and student engagement has grown significantly with the initiation of MBSE coursework and projects
- Three labs currently available
 - Unclassified Lab available for NASA, FAA and DoD non-FOUO/CUI projects (M40)
 - Two NISPOM 800-171 compliant facility for DoD FOUO/CUI projects (M41 and M45)
- ISEEM Work and focus of ISEEM Faculty is NASA related
- Focus of recent projects by A2R has been to address Model Based Acquisition and Support for FVL and MOSA Transformation
 - Support for FLRAA PMO
 - Support for AMCS Development within AMSA
 - Support for UHPO for Obsolescence Management and Integration of a New Flight Control Computer
 - Support for PM Apache in the Development of GFAD Capability and Sustainment
 - Support for Adventium Labs and SEI in the Development of Osate Tool for AADL
 - Support to the VLC in the development of Functional Requirements for Airframe and Mission Equipment Suppliers

SYSTEMS DEVELOPMENT AND FIELD SUPPORT

- Army Apache Block III National Airspace Trainer: Engineering and Software Design and Support, System Assembly, Integration, Testing, and Field Support
- NASA Hurricane Imaging Radiometer (HIRAD): Electrical and Electronics Design, Integration, Testing, and Field Support
- NASA Advanced Microwave Precipitation Radiometer (AMPR): Testing and Field Support

UNMANNED AIRCRAFT SYSTEMS (UAS) CAPABILITIES SUMMARY

UAS research and testing supporting commercial, military and government customers alike include performing or support in the following areas:

- Extensive engineering, piloting, and research experience in UAS
- A core university on the Alliance for System Safety of UAS through Research Excellence (ASSURE Team – the FAA UAS Center of Excellence)
- Fully experienced in several areas of UAS Threat, Threat Systems, and UAS Detections systems testing
- Fully equipped UAS Lab, machine shop, harness design and fabrication, PCB board development, software development, thrust/power test stand, and test facilities allowing A2R to support a broad range of customers as well as Centers and Departments with research and student projects
- Geographic information systems (GIS) and remote sensing image/data processing workflows
- FAA Part 107 remote pilot certification exam preparation and flight skills training
- National Disaster Response Team supporting operations for recovery
- Advanced topics and UAS technology course development
- Active AUVSI Student Club at UAH
- Students fully engage in A2R UAS research with Industry or through working on internal research projects

RFAL 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 A2R. Mr. Mark Gauldin is the Associate Director for Reliability within RFAL and leads the team on a daily basis.

RFAL is an ISO 9001:2015 Certified organization for their Reliability Testing Services. This certification can be supplied to any potential customer upon request.



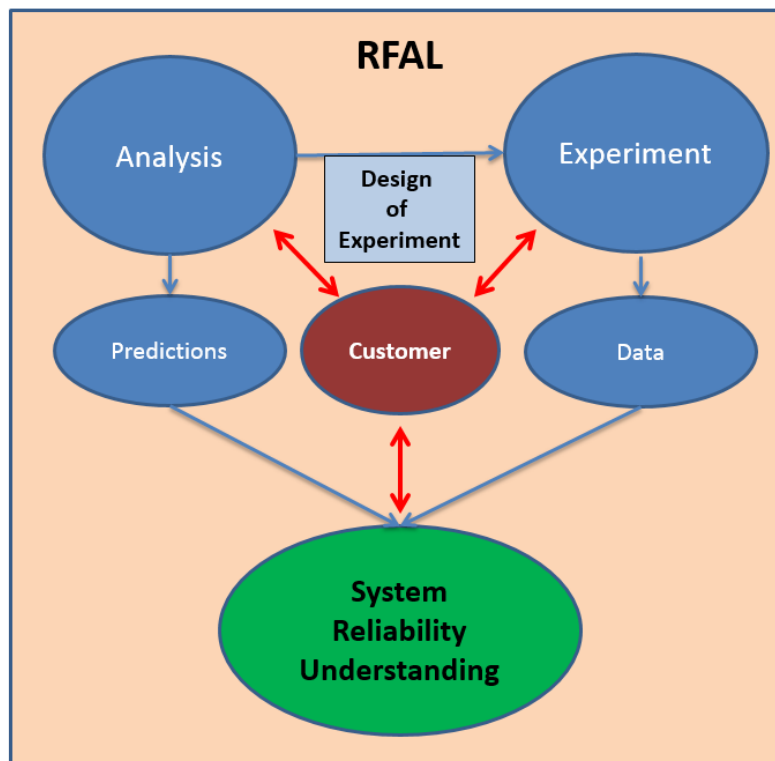
The capability of RFAL extends beyond their staff to the entire campus staff and faculty. The ability to reach out to the UAH staff and faculty provides RFAL areas of expertise across many disciplines. This ability is reflected in the quality product that is provided to our customers.

WHO IS RFAL

RFAL is a research organization 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:

RFAL Process



- 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.

RFAL LAB RESEARCH FOCUS

- Lab is focused on providing our customers with a full range of capabilities grounded in the Reliability Engineering Discipline.
- Offer capabilities that span the life cycle of a product from Design for Reliability to After Market Testing, aka... *"Cradle to Grave"*
- Services include (but not limited to):
 - ❖ 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)
 - ❖ Root Cause Failure Analysis
 - ❖ Probability Risk Assessment (PRA)
 - ❖ Testing to determine design and destruct limits
 - ❖ Physics of Failure / Root Cause Analysis
 - ❖ 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
 - ❖ Component Level Reliability Testing
 - ❖ Product Development, Optimization, and Validation
 - ❖ Environmental Simulation Testing
 - ❖ MIL-STD Qualification Testing
 - ❖ Airworthiness test planning and reports

RFAL QUALITY

QUALITY POLICY

RFAL is a test laboratory that relies on funding from testing contracts in order to help fund its organization. It recognizes that to maintain that source of funding it must consistently provide high quality testing services that meet or exceed interested parties' expectations in order to achieve / maintain customer satisfaction. To demonstrate our commitment to customer focus, RFAL has implemented a Quality Management System (QMS) to continue our being compliant with our ISO 9001:2105 Certification. RFAL is committed to the continual improvement of this QMS in order to ensure that it remains effective in a dynamic business environment.

All testing services provided by RFAL, including testing, test planning, and test supervision, shall comply with requirements that are contractually agreed upon by the customer and RFAL. All employees performing these services shall be competent and qualified to perform their assigned tasks. All testing services shall be completed within the schedule that RFAL and the customer contractually agree upon.

It is the responsibility of all RFAL employees to familiarize themselves with the documents within the quality management system in order to ensure that the policies and procedures within are incorporated into their work. RFAL employees are also encouraged to engage the QMS by observing and reporting to management potential areas of improvement in the QMS.

QUALITY OBJECTIVES

RFAL strives to meet all requirements 100% of the time and has implemented a Quality Management System employing continuous improvement to achieve that desired goal. However, from a Risk Based Approach we understand that we must plan for and mitigate the risks involved in business. Based on this, we have established the below measurable objectives consistent with our Quality Policy:

- Customer Responses – Expectations 98% of the time.
- Delivery of Contract Data Requirements List items (CDRL) on-time 98% of the time.
- Customer satisfaction at 95% satisfaction.

RFAL STRATEGIC DIRECTION

VISION

Expanding the body of knowledge in the reliability engineering discipline by assisting customers with the full range of reliability services.

MISSION

RFAL is committed to providing world-class reliability services to provide our customers with the appropriate tools to design and manufacture the highest quality product.

VALUES / GOALS

- Team collaboration to achieve a common goal
- Deliver services to support customers at a fair price
- Exceed the customers expectation with every deliverable
- Train a workforce that will support our customers abilities
- Operate with integrity
- Provide fact based decisions and data to support the services provided
- Always do the right thing

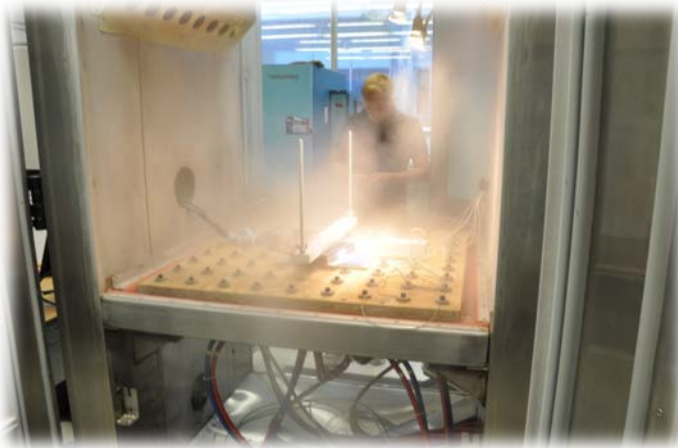
LAB EQUIPMENT

HALT CHAMBER

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

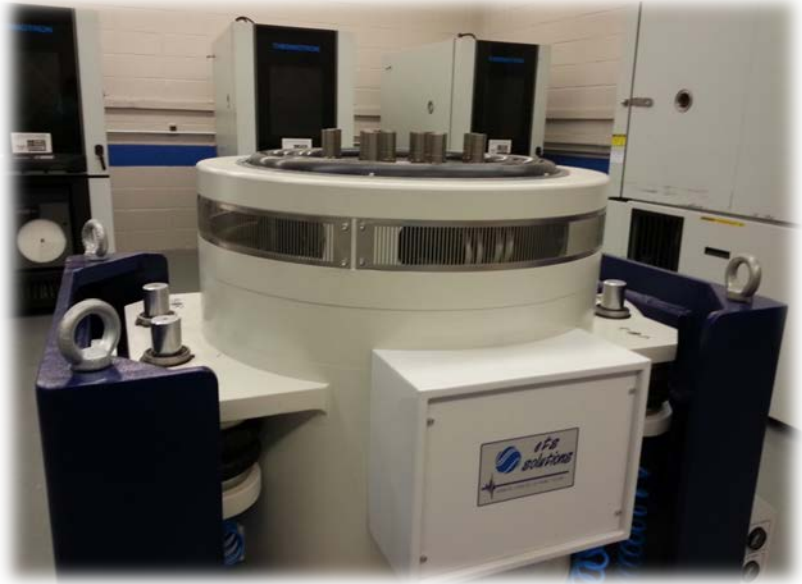


The HALT "Highly Accelerated Life Testing" chamber is used to test the robustness of system components. The chamber allows test specimens to be subjected to vibration in 6 degrees of freedom and up to 100g(rms) (root mean square). The system can simultaneously be subjected to thermal shock and vibration. 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.

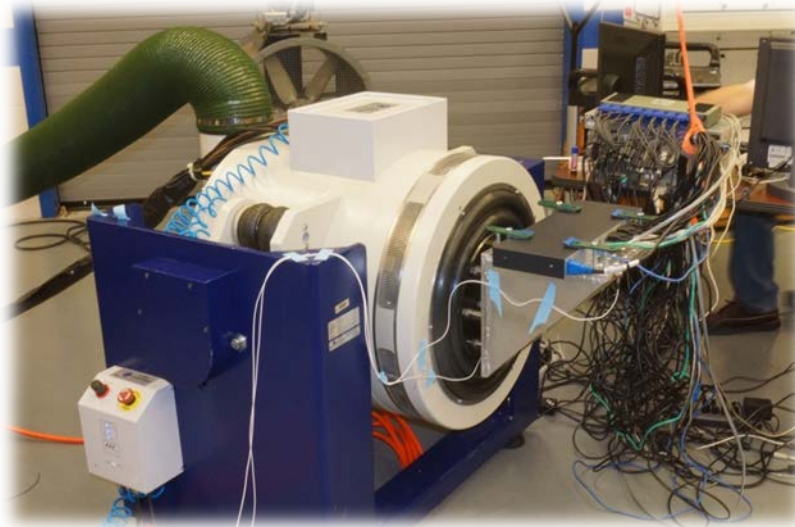


DYNAMIC VIBRATION SYSTEM

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.

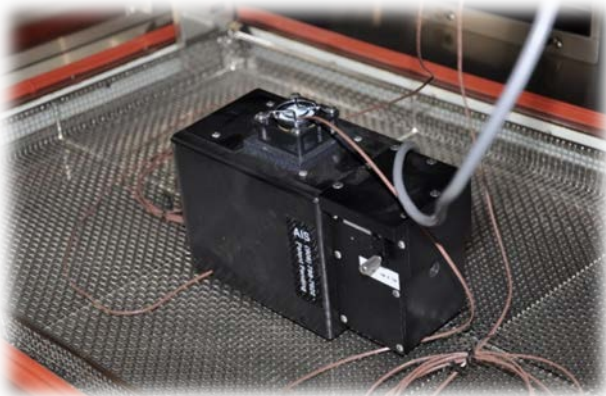


THERMAL SHOCK

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.



CYCLIC CORROSION TEST CHAMBER

Manufacturer: Ascott

Type/Model: CC1000xp

Chamber Capacity: 1000 Liters/35.3 cu ft

Condensation humidity mode:

- **Temperature Range:** Adjustable from ambient to +50°C/+122°F
- **Humidity Range:** Fixed at 95% - 100% RH

Salt spray mode:

- **Temperature Range:** Adjustable from ambient to +50°C/+122°F
- **Salt fog fall-out rate:** Adjustable from 0.5 to 3.0ml per 80cm² per hr

Air drying mode:

- **Temperature Range:** Adjustable from ambient to +70°C/+158°F
- **Humidity Range:** Uncontrolled

Applications:

- ASTM D2247 Condensation Humidity Specification
- ASTM D1735 Water Fog Humidity Specification
- ASTM B117 Salt Spray/Mist/Fog
- ASTM B287 Salt Spray/Mist/Fog
- ASTM B368 Salt Spray/Mist/Fog
- ASTM G43 Salt Spray/Mist/Fog
- ASTM G85 Annex A1-A5 Salt Spray/Mist/Fog
- ASTM G5894 Salt Spray/Mist/Fog
- SAE J 2334 Cyclic Corrosion Test Specification
- **NOTE: THESE ARE THE US SPECIFICATIONS ONLY BUT THE EQUIPMENT IS ABLE TO PERFORM OTHERS**



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 orthopedic 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.



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

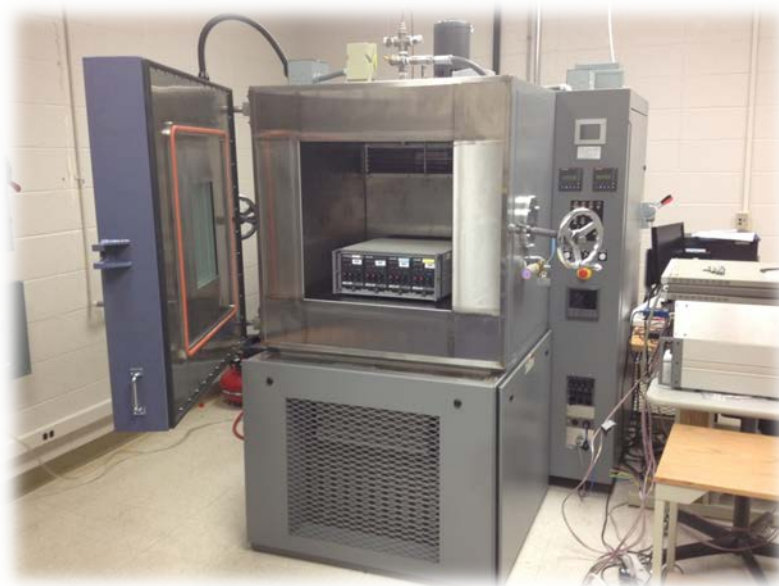
Humidity Range: 20%RH to 95%RH +/-5% (Non Altitude Mode); Greater than 20% uncontrollable in Altitude Mode below 5,000 feet

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

These environmental chambers are 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

Manufacturer: ESPEC

Type/Model: ESL-2CA

Working Envelope: 19.7" W x 23.6" D x 29.5" H

Operating Temperature: -35°C to 150°C (-31°F to 302°F)

Humidity Range: 10%RH to 98%RH



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 FURNACE

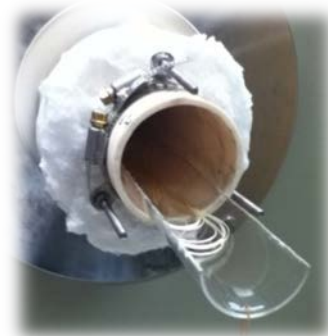
Manufacturer: Sentro Tech Corporation

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.

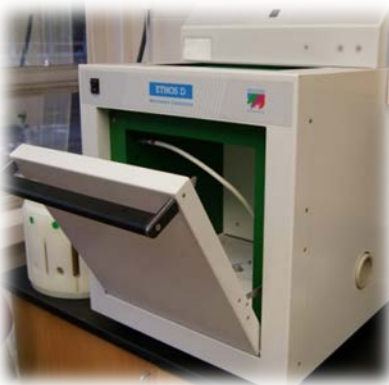
MICROWAVE DIGESTION LABSTATION

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: 1×10^{-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:	1.0×10^{-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.



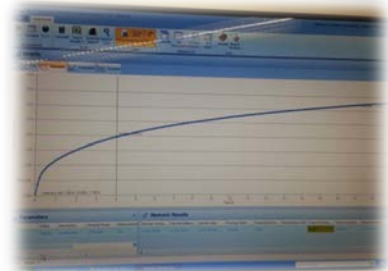
THERMAL CONSTANTS ANALYZER

Manufacturer:	HotDisk
Type/Model:	TPS 2500 S
Thermal Conductivity:	0.005 to 1200 W/mK
Thermal Diffusivity:	0.1 to 700 mm ² /s
Measurement Time:	1 to 1280 seconds
Reproducibility:	Typically better than 1%
Accuracy:	Better than 5%
Temperature Range:	-253°C to 1000°C



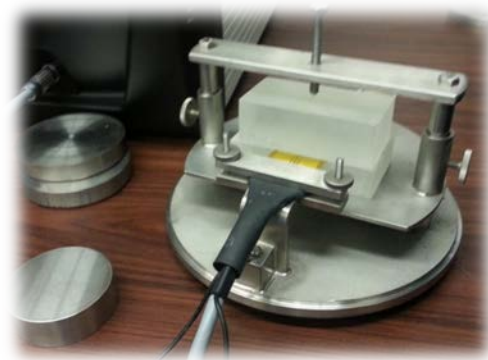
Additional Software Module: Anisotropic

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

Measurement Type: B & C



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.



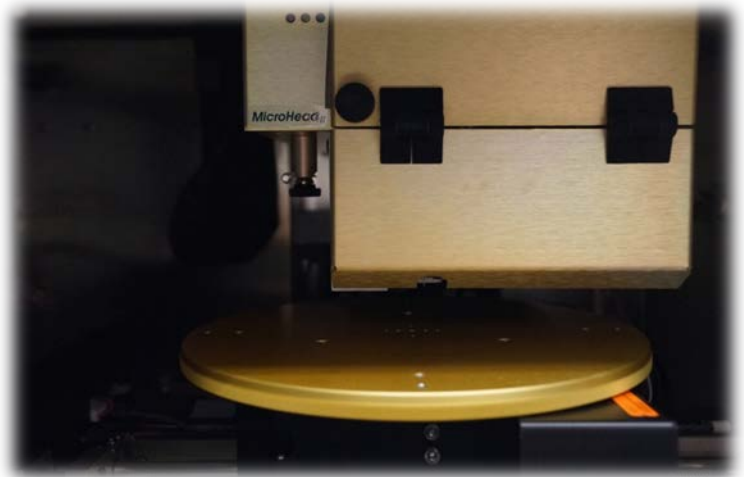
SURFACE PROFILER - PROFILOMETER

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 g_{pk}

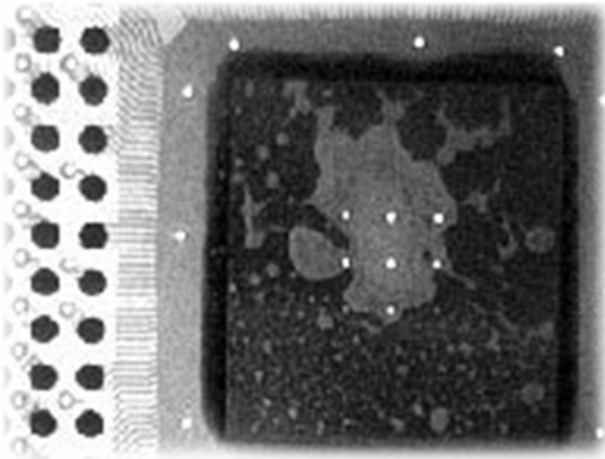


The accelerometer calibration station is an important tool used to verify the accuracy of piezoelectric accelerometers. Piezoelectric transducers create a voltage output when stress is applied to the material. The voltage output is read and filtered by a computer to translate accelerometer output into 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.

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.



A2R SUPPORT CAPABILITIES

OPTICAL 3D-SCANNING SYSTEM

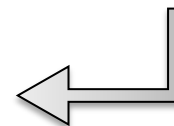
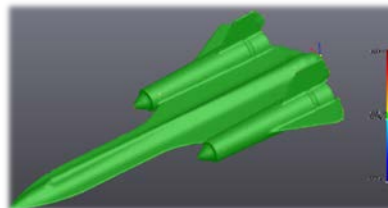
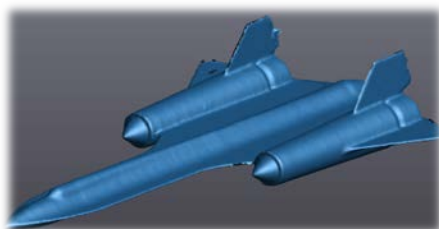
Manufacturer:	Creaform
Type/Model:	MetraSCAN 3D 750 Elite, C-Track
Resolution:	0.050mm (0.002inches)
Accuracy:	0.030mm (0.0012inches)
Measurement Rate:	480,000 measurements/second



The MetraSCAN 3D 750 Elite and C-Track make up a portable 3D laser scanning system that offers complete reverse engineering and inspection solutions. The system uses a tracker (C-Track) to reference fixed target points on and around the part while the scanner (MetraSCAN) simultaneously detects the deformation of its laser grid on the part. Creaform's software (VXelements) generates a live mesh output that is ready to use immediately after the scan is complete.

Workflow:

- Capture 3D mesh data of part
 - Can scan parts with dimensions as small as 0.002 inches with an accuracy of 0.0012 inches
- Constrain mesh data
 - Normal and 3D measurements can be taken immediately upon scan data acquisition
- Reverse-engineer a 3D CAD model
- Inspection: Import CAD model into VXelements and compare to original scan data
 - Can also compare a production CAD model to scan data



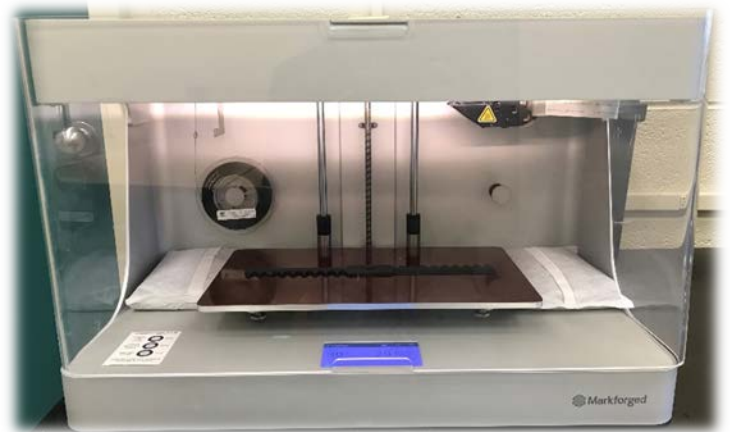
FIBER-REINFORCED 3D PRINTER

Manufacturer: Markforged

Type/Model: Mark Two Desktop 3D Printer

Build Volume: 320mm x 132mm x 154mm
(12.5" x 5.1" x 6")

Z Layer Resolution: 0.1mm (0.004inches)



The Mark Two is an industrial-grade 3D printer capable of printing high-performance composite parts as strong as aluminum. In addition to printing plastic (nylon with shredded carbon fiber), it can also print parts with composite fiber, adding strength, stiffness, and durability to parts which are ready to use straight off the print bed.

Printing Materials:

Plastic

- Onyx

Fiber:

- Carbon Fiber
- Kevlar
- Fiberglass
- High-Strength/High-Temperature Fiberglass



RC BENCHMARK THRUST STAND

Manufacturer: RC Benchmark

Type/Model: Series 1580

Max Propeller Size: 12 inch

Design Specifications of Measured Properties:

Specification	Min.	Max.	Tolerance	Unit
Thrust	-5	5	0.5%	kgf
Torque	-1.5	1.5	0.5%	Nm
Voltage	0	35	0.5%	V
Current	0	40	1%	A
Angular speed*	0	190k	1	eRPM
Coil resistance	0.003	240	0.5%	Ohm
Digital scale	0	3	0.5%	kgf

*Electrical RPM, divide by the number of motor poles to obtain true mechanical RPM.



The RC Benchmark software produces real-time graphs of motor performance during testing, enables manual motor control, has self-calibration capability, and allows export of test data in CSV format. The software comes with several automated test formats to include ramp and step tests, and it allows for user-scripted tests. All tests are done using a power supply in order to eliminate testing errors due to battery voltage drops.

A2R-DESIGNED THRUST STAND

Manufacturer: A2R

Type/Model: N/A

Max Propeller Size: 20 inch

The A2R-designed thrust stand allows testing of up to 20-inch propellers and can measure up to 25 kg of thrust. The Arduino-based measurement hardware and firmware provides custom scripting of tests, measure of thrust, voltage, and current. All tests are done using a power supply in order to eliminate testing errors due to battery voltage drops.

