SOUTHERN RESEARCH ENGINEERING

Capabilities Briefing

2010
Engineeering Division

- Advanced Materials Research and Characterization
- Electromechanical Systems Design and integration
- Environment and Energy Research

132 Engineering Employees

- BS
- MS
- PhD
- Technical Support

- 4 Locations in Alabama
  - Birmingham (2), Huntsville, and Wilsonville
  - Durham, North Carolina
Systems Development Department
Electro-Mechanical Systems

- Design, Modeling, Fabrication, Integration, Test and LRIP Production Capabilities
- Stabilized Platforms
  - EO/IR Seekers
  - Scanning Mirror Assemblies
  - Gimbals--- 5” to 33”; 2, 3, or 4 axes
- Servo Controller Electronics Design
Imaging Systems and Targeting

- Visible and IR image processing
- Real-time contrast enhancement
- Cueing
- Video trackers
  - VME-based CCAs
  - PC-based
  - HDTV Video Tracker
- Inertial pointing and target geo-location extraction
Systems Integration - pods

• Aircraft integration
  – Experience on multiple platforms
  – Fixed/rotary wing
  – Low-speed/supersonic
  – Turnkey systems
  – User-configurable payloads

• Sensor Integration
  – Mechanical Packaging
  – Electronics Development/Support
Systems Integration – Large Multi-axis Turrets

- Multi-sensors compatibility
- Readily configured for various payloads
- Large collection apertures
- Longer focal length lens capability
**Airborne Imaging and Recording System (AIRS)**

- System design and development
- Pre/post mission support
- New sensor package development
- Can be used for persistent surveillance
- Geo-location extraction
WB57
Various Payloads for AIRS

WAVE

Tsunami

WAVE II

NEHI-ORANGE

NCAM

ATOMMS
Sample Imagery 50K’ Alt.
Sample Imagery 50K’ Alt.
Mechanics and Materials Research
Mechanical, Thermal, and Physical Properties Characterization

- Mechanical and Subscale Structural Testing
  - Cryo (-260°C) to Elevated (3030°C) Temps

- Thermal Properties and Analysis Testing
  - Cryo (-260°C) to Elevated (3030°C) Temps

- Physical Properties
  - Permeability, Porosity, Chemistry, Microscopy, Moisture Properties, Density, etc.

- Non-Destructive Evaluation
  - Radiography, CT, Ultrasonics, Resistivity, Eddy Current
Mechanics and Materials Research

- Missile Defense
- Aero Propulsion
- Composite Flight Hardware
- Test Technology Development
Mechanics and Materials Research

- Hypersonic Vehicles - Prompt Global Strike
  - Ground testing
  - Material characterization
  - Aero-Thermal modeling

- NASA’s Heavy Lift Programs
  - Builds on our Shuttle program legacy
  - Advanced propulsion and heatshield materials
Ground Testing for Hypersonics

- Supports AF, Navy and Army in Ground Test Evaluations of Candidate Materials and Shapes

- Thermal Protection Materials Ground Test Experience / Improvements AEDC arcs HEAT-HR, -H1, -H2, -H3
  - AEDC Tunnels A, B, 9 and DET
  - AEDC Ballistic Range
  - NASA-Ames IHF and AHF Arcs
  - Boeing LCAT Arc
  - USAF LHMEL Laser

- Post-Test Analyses
  - define sample boundary conditions
  - evaluate material ablative/thermal performance
Strain Field Visualization

• Non-contact method of measuring shape & strain on surface of material
• Obtain strain distribution instead of only single value
• Visualize how strain changes with increased load, temperature, etc.
Hypersonic Vehicles
Large Structures Testing

• Facilities
  – 10’x10’x12’ high load frame
  – multi-axis servo-hydraulic
  – 100+ channels data acquisition

• Test Engineering
  – SLT planning and coordination
  – Test fixture design and fabrication
  – Specimen prep and instrumentation
  – Data reduction and reporting
Environment and Energy
Environment and Energy
North Carolina Overview

• Established in 1991
• ~50 Staff
  – Engineers (BS to PhD)
  – Scientists and chemists
  – Technicians & mechanics
  – Administrative staff

• Facilities
  – 42,000 ft² of office, R&D prototyping, & lab space
  – Technology field deployment/performance verification teams and equipment

• Clients
  – Industry, government, technology implementers & developers
Environment and Energy - North Carolina

• Technology Development & Deployment Support
  – Prototype & pilot advanced energy & fuel mfg. technology
  – Manage commercial demo's of energy & transport technologies
  – 3rd party performance testing
  – Technical feasibility assessment
  – Assessment of technology deployment strategies

• Industries and Technology Areas
  – Advanced energy and transportation devices: bioenergy, biofuels, waste-to-energy, distributed power, co-gen...
  – Fossil fuel production and distribution: coal, oil, gas
  – Greenhouse gas mitigation, criteria pollutant mitigation
Recent Energy Technology Research & Development Efforts

- Biomass to clean diesel, alcohol, or sugar using two biorefinery pilot plants (thermochemical, hydrolysis)
- New biomass/coal feeder for advanced power production facilities
- Advanced hot syngas cleaning reactor for biomass
- CO$_2$ & MSW to with gasification
Clean Energy Technology Development Center *(Durham, NC)*
Recent Small-Scale Technology Deployment Efforts

- Five different fuel cells: a private home, two commercial sites, two waste sites
- New fuels and additives for mine vehicles and locomotives
- Two farm manure waste-to-energy systems coupled to microturbines & advanced engines
- Geothermal water heater at a commercial businesses
- Zero emission natural gas wellhead gas sweetening unit
Recent Moderate-Scale Technology Deployment Efforts

• Project Description
  – Plan for and install a system to capture and utilize extremely low energy landfill methane gas to produce power, eliminate flaring and reduce emissions
  – Perform independent third party performance verification of the integrated system (technology and economic performance)
  – Client: DoD, Fort Benning, GA

• Technology Description
  – Flex-Microturbine®, a unique power plant that generates electricity from gases with heat contents of 15 BTU per cubic foot.
Recent Moderate-Scale Technology Deployment Efforts

• Project Description
  - Plan for and install a solar driven chiller to provide cooling and hot water for a food service operation
  - Perform independent third party performance verification of the integrated system (technology and economic performance)
  - Client: DoD, Parris Island, SC

• Technology Description
  - Integrated hot water solar panels and high efficiency adsorption chiller system
NYSERDA Clean Diesel Technology
Field Demonstration Program

- Provide assessments of the *in-use performance* of commercially available *diesel retrofit control technologies* to expand energy-efficient diesel emission control technology options for off-road applications in New York State.
Environment and Energy – Alabama Operations

Power Systems Research Group
- Combustion Research Facility and Lab-Scale Gasifier
- Catalyst Test Facility & Development Lab
- Fossil Fuels, Biomass, and Flyash Analyses

Environmental Services Group
- Precipitator, Baghouse, Scrubber Evaluations
- SCR Studies, Analytical Services, Electrical Resistivity
- Water/Wastewater Analysis and Remediation

National Carbon Capture Center (Wilsonville)
- CO₂ Capture Research (Pre- and Post-Combustion)
- Hot-Gas Cleanup Research
- On-Site Analytical Support
Biomass Testing for Co-Firing and Coal Replacement

- New and potential regulations have increased interests in biomass for power generation.
- Canadian utilities required to convert from coal to 100% biomass or shut down plants.
- Ability to store, mill, and burn fuel and control alkali metals are critical issues being addressed.
- Projects with EPRI, OPG, Vendors, and other utilities.
Oxy-Firing for CO₂ Mitigation

- Retrofit for existing coal-fixed power stations
- Minimized capital expenditure
- Staged-oxygen burners – moderate heat release, provide stable flame, and reduce NO

- Oxygen Introduced at burner
- Pure CO₂ in exhaust stream
- CO₂ – sequestration technologies

MAXON Corporation Oxy-Burner with flue-gas recycle at Southern Research

Flue-gas recycle loop
Capabilities with Sorbents and Catalysts

• Sorbent/Catalyst Development
  — Grinding, solution preparation, precipitation, precipitate recovery, and drying
  — Activate catalysts by reduction in H₂, CO, etc
  — Spray dryer for small-pilot-scale production

• Sorbent/Catalyst Characterization
  — PSD, surface area, porosity, pore-size distribution
  — SEM/EDX
  — TGA, DSC, and DTA for studies of reactivity
  — Hot-stage, environmental SEM to observe reactions on and in particles

• Sorbent/Catalyst Evaluation
  — Reactivity studies with controllable synthetic gas mixtures
  — Real-time gas analysis by GCMS/FTIR/GC
  — Injection of sulfur compounds, halides, and trace metals to study poisoning
Environmental Field Services

• Field evaluation of NO\textsubscript{x} control, Hg oxidation, and SO\textsubscript{3} formation.
  — Effect of SCR on mercury oxidation.
  — SO\textsubscript{3} formation in boilers.
  — Long-term baghouse monitoring program.

• Highly-regarded studies of fly ash properties.
  — First demonstration of method for recreating particle-size distributions.

• Unique capabilities in scrubber mist eliminator evaluation using SRI-developed video droplet analyzer.
Vapor-Phase Mercury Measurement

QSISTM Probe and Gas Conditioning System

Mercury Monitor and Spike Source
Water & Wastewater Treatment

Remediation Steps

1. Determination of the chemical and physical constituents in effluents.
2. Determination of problematic constituents.
3. Remediation strategies for the identified problematic constituents.
   - Bench, Bucket, Pilot and Full-scale testing
Water & Wastewater Treatment

Capabilities at Southern Research

• Remediation of Problematic Constituents
  – Selenium
  – Mercury
  – Arsenic
  – Nitrogen forms
  – Biochemical oxygen demand

• Analytical Methods
  – Total inorganic analyses (ICP-ORS-MS)
  – Speciation of Selenium and Mercury
  – Water Chemistry Parameters
Backup Slides
Materials Characterization

- Materials Characterization is the core technology of Southern Research Engineering Division
- Key technical developments date to mid 1950’s
  - Gas Bearing Tensile (IR100)
  - 5500°F (3030°C) furnace for general use
  - 6500°F (3590°C) furnace for special applications
- Developments driven by high temperature, brittle material applications
  - Reentry
  - Planetary reentry
  - Nuclear
  - Launch Vehicles
  - Aeropropulsion
Mechanical Property Measurements

- Full Range of Properties
  - Tension
  - Compression
  - Shear
  - Shear
  - Fatigue
  - Fatigue
  - Creep
- Cryogenic to 5500° F
- Inert, Air, Environmental Conditioning etc.
- >40 Facilities,
- Hundreds of Set-ups
  - Extensive experience in testing composites, brittle materials and other materials with unusual behaviors
  - Development of tests techniques appropriate for these materials and environments
Mechanical Property Measurements

- **Specialized Testing Capabilities**
  - Gas Bearing Tension, Compression and Torsion (to 5500°F)
  - Cryogenic Tension and Compression (-440° in Dev.)
  - High Temperature Ring Tests (to 5000°F)
    - Tension
    - Compression
  - Oxidative Fatigue (Cryogenic to 3000°+)
  - Yarn/Fiber/Wire Tensile/Creep tests (to 5500°F)
  - Microyield (f/°T)
  - Tensile/Compressive Creep in Air (to 3000°F)
  - Thermal Stress Testing
  - Biaxial Flexure and Torsion
  - Restrained Thermal Growth (coupon and ring)
  - Rail, Saddle and Iosepescu shear
Thermal Property Measurements

- **Thermal Conductivity Testing**
  - Comparative Rod Apparatus - Cryo to 2000° F
  - Radial Inflow Apparatus - 1500 to 5000° F
  - Pulse Laser Thermal Diffusivity - RT to 3000° F
  - Modified C-177 Guarded Hot Plate

- **Thermal Analysis Testing**
  - Nietze 404 DSC - RT to 2600°
  - Adiabatic Calorimetry
  - Ice Calorimetry
  - TA DSC
  - TA DMA
  - TA TGA
  - SRI TGA - RT to 2000° (3600°/min), O₂, Multi - gm samples
Thermal Property Measurement Capabilities

Specialized Testing Capabilities

- Cryocoolers for cryogenic properties
- Thermal conductivity under load.
- **Vacuum thermal response measurements**

ATMOSPHERIC PRESSURE TO VACUUM
TEMPERATURE OVER 3000 DEGREES (4500)
Thermal Property Measurements

- Thermal Expansion Facilities
  - NIST Quartz Dilatometers (Cryo to 1800° F)
  - Horizontal Quartz Dilatometers (Cryo to 1800° F)
  - Graphite Dilatometers (RT to 5000° F)
  - Optical Thermal Expansion (RT to 5000° F)
  - Precision Thermal Expansion (20 K to 400 K)
  - Ring Thermal Expansion (RT to 5000° F)

- Analog
  - Simulation Facility
  - LHMEL (USAF)
  - Quartz Lamps
  - Oxyacetylene Torch

- Total Normal Emmissivity
Thermal Property Measurements

- Thermal Properties Testing
  (-440° F to 5500° F)
  - Thermal Conductivity
  - Thermal Diffusivity
  - Thermal Expansion
  - Specific Heat
- Thermal Analysis Testing
  - TGA
  - DSC
- Analog Facilities
- Thermal-optical
- Physical
- Mass Flow
Radiant Facility II

- Infrared heat source by Research, Inc.
- Up to 12 x 9” heated area
- Up to fifteen 2000 W / 240 V bulbs
- Water-cooled, polished aluminum reflector
- Capable of temperature or flux control
- Data logging with Agilent 34970A and Labview
- Horizontal
New Ultrasonic Spectroscopy Technique

- Rapidly Swept Wave
- Entire Waveform Digitized
- FFT of Sweep Gives Flat Spectrum
- Bandwidth and Amplitude User Defined

![Graph showing Normalized Input Spectrum for 0.5 to 2.25 MHz]

Normalized Input Spectrum for 0.5 to 2.25 MHz Compared to Traditional Broadband Input Spectrum

Ultrasonic Spectroscopy Modes of Interaction

- Attenuation as a Function of Frequency
- Dispersion/Defect Interaction
- Resonance
Other Measurement Capabilities

- **Permeability**
  - Ambient to 3500° F
  - High Pressure (incl. H₂)
  - Effect of loads

- **Porosity**
  - Hg porosimetry
  - He Pycnometry
  - Liquid Absorption

- **Microscopy**
  - SEM
  - Optical

- **Chemistry**
  - Resin Content
  - Wet chemistry as required
Non-destructive Characterization

- Radiography
  - Collimated
- Computed tomography
- Ultrasonics
  - Velocity
  - Pulse echo
  - Attenuation
- Electrical resistivity
- Eddy current
- Metrology

- Defect detection
- Material identification
- Material fingerprinting
- Physical properties
Precision Metrology

- **Ordered Scanner**
  - Measures Z height along an X-Y grid
  - Specular & Diffuse
  - Multiple systems some using confocal and some triangulation
  - 2 mil accuracy

- **Portable CMM**
  - 8 foot Ø measurement volume
  - 1 mil accuracy with hard point probe
  - 3 mil accuracy with laser line scanner