Research at Missouri S&T

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Grants and Contracts History

FY11 Sponsored Awards by Source (Total Amount: $43.2M)

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
<th>FY11 Amount</th>
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<td>DOD</td>
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<td>NSF</td>
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<td>$6.1M</td>
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<td>US DOT</td>
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<td>$5.2M</td>
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<tr>
<td>DOE</td>
<td>9%</td>
<td>$3.9M</td>
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<tr>
<td>ED</td>
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<td>Industry</td>
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<td>DHHS</td>
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<td>NRC</td>
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<tr>
<td>Other Fed</td>
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<tr>
<td>Other</td>
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<tr>
<td>DOC</td>
<td>3%</td>
<td>$1.3M</td>
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</table>

Expenditures:
- FY01: $22.19M
- FY02: $26.53M
- FY03: $28.90M
- FY04: $34.81M
- FY05: $34.76M
- FY06: $36.26M
- FY07: $32.27M
- FY08: $37.70M
- FY09: $38.08M
- FY10: $44.69M
- FY11: $45.88M
Missouri S&T Core Research Strengths
State-Supported Centers
- Center for Bone and Tissue Repair and Regeneration
- Center for Infrastructure Engineering Studies
- Cloud and Aerosol Sciences Laboratory
- Energy Research & Development Center
- Environmental Research Center for Emerging Contaminants
- Intelligent Systems Center
- Materials Research Center
- Rock Mechanics and Explosives Research Center

Externally-Funded Centers
- Center of Excellence on Aerospace Propulsion Particulate Emissions Reduction Research
- NSF Engineering Research Center on Future Renewable Electric Energy Delivery and Management Systems (NC State University - Lead)
- NSF Industry/University Cooperative Research Centers
  - High Energy Dielectrics
  - Intelligent Maintenance Systems
  - Electromagnetic Compatibility
  - Net-Centric Systems
- US DOT National University Transportation Center

Industrial Consortium
- Center for Aerospace Manufacturing Technologies (CAMT) Industrial Consortium
GOAL
• Develop long-term partnerships among industry and government in the area of Monitoring, Diagnostics and Prognostics

OBJECTIVES
• Simulate highly leveraged industry/university cooperation by focusing on fundamental research recommended by Industrial Advisory Boards
• Develop strong industrial support of and collaboration of research and education
• Direct transfer of university developed ideas, research results, experience and technology to US industry
• Provide next generation scientists and engineers with a broad industrial oriented perspective on engineering research and practice

MEMBERSHIP LEVELS AND BENEFITS
Membership Levels: 40K/year for Full Member; 11K/year for Associate Members (< 500 employees)

- Members can greatly leverage their internal R&D resources by joining the Center.
- University will cost share all indirect costs associated with the membership funds.
- Near-zero maintenance technology can result in significant cost savings

Missouri S&T CORE COMPETENCIES
(1) Sensing and Monitoring
  - Sensing Techniques
  - Wireless Sensor Networking (Missouri S&T Mote)
  - System on a Chip

(2) Diagnostics and Prognostics
  - Data Fusion
  - Neural Networks
  - Fuzzy Logic
  - Intelligent Agents

(3) Advanced Simulation
  - Virtual Reality
  - Virtual Prototyping

IMS Center Sites: University of Cincinnati, University of Michigan and Missouri S&T
Missouri S&T Industry Members: Boeing, Caterpillar, Chevron, Festo, Honeywell and 21st Century Systems
Compressor Stiction and Valve Failure Prognostics

CONCLUSIONS
• Our method uses only temperature and pressure signatures to detect stiction on valve plate
• Developed method using wavelet transform and logistic regression detects stiction condition with 98.2% accuracy
• The proposed NN model that is trained with hybrid PSO-EA dynamically predicts trend of valve performance and time to failure at 2 hr horizon

MOTIVATION
• Maintenance costs of reciprocating compressors are 3 time higher than centrifugal compressors
• Unscheduled compressor shutdown can cost $0.1M/day
• Prediction of failure allows to reduce cost of periodic, preventive maintenance of compressors
• Stiction and spring degradation are the predominant causes for valve plate failures (70% of maintenance activity on typical compressors)

OBJECTIVES
• Develop a maintenance method for compressors to:
  o Assess and predict performance degradation of a compressor; and
  o Optimize the compressor’s performance by monitoring the performance of individual components.

RESULTS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Total Number of trials tested</td>
<td>2000</td>
</tr>
<tr>
<td>False Positives</td>
<td>1.3%</td>
</tr>
<tr>
<td>False Negatives</td>
<td>0.5%</td>
</tr>
<tr>
<td>Correct classifications</td>
<td>98.2%</td>
</tr>
</tbody>
</table>

COLLABORATION
NSF, Festo, Boeing, Caterpillar, Chevron

HARDWARE
• Compressor testbed equipped with typical set of sensors

CONCLUSIONS
• Our method uses only temperature and pressure signatures to detect stiction on valve plate
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Center for Aerospace Manufacturing Technologies
(POC: Dr. M. Leu)

**About the Center**
The Center for Aerospace Manufacturing Technologies (CAMT) was established in May 2004 at the University of Missouri-Rolla (UMR) with major funding from the Air Force Research Laboratories.

CAMT is a joint venture of UMR, Boeing Phantom Works, and the Air Force Research Laboratories.

CAMT has ten research thrust areas, each led by an UMR faculty member in coordination with Boeing and AFRL faculty.

CAMT involves 30 faculty members and more than 50 graduate and undergraduate students and post-doctoral researchers at UMR.

**Mission**
CAMT is created to serve as a national center of excellence for research, development, evaluation, demonstration, and transfer of new and optimal methodologies and tools for the rapid and cost-effective manufacture of aerospace components and products.

**Objectives**
- Research, develop, evaluate, demonstrate and transfer advanced technologies of critical importance to the Air Force and the aerospace supply chain in the United States.
- Create knowledge, methodologies and tools to improve affordability, rapidity, quality, productivity, reliability, and safety in aerospace manufacturing.
- Disseminate the generated results to the aerospace supply chain through direct technology transfer as well as education, training and outreach activities.
- Serve as a role model of university-industry-government collaborative relationship.

**Advanced Simulation**
Objectives:
1. To develop shop floor level auto-ID solutions to build better products and to demonstrate the effectiveness of these solutions using hardware-in-the-loop simulation models.
2. To develop a dynamic computer simulation of the manual installation of fasteners and to demonstrate the potential improvements in joint design, manufacturability, productivity, and worker safety.

**Rapid Prototyping**
Objectives:
1. To develop and demonstrate the ability to manufacture near-net-shaped high performance ceramic parts utilizing enabling technologies without tooling and with minimum post-processing.
2. To develop and evaluate the UMR laser deposition model over a range of geometries, alloy types, and laser types to predict and demonstrate the deposition parameters.

**Non-Destructive Evaluation**
Objectives:
1. To develop efficient and reliable methods for detecting cracks under thick boron repair patches and weak bonds using microwave and ultrasonic techniques.
2. To develop a multi-modal approach for detecting corrosion under paint and in lap joints using diffusion of eddy current and microwave techniques.

**High Speed Machining**
Objective: To extend the knowledge base in the practice of machining Titanium and in characterizing mechanical properties of machined Titanium.

**Laser Materials Processing**
Objective: To use a Femtosecond Laser to precision machine microscale structures, to develop multiscale quantum models to fundamentally understand the governing physics, and to optimize key process parameters.

**Abrasive Slurry Cutting**
Objectives:
1. To establish the ability to meet specifications in linear cutting and hole drilling and to demonstrate commercial and technical viability and value.
2. To optimize tool parameters and cost benefits for abrasive waterjet milling.

**Non-Chrome Coatings**
Objective: To develop a non-chrome conversion coating on aluminum alloys that works with the existing non-chrome primer technology.

**Friction Stir Processing**
Objectives:
1. To define Friction Stir Welding process parameters to produce defect free aluminum lap and T-joints in the presence of gaps and mismatches.
2. To prevent corrosion of lap joint welds by the sealing of forming surfaces to prevent crevice corrosion and by the determination of process windows to minimize galvanic potential differences between base metal, HAZ, and weld nugget.

**Composites Manufacturing**
Objective: To improve and expand the Vacuum Assisted Resin Transfer Molding process to manufacture high performance composite parts.

**Electronic Materials Processing**
Objectives:
1. To provide a detailed study on the impact of switching to lead-free solders to meet environmental regulations.
2. To investigate methods for improving prediction of the intra-system coupling using Electromagnetic Compatibility (EMC) analysis in a moderately complex arrangement as a basis for expansion to more complex systems.
3. To develop composites based on dielectric and/or magnetic functionality for eye protection systems against laser threats.

http://campus.mst.edu/camt/
Present Members of CAMT Industrial Consortium

Gold Member  ($200,000 Annual Fee)

Full Member  ($50,000 Annual Fee)

Assoc. Member  ($15,000 Annual Fee)
Additive Manufacturing

- Tool-less, light-out process because the process is fully automated and there is no need for fixtures
- Make 3-D parts with complex geometries and any desired features (cooling channels, lattice structures, etc.)
- Easily incorporate composite and functionally gradient materials to achieve properties that are not possible with conventional processes
- Significantly reduce time and cost in producing small-quantity and individualized parts

Diagram:
- Laser
- Powder Feeder
- Nozzle
- Metal Removal
- 5-axis CNC table
- Metal Deposition
- After Material Deposition
- After Machining
Hydrokinetic Energy

Hydrokinetic Energy Potential in Missouri

ISSUED HYDROKINETIC PRELIMINARY PERMITS

OBJECTIVE

• Develop cost-effective and reliable prototype hydrokinetic energy systems for rivers using a comprehensive systems approach
• Proof-of-concept demonstration of a composite turbine blade that can acquire and transmit data about its structural health

TECHNICAL APPROACH

System Analysis
• Anatomical analysis of alternative energy systems
• Materials and processes linkage layout
• Development of a repository of concepts and theoretical analyses

Performance-Cost Analysis
• Design optimization at system level
• Pros-cons analysis of advanced materials use

Technology Demonstrator
• Design of set of technology demonstrators
• Prototype fabrication and technology transfer

• Manufacturing of prototype systems – 1-10 kW range

BUSINESS DETAILS

• Funding: Office of Naval Research ($1.96M) and Department of Energy ($200K)
• Duration of Project: 8/10 – 8/12
• Principal Investigators: K. Chandrashekhara, Arindam Banerjee, Jonathan Kimball, Xiaoping Du, Joshua Rovey

BROADER IMPACTS

• Development of a systems approach to alternative energy systems and an engine for innovation in an area of critical national need
Geomechanical Simulation of CO₂ Leakage and Cap Rock Remediation

**BUSINESS DETAILS**
- Funding: Department of Energy
- Award: $917,604
- Duration of Project: 10/2009 – 10/2012
- Principal Investigators: Runar Nygaard, Baojun Bai, Andreas Eckert

**COLLABORATION**
City Utilities of Springfield

**OBJECTIVE**
- Locate CO₂ leakage from subsurface injection
- Simulate cap rock leakage probability and rates
- Develop leakage remediation methods

**TECHNICAL APPROACH**
- Create a shared mechanical earth model of City Utilities of Springfield shallow CO2 sequestration demonstration site
- Perform coupled 3D reservoir and multi scale geomechanical modeling of leakage risk and rates
- Develop fracture leakage remediation methods for sealing fractures and faults

**FAULT STABILITY ANALYSIS**
Due to CO₂ injection the reservoir pore pressure will increase and pre-existing fracture sets are likely to be reactivated and act as fluid leakage pathways.

**BROADER IMPACTS**
- Increase the ability to identify risk of leakage from CO₂ sequestration projects.
- Develop new numerical simulation methods to identify rates and location where leakage can occur
- Develop new materials to seal of fracture leakage in cap rocks
BUSINESS DETAILS

- Funding: NSF - $500,000, CAMT/AFRL - $900,000
- Duration of Project: 09/2007 - 08/2008
- Principal Investigators: F. Scott Miller, Jay Switzer, Hai-Lung Tsai, Melanie Mormile, Matt O'Keefe

SCOPE

- The research mission of Missouri S&T will be enhanced in the following areas:
  - High resolution imaging - images of sample surfaces to 1,000,000X with resolution of 1 nanometer
  - Cross-sectioning - remove surface layers to reveal structures below, or to provide cross-sectional views of layered specimens
  - Rapid TEM specimen preparation
  - Three dimensional reconstructions at nanometer resolutions by serial sectioning and imaging

BROADER IMPACTS

- This instrument is the only dualbeam FIB/SEM in the state, so the opportunities for collaborations with universities, government agencies and industrial partners in the state of Missouri and surrounding areas have been greatly enhanced.
Technology Transfer

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<tr>
<th>Year</th>
<th>Invention Disclosures</th>
<th>Patents Filed</th>
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WARNING

ABOUT

PICTURES
Bioactive Glass Fiber

Licensed to MO-Sci as Derma-Fuse (Humans)

Use as Wound Care/Healing agent

Licensed to Redi-Glass as Redi-Heal (Animals)

Dog bite Laceration

6.6cm L x 7.5cm W x 2.5cm D

6.0cm x 6.75cm x 1.5cm

~50% decrease in volume

Resolved
Pro-Perma Engineered Coatings LLC

- Ceramic Coated Re-bars
  - Self-healing ceramic enamel coating for rebar which provides excellent corrosion resistance
  - Improves bond strength between rebar and concrete resulting in less rebar needed
  - Stronger more blast resistant structures
  - Market size currently estimate at $4B

- Licensed technology developed by Dick Brow and Genda Chen

- Improvement developed at Missouri S&T to be licensed to Pro-Perma
Innovation Park

Technology Development Center
Technology Development Center
@ Innovation Park

Collaborate, Research, Develop, Grow
• 18,000 sg ft Class A office building
• Office suites from 6,000 to 150 sq ft
• Open Collaboration space
• LEED* silver designation (Pending)
  Leadership in Energy & Environmental Design (LEED) is an internationally recognized green building certification system

Existing Tenants
• MOEDGE
• Marxkos – Attorney at Law
• Missouri Enterprise
• Rolla Regional Economic Commission
• M2 Wave Technologies
• IST Rolla

Clients under discussion
• Environmental
• Software
• Energy company
• Health Care training
How Can Industry Connect with S&T to do Research?

• Membership Agreement - join one of the consortia
• Research Agreement - sponsor a research project of mutual interest and benefit
• Fee for Service Agreement – access specialized facilities
• Teaming Agreement - collaborate with S&T to jointly pursue federal funding opportunities
• Strategic Partnership - all of the above
What are the Steps to Sponsor a Research Project?

- Identify research problem by company
- Connect faculty and company technical POC
  - Faculty expertise database (see http://www.mst.edu/research/index.html)
  - Host company team on campus for initial discussion
- Jointly develop Statement of Work and budget
- Negotiate terms and conditions of contract – S&T Office of Sponsored Programs and company contracting office
- Execute contract – VP Research signs on behalf of the University
Missouri S&T … serving the needs of the State of Missouri and the nation since 1870!