

Local AIAA Saint Louis Section University Research Program Emphasis Relating to Aerospace

The content in this article is from a set of presentations that these universities made to our AIAA section on February 8, 2022.

Missouri Science & Technology

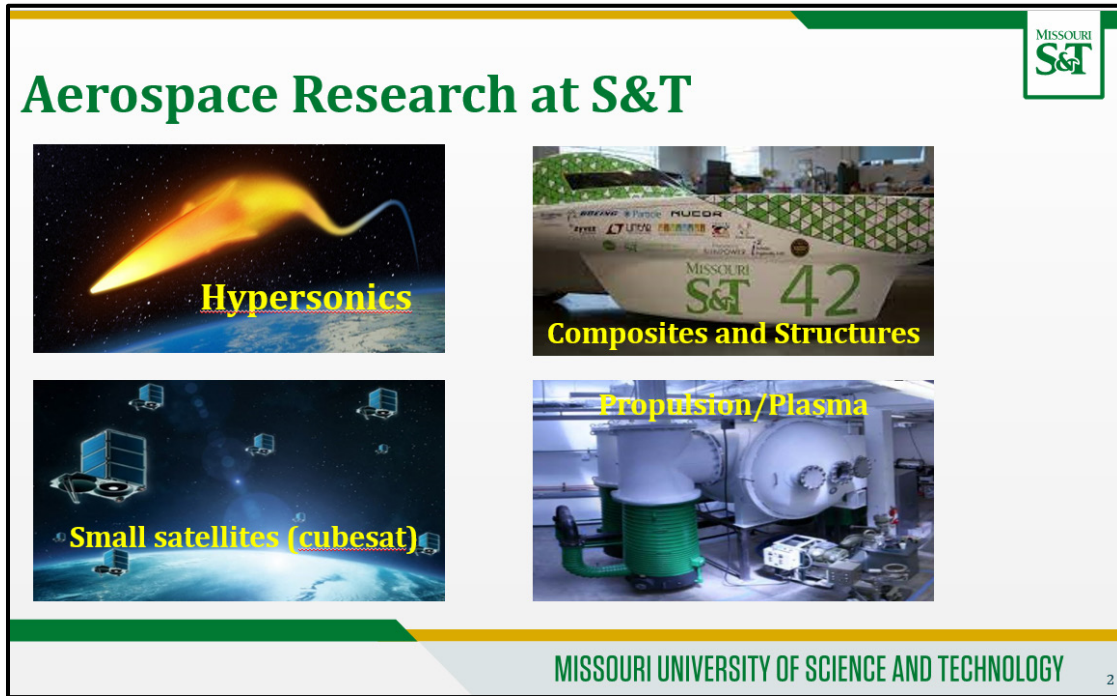


Figure 1 – MS&T Aerospace Research – Focus Areas



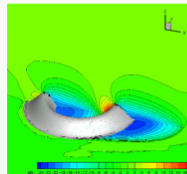
Figure 2 – Center for Aerospace Manufacturing Technology



Figure 3 – Missouri Manufacture Protoplex

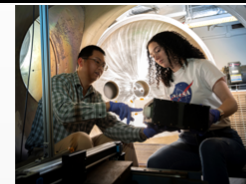
Fluid/Gas Dynamics

- Computational Fluid Dynamics (CFD) and Direct-Simulation Monte Carlo (DSMC) modeling of gases
- First-principle-based particle simulation algorithms for complex fluid problems – wind borne debris in tornado, particulates in advanced manufacturing



Plasma Science and Engineering

- High-fidelity kinetic modeling of plasmas
- Ground laboratory investigations of plasma phenomena for both ground and space applications – from advanced manufacturing to lunar exploration



- Large vacuum chamber (6-ft diameter, 10-ft long)
- Plasma source(s) and diagnostics
- **Lunar exploration**
- **Space propulsion**
- CPU/GPU supercomputers

PoC: Daoru (Frank) Han, Ph.D.
Assistant Professor
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Funding

- NASA, AFOSR, NSF

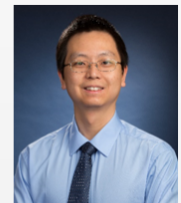


Figure 4 – Fluid/Gas/Plasma, Space Propulsion and Exploration Research

SmallSat Technology Development

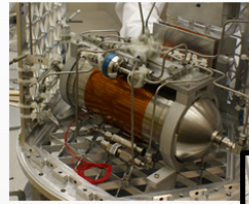
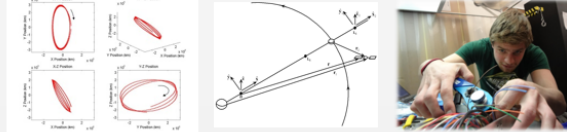
- Develop improved small satellites and their associated technologies
- MR & MR SAT microsats launch in ~two years to demonstrate cold-gas propulsion and stereoscopic imaging through formation flight mission

Innovative Orbit Design/Optimization

- Expand mission capabilities
- Focus on libration point orbits for SmallSats/CubeSats

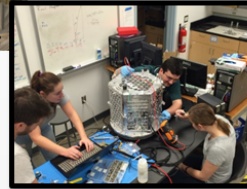
CubeSats in Development

- 6U and 3U being developed for AFRL/NASA



Design,
fabricate, and
test CubeSats
and microsats!

Part of the
SmallSat
"revolution"



Slide: 5 of 9
Fluid/Gas/Plasma, Space

PoC: Henry (Hank) Pernicka
Curator's Distinguished Teaching
Professor of Aerospace Engineering
pernicka@mst.edu, 573-341-6749

Funding

- AFOSR/AFRL, NASA, Amelia Earhart Fellowships, DoD SMART Fellowships Fellowships



Figure 5 – Small Sats and Astrodynamics Research

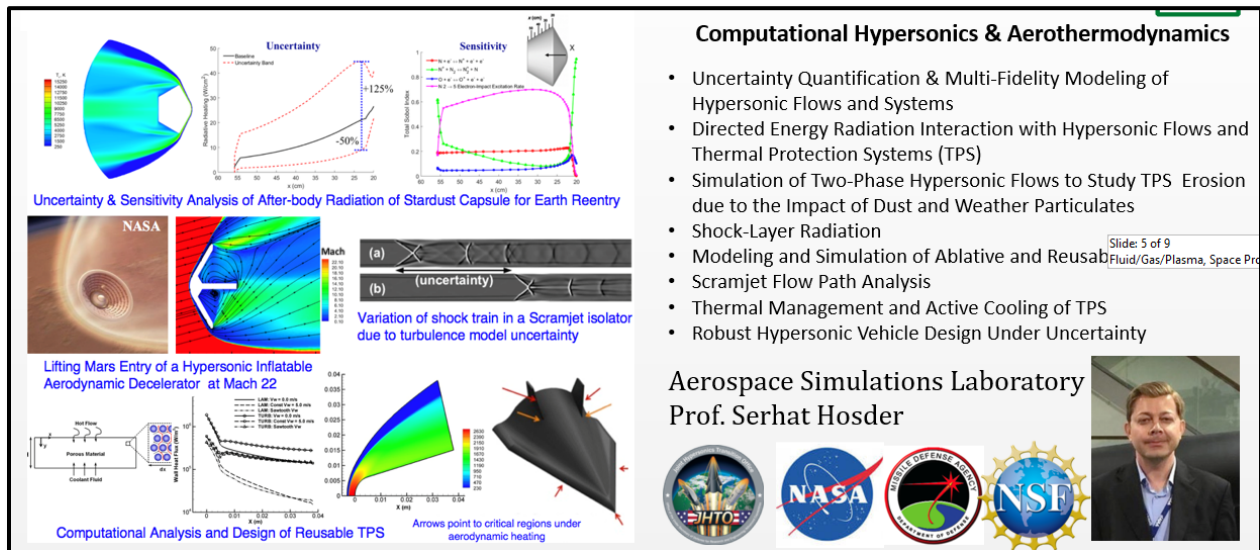


Figure 6 – Computational Hypersonics Research

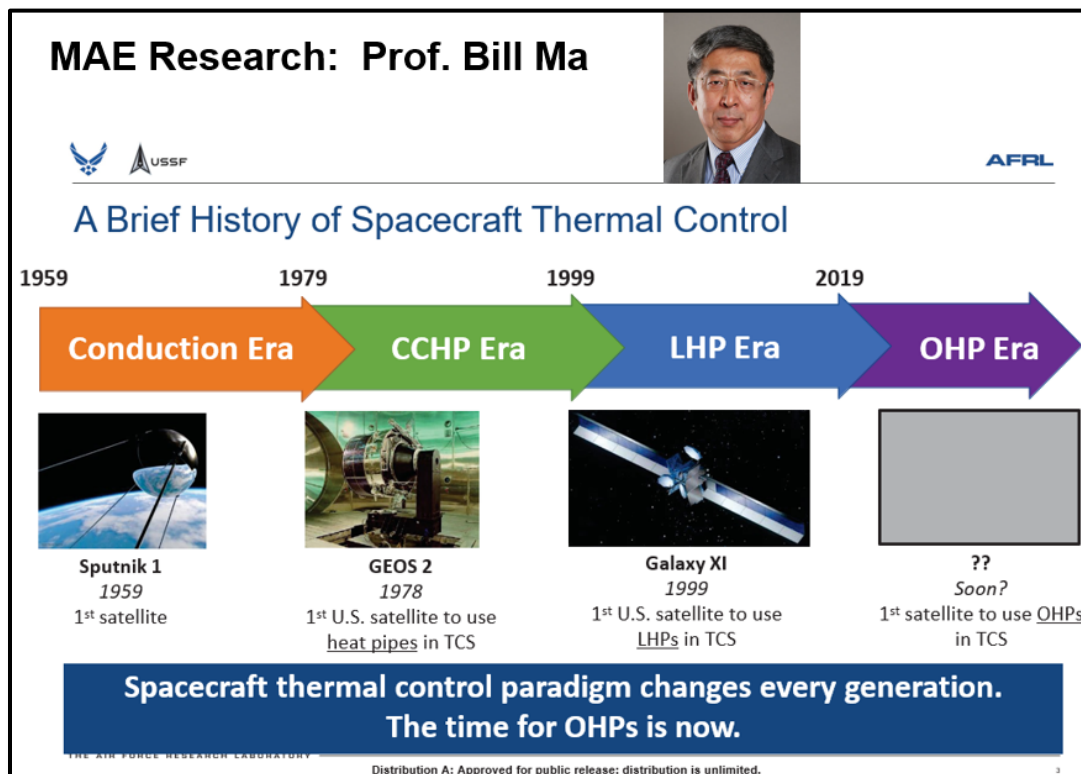


Figure 9 – Spacecraft Thermal Control Research

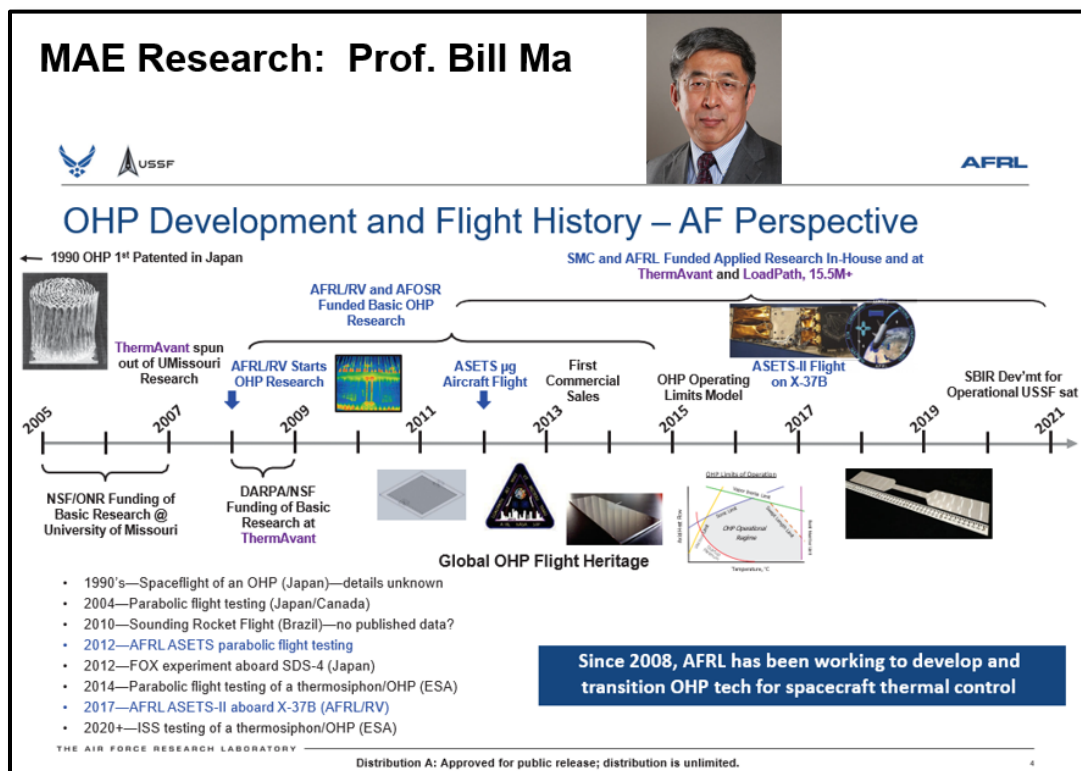


Figure 10 – OHP Development & Flight History



Figure 11 - Collaborative Autonomy and Safety for Teamed Human & Unmanned Aircraft Systems in Fast Evolving Wildfire Environment Research

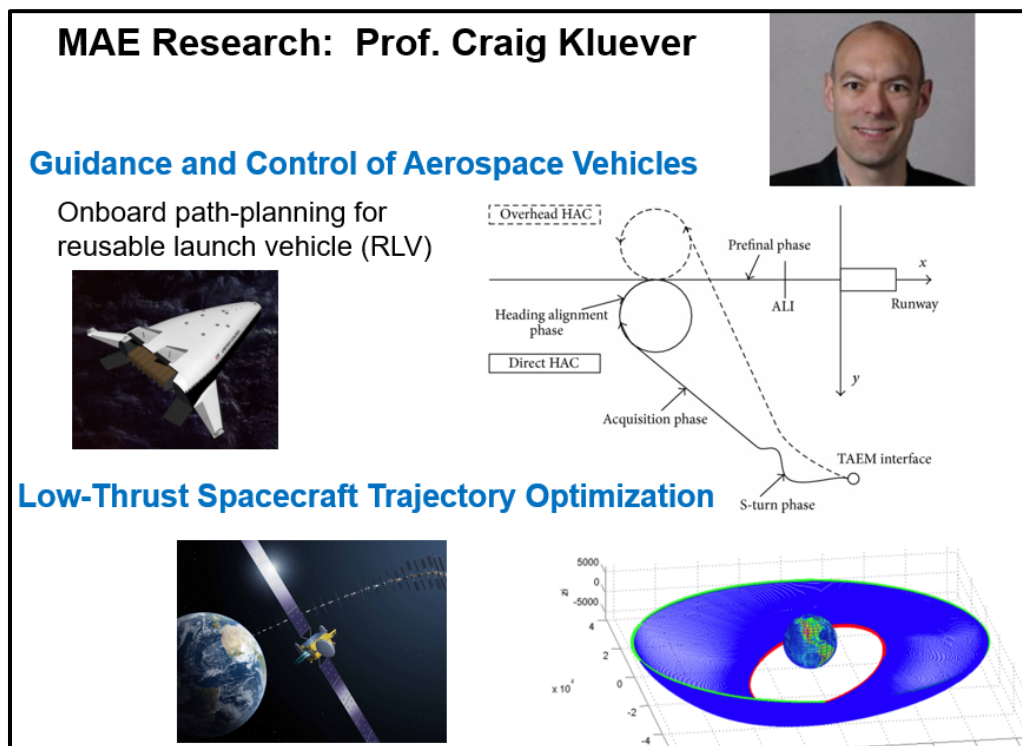


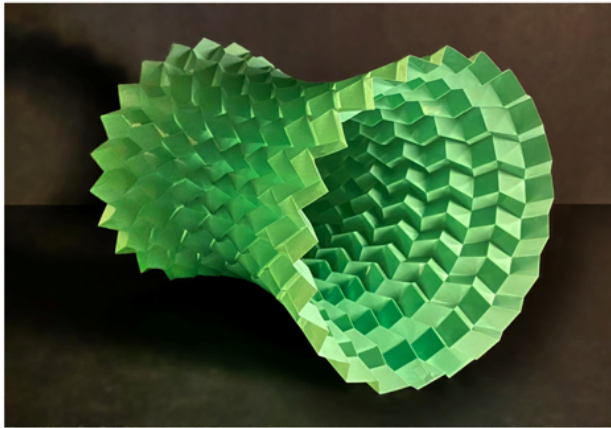
Figure 12 - Guidance & Control of Aerospace Vehicles and Low Energy Trajectory Optimization of Spacecraft Research

MAE Research: Prof. Hussein Nassar



Finite Elasticity of Deployable Structures

NSF CAREER – Hussein Nassar



- This is an origami structure folded out a single flat sheet of PET.
- The observed geometry is the result of a competition between the elastic energy stored in the folds and the kinematic constraints of inextensibility.
- What mathematical models explain these geometries?

Figure 13 – Finite Elasticity of Deployable Structures Research

Programming Mechanical Properties - Smart Metamaterials

Prof. Guoliang Huang

- Effective material parameters controlled by program codes.
- Adaptively dynamic and energy control in real-time.
- Novel and unprecedented wave propagation and applications in the field of structural dynamics.

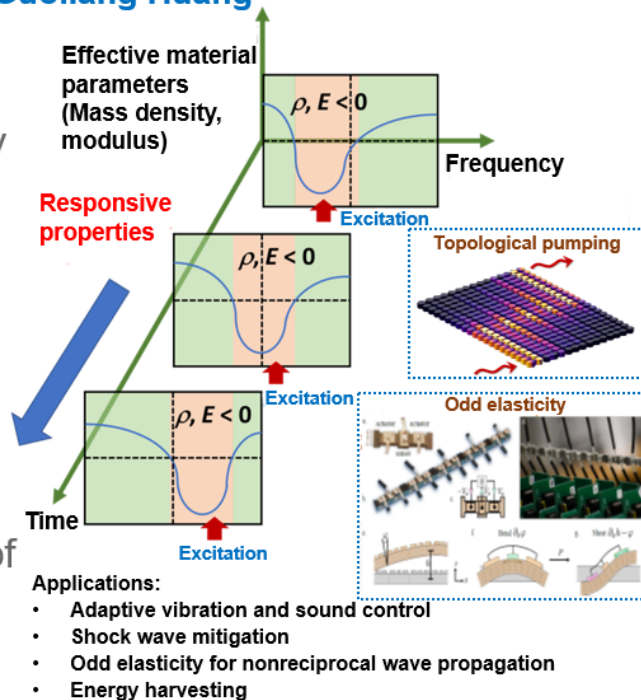
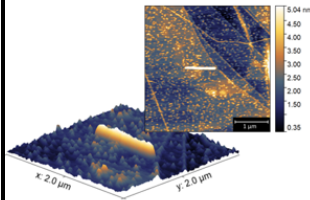


Figure 14 - Programming Material Properties & Smart MetaMaterials Research

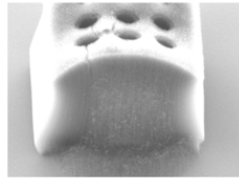
MAE Research: Prof. Matt Maschmann



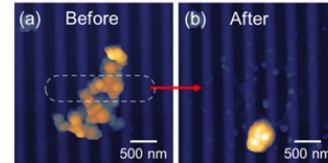
Matt Maschmann Research Group Highlights



Area-Selective Atomic Layer Deposition
Area-selective atomic layer deposition of oxides is demonstrated with a resolution of approximately 50 nm. The process may be used to define features for semiconductor devices without the need of conventional lithography.



In-Situ SEM Growth of CNTs
Carbon nanotube (CNT) arrays have been synthesized within a scanning electron microscope (SEM) to observe their self-assembly mechanics. Understanding these mechanisms may lead to "materials-by-design" approaches.



Nanoenergetic Material
Nanoenergetic materials store significant chemical energy that is released in high-temperature reactions. By rapidly heating individual nanoparticles, we have discovered new reaction mechanism that could greatly increase the power density of this class of materials.

Figure 15 - Area Selective Atomic Layer Deposition, In-Situ SEM Growth of CNTs, & Nanoenergetic Material Research

St Louis University



Mike Swartwout, Ph.D.
Associate Professor, Aerospace Engineering

Keywords: *small spacecraft, design, mission assurance, autonomy, model-based systems engineering*

Research Interests:

- Design and Operation of Small Spacecraft
- Mission Assurance
- Autonomous Operations
- Database Management/Mining

Recent Research Projects:

- *CubeSat Mission Assurance (PI, w/NASA Goddard, ongoing). Create and curate database of all CubeSat missions, developing design heuristics to improve mission reliability*
- *Argus-2 Mission (PI, w/NASA, in orbit February 2020). Led student team in design, fabrication testing and operations of imaging/autonomy spacecraft*
- *DARLA Mission (PI, w/AFRL, ongoing). Leading student team in development of an autonomous event-detection and response network*



SLU-built spacecraft during Integration & Test



Defining and improving mission reliability for CubeSats

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Saint Louis, MO 63103
- **Faculty Bio Link** – <https://sites.google.com/a/sl原因u.edu/swartwout/>

Figure 16 - Small Aircraft, Design, Mission Assurance, Autonomy & Model-Based Systems Engineering

AirCRAFT Lab

<https://sites.google.com/a/slu.edu/aircraft-lab/> • Srikanth.Gururajan@slu.edu; (314) 977-8355

Srikanth Gururajan, Ph.D. Associate Professor

Keywords: Unmanned Aerial Systems (UAS), Drones, Flight Testing, Neural Networks, Virtual Reality, UAS for STEM Education

At a glance:

In the AirCRAFT Lab, research is focused on Unmanned Aerial Systems (UAS) or Drones, particularly on ensuring their in-flight safety under failure conditions, by incorporating artificial intelligence and machine learning techniques. The capabilities in AirCRAFT Lab includes the design, fabrication, instrumentation and flight test evaluation of flight control algorithms on various UAS platforms, including fixed wing and multirotors. Current work in the AirCRAFT lab also extends to exploring morphing geometry multirotors and the application of Virtual Reality, natural interaction (voice and gestures) to command and control of drones, as well as using Drones for K-12 STEM education and outreach.

Research Interests:

- UAS Design, Fabrication, Flight Testing
- Fault Tolerant Flight Control
- Machine Learning (ML)/Artificial Intelligence (AI) for Virtual Sensors
- VR/Natural Language for Command and Control of Drones
- Morphing Geometry Multirotors
- UAV Pursuit-Evasion
- UAS for STEM Education

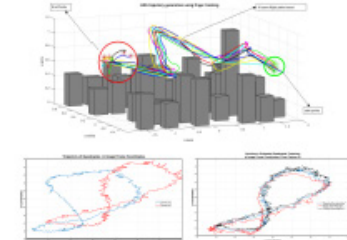
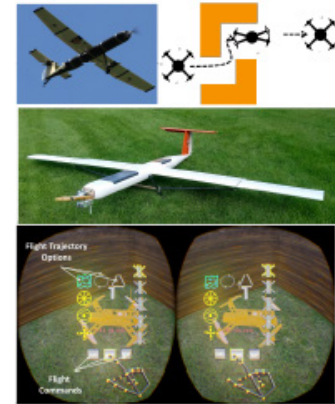
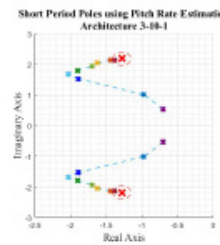
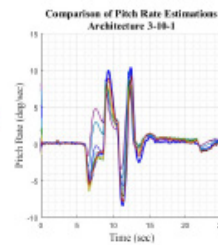


Figure 19 - Unmanned Aerial Systems (UAS), Drones, Flight Testing, Neural Networks, Virtual Reality & UAS for STEM Education Research



Mark McQuilling, Ph.D.

Professor, Program Coordinator, Mechanical Engineering

Keywords: fluid physics, wind tunnels, computational fluid dynamics, shock waves, turbomachinery, dentofacial and cardiothoracic fluid dynamics



SAINT LOUIS UNIVERSITY

**PARKS COLLEGE OF ENGINEERING,
AVIATION AND TECHNOLOGY**

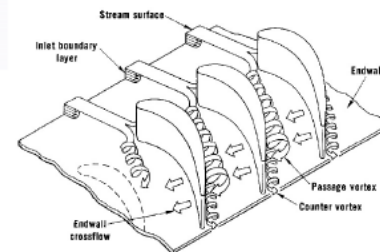
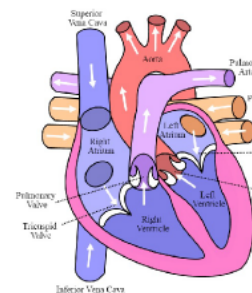
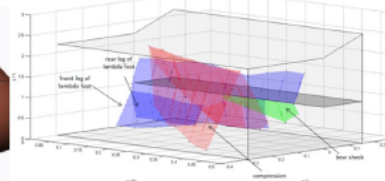
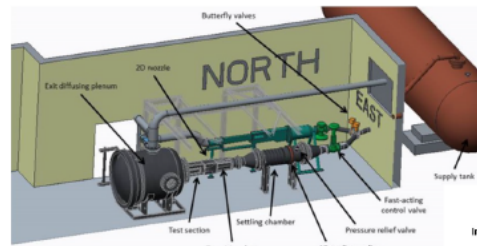
Research Interests:

- Experimental and computational fluid mechanics
- Shock wave - boundary layer interaction
- Turbomachinery aerothermodynamics
- Biofluid mechanics
- Airdrop system aerodynamics

Recent Research Projects:


- **"Advanced Flow Control for Shock Wave – Boundary Layer Interaction"** with The Boeing Company
- **"Airfoil Exit Mixing Loss Investigation"** with Honeywell Aerospace
- **"Advanced CFD Simulations of Cardiovascular Configurations Relevant to the Aorta and Aortic Valve"** with Dr. Dawn Hui, (former) SLU Cardiac Surgeon

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- Research funding awarded by The Boeing Company, Honeywell Aerospace, Air Energy Global, US Army Natick Soldier RDEC, US Army Aviation and Missile RDEC
- Currently mentoring 2 MS theses (3 PhD, 8 MS alumni)
- Member of AIAA, ASME, ASEE
- Over 95 research publications and presentations

Figure 20 - Fluid Physics, Windtunnels, Computational Fluid Dynamics, Shock Waves, Turbomachinery, Dentofacial & Cardiothoracic Fluid Dynamics Research




Dr. Sridhar Condoor
Professor, Saint Louis University
<https://www.linkedin.com/in/sridhar-condoor/>

Design Innovations

Professor with a demonstrated history of working in the design innovation and technology entrepreneurship areas. Skilled in Innovation Management, Applied Research & Product Design, Entrepreneurship, and Training Next Generation Innovators and Entrepreneurs.

Author of multiple books including Innovative Conceptual Design and technical publications. Innovator of Wind turbine and other designs Leader in the area of Design Innovation, Technology Entrepreneurship and Medical Product Development



Growing Entrepreneurial Mindset - The series of lectures and activities will expose you to strategic thinking in starting a new venture. Learn about the three key elements of modern entrepreneurship: the recognition and creation of opportunities, the development of strategies to realize those opportunities, and the packaging of those opportunities for maximum impact in intended markets.


Research Interests

Innovative concept design – From need identification to concept development, design is a non-linear and highly creative process. Interest is in developing practical techniques for improving the effectiveness of this phase

Structural form design – With more analytical tools and techniques, the art of structural form design is lost. Interest is in development of design canvases to improve form synthesis


Technology entrepreneurship – The concept of value and technology education is crucial for the success of a tech startup. Interest is in the development of value proposition case studies

Figure 21 - Design Innovations research: specifically Innovative Concept Design, Structural Form Design & Technology Entrepreneurship



Jenna Gorlewicz, Ph.D.
Associate Dean of Research and Innovation
Special Assistant to the Vice President of Research and Partnerships for Innovation
Associate Professor, Mechanical Engineering

Keywords: haptics, robotics, mechatronics, human-centered design, multimodal interfaces, medical devices, entrepreneurship



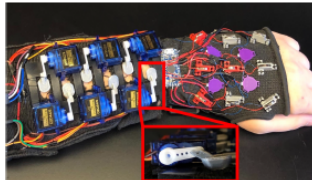
At a glance:
Dr. Gorlewicz directs the Collaborative Haptics, Robotics, and Mechatronics (CHROME) Lab. Her research interests are in human-centered design, haptic and multimodal interfaces, robotics, medical devices, engineering education, and entrepreneurship. Her current research projects include a protactile inspired wearable haptic sleeve; multimodal digital graphics for accessibility; smart, tangible learning manipulatives; social connectedness in telerobotics; a steerable port for neurosurgery; and a hockey puck for the blind. She is co-leading a new initiative at SLU centered around people and technology, synergizing engineering, computer science, and anthropology to rethink technology design. She is also co-founder of an ed-tech company, Vital.

Research Interests:

- Human-centered and community-driven design
- Design, modeling, and control of haptic interfaces, including wearable devices
- Multimodal interfaces and telerobotics
- Haptic and Human-machine interfaces for medical systems
- Minimally invasive medical devices and robot-assisted surgery
- Technology Transfer and Entrepreneurship

Highlights:


- Deeply vested in innovating with communities
- PI on research awards totaling ~\$4 million, including an NSF CAREER award
- Interdisciplinary collaborations spanning anthropology, computer science, psychology, and medicine
- Founder of VITAL, an educational software start-up awarded NSF SBIR funding



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Figure 22 - Haptics, Robotics, Mechatronics, Human-Centered Design, Multi-Modal Interfaces, Medical Devices and Entrepreneurship Research

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Jeff Ma, Ph.D.
Associate Professor of Mechanical Engineering


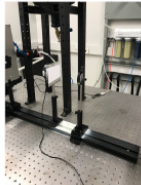
Keywords: Modeling of advanced manufacturing processes and other physical processes, Computational Solid Mechanics, Monitoring and testing of manufacturing and other physical processes, Robotics/Mechatronics/Automation, Machine Learning/AI



At a glance:

Dr. Ma's research at SLU focuses on advanced manufacturing technology, which includes laser-assisted manufacturing, laser peening/machining of advanced materials, micro electrical discharge machining (EDM), Vibration Assisted Nano Impact machining by Loose Abrasives (VANILA) process for brittle materials. He also has extensive research experience of intelligent monitoring and testing of manufacturing processes using Artificial Intelligence (AI) and fuzzy logic and signal processing. He authored 116 peer-reviewed publications. His research has been funded by NSF, NASA, SLU, and industry. He works closely with the Manufacturing System Laboratory, the Mechatronics Laboratory, and the Laser Peening Laboratory at SLU. Dr. Ma serves as co-chair/chair of Track 3 "Material Removal" within NAMRI/SME Scientific Committee for terms of 2018-2022 and he also serves as an associate editor for Elsevier Journal of Manufacturing Processes.

<p>Research and Educational Interests:</p> <ul style="list-style-type: none"> • Numerical and experimental investigation of advanced manufacturing processes and other physical processes • Laser-assisted machining of brittle materials, femtosecond laser-matter interaction, laser peening of advanced materials • Computational Solid Mechanics • Monitoring and testing of manufacturing and other physical processes/failure of mechanical systems • Robotics/Mechatronics/Automation • Machine learning/AI & signal processing 	<p>Highlights:</p> <ul style="list-style-type: none"> • 2014 SLU Parks College Outstanding Graduate Faculty Award • 116 peer-reviewed publications • Member of SME, SAE, and ASME • An associate editor for Elsevier SME Journal of Manufacturing Processes
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Mechatronics lab Laser peening lab

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Figure 23 - Modeling of Advanced Manufacturing Processes and Other Physical Processes, Computational Solid Mechanics, Modeling and Testing of Manufacturing and Other Physical Processes, Robotics / Mechtronics / Automation and Machine Learning / AI Research

Washington University


ADVANCED MATERIALS



Example projects

- **Dr. Flores:** Design metallic alloys; Metallic glasses and Manufacturing techniques.
- **Dr. Guan:** Stem-cell for brain tissue regeneration, Bone tissue engineering, Cardio-vascular tissue engineering
- **Dr. Mishra:** Design new materials for energy, Atomic scale modeling, electron microscopy
- **Dr. Bae:** Develop material building blocks, develop advanced solar cells, heterogeneous integration of ubiquitous electronics with AI cognitive function.









Profs: Bae, Flores, Guan, Mishra, Singamaneni

[Research page link](#)

Figure 24 – Advanced Materials Research

BIOMECHANICS & MECHANOBIOLOGY



Example projects

- Dr. Bayly: Develops imaging methods to study Biomechanics from cell motility to traumatic brain injury.
- Dr. Genin: Interface between tissues at the attachment of tendon to bones
- Dr. Wagenseil: Cardio-vascular biomechanics and Mechanobiology
- Dr. Lake: Orthopedic soft tissues
- Dr. Pathak: Mechanobiology of Cancer metastasis.
- Dr. Bersi: Role of immune system in hypertension, Cardiac Fibrosis



Profs. Bayly, Bersi, Genin, Lake, Pathak, Wagenseil

[Research page link](#)

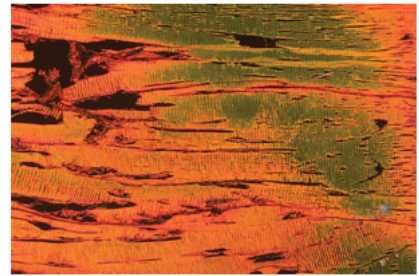


Figure 25 - Biomechanics and Mechanobiology Research

THERMAL – FLUIDS IN ENERGY



Example projects

- Dr. Agonafer: Develop 3-D electrodes for energy storage devices, Thermo-Chemical / Electro Chemical energy storage, Micro/Nano Fluidics
- Dr. Meacham: Micro Fluidics, Micro Electro Mechanical systems.
- Dr. Weisensee: Heat transfer and Fluid dynamics in multi phase systems for energy and manufacturing applications



Profs. Agonafer, Meacham, Weisensee

[Research page link](#)

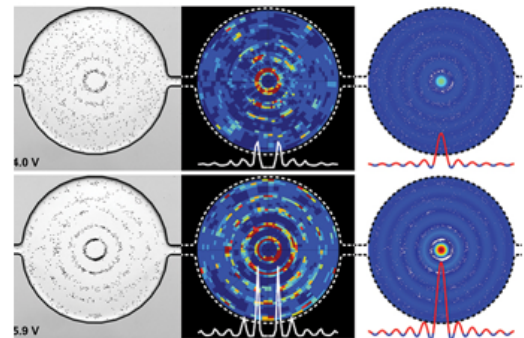


Figure 26 - Thermal - Fluids in Energy Research

AEROSPACE

Example projects

- **Dr. Peters:** Dynamics, Vibration, Aeroelasticity, Applied Aerodynamics, and Rotary-Wing systems
- **Dr. Agarwal:** CFD, Ground effect aerodynamics, Flow control, and Hypersonic flow
- **Dr. Sastry:** Material selection in engineering design, Deformation and Fracture of engineering materials.
- **Dr. Jakiela:** Design, Optimization, and Manufacturing



Profs. Agarwal, Peters

Figure 27 – Aerospace Research