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AFOSR CoE: Aerospace Morphing via Integrated Sense, Assess and Respond

Year 1 Annual Program Review, September 23, 2024

Sinclair Conference Center, Suite 12-101, Room 116

444 W. Third Street, Dayton, OH 45402-1460 ([Registration Details](#))

Monday, September 23, 2024 (note: all times ET)	
7:30 - 8:30	Arrival
8:30 - 8:45	Welcome remarks <i>Dr. Gregg Abate, AFOSR</i>
8:45 - 9:00	DoD Motivation for Intelligent Morphing Structures <i>Dr. Ben Dickinson, AFRL/RW</i>
9:00 - 9:30	AEROMORPH CoE Overview of Year 1 <i>Dr. Billy Oates, FSU</i>
9:30 - 10:00	TA1: Sensor Miniaturization, Integration and Information Processing <i>Dr. Mark Sheplak, UF</i>
10:00 - 10:30	Break
10:30 - 11:00	TA2: PRCs for Processing of Unsteady Aerodynamics <i>Dr. Patrick Musgrave, UF</i>
11:00 - 11:30	TA3: Assessing Information Content in Digital and Physical Reservoirs <i>Dr. Billy Oates, FSU</i>
11:30 - 1:00	Break for lunch
1:00 - 1:30	TA4: Actuation Localization from Collocated Sense and Assess <i>Dr. Rajan Kumar, FSU</i>
1:30 - 2:00	TA5: Novel Control with Advanced Response Times <i>Dr. Christian Hubicki, FSU</i>
2:00 - 2:20	Enabling Technologies for Morphing Structures <i>Dr. Rich Beblo, AFRL/RQ</i>
2:20 - 2:40	Sensing and Materials Challenges for Morphing Skins <i>Dr. Lisa Rueschhoff, AFRL/RX</i>
2:40 - 3:00	Harnessing Mechanics for Information Processing <i>Dr. Phil Buskohl, AFRL/RX</i>
3:00 - 3:30	Break
3:30 - 4:45	Open Discussion on Progress and Next Steps <i>Discussion Leader: Dr. Billy Oates, FSU</i>
4:45 - 5:00	Closing Remarks <i>Dr. Gregg Abate</i>
~6:00 p.m.	No-Host Dinner (optional)

AFOSR MURI: Fluid-Metamaterial-Interaction to Revolutionize Passive Flow Control of Aerodynamic Vehicles

Year 1 Annual Program Review, September 24, 2024

Sinclair Conference Center, Suite 12-101, Room 116

444 W. Third Street, Dayton, OH 45402-1460 ([Registration Details](#))

Tuesday, September 24, 2024 (note: all times ET)	
7:30 – 8:00 a.m.	Arrival
8:00 – 8:15 a.m.	Welcome remarks – Dr. Gregg Abate AFOSR
8:15 – 8:45 a.m.	“Overview of Fluid Metamaterial Interaction (FMI) MURI Progress,” Prof. Katie Matlack, University of Illinois
8:45 – 9:15 a.m.	“Computational Tool Development for FMI,” Prof. Jane Bae, Caltech, Prof. Andres Goza, University of Illinois
9:15 – 9:45 a.m.	“FMI between Resonant Phononic Materials and Turbulent Boundary Layer for Drag Reduction,” Prof. Jane Bae, Caltech, Prof. Katie Matlack, University of Illinois
9:45 - 10:15	Break
10:15 - 10:45	“Topological phononic materials for FMI,” Prof. Andres Goza, University of Illinois, Prof. Harold Park, Boston University
10:45 - 11:15	“Resonant Surface Vibration Coupling with Fluid Modes,” Prof. Phil Ansell, Prof Katie Matlack, University of Illinois
11:15 - 11:45	<i>Open discussions for feedback and questions</i>
11:45 - 1:00	Break for lunch
1:00 - 1:30	“Responsive multistable materials for turbulent boundary layer separation control,” Prof. Tess Saxton-Fox, University of Illinois, Prof. Jordan Raney, University of Pennsylvania
1:30 - 2:00	“Airfoil Decambering with Bistable Materials,” Prof. Phil Ansell, University of Illinois, Prof. Jordan Raney, University of Pennsylvania
2:00 - 2:45	“Controlling Instabilities in Flow with Phononic Subsurfaces,” Drs. Juhl, Barnes, & Medina, AFRL
2:45 - 3:15	Break
3:15 - 3:45	“Compressible Tollmien-Schlichting Wave Control,” Prof. Phil Ansell, Prof Katie Matlack, University of Illinois
3:45 - 4:00	“Progress summary and next steps,” Prof. Katie Matlack, University of Illinois
4:00 - 4:45	<i>Breakout session for meetings between academics and AFRL</i>
4:45 - 5:00	<i>Wrap up, open discussions for feedback and questions</i>
~6:00 p.m.	No-Host Dinner (optional)



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AFOSR CoE: Aerospace Morphing via Integrated Sense, Assess and Respond

PI: Dr. Billy Oates, FSU-FAMU

This Center of Excellence (COE) will conduct fundamental research that transforms the way in which conventional distributed sensing, state estimation, morphing structures, and control are applied to high speed aerospace systems. Our team will address the limitation of conventional feedback loops using novel sensing motifs and inherent coupling to adaptive structures to create an agile and robust aerospace system with integrated sense, assess, and respond functionality. To achieve this goal, we propose an inter-disciplinary approach that leverages diverse methodologies and team member expertise in information theory, physics-based models, reservoir computing, sensors for high speed environments, morphing structures, control, and experimental aerodynamics to meet the goals of an integrated sense, assess, and respond framework. This foundational research will explore and develop advanced information processing methods that can rapidly convert sensor data into actionable information through a physical interpretation of aerodynamic structural dynamic responses in real-time. Relationships between information theory and physical models will advance beyond conventional statistical mechanics, thermodynamics, and dynamical systems and will be tested experimentally to demonstrate how adaptive aerospace structures extract data, convert it into information, and formulate knowledge about complex aerospace structures operating in high speed environments. This information will be used to define morphing materials requirements and help guide systems integration for nonlinear control strategies. We will apply tools from information theory, network science, reduced-order multi-physics fluid-structure modeling, physical reservoir computing, advanced sensing, experimental aerodynamics and control to create an integrated sense, assess, and respond aerodynamic system. This research will be executed in close collaboration with AFRL-RW, RX, and RQ through workforce development and joint projects to facilitate transition of fundamental research to the next generation warfighter.

AFOSR MURI: Fluid-Metamaterial-Interaction to Revolutionize Passive Flow Control of Aerodynamic Vehicles

PI: Prof. Katie Matlack, University of Illinois

This MURI program will establish the field of fluid-metamaterial interaction (FMI) that will discover new fluid-structure coupling between innovative materials and critical aerodynamic flows to enable passive control of transition delay, drag reduction, and separation. The program is driven by the underlying scientific question of how do distinct classes of metamaterials interact with dynamics of dominant flow coherences in turbulent flows, and how are these interactions affected by porosity and surface texture. The objectives are (1) Characterize FMI of wall-bounded flows when both the surface and subsurface have engineered dynamic and mechanical responses. (2) Establish a foundational understanding of FMI through the lens of aligning interaction regimes between the solid and fluid. (3) Quantify how the FMI scales with fluid and solid properties and identify meaningful dimensionless numbers that collapse FMI observations. (4) Develop new computational engineering tools for FMI, including high-fidelity computational frameworks and reduced-order modeling paradigms. (5) Manufacture metamaterials on realistic length scales for FMI, and develop comprehensive experimental methods to capture and understand the flow physics underlying FMI. To successfully establish this multi-disciplinary area of FMI, we assembled a team of 7 experts over 4 universities, with expertise spanning all areas within FMI: multiple classes of mechanical metamaterials, architected materials, advanced manufacturing, computational mechanics, FMI simulations, experimental turbulent dynamics, experimental fluid dynamics, and turbulence modeling. Our approach centers around a synergistic collaboration between fluids and mechanics experts to marry expertise in turbulent flow dynamics, FSI, and advances in materials science, mechanics, and manufacturing to enable an intelligent pairing of specific mechanical metamaterials with specific flows. This program will introduce new engineering tools, including high-fidelity computational frameworks, reduced-order model paradigms, coupled experimental methodologies, and manufacturing capabilities, to lay the scientific foundation for FMI application-specific surface/subsurface structural systems in passive, dynamic flow control for the Air Force's vehicle of tomorrow. The FMI discovered through this program are anticipated to produce transformative leaps in our scientific understanding of FSI. This will strongly impact DoD, resulting in application-specific surface/subsurface structural systems that make passive, dynamic flow control a reality. The outcomes of this research program are expected to produce disruptive improvements to the energy requirements and flight envelope of air-vehicle operation, which is imperative to the future financial sustainability and continued superiority of the DoD energy ecosystem.