



A NASA Perspective on UQ and Machine Learning for Physics-Based Modeling

UQ-MLIP 2024 Industry Panel
August 13th, 2024

James Warner

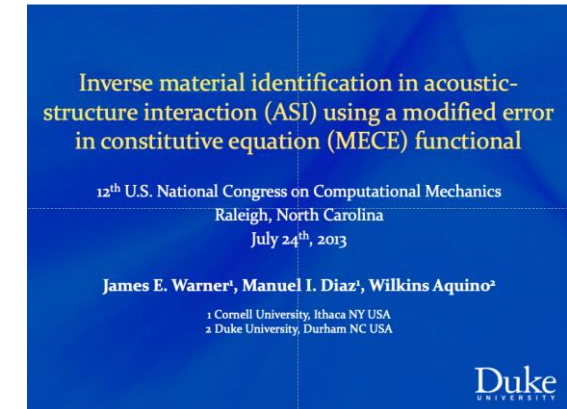
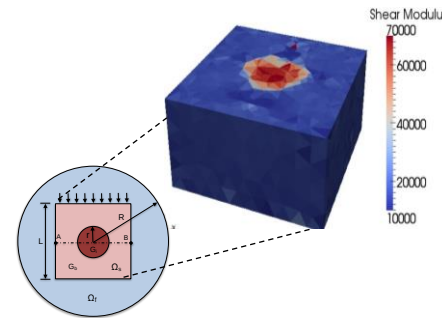
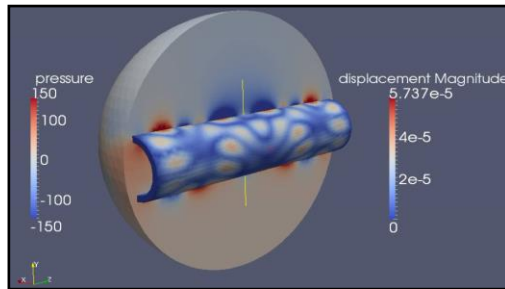
Senior Computational Scientist

NASA Langley Research Center, Hampton, VA

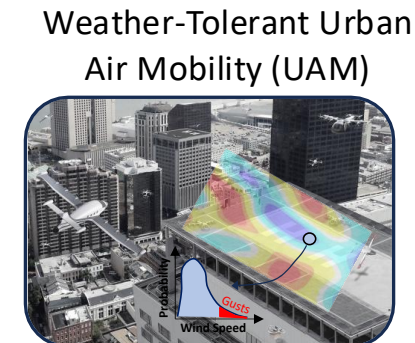
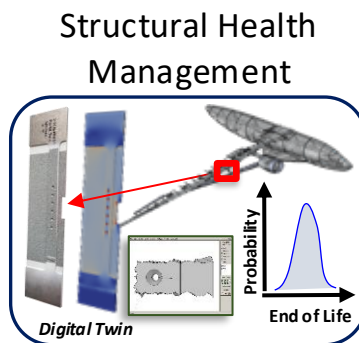
Team: Geoffrey Bomarito, Patrick Leser, Paul Leser,

Michael Stanley, Tristan Shah, Josh Pribe

- **Binghamton University** - *B.S. Mechanical Engineering (2008)*
- **Cornell University** - *MS/PhD Civil & Environmental Engineering (2014)*
 - **Focus:** Computational solid mechanics
 - **Thesis research:** Inverse problems under uncertainty for biomedical applications



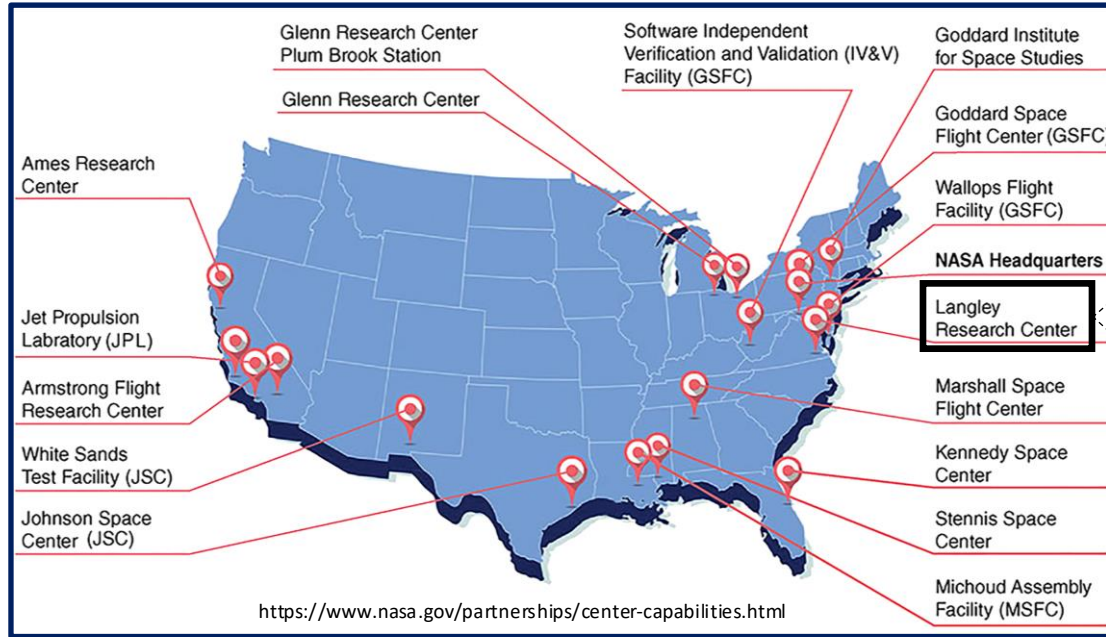
- **NASA - Senior Computational Scientist (2014 – Present)**
 - **Branch:** Durability, Damage Tolerance, and Reliability
 - **Research areas:** multifidelity UQ, generative AI, physics-informed ML, reliability analysis
 - **Applications:**



NASA Langley Research Center



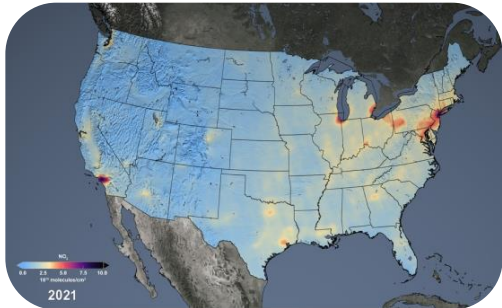
NASA Facilities and Centers Across the US



Langley Research Center, Hampton, VA



Earth's Atmospheric Composition



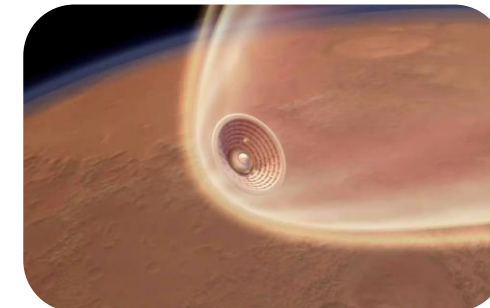
On-Demand Mobility Technologies



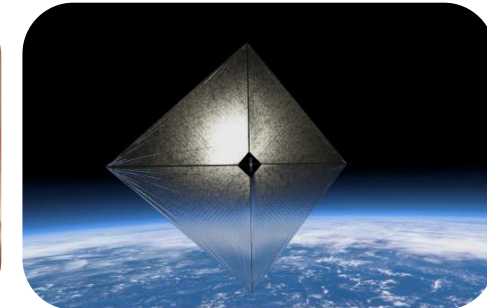
Commercial Air Transport Technologies



Entry, Descent & Landing Systems



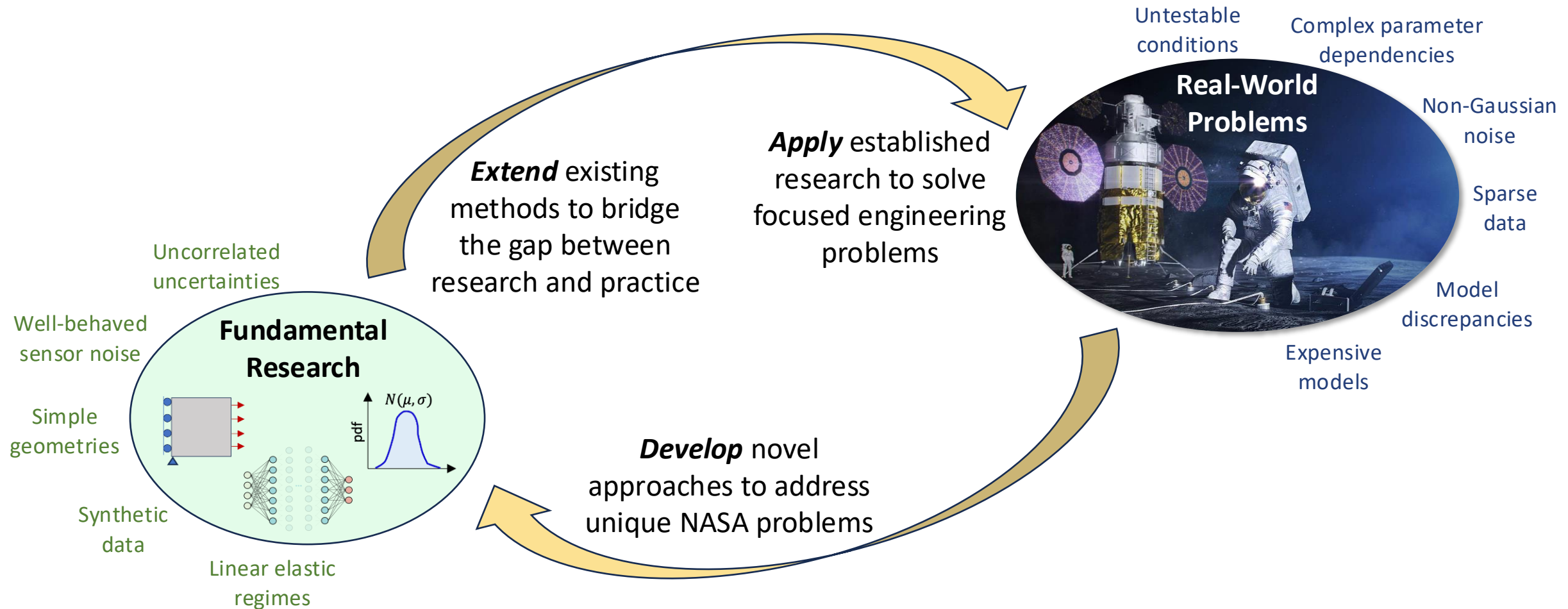
Advanced Space Structures



Research Perspectives at NASA



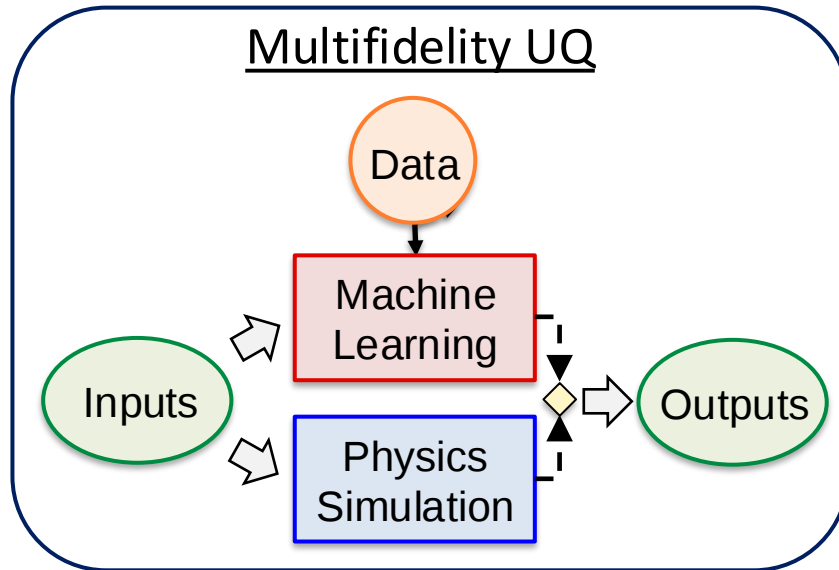
- Goal: connect cutting-edge research to NASA mission needs



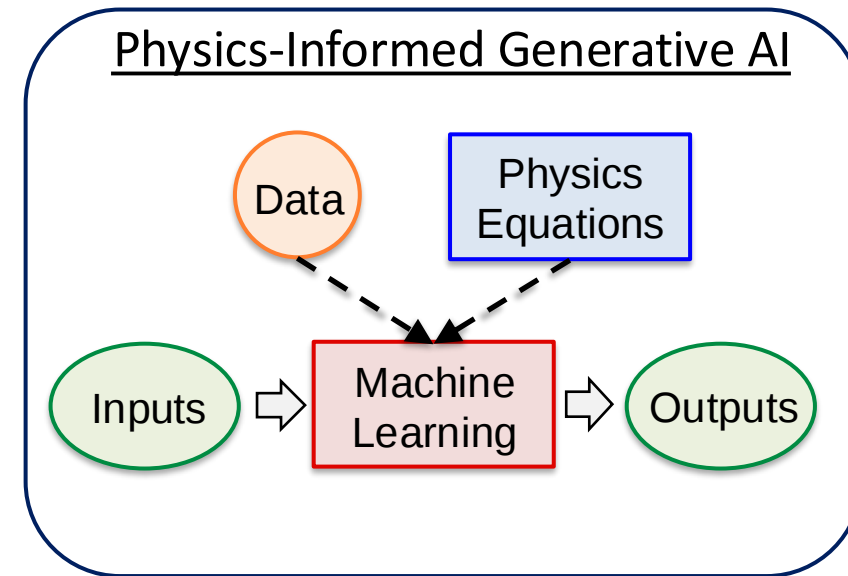
Research Interests in UQ and ML



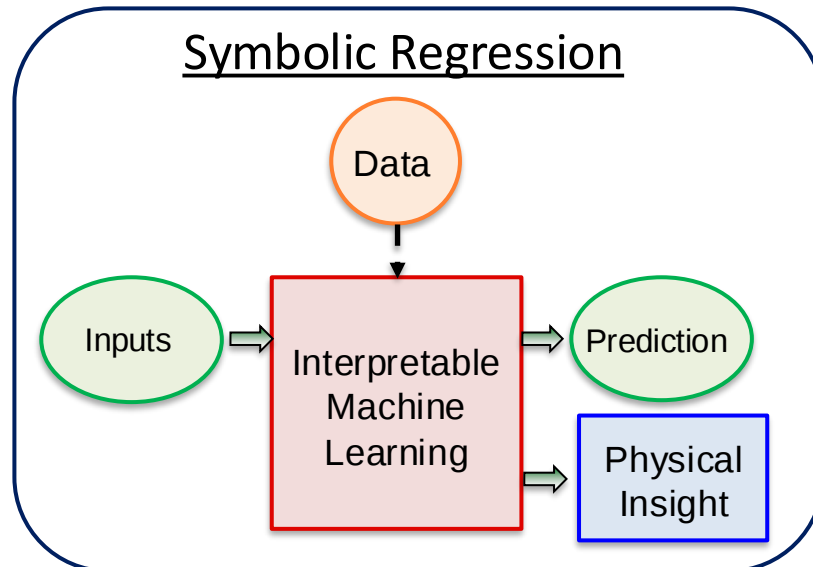
Multifidelity UQ



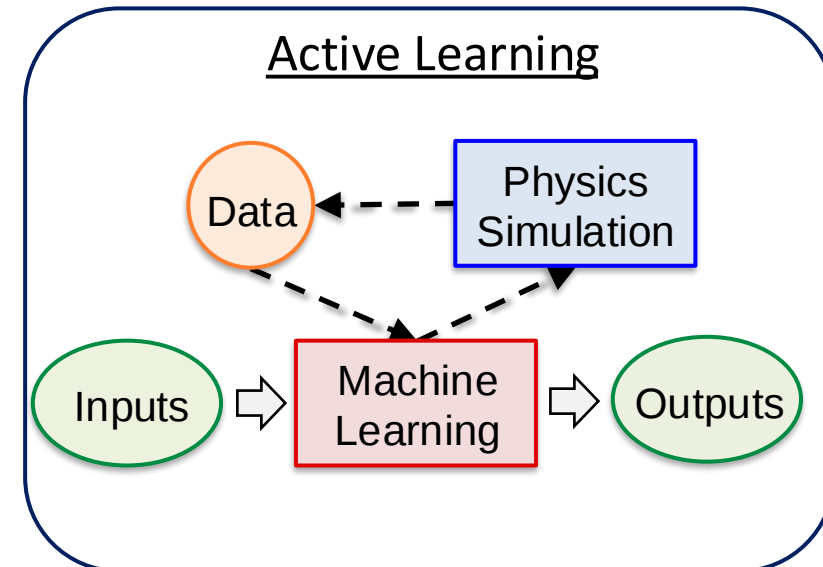
Physics-Informed Generative AI



Symbolic Regression



Active Learning

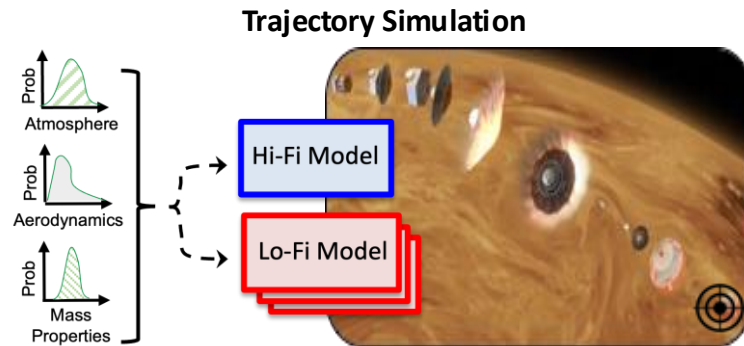


Research Interests in UQ and ML



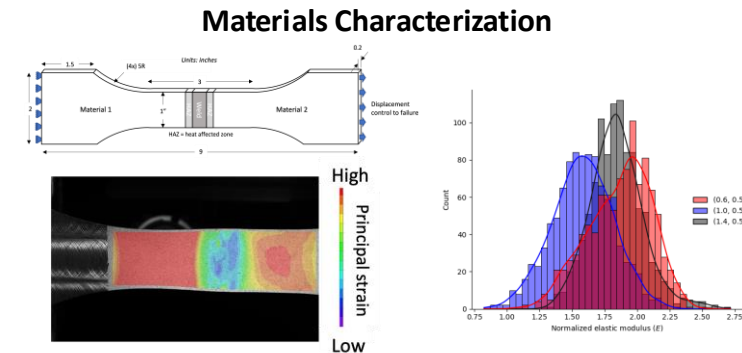
Multifidelity UQ

- Perform multifidelity estimation in an online setting with limited *a priori* knowledge



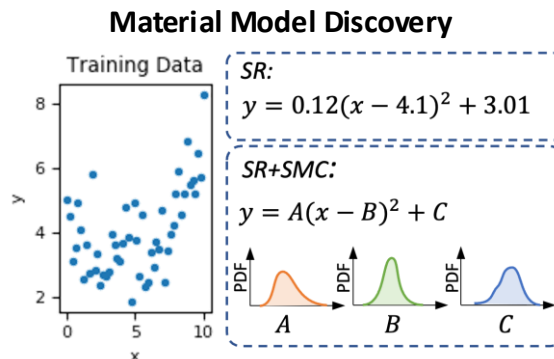
Physics-Informed Generative AI

- Handle specimen-to-specimen variability and measurement errors simultaneously



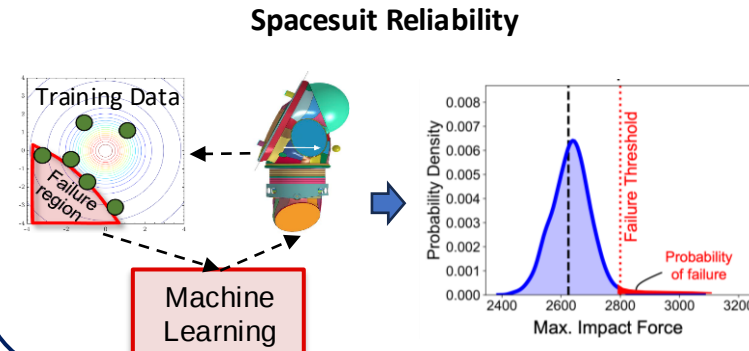
Symbolic Regression

- Discover equations from data when measurements are noisy and limited



Active Learning

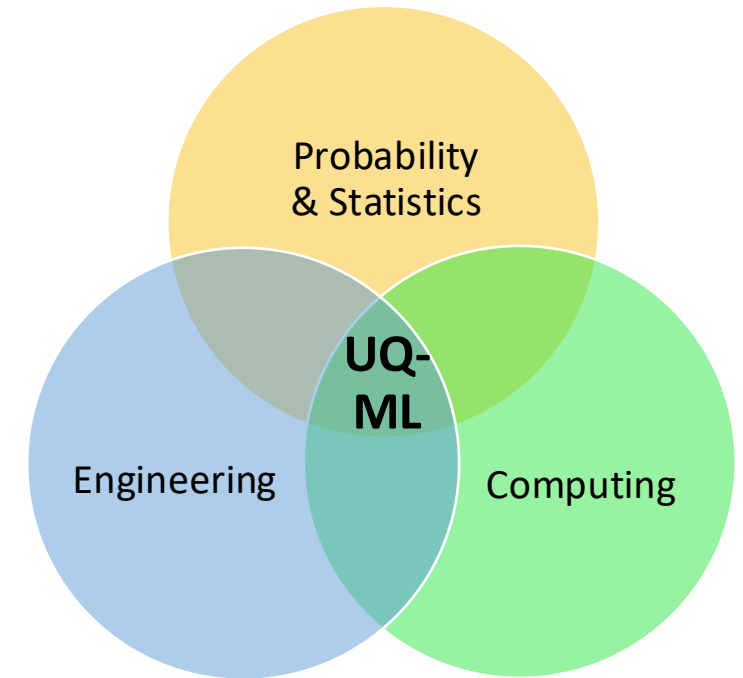
- Embed conservatism into reliability analysis for safety-critical applications



Challenges



- Workforce
 - Lack of candidates with broad UQ/ML skillsets
 - Inability to match industry salaries
 - Difficulties hiring foreign nationals
- Intellectual property
 - Lengthy process to release software/data
 - Recent executive order promises to address this
- Cultural
 - Slow adoption of state-of-the-art UQ/ML for engineering
 - Philosophical differences among UQ practitioners
- Technical
 - Lack of robustness for cutting-edge research applied to messy real-world problems
 - Verifying stringent reliability requirements with imperfect models



Avenues for Collaboration



- UQ Seminar Series
 - Limited slots for invited travel available for interested speakers
- Internships
 - [NASA STEM Gateway](#)
- Fellowships
 - [NASA Space Technology Graduate Research Opportunities \(NSTGRO\)](#)
- Proposal opportunities
 - [NASA Solicitation and Proposal Integrated Review and Evaluation System](#)
 - [NASA unsolicited proposal handbook](#)

NASA UQ Seminar Series

2023

Ralph Smith (NC State)
Paris Perdikaris (U. Penn)
Alex Gorodetsky (U. Mich.)
Bobby Gramacy (Virginia Tech)
Giuseppe Cataldo (NASA Goddard)
Mike Shields (Johns Hopkins)
Mike Eldred & Gianluca Geraci (Sandia)
Youssef Marzouk (MIT)

2024

Ramin Bostanabad (UC Irvine)
Gianluca Iaccarino (Stanford)
Benjamin Peherstorfer (CIMS)

... More TBA

