



## Interdisciplinary Research Themes

### 2018 Year End Report

## 2018 Interdisciplinary Research Themes Annual Report

The College of Engineering and Applied Sciences (CEAS) at the University of Colorado has a strong tradition of research excellence within its departments, programs, and research centers. However, some of the most pressing technical and societal challenges of the future require our faculty and students to conduct research in interdisciplinary teams. These interdisciplinary challenges necessitate a new approach to research collaboration. To accelerate our research impact, the College initiated six Interdisciplinary Research Themes (IRTs) in January 2018.

- Autonomous Systems
- Imaging Science
- Multi-Functional Materials
- Precision Biomaterials
- Quantum Integrated Sensors System
- Water-Energy Nexus

The overarching purpose of the IRTs is to foster collaborative, interdisciplinary research. Through the IRTs, we will increase the number and size of funded research projects thereby increasing our impact on society.

The College established the IRTs through an open and competitive process. Our faculty submitted 29 IRT proposals and six were ultimately selected by the department chairs, associate deans, and dean to receive internal funding. Each IRT consists of 25-50 self-selected faculty from within the College. The successful IRT teams chose faculty directors to lead the efforts. With a total internal investment of \$4.5 million, each IRT director was provided with \$750K over a four-year period to achieve its IRT goals. The IRT metrics for success include industry collaborations, national reputation, and research proposals/projects. More than half of the funding was awarded to faculty as seed grants to initiate promising research that could lead to larger funded opportunities.

### **Purpose of Report**

This report summarizes the first year of IRT implementation, including key accomplishments and status of the six IRTs. Input for this IRT summary report was extracted from the six IRT Directors' annual reports. Please direct overall questions regarding the IRT program or this annual report to the Associate Dean for Research, Research Support Office, College of Engineering and Applied Science, at [RSO@colorado.edu](mailto:RSO@colorado.edu) or (303) 492-7179. Please direct questions about the individual IRTs to the directors.

- **Autonomous Systems** – Dr. Eric Frew, Associate Professor, Smead Department of Aerospace Sciences
- **Imaging Science** – Dr. Todd Murray, Associate Professor, Department of Mechanical Engineering

- **Multi-Functional Materials** – Dr. Nicolas Correll, Associate Professor, Department of Computer Science and Dr. Sean Shaheen (Acting), Associate Professor Department of Electrical, Computer and Energy Engineering
- **Precision Biomaterials** – Dr. Kristi Anseth, Professor, Department of Chemical & Biological Engineering
- **Quantum Integrated Sensors System** – Dr. Juliet Gopinath, Associate Professor, Department of Electrical, Computer and Energy Engineering
- **Water-Energy Nexus** – Dr. Karl Linden, Professor, Department of Civil, Architectural and Environmental Engineering

### **IRT Description**

<https://www.colorado.edu/engineering/research/interdisciplinary-research-themes>

Over the next four years, the College of Engineering and Applied Science will be investing internal resources into six major interdisciplinary research themes (IRT) as part of our strategic vision to build on our college and campus strengths, prepare for future research opportunities, and accelerate our positive impacts to our state and nation.

### **Autonomous Systems**

<https://www.colorado.edu/irt/autonomous-systems/>

We investigate how smart, safe, and secure autonomy can expand and exploit the full capabilities of these networked systems. This theme convenes faculty with expertise in robotics, cyber-security, verification and validation, control theory, artificial intelligence, unmanned systems, machine learning, formal methods, and human-robot interaction.

### **Imaging Science**

<https://www.colorado.edu/irt/imagingscience/>

Imaging Science will transform society by saving lives through medical imaging, improving industrial safety and productivity through nondestructive testing, increasing integrated electronics performance through fast metrology, and enabling the extraction of resources in environmentally friendly ways through seismic imaging.

### **Multi-Functional Materials**

<https://www.colorado.edu/irt/mfm/>

We aim to establish the science of integration of materials that metabolize energy into distributed sensing, actuation, and computation. This theme will develop artificial systems with biological properties by bringing together campus researchers from across the domains of biology, physics, computer science, material science, electrical engineering and mechanical engineering with open access to industry.

### **Precision Biomaterials**

<https://www.colorado.edu/irt/precisionbiomaterials/>

We will integrate biomaterials design with drug and cell-based technologies to engineer and validate new combinational health care products and translate clinical needs into therapies, spanning from molecular design to medical product design. Through this materials-centric approach, we will provide next-generation, disruptive therapeutic interventions for a broad spectrum of diseases with unmet medical needs.

### **Quantum Integrated Sensors System (QISS)**

<https://www.colorado.edu/irt/qiss/>

The QISS theme was originally established In January 2018 to promote Colorado as the preeminent national resource for quantum applied science and engineering, in quantum technology, and in quantum science and engineering education. In January of 2019, the QISS IRT was combined with the larger campus effort, [CUbit Quantum Initiative](#), to foster interdisciplinary work across the CU campus.

### **Water-Energy Nexus**

<https://www.colorado.edu/irt/wen/>

The interactions between water, energy, and associated systems have profound impacts on our society. As such, the nexus of water and energy is, and will continue to be, one of the world's leading long-term technical challenges. The Water-Energy Nexus theme aims to bring together researchers from different disciplines to address the pressing challenges surrounding water, energy and associated systems such as food, land, air quality and climate.

### **Most Significant IRT Accomplishments in 2019**

#### ***Autonomous Systems:***

- Awarded over \$20.9M for 28 autonomy-related projects since Jan 1, 2018 (the start of the IRT initiative), with funding from DARPA, DHS, DOE, NSF, DOD, NASA, and industry. Of these projects, 16 include multiple CU investigators.
- A total of over \$48.3M in autonomy-related projects has been proposed by ASIRT faculty.
- Awarded \$4.5M DARPA project "MARBLE: Multi-Agent Autonomy with Radar Based Localization for Exploration" led by Sean Humbert with Chris Heckman, Christopher Williams and Eric Frew, is result of collaboration initiated at an ASIRT workshop.

#### ***Imaging Science:***

- Submitted eight provisional patents, founded or received funding for three startup companies, and have been successful at establishing new research ties with numerous companies including Teledyne Scientific, Lockheed-Martin, Medtronic, and Oculus Research.
- Led four (> \$1.0M) funded proposals (\$8.8M total), two pending proposals (\$5.0M total), and two proposals that were not funded and will be resubmitted (\$5.5M total).

***Multi-Functional Materials:***

- Awarded (Christopher Keplinger and collaborators) \$2M from the NSF EFRI program for a project on [An End-To-End Framework For Soft Robot Design And Control Based On High-Performance Electrohydraulic Transducers](#). Keplinger's work on Hydraulically amplified self-healing electrostatic actuators appears in [Newsweek](#), [National Geographic](#), [Tech Times](#), [Science Daily](#), and elsewhere.
- Awarded (Gregory Whiting and collaborators) a \$1.7M award from DARPA for a project on [Precision Agriculture using Networks of Degradable Analytical Sensors \(PANDAS\)](#).

***Precision Biomaterials:***

- Report Pending

***Quantum Integrated Sensors System:***

- The QISS IRT helped to establish a campus quantum initiative (CUbit), that encompasses the entire University. The QISS Director, Juliet Gopinath, has now become a CUbit Associate Director anlong with Jun Ye from JILA. Steve O'Neil is serving as the Executive Director.
- Submitted a preliminary proposal to NSF for the QSS Fellow in Information Sciences.

***Water-Energy Nexus:***

- Faculty members Reiker and Linden are teaming to pursue an NSF IUCRC on Environmental Health & Safety with the oil and gas industry. Discussions with Chevron on potential partnerships between Reiker/Hannigan/Chevron on methane leak detection.
- Awarded Jennifer Cha as Co-PI, NSF Soft Materials Research Center (MRSEC) and Co-PI, GAANN Program in Materials for Energy and Sustainability.
- Faculty members teamed on three separate National Lab-led teams pursuing the \$100M 5 year DOE Energy-Water Desalination HUB.

## IRT Membership

IRT	Total # of Members	Departmental Split							
		AES	ATLAS	ChBE	CEAE	CS	ECEE	ME	Other
Autonomous Systems	52	13	0	0	4	19	9	7	0
Imaging Science	39	1	0	5	5	1	14	8	5
Multi-Functional Materials	50	5	0	8	3	6	8	16	4
Precision Biomaterials	24	0	0	10	1	2	3	8	0
Quantum Integrated Sensors Systems	45	4	0	2	0	3	14	8	14
Water-Energy Nexus	53	1	0	6	20	2	8	11	5