Systems Engineering Research Center (SERC)
Capstone Marketplace Update
Fall 2019

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SERC Vision and Mission Statement

Vision

The *Networked* National Resource to further systems research and its impact on issues of national and global significance

Mission

The SERC will be the primary engine for the U.S. government in Systems Engineering (SE) research. In doing so, the SERC will:

- **Catalyze** community growth among SE researchers and end users by enabling collaboration among many SE research organizations (who),
- **Accelerate** SE competency development through rapid transfer of its research to educators and practitioners (how),
- **Transform** SE practice throughout the government by creating innovative methods, processes, and tools that address critical challenges to meeting mission outcomes (what).

Systems Research--with Networked Impact

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About the SERC

- The System Engineering Research Center (SERC) is a U.S. Department of Defense sponsored University Affiliated Research Center (UARC), one of 16 UARCs doing DOD research.
- Stevens Institute leads a consortium of over 20 universities that comprise the SERC, in systems engineering research activities. The SERC is the only UARC academic consortium.
- SERC manages DOD funds to universities' principal investigators, and their graduate and undergraduate students.
- In the last 10 years, SERC has engaged more than 450 researchers to enhance understanding of "systems" across engineering, finance, telecommunications, computing, transportation, and other domains important to defense and security needs.

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What are Capstones?

Many types of Capstones done at Universities today—

- "Capstones" are project-based learning events for senior undergraduate students. Can be found in engineering, scientific, management, business, other academic departments
- Professors generally select teams and assign project topics
- Two semester projects are common, some Capstones are one semester
- Can include Industry sponsorship and participation

SERC-Sponsored Capstones provide unique opportunities to universities and government customers

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SERC Capstones are Different

- Real Customers with Real Problems
- Increases "bandwidth" of traditional govt R&D efforts
- Low cost
- Approaches can be "Out of the Box"
- Cultivates innovation, "MacGyvers", and graduates who want to work on important projects

Growing interest among students and universities for SERC Capstone topics

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SERC Capstones by the Numbers

6 Years SERC Capstones have been run

46 Capstone Research Topics proposed in 2018 from 8+ military units and USCG

31 Capstone projects worked 2018-2019

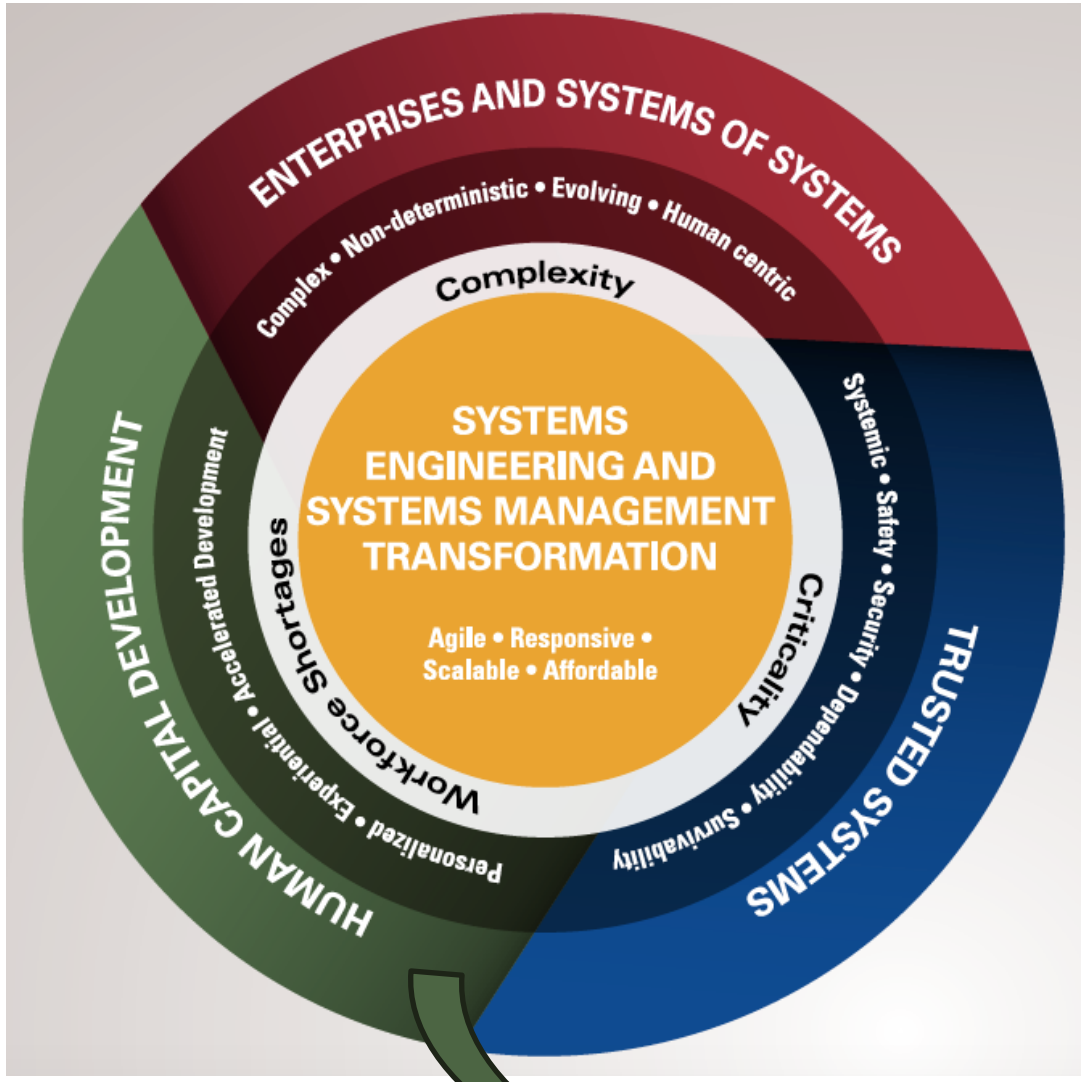
12 Universities participated in 2018-2019

5 "Outside" Universities worked Capstones

5000 Approximate dollar funding for each project

27 New projects starting Fall 2019

Capstones are part of SERC Research



Enterprises and System of Systems (SoS)

- *Enterprise Analysis*
- *System of Systems Modeling and Analysis*

Trusted Systems

- *Systemic Security*
- *Systemic Assurance*

SE & Systems Management Transformation

- *Affordability and Value in Systems*
- *Quantitative Risk*
- *Interactive Model-Centric Systems Engineering*
- *Agile Systems Engineering*

Human Capital Development

- ***Evolving Body of Knowledge***
- ***Experience Acceleration***
- ***System Engineering (SE) and Technical Leadership Education***

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Capstones Extend SERC's Network

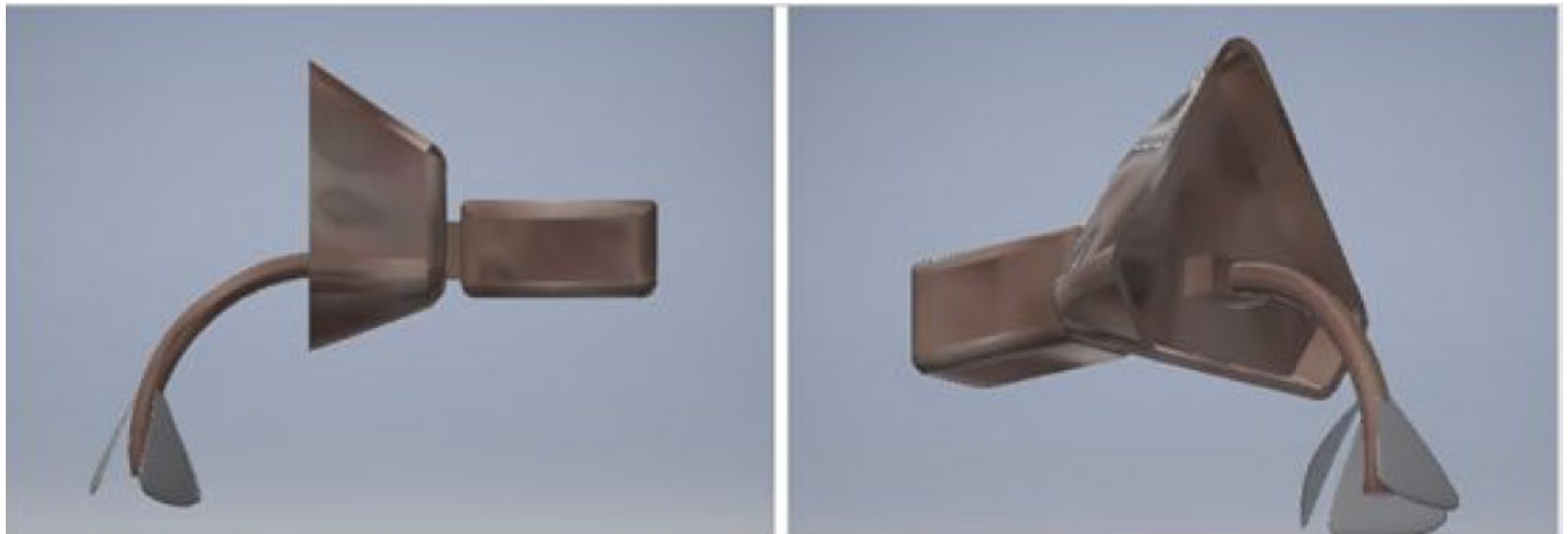
"Outside" Capstone Universities:

San Jose State University
Oklahoma State University
US Naval Academy
University of Texas-Austin
Connecticut College
University of Rhode Island
University of Hawaii at Manoa
Tuskegee Institute
Sweet Briar College
Coast Guard Academy
United States Military Academy West Point
Smith College
Johns Hopkins
Michigan Technical University

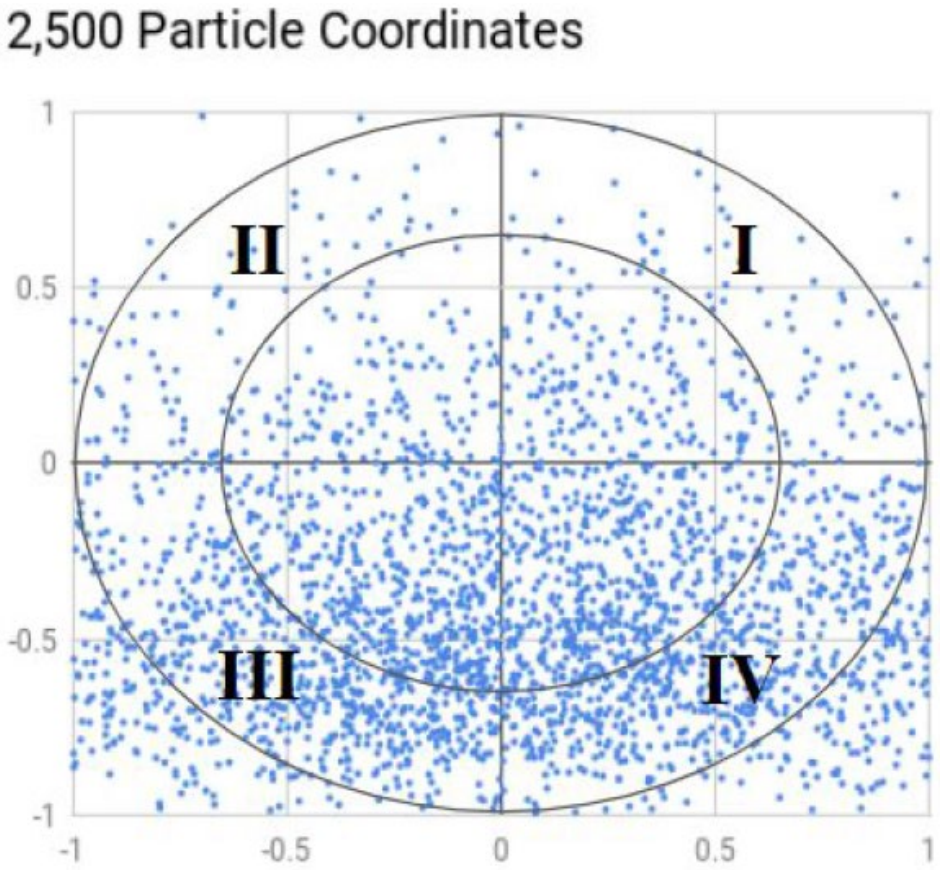
2018-2019 Research Topics

Self Intubating Airway Device

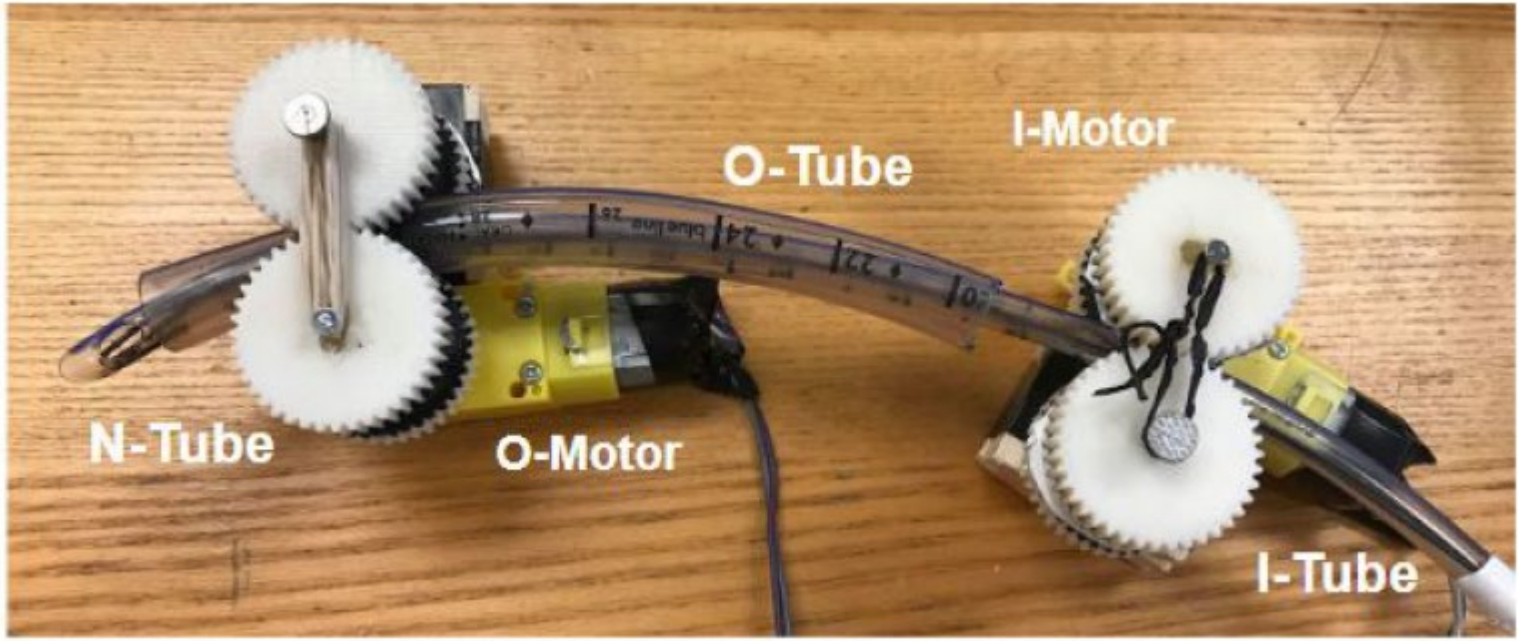
Develop a Self-intubating snake, a multidirectional device that can be loaded with an endo-tracheal (ET) tube and advanced into the mouth of a warrior in need of an airway. This device reduces the exposure of an operator to hostile fire.



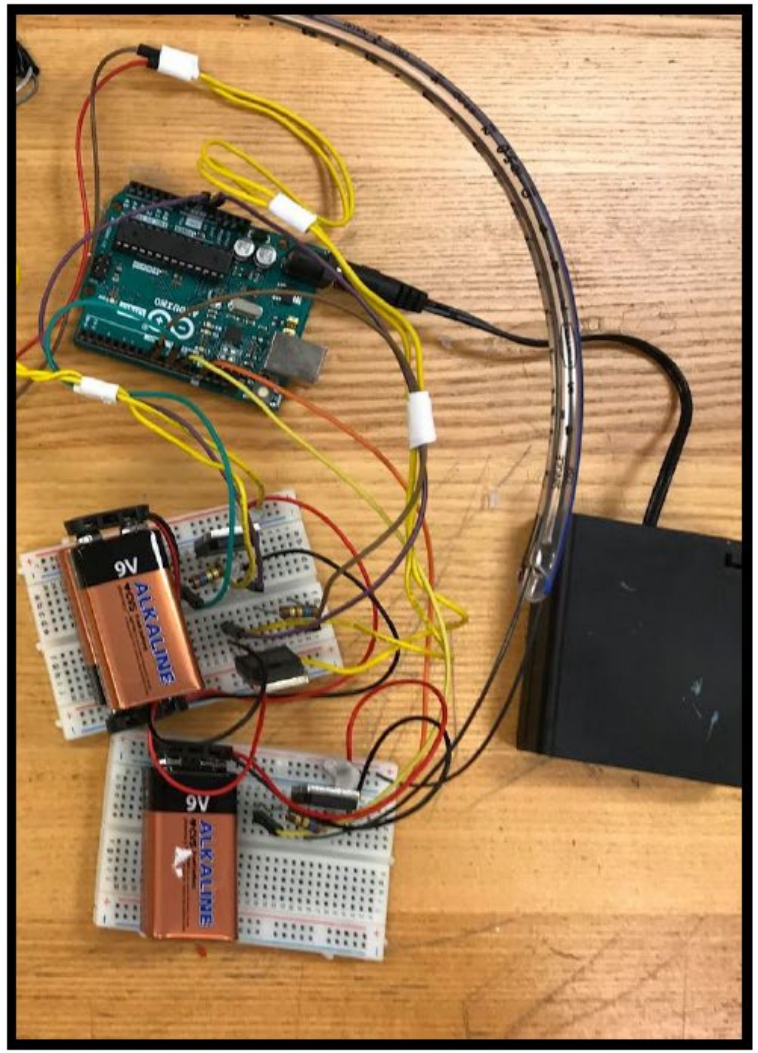
CO2 Tracking Models

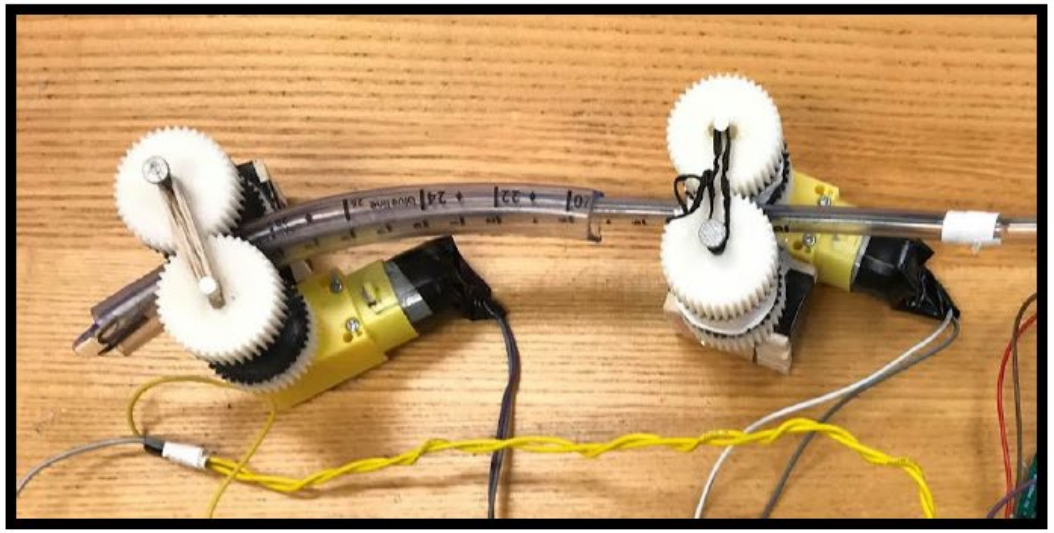


Initial Component Assembly:



Completed System:





Vision Undersea

Sponsored by:
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Michigan Technological University
Mechanical Engineering Department

Strgic Education Through Naval Systems
Experiences Enterprise (SENSE)

System Design

Sonar

- Garmin Panoptix with live scope

Power Source

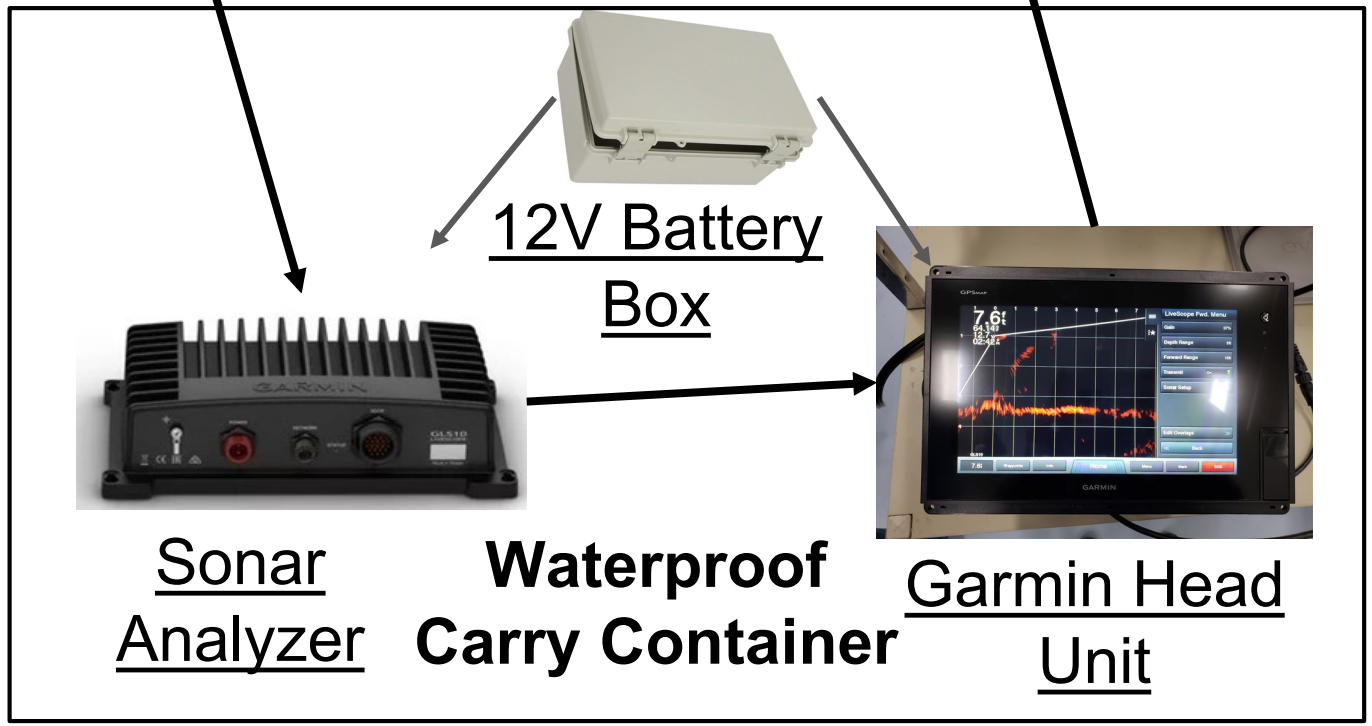
- Waterproof battery box

Display

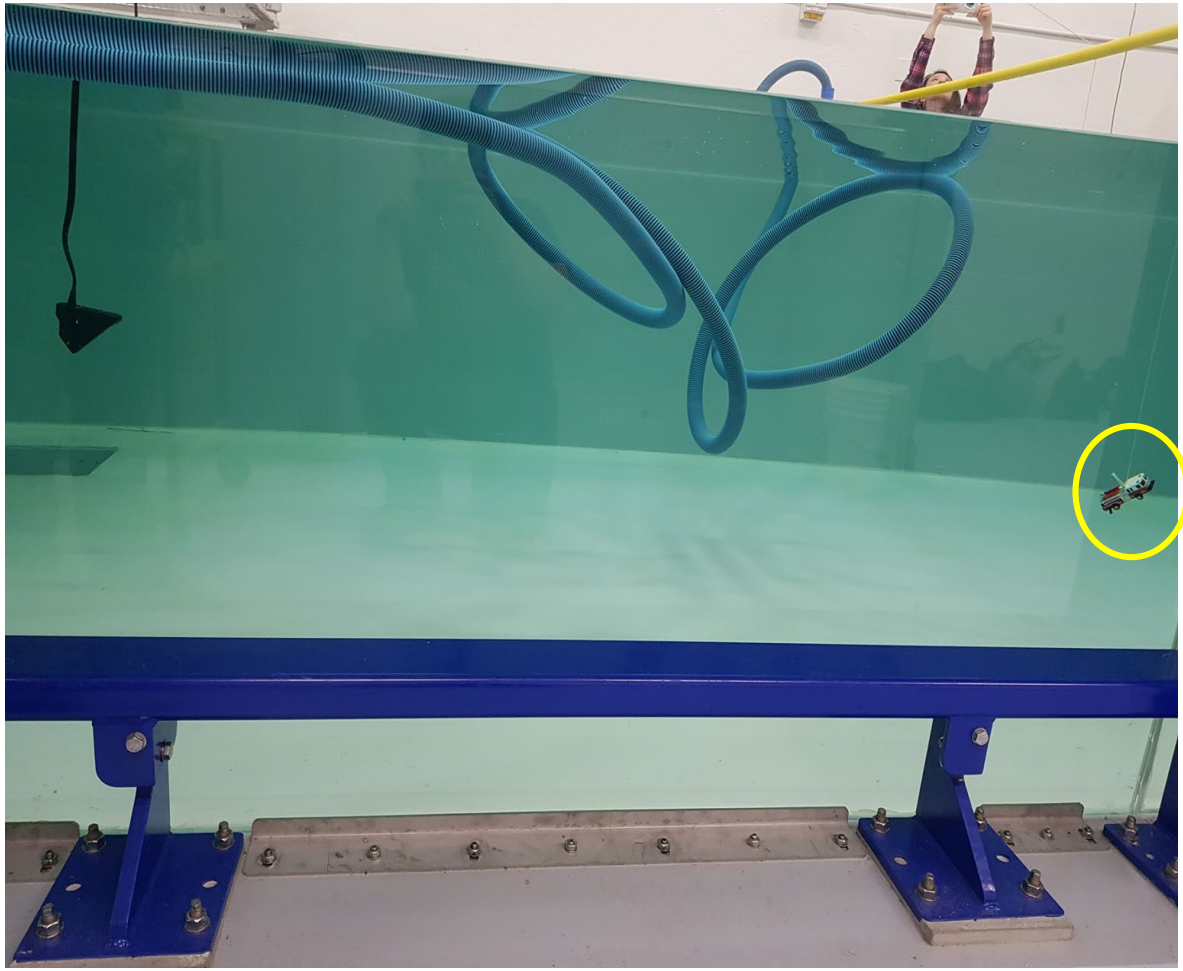
- Shadow Nav Vision System (JFD / NSWC - PCD)

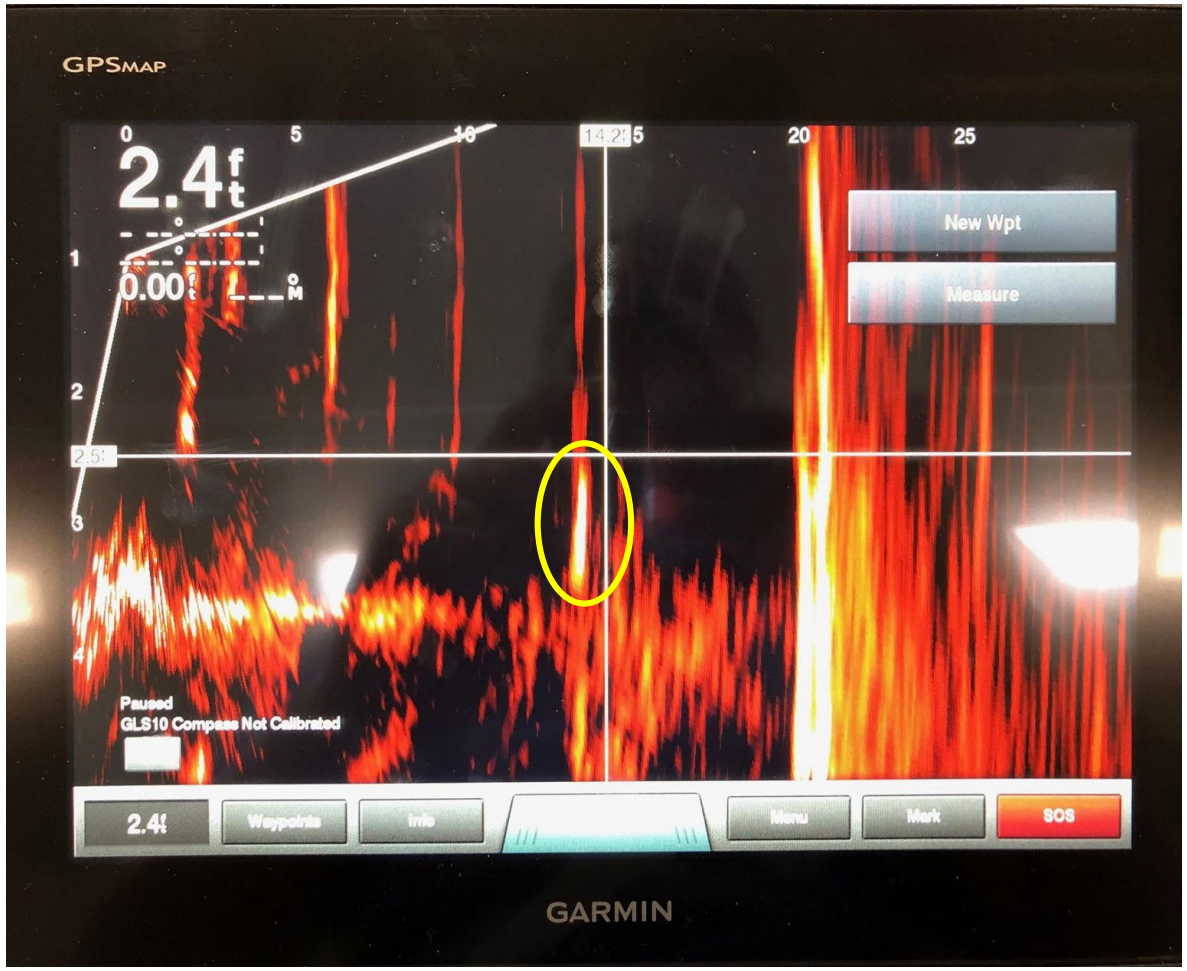
Livescope Transducer

Navy Combat Diver Display System



Wave Tank Test





Closing Remarks (from MTU)

- **Overall a successful proof of concept and exploration**
  - As students we learned about many skills:
    - Circuitry, sonar, 3D printing, waterproofing, prototype
      design process for military applications
- NSWC PCD
  - Educational Partnership Agreement in place
  - Potential for projects next semester

- Thank you to SERC and SOCOM

Capstones have transitioned to Programs

Problem—

Configure a Water Activated Personal Flotation Device that won't inflate in heavy spray on small boat operations, but will protect an unconscious or injured user who may fall into the water inadvertently

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Vessel Disablement

Stopping non-compliant vessels under sail or with highly robust, protected propulsion systems

Prototype Developed by Academic Team Proved 100% Effective in 5 of 5 Underway Tests duplicating Operational Scenarios

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2019-2020 Capstones

Research Topic	Number of Universities	Customer
Cooling aid for Maintainers in Protective Gear	2	AFRL
Quick On/Off Pulse-Ox Monitor	2	AFRL
Mass Rescue Devices	2	AFRL/USCG
Lightweight Hook	1	NSW
Maritime Disablement	2	NSW
Military Freefall Flight Data Recorder	1	NSW
Combat Swimmer Data Recorder	2	NSW
Combat Shooter Data Recorder	1	NSW
Ground Force Commander Simulator	1	NSW
Physical and Cognitive System Enhancements	1	NSW
FLIR Camera Verification of GPS Navigation Integrity	2	NSW
Deice/Anti-icing for Unmanned Aerial Systems	1	NSW

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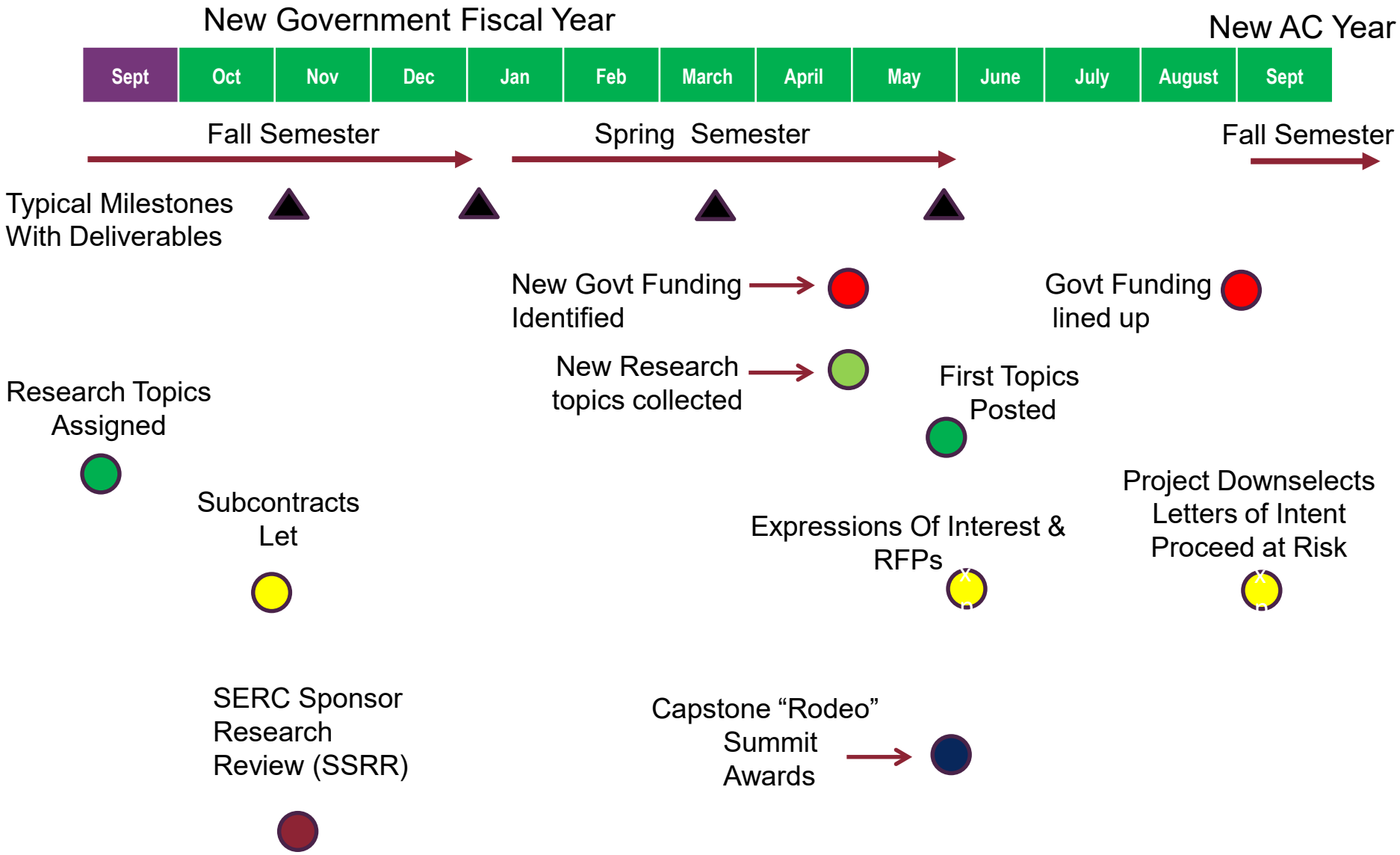
Capstones cont'd

Research Topic	Number of Universities	Customer
Future Vehicle Stopping	1	SOCOM
Quantum Computing - Algorithm Development for Military Optimization Problems	1	USD (R&E)
Augmented/Mixed/Virtual Reality Training	2	USD (R&E)
Blockchain-based Tracking of Machine Learning Algorithms	1	USD (R&E)
Data Glove for UAS control	1	USD (R&E)
Self Intubating Airway Device	1	USD (R&E)
Instrumented Combat Boot	1	USD (R&E)
Traumatic Brain Injury Self Assessment	1	SOF
Total Student Teams	**27**	

Capstone Timelines



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Thrust of SERC Capstone Experience

- Energizes “innovation” in DOD and in other government organizations
- Taps into the many good ideas which are “below the radar” on formal R&D programs—especially those from the most junior people
- Provides students and schools “real” problems owned by “real people”
- Introduces a layer of “system engineering” thinking to students’ problem solutions—without a lot of process “overhead”
- Creates model business environments; student teams develop solutions and track technical performance, schedule, costs, and other resource constraints in design reviews with their gov’t customers

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Capstone Benefits for DOD

- Ideas and approaches to solutions often unconventional and "Out of the Box"
- Value added– Can be high return on moderate investments in comparison to resources needed for industry or govt studies. Average project is $5K for 2 Semesters' work
- Increases bandwidth of Organizations' R&D efforts at low cost
- Increases DOD Client knowledge of technical issues, and interest in advanced technical education opportunities for SME's and other personnel
- Generates student interest in DOD and future employment and service

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DOD Customer Quotes:

"Employment of a student team ensures that the results of the project reflect views unfettered by organizational prejudices and preconceptions...**a perfect 'tabula rasa'**."

"In one project related to maritime issues, a student team outperformed a warfare laboratory that had been involved in the same project **for over ten years**."

"One Naval Special Warfare Group has enjoyed the use of multiple student teams. In each case, the recommendations and work performed by the teams has been employed to actually field an item (PFD actuator) and to inform the way ahead for myriad topics--maritime disablement, vehicle armor, etc."

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How to Learn More

- Capstone Marketplace website:

  www.capstonemarketplace.org

- Email us:

  capstonemarketplace@stevens.edu

  wshephe1@stevens.edu

  mdelorme@stevens.edu

Backups

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Capstone Considerations

- SERC writes Subcontracts with Universities for teams' Capstone work
- Specific Deliverables—Design Reviews and Final Products
- Emphasis on Cost and Schedule as well as Technical Performance
- Students have limited resources—time, money, facilities
- Govt Customers help keep the students "on the rails"
  - —Customers provide Subject Matter knowledge
- Design reviews—Modeled on business standards
- Approx 20 hours of customer participation needed over the Academic Year

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Capstones and Control of Information

- Most Capstones have to be unclassified—we can do classified work at Service Academies
- Student participation generally not restricted by universities. ITAR rules on “export” of information have to be followed.
- Universities can choose or pass on problems which need U.S. students only.
- Originator has option to control project information and dissemination. Limits on publication, presentations, etc.
- Intellectual Property (IP) follows government rules (FAR)

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Capstone Projects 2018-2019

31 Projects from:
SOCOM
Air Force Research Lab
USCG

Academic Performers:
Auburn
Michigan Technological University
Missouri University S and T
North Carolina A & T State University
Oklahoma State University
San Jose State
Stevens Institute of Technology
Texas A&M University
University of Maryland
University of Texas at Austin
USNA
Virginia Tech

Examples of Other Research Topics

- **2018 SOF 18 Traumatic Brain Injury Self Assessment**

The government is interested in the development of a Traumatic Brain Injury (TBI) assessment Android Tactical Assault Kit (ATAK) app. This will provide an immediately available assessment app on performer's personal ATAK.

- **2018 NSW 11 "Flare" Sensor**

Military freefall parachuting requires operators to execute a unique "flare" maneuver to reduce their rate of descent and forward velocity as they land. Analysis of the problem and identification of new methods, sensors, equipment, procedures, indicators, etc. are sought--to make the flare maneuver more reliable and safe, giving the operator a consistent soft landing with minimal risk of injury.