



SYSTEMS
ENGINEERING
RESEARCH CENTER

Systems Engineering Capstone Marketplace

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Sponsor:

USSOCOM

DASD (SE)

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EXECUTIVE SUMMARY

The goal of this project was to continue to investigate methods and means to further the SERC Capstone Marketplace that was established in 2013, refined in 2014, and further developed and designed in the 2016-2017 academic year. Previous SERC research in RT-19/19a, RT-43, RT 105, and RT-131 has shown that multidisciplinary capstone programs can enhance development of systems engineering competencies.

The Capstone Marketplace is an online tool intended to match multi-disciplinary student teams with challenging engineering projects. While web based tools exist for matching students to projects at individual institutions, the Capstone Marketplace is intended to enable broader participation and as such is open to all institutions with the capability of participating in undergraduate level capstone projects. The marketplace project sponsors and/or mentors provide domain expertise and advice, students research the project details and work towards solutions, while faculty supervisors help guide the teams and grade their work. The Capstone Marketplace makes it easier for sponsors to reach out to a broad pool of students and provide them with the added benefit of an engaged and knowledgeable mentor. Students can more easily find projects best matched to their interests and needs and faculty have an open source for student projects that can lead to new research partners and collaboration.

The project consisted of four phases:

1. Initiating and supporting a fourth and fifth year of Capstone Marketplace projects
2. Marketing the Capstone Marketplace to attract additional sponsors and participating schools
3. Refining the Capstone Marketplace website/portal
4. Development of support materials for sponsors and schools that use the marketplace

Activities of these phases overlapped, but initiation and support of the past year and marketing for future projects were mostly separate.

INITIATING AND SUPPORTING CAPSTONE MARKETPLACE

PARTICIPATING SPONSORS AND PROJECTS

United States Special Operations Command (USSOCOM) was the main sponsor for the academic years 2015-2016, with the 2016-2017 extension, with several capstone projects available for students and faculty to choose. The original projects listed for the academic years were as follows. As it will be mentioned later, there was then potential for the faculty advisors and students to submit proposals for USSOCOM's consideration.

Table 1. SERC Sponsored Projects Listed Online

Sponsor	Project
*SOCOM	Advanced Body Armor

*SOCOM	Austere Landing Zone Assessment
*SOCOM	Avoiding Information Overload
*SOCOM	Vessel Disablement
*SOCOM	Enhanced Performance #6
*SOCOM	Water/Pressure-Activated Personal Flotation Device
SOCOM	Armored Window Improvement
SOCOM	Body Worn Processor
SOCOM	Novel/Innovative Communications
SOCOM	Communications Junction Box Size Reduction
*SOCOM	Advanced Power Technologies

Asterisk denotes projects where there were identified potential participants.

PARTICIPATING SCHOOLS/PROPOSED PROJECTS

The SERC invited engineering schools to participate in the 2015-2016 academic year prior to October. This resulted in five schools being able to participate – 5 faculty advisors with a total of 23 students.

Table 2. SERC Projects Selected for Funding

Project Name	School	Academic POC
Enhanced Performance (#6) (Team EPITOME)	Stevens Institute of Technology	Dr. Vikki Hazelwood, 5 students
Enhanced Performance (#2) (Team Exoskeleton)	Stevens Institute of Technology	Kishore Pochiraju, 4 students
Water/Pressure-Activated Personal Flotation Device (cont #5) (Team BloFish)	Stevens Institute of Technology	Dr. Marissa Gray, 4 students
Austere Landing Zone Assessment (#7 Cont) (Team Austere Landing Zone)	Stevens Institute of Technology	Dr. Leslie Brunell, 4 students
Underwater Navigation and Communications (Team	Georgia Tech	Dr Mick West, 6 students

Shortly after the 2016 academic came to a close, the sponsors, specifically Commander Greg Sutton, requested that the project continue into the summer to make further improvements to the design after a visit to Virginia Beach to debrief on the progress of the project.

In academic year 2016-2017, several projects were proposed for approval to USSOCOM. This also included a new format agreed upon between SERC and USSOCOM. After reaching out and networking to several participating universities, it was noted that there were numerous ideas on projects that may be of particular interest to the sponsors. On the website, we added the feature to propose a project to the sponsor. In the new feature, we listed the mission and objective statements of USSOCOM and included their website for the faculty and students at participating universities to view and ensure their proposed projects were in line with the sponsor’s objectives. We also met and discussed the individual potential projects with each faculty member to help them better understand the Capstone Marketplace and working on a DoD contract. This concluded in the Precipitation Driven Flood Forecast Model proposed

project to be outside USSOCOM’s scope, further solidifying the advantage of meeting with the faculty member beforehand to overview the FARs and DFARs associated with working on this contract. The 2016-2017 Proposed Projects were as follows:

Table 3. SERC Proposed Projects for 2016-2017 Academic Year

Project Name	School	Academic POC
Enhanced Performance (#6)	Stevens Institute of Technology	Dr. Vikki Hazelwood
Enhanced Performance	Stevens Institute of Technology	Dr. Kishore Pochiraju
Water/Pressure-Activated Personal Flotation Device	Stevens Institute of Technology	Dr. Marissa Gray
NEW: Precipitation Driven Flood Forecast Model (removed after individual meeting)	Stevens Institute of Technology	Dr. Alan Blumberg
NEW: Reduction of Slamming Loads on Small High-Speed Craft	Stevens Institute of Technology	Dr Raju Datla
Water/Pressure-Activated Personal Flotation Device	Stevens Institute of Technology	Dr. Mirjam Fürth
Manned Mini-submarine Variable Depth Anchoring System	Stevens Institute of Technology	Dr. Milan Simonovic
NEW: TBD/Fatigue Testing Applicable to both Humans and Animals (Spring Semester)	Stevens Institute of Technology	Dr. Marissa Gray
Human Performance Augmentation (Spring Semester)	North Carolina A&T State University	Dr. Tonya L. Smith-Jackson
NEW: Power line awareness for Low Altitude Aircraft	University of Alabama Huntsville	Dr. Shankar Mahalingam
NEW: Real-time External Perspective for Drones	University of Alabama Huntsville	Dr. Shankar Mahalingam

Those designated as “new” are projects proposed by students and/or faculty that were not already listed Capstone Marketplace projects on the website by the sponsor. Unfortunately, we were unable to initiate projects due to delay in the academic year. The following were the ones that were able to start. Dr. Marissa Gray continued to work on the Enhanced Performance #6 with John Anderson from USSOCOM.

Table 4. SERC Proposals Selected for 2016-2017 Academic Year

Project Name	School	Academic POC
Enhanced Performance (#6)	Stevens Institute of Technology	Dr. Vikki Hazelwood
Water/Pressure-Activated Personal Flotation Device	Stevens Institute of Technology	Dr. Marissa Gray
Water/Pressure-Activated Personal Flotation Device	Stevens Institute of Technology	Dr. Mirjam Fürth

Along with the above tasks, we were able to also quickly turnaround a proposal from Auburn University titled “Open Source Investigations into Three DOD Relevant Research and Technology Questions” with Dr. Robert Norton.

PROJECT RESULTS

Projects that had points of contact at USSOCOM were deemed successful, with continuations into summer or the following academic year. Those that were not as successful had several conditions associated that may have contributed to the decreased performance, such as:

- Inability to establish proper initial communications between sponsor point of contact and the team.
- Rushed timeframe due to delay in approval and/or funding.

The first point is a recurring problem and is addressed in a later section of this report. The second is as well. There have been unconventional teams in previous CM projects that operated outside of the typical capstone design format and managed great success, including in this academic year. However, the fault likely lies with the inability to obtain the best students for the projects and also the ability to execute in the structured format that most faculty advisors are used to.

INTEGRATED LIFECYCLE MODEL/ROADMAP FORWARD

The core of Capstone Marketplace is the website which establishes where students, faculty, and mentors can view the potential projects suggested by the sponsor as well as submit proposed projects. Below is a timeline of the process of identifying, posting and matching projects to successful applicants and sponsor subject matter experts (SMEs). The website was populated with 10 of 12 projects for the 2015-17 academic years by close of the spring semester, however, a firmer foundation on the management and expectations of the CM should be established. A more appropriate time frame is mid-spring semester when students begin to pre-select projects and develop relationships that lead to team formation. The nature of the academic calendar and its deviation from the primary projects sponsor's standards present a distinct challenge in this regard. Multiple attempts were made to engage schools to submit proposals for these late projects without success.

1. Project Proposal Solicitation (May- July)
 - Sponsors submit proposals to Marketplace (with help from Marketplace administrators).
 - Faculty/students are able to submit proposals to the CM portal.
2. Bidding by Student Teams (May – August)
 - Faculty and students browse marketplace and make bids on projects (with help from Marketplace administrators).
3. Matching of Teams to Projects (May – August)
 - Sponsors select teams (with help from Marketplace administrators).

4. Execution of Projects (September – May)

- Student teams work on projects under supervision of faculty.
- Sponsors advise and review work (suggestion of checking in/phone call one to two times per month with faculty and/or students).

5. Feedback from Sponsors, Students and Faculty (May – June)

- Marketplace administrators collect feedback from all participants to use in improving advice in future years.

Information and resources are able to be added to the website to better enable participating students and faculty to implement SE processes and tools and to provide guidelines for topics such as intellectual property, disclosure of project information, publication of research results, and communication protocols. The guidelines were intended to reduce some of the complications associated with the collaboration between undergraduate academic programs and US DoD sponsors with respect to procedures and processes that arose in previous Capstone Marketplace projects. In 2014-15 several issues regarding disclosure of information and communication breakdowns continued to occur, though efforts were made to remove. In 2015-2016, we implemented team meetings with the Executive Director of Sponsored Programs (Stevens), Executive Director of Intellectual Property (Stevens), the SERC Program Manager of Operations, and the Principal Investigator of Capstone Marketplace to walk through Intellectual Property, Fabricated Equipment, deliverable markings, and information flow (see appendices for copies made available to each team).

Moving forward, we also suggest implementing some other cross-cutting orthogonal activities across the CM.

Table 5. Cross-Cutting Orthogonal Activities Table

WHY – Objectives	WHAT - Initiatives
<p>Inform students on appropriate decorum while working with the SERC: the applicable Intellectual Property rights as stated by FAR and DFAR, proper markings on all publications/presentations/deliverables through contract, and fabricated equipment.</p> <p>This was initiated last year, but the objective would be to make it a more formal process. This is to ensure that all the end deliverables and objectives are met with no surprises and students understand the expectations and FAR/DFAR aspects of the project as well as the aspect of sensitivity, should any arise.</p>	<p>All senior design teams will go through a 1 hour seminar on Intellectual Property rights, deliverable markings, and related topics</p>
<p>To ensure students are gaining knowledge on SE and SE design. This will be done in a manner that translates SE principles into a set of simple, reflective questions in a language that is very practical – Selected questions are included in the attachment. One of the ideas of the Capstone was to expose undergraduate students to systems engineering (overview, principles, methods, processes, and tools) with the idea of enabling them to start understanding systems thinking and equip them to transition into the workforce with greater ability to impact whatever program they are designated.</p>	<p>Senior design teams will go through three 1 hour webinars on systems engineering and design. Once developed, these webinars will be posted on the SERC website as a resource for other students.</p>
<p>To have students apply what is learned. It also will provide insight to newer tools being used by undergraduate students, and help create a larger repository of impressions for analysis by the sponsors.</p>	<p>All senior design teams will be given access to a systems modeling tool and requested to develop the requirements and architecture models for their systems in a model centric environment</p>
<p>Continuously improve the Capstone Marketplace, understand the true impact SE and systems thinking had on the students, and to gauge the influence of modeling on the projects and students. This will also serve as a verification/validation on the survey results.</p>	<p>All design teams will develop a reflective paper on the influence of systems engineering and thinking on their projects; the influence of the modeling tools – and thoughts on how to improve this experience</p>
<p>To track students — the baseline, progress, final stages, and where the student is placed in the workforce. Another objective is to show continuing credibility to the foundational research that the multidisciplinary teams are beneficial to the students appreciation and use of systems thinking. Another objective is to learn from the students — to see what new, hot tools the students are using to develop their models to produce the products and deliverables. This can help sponsors stay abreast of new, upcoming tools.</p>	<p>1.Students will be given a before and after survey to assess their knowledge of systems engineering, model-centric engineering, and to gauge their methods, processes, and tools used prior and during the project. The end survey will also inquire if the student is going into government, academia, or industry.</p>
<p>Create excitement and opportunity amongst teams sponsored through the Capstone Marketplace, and the opportunity to present at NDIA which would further expose the students to key personnel Defense Industry and Defense Industrial Base.</p>	<p>Evaluate the sponsored senior design projects, help identify the winning team – this team will get a chance to present their project at the NDIA symposium the following year and be recognized in this forum.</p>
<p>To promote the Capstone marketplace to potential sponsors, universities, and ideal students.</p> <ol style="list-style-type: none"> 1. Necessary to engage outstanding students as soon as possible, and the exposure of students participating on the projects could entice more to participate. 2. This would also help usher more universities within the consortium to participate. Having the ability to show something substantial, such as a picture or interesting update, makes the projects palpable. 3. For potential sponsors, they can see how engaged the students are. 	<p>Social media outlets (Twitter, Facebook, etc.) will be made available for students to post pictures of progress, teamwork, and final projects.</p> <p>Teams will be briefed on proper markings to show sponsorship from SERC and any others (i.e., USSOCOM)</p>

An example of key systems engineering questions for the students is in the appendix. It would be beneficial to meet with the USSOCOM sponsors for a one-day workshop on initiating the timeline, orthogonal activities, and further development of the website and accommodations necessary for full ability to view and be involved in the project. This would also enable the foundation to be solidified and then in the future, further refined and developed.

WEBSITE

A new website was developed and launched through this research with a several key goals; enabling the scaling of participation without creating excess administrative needs, enabling the transition of the marketplace from within the SERC to another independent entity or as a stand-alone service, and to improve the user experience and better establish the website as a project resource. This is, however, still being updated by pulling over information from the old website as well as building out sections and testing areas with outside participants.

The list below identifies the new capabilities sought after from the foundation previously set, and which were successful in implementing/setting up for full launch:

- Team formation:
 - Searchable key topics database that will tie together:
 - Project requirements as defined by the sponsor,
 - Areas of expertise or interest as defined by mentors and faculty,
 - Areas of interest, experience and academic disciplines as defined by the students.
 - This will enable identification of synergies between all users with the goal of better enabling multiple institution collaboration and participation of non-sponsor mentors or SMEs.
 - The above has all been made available through the new platform, but does need to be built out more specifically. Previously, the search function did not allow for pulling specific phrases or areas of interest, however, that has been improved.
 - A message board to allow for communication at the preliminary team forming stages where potential students can establish a line of communication the same way students in a single institution may communicate amongst themselves to team form based on interest and capabilities.
 - This has been developed, but we do need to test.
- Project support:
 - The resources section of the website will continue to be expanded
 - A tool for securely storing relevant project materials will be added to enable sharing across institutions, sponsors, mentors, and if applicable the public viewers of the website.
 - A shared project calendar permitting transition to popular web based calendar tools.
 - The securing project materials has been added, however, the shared project calendar still needs to be implemented.

- Assessment:
 - Core systems engineering principles are being established and a pre-project and post project assessment will be developed to better enable an assessment of student learning and the efficacy of the Capstone Marketplace.
 - As specified in the cross-cutting orthogonal activities, core activities have been identified to view and share progress of teams and their understanding of systems engineering principles.

OUTREACH

SOLICITING PROJECT PROPOSALS FROM SPONSORS

The SERC team met with potential sponsors to provide information on the Capstone Marketplace. This ranged from presentations and in-depth discussions of information at system engineering industry events, to discussions/networking with contacts developed through existing professional relationships. The enthusiasm to get involved is certainly present, and many meetings lead to in-depth discussions and follow ups.

Below is a summary of some of the key events attended and groups contacted and/or briefed on the Capstone Marketplace:

- NDIA Systems Engineering Conference
- INCOSE International Symposium
- INCOSE Interworking Group (January Meeting)
- NOAA/NWS
- SE Forum
- NDIA SE Division Meeting
- Office of the Science, Technology, Engineering, & Mathematics (STEMS) Development Program within the Department of Defense
- Undergraduate IWG Knowledge Exchange Summit
- Scholastic
- MITRE
- Boeing
- Booz Allen-Hamilton
- Differing SYSCOMS that could be involved

MITRE has stated that they would pursue doing 2 CM projects per academic year.

SOLICITING AND ENCOURAGING ACADEMIC PARTICIPATION

A briefing of Capstone Marketplace was given at the SERC Executive Advisory Board with a majority of the collaborating universities' Vice Provost of Research present. This helped engage key members within the consortium. Along with those, we also sent an email to each of the

Deans of Engineering. From the email, we received positive feedback for future collaboration, and have further discussed with participating universities their involvement. Briefings during SERC Collaborator WebEx's were provided, as well as participation in academic forums that were focused on capstone projects, for instance at the Conference on Systems Engineering (CSER) and the Annual SERC Sponsored Research Review (SSRR). Of course, additional outreach to individual institutions and faculty members was ongoing throughout the project, and a much better understanding has been established. The significant perception that participation in the CM will require excessive administrative effort and reporting has been thwarted through conversation and examples of execution, but an explanation should be included in the website specific to each project.

SERC Leadership also went to understand the relationship between CM and the Stanford Hacking for Defense Initiative and to explore the intersection of systems engineering and innovation.

LESSONS LEARNED AND RECOMMENDATIONS

ALIGNING SPONSOR INVOLVEMENT WITH ACADEMIC CALENDAR

The alignment of the project solicitation to selection and execution is essential to project success. Identifying and publishing desired projects to the website between March and July would be ideal for curating the best students. It also helps engage the academic community, such as the faculty, Deans of Engineering, and Vice Provosts of Research. The information is more widely acknowledged if done during the spring to early summer semesters. The selection of the projects prior to the start of the fall semester would be beneficial for the students since they often have to start working on their projects in the fall.

The role of the sponsor's subject matter expert (SME) is crucial to driving a successful project, and the earlier the SME can be involved, the better. The aforementioned timelines would be advantageous to USSOCOM finding early involvement from SMEs as well, but it is necessary to obtain which projects should be selected for funding as early as possible, so that the teams may be alerted. The projects are run on a short timeline with the need of critical information early. Of course, additional reviewers and mentors can be found by contacting local chapters of professional societies or personal contacts. For instance, one student in spring 2017 was able to interview a relative who was a former Navy SEAL to help understand the need, outlook, and requirements for the stakeholder.

The SERC ended up exploring the option of deobligating funds to reobligate or to utilize a NCE to help with the following year's CM projects. Only 5 projects were designated for the 2015-2016 academic year, with an additional project over the summer, and in hopes of fulfilling more projects as the academic year and summer progressed, the funds were held. The small number of funded projects came from the unknown of whether it would be selected for funding, and

the timeframe of the initiation with the sponsor. Students and faculty try to obtain the project information, including funding process, by early fall semester.

For 2015-2016 academic year, there was immediate awareness of a potential deobligation or NCE if the remaining projects could not be assigned. The deficit comes not only from the lack of projects, but also the fact that some projects do not need the full \$10,000 delegated, and the lack of charging the expected personnel to help manage the Capstone Marketplace impacted the bottom line. However, aligning the go-ahead on projects more with the academic calendar would allow the sponsor and CM PI insight into the budget necessary for each project. Therefore, the funding can be adjusted and appropriately allocated to the sponsor needs.

FACULTY AND STUDENT INVOLVEMENT

The faculty advisors much be able to participate and disseminate information to their respective design teams. There is minimal burden added to them, however, the advisors still need to oversee their work and provide guidance while being able to advise sponsors of realistic expectations. Utilizing the discussions forum through the website would enable faculty to oversee communications and act as necessary.

Student involvement is the most critical component of the CM. The institution of a friendly competitive atmosphere through opportunity to have a “winning” team present their project at the NDIA symposium the following year would help cultivate excitement. Also, the creation of social media outlets (Instagram, Twitter, Facebook, and LinkedIN group) would not only promote the Capstone to potential sponsors and universities, but also engage outstanding students as soon as possible. Students like to showcase their work, and this provides the means to do so. An Instagram and Twitter have been initiated (both have usernames SERCCapstone), though they have not yet been used. Part of this, is they need to be promoted throughout the lifecycle of the project and presented as a part of the experience. These were initiated in the midst and towards the end of the project lifecycle. This would be something the sponsor and PI could work on establishing together (i.e., information to include such past projects that are desirable for promotion, etc.).

FOUNDATION FOR SUSTAINED GROWTH

As we have moved forward with running the CM, the need for structure and a platform for sustained growth became evident, especially if the 2019 CM Objective (shown below) will be achieved. The vision for the Capstone was to have as many of the collaborating universities involved with numerous projects and sponsors involved. There has already been great feedback from universities on how they have developed their capstone courses to be more interdisciplinary and open to outside involvement and guidance. During this task, Michael Pennotti helped evaluate the current structure and help guide an architecture for success that

is scalable. His report was that he found widespread enthusiasm for the concept, but also widespread frustration with the ever-changing points of contact and significant obstacles with the DoD funding cycles and academic calendars. His recommendation is to have a leader with the ability to take a greater and more concentrated effort than what has been available in the past.

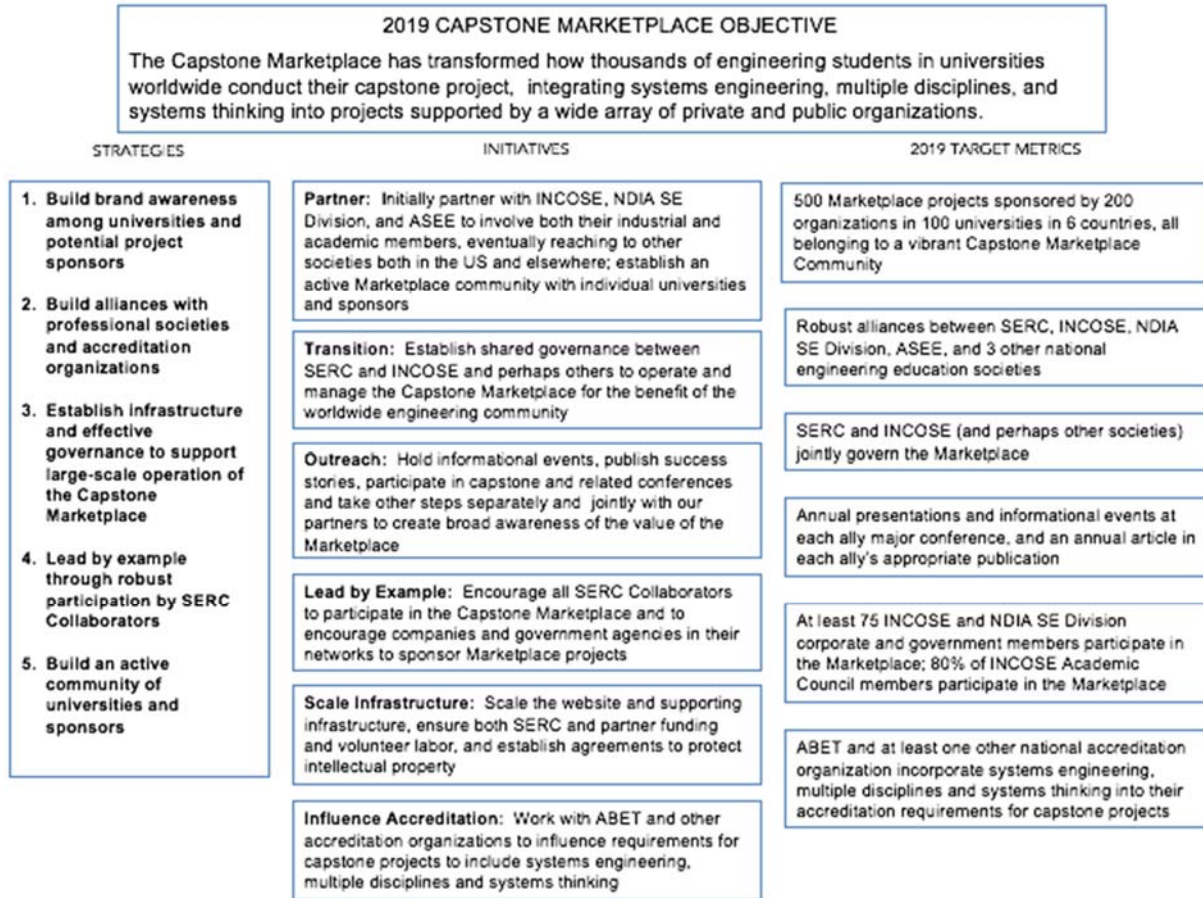


Figure 1. 2019 Capstone Marketplace Objective

CONCLUSIONS

Overall, there is tremendous interest in the topic, and the CM continues to be viewed as a success by the participants across the three groups: academic, sponsor, and mentor. However, there needs to be a more robust and consistent approach from the leadership to realize its potential, and create a foundation to then sustain it.

Aligning discussions and decisions between the DoD and academic calendars will be pivotal to the success of the Marketplace. Enabling that open, consistent line of communication and demonstration of project progress will help ignite interest and participation as it continues. The growth of the Capstone into a year-round discussion with several ongoing and potential

projects is a goal. For instance, the Auburn task was started late, however, it was a success for a quick turnaround on contract, and also demonstrated the power of discussion with potential smaller projects that would be of interest to the sponsor.

Increasing academic participation may be a challenge with schools who have a strong, existing relationship with industry partners. However, several lessons learned regarding opportunities and challenges to broader participation are noted in this report, and once a foundation is set, it would be worth pursuing multi-school collaboration.

The primary sponsor of CM projects has expressed a desire for them to continue, and have provided beyond excellent SMEs. Almost every faculty member and student has stated that the SMEs approached participation from a great perspective of steering students but not directing them towards a given solution. In several instances this approach has led to solutions that have been moved forward for additional research. It would be wonderful to have a workshop with the primary sponsor, USSOCOM, if we do indeed continue to discuss schedule, potential projects (both proposed by USSOCOM and the SERC Collaborating universities), website, and social media platforms. We should also find an additional participating faculty member with the availability to have a greater, more concentrated effort than previously done.



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<http://www.sercuarc.org/>

**“STUDENT RESEARCH PROJECTS
and
INTELLECTUAL PROPERTY”**

I. GENERAL INFORMATION

Student research opportunities are a university objective for those students interested in the research process and associated entrepreneurial experience. While all research does not automatically lead to the development of intellectual property, it's a circumstance that does occur. This document is created to address that circumstance and ensure that student researchers, the faculty advisor and the university's interests are all protected and soundly managed.

II. UNIVERSITY “PATENT POLICY”

The University's "Patent Policy" is found on the Stevens' webpages and describes all aspects of ownership associated with research, sponsored and unsponsored and whether the inventor is a faculty, staff or student.

III. STUDENT RESEARCH

Specifics regarding the rights of inventorship as it regards students is found at III(E)(1, 2 and 3) in the "Patent Policy." In order to ensure correct assignment of rights and responsibilities, all student inventors (and their faculty advisors, if applicable) should contact the Stevens' Office of Innovation and Entrepreneurship as soon as it is thought that intellectual property has been developed. This will help all affected parties and decrease the opportunity for misunderstanding.

IV. SERC CAPSTONE MARKETPLACE PROJECTS

Capstone Marketplace projects are undertaken by student teams at various universities within the SERC Collaboration. The projects are engaged to satisfy the needs of government sponsors and further the government's interest in and support of the general education and research process. Sometimes the projects will result in the generation of intellectual property and it is important that all individuals involved in the projects clearly understand their rights as well as their obligations to the government. CAPSTONE projects issued by the SIT (SERC) are federally sponsored awards and subject to the contract obligations of relevant FARs and DFARs. (Additional information regarding CAPSTONE Projects is available in the document entitled "CAPSTONE PROJECTS—Release of Information and Intellectual Property.")

SUMMARY OF DISCUSSION:

Signature and date of Student Team Member: _____

Signature and date of Faculty Advisor: _____

"CAPSTONE PROJECTS"

RELEASE OF INFORMATION AND INTELLECTUAL PROPERTY"

*

I. GENERAL INFORMATION*

Capstone/Marketplace projects are undertaken by student teams within the SERC Collaboration, as well as other participating universities. The projects are engaged to satisfy the needs of government sponsors and further the government's interest in and support of the general education and research process. Sometimes the projects will result in the generation of intellectual property and it is important that all individuals involved in the projects clearly understand their rights as well as their obligations to the government. **CAPSTONE projects issued by the SIT SERC are federally sponsored awards and subject to the contract obligations of relevant FARs and DFARs.**

II. POINTS OF CONTACT*

Each project should have a **Faculty Advisor** who will provide guidance to the student team. Each project sponsor should identify a point of contact in their organization who will provide assistance to the team and act as the **Client** for the project. Points of contact will primarily be between the Faculty Advisor, the student team and the Client/government sponsor; however, responsibility for reporting the development of intellectual property developed as the result of CAPSTONE sponsorship rests with the Stevens' SERC.

III. DISCLOSURE AND RELEASE OF PROJECT INFORMATION*

The overwhelming majority of Research Tasks (RTs) issued by the SERC are fundamental research and the award recipients may publish without sponsor review or approval. Projects that do have publication restrictions will be clearly identified and SERC Collaboration universities may choose not to accept these projects. Since government requirement of prior review and approval could result in the delay or restriction of this thesis or dissertation material, it is important that CAPSTONE student teams be apprised of this circumstance.

IV. INTELLECTUAL PROPERTY*

At a minimum, development of intellectual property during a CAPSTONE experience is subject to the requirements of FAR 52.227Q11 and possibly 52.227Q13, which require that the SERC report all such intellectual property to the government and that the government receive a license. Appendix F of the "Sponsored Research Agreement (SRP) Provisions" recognizes the authority of each university's own Patent Policy as it regards assignment of inventorship and copyright; however each university's Patent Policy and processes must be able to accommodate the requirements of reporting and the assignment of licenses to the government by means of Contractor/Subcontractor ownership of IP. In the event the intellectual property is developed by a collaborating institution, the signature of the authorized official at Clause 31 in the Subcontract/Sponsored Research Agreement acknowledges understanding and agreement with these requirements. The following process describes the collaborating institution's interaction with the SERC:

- **DEVELOPED AT COLLABORATION UNIVERSITY**—Faculty Advisor notifies their university business office as well as the SERC Manager of Program Operations, who will notify the Stevens Office of Innovation and Entrepreneurship (SEE APPENDIX F—IP PROVISIONS)
- **DEVELOPED AT STEVENS**—Faculty Advisor notifies SERC Manager of Program Operations, who will notify the Stevens Office of Innovation and Entrepreneurship (SEE APPENDIX F—IP PROVISIONS)

The following section advises the Student Team members, the Faculty Advisor and the Collaboration University (if relevant) of publication restrictions. Additionally, each member of the Student Team and the Faculty Advisory acknowledges receipt of this information by means of their signature on this memo.

Are there publication restrictions on RT# _____? YES NO

Signature and date of Student Team Member: _____

Signature and date of Faculty Advisor: _____

SERC PROCESS MEMO: "SERC CAPSTONE Ts and Fabricated Equipment s. Deliverables"

Sometimes the difference between equipment, fabricated equipment and a project deliverable requires clarification. This PROCESS MEMO seeks to provide guidelines to the SERC research community in this regard.

Typically, a deliverable is an item of equipment or scientific instrumentation created by Stevens' personnel in connection with a sponsored project to which Stevens will not hold title. Additionally, it is often the case that the *deliverable* will be provided to the sponsor or another party at the end of the project; although the sponsor can decide on alternative disposition of the item at project end.

If an item is a *deliverable*, it cannot be Fabricated Equipment. Merely connecting components together in a system (physically or virtually) does not constitute Fabricated Equipment. Projects where the construction of a piece of equipment is the sole purpose of the sponsored project are not eligible for the Fabricated Equipment exemption to application of F&A. Essentially, Fabricated Equipment is a tool to conduct the research as opposed to being the focus of research itself. An explicit prototyping activity in the project plan would not be considered to be a fabrication task since the prototype does not result in a functional piece of equipment. Thus, fabrication must be carried out according to a plan that does not require experimentation with concepts or with the approach. The development of the design is considered to have occurred prior to the fabrication and not in parallel with it.

Sometimes, as in the case of SERC CAPSTONE projects, funds are provided by the SERC sponsors for the purpose of providing research, design or assembly opportunities to undergraduate or graduate students in furtherance of their educational experience. In these cases the amount provided by the sponsor may exceed the \$5,000 threshold that generally describes 'equipment;' however, the sponsor may not consider this as either the fabrication of equipment or as a *deliverable*. Disposition of these end items will be determined by the sponsor as the result of dialogue during the project.

Defining the Problem Key Questions:

1. What operational need or market opportunity is your system intended to address?
 - *Assessment Criteria: The need for the system is well understood, fully described in the language of the stakeholders and free of solutions.*
2. Who are the most important stakeholders and what are the key requirements of each?
 - *Assessment Criteria: The key stakeholders have been identified and their most important requirements defined, validated and clearly stated.*
3. What are the three to five most important features of your system that distinguish it from those of your competitors?
 - *Assessment Criteria: Features are specific, quantifiable (or readily observable), and important to the customer.*

Deciding How the System Will Work Key Questions:

7. What top-level functions will your system have to perform in order to accomplish its mission?
 - *Assessment Criteria: Top-level functions are few in number (3-6) and fully represent the required system functionality.*
8. How else could you have partitioned the system functionality and why did you choose to partition it the way you did?
 - *Assessment Criteria: Alternative decomposition is plausible and the rationale for selecting the chosen partition is sound.*
9. How will the top-level functions interact with each other and with their external environment?
 - *Assessment Criteria: Key operational scenarios can be traced through the top-level functions.*
10. How well will your functional architecture perform and what evidence can you provide to support that assessment?
 - *Assessment Criteria: The functional architecture has been analyzed to verify that it achieves the key system requirements.*

Creating an Operational Concept Key Questions:

4. What is your proposed system concept? What alternative concepts did you consider and why did you choose the one you proposed?
 - *Assessment Criteria: Broad range of concepts defined and systematically analyzed against criteria linked to key stakeholder needs.*
5. How will your proposed concept operate within the larger context to achieve its intended purpose?
 - *Assessment Criteria: The external systems with which the system will interact have been identified, the system boundary has been clearly defined, and the interactions between the system and the external systems have been specified from a black box perspective.*
6. What are the key specifications that will drive the system's design and development?
 - *Assessment Criteria: System requirements a) have been derived from and are linked to the stakeholder requirements, b) describe what the system shall do but not how, and c) are verifiable and properly written.*

Implementing the Functions Key Questions:

11. What are the major subsystems of your system and how do they map to the functions the system must perform?
 - *Assessment Criteria: Subsystems defined and mapped to the top-level functional architecture.*
12. What are the key interfaces between the subsystems and between them and the external systems with which the system interacts?
 - *Assessment Criteria: External and internal interfaces defined and mapped to corresponding external and internal inputs and outputs.*

Specifying Components Key Questions:

13. What are the key requirements for each of your major subsystems?
 - *Assessment Criteria: Verifiable subsystem requirements derived from key system requirements*
14. What tradeoffs were made in deriving your subsystem requirements?
 - *Assessment Criteria: Tradeoffs systematically analyzed against well-defined criteria and reasonable decisions*
15. What are the most important technical risks for your system and how will you mitigate each?
 - *Key technical risks identified, properly characterized as to likelihood and consequence, and suitable mitigation plans provided for each*

Integration and Test Key Questions:

18. How will you prove to your customer that the system meets his/her needs in the operational environment?
 - *Assessment Criteria: Plans in place to demonstrate that the system meets the original customer needs and to gain final customer acceptance*
19. How will you respond when problems arise?
 - *Assessment Criteria: Plans and resources in place to diagnose, fix and test field-found faults and to certify that corrective actions have been successful*

Integration and Test Key Questions:

16. How will you integrate and test the components of your system? Why?
 - *Assessment Criteria: Plan in place to systematically test all key interfaces and risk items against corresponding specifications*
17. What resources and facilities will you need to verify that the system meets its specifications?
 - *Assessment Criteria: Test systems fully designed and plans in place to ensure they are available when needed*