STAFF SUMMARY SHEET

	TO	ACTION	SIGNATURE (Surname), GRADE AND DATE		TO	ACTION	SIGNATURE (Surname), GRADE AND DATE
1	DFEM	sign	Sanchez (Rhymes) LtCol 27 Oct 14	6			
2	DFER	approve	Solti, AD 22, 28 Oct 14	7			
3	Originator	action		8			
4				9			
5				10			

SURNAME OF ACTION OFFICER AND GRADE	SYMBOL	PHONE	TYPIST'S INITIALS	SUSPENSE DATE
Maj Cooper	DFEM	333-2889	cac	20141030

SUBJECT	DATE
Clearance for Material for Public Release USAFA-DF-PA- 475	201410~~24~~ 27

SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.
Authors: Maj Cory Cooper, DFEM, x2889, Dr. Joseph Fulton, DFSE, x6679, Capt Jeremy Homan, DFSE, x3545

Title: Capstone dichotomies: a proposed framework for characterizing capstone design experiences

Circle one: Abstract Tech Report Journal Article Speech (Paper) Presentation Poster

Thesis/Dissertation Book Other: ________

Check all that apply (For Communications Purposes): * Add Disclaimer

[] CRADA (Cooperative Research and Development Agreement) exists

[] Photo/ Video Opportunities [] STEM-outreach Related [] New Invention/ Discovery/ Patent

Description: This is an inital framework/background paper describing the approach that will be used to establish a broad understanding of engineering capstones and their characteristics. Future papers in this topic will explore how capstones are characterized and if correlations exist with capstone student outcomes.

Release Information: The attached paper is being submitted for the 2015 Conference on Systems Engineering (CSER).If accepted, the paper will be presented at the conference at Stevens Institute of Technology, Hoboken, NJ, 18-19 March 2015.

Previous Clearance information: none, initial publication in reserach project

Recommended Distribution Statement: Distribution A: approved for public release, distribution unlimited

3. DISCUSSION: This paper is an initial framework/approach style conference paper in support of a larger Scholarship of Teaching and Learning draft proposal. Initial paper submission deadline is 1 Nov 2014 for conference editor review/acceptance.

4. RECOMMENDATION: Approve document for public release. Suitability is based solely on the document being unclassified not jeopardizing DoD interests, and accurately protraying official policy.

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Tab
1. Copy of Article

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2015 Conference on Systems Engineering Research

Capstone Dichotomies: a proposed framework for characterizing capstone design experiences

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Abstract

At the United States Air Force Academy (USAFA) and many other engineering schools, the culminating experience prior to award of a degree is a capstone design experience. The desired outcomes for such a capstone design experience are very similar across engineering programs. Each program or discipline has freedom in how they achieve these outcomes, so long as it is a deliberate and traceable approach back to the desired outcomes. This freedom allows each discipline to tailor their capstone design experiences to those appropriate to their domains. When students are developed fully within a single discipline program that also offers their capstone, the structure promotes alignment of the student, instructor, and advisor expectations. However, as students are assigned outside of their core discipline to support other capstones, misunderstanding of how their unique skills support the capstone outcomes increases. The ability to then compare capstones beyond the top-level outcomes becomes difficult. This is the case for systems engineering (SE) majors at USAFA where they are allocated to other engineering capstones. In order to trace these distributed students' capstones back to a common set of outcomes, a framework for understanding the full spectrum of their experiences is needed. This paper will review previous work in characterizing capstone experiences, present the method used to frame USAFA's capstones, and show a proposed a set of key characteristics and associated rubrics.

Peer-review under responsibility of the scientific committee of Stevens Institute of Technology.

Keywords: capstone; framework; undergraduate; characteristics; dichotomy

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Peer-review under responsibility of the scientific committee of Stevens Institute of Technology.

1. Introduction

The United States Air Force Academy (USAFA) and many other engineering schools provide a culminating engineering design experience prior to award of the degree. The desired outcomes for such a capstone design experience are very similar across engineering and applied science programs. Each program or discipline has freedom in how they achieve these outcomes, so long as it is a deliberate approach and traceable back to the desired capstone outcomes. The overall program outcomes must be shown to meet the Accreditation Board for Engineering and Technology (ABET), and as a capstone experience, many times the capstone outcomes align very well with the program outcomes. This freedom allows each discipline to tailor their capstone design experiences to those outcomes appropriate to their domains. Shown below are the Course Student Outcomes for a Systems Engineering (SE) major participating in a capstone at USAFA.

1. Understand and implement rigorous systems engineering practices.
2. Critically analyze and trade-off program requirements & constraints (cost, schedule & performance) to develop realistic system design options.
3. Demonstrate independent learning by researching and assessing specific issues of system performance and applying them to individual team tasks.
4. Demonstrate an ability to work effectively as a member of a Systems Program Office team, in both leader and follower roles, by: understanding program goals and objectives; identifying problems, analyzing alternatives and implementing solutions; diligently tracking and documenting decisions and analytical results; and successfully completing program milestones.

When students are developed fully within a single discipline program that also offers their capstone, the structure promotes the student, instructor, and advisor expectations (e.g. a mechanical engineering major completing a mechanical engineering capstone project within the Department of Engineering Mechanics supported completely by mechanical engineering faculty). However, as students are assigned outside of their engineering discipline to support other capstones, potential for misunderstanding of how their unique disciplinary skills support the capstone outcomes increases (e.g. a systems engineering major completing a space satellite design capstone project within the Department of Astronautical Engineering supported by a combination of astronautical, mechanical, and systems engineering faculty).

Systems engineers at USAFA are developed in a program that is based on the premise that an SE should have a strong foundation and ability to operate capably in a classic engineering domain. So by the SE program's very design, SE students are meant to be embedded in other engineering domain projects to bring their domain-independent education and skills to bear. But, this program design comes at a risk. The ability to compare capstones beyond the top-level student outcomes becomes a difficult process without some way of characterizing the similarities and differences among different capstone projects themselves. This potential for misalignment is the case for SE majors at USAFA where they are allocated to other existing engineering program capstone projects. This challenge directly applies to the SE program's distributed construct where it is difficult to establish multidisciplinary teams without an "overarching college-wide structure in place to make it happen."[1].

Multidisciplinary teams/projects are possible through specific student enrollment in their major-aligned capstone course number and careful advisement of projects to enable their respective outcomes. This is the case with SE students who are placed on capstones hosted by other disciplines (e.g. human factors engineering, aeronautical engineering, electrical and computer engineering, etc.). The SE students are physically on the same project, but enrolled/advised in a separate capstone course number that maintains the linkage back to the SE degree program.

Systems engineering students are placed outside of a centralized capstone course for several reasons unique to SE. First, the application of SE depends heavily on having one or more application domains (or disciplines) to enable the full value of SE to be realized. It is the integration, traceability, and formalized technical communication that SE brings to a project. Without an application domain, SE is reduced to merely doing systems analysis for analysis' sake. Second, SE majors are placed outside of a central SE capstone due to the current organizational structure of the SE program at USAFA. The few core SE instructor billets are insufficient to exclusively support capstone projects for the current SE student load—roughly 65-80 students per class year.

In order to support and trace these distributed students' capstones back to a common systems engineering set of outcomes, a framework for understanding the full spectrum of their experiences is needed. Establishing such a framework is difficult because of the wide variety of discipline-specific projects that vary based on many characteristics (e.g. funding source, team size, initial definition state of customer needs, skill diversity of the team, etc.). This research seeks to understand the previous efforts to characterize capstone experiences, present a method used to frame USAFA's capstones, and show a proposed a set of key characteristics and associated rubrics.

2. Related work

Previous research within the topic of capstones appears to focus largely on methods of assessing capstones for accrediting bodies such as the Accreditation Board for Engineering and Technology (ABET)[2,3]. Authors that were involved with their university's ABET visit documented their approaches to developing a rigorous engineering experience that could assess their program's desired program student outcomes.

There is also research that addresses the comparison of single dichotomous pairs of characteristics for a capstone (e.g. single to multi-disciplinary teams[4,5], small vs. large groups[6], short vs. long duration projects[2], and determined which characteristic had merit for various stakeholders.

Frameworks have been developed for understanding various parts and phases of capstones as well. One effort promoted a Quality Function Deployment (QFD) approach to describing the integrated engineering design education through capstones[7]. Others have described the three key elements (student preparation, project selection, and instructor mentorship) that frame a capstone and must be addressed before the capstone should even be attempted[8]. One group used an uncertainty, complexity, and pace (UCP) model to characterize management style and application within the development of an Israeli fire control system[4]. A group at the US Military Academy's system engineering department present four essential elements (real world problems, using a total design process, closing engineering competency gaps, and integration of technical skills) that are key in order to meet student, faculty and ABET's expectations for a meaningful capstone experience[9]. Related to capstones, technical projects in general have been evaluated to develop a framework to understand "hard" vs. "soft" projects through identification of seven key dimensions[10]. Crawford and Pollack's research was particularly interesting in that they presented a seven-dimension framework for evaluating whether a project was "hard" or "soft." In each of these frameworks, direct application to the distributed SE capstone construct is incomplete. Where possible, this previous research will be used to illustrate effective parallel framing methods and aid in characteristic rubric generation for areas already studied.

The unique aspect of the current research project is that it seeks to develop a more complex and holistic framework to understand the capstone experience across many disciplines. The need for this multi-faceted approach is unique to "sharing programs" (e.g. system engineering) that must allocate students into projects hosted in separate programs. Previous research support a product vs. skill teaming construct that allows for product focus, but sharing universal skillsets to enhance a capstone project[5]. The ability for advisors central to the "sharing program" to compare and contrast the experiences is important to ensure that common capstone student outcomes are being attained regardless of domain. The value of such a framework, however, goes beyond just the central understanding of the capstone landscape and will provide the entire capstone community a shared understanding for discussion and improvement.

3. Research objective & approach

The primary objective of this research is to analyze the following three questions regarding the classification and correlation of capstone characteristics with attainment of the capstone course student outcomes. Ultimately, the results of this research will inform stakeholders of the capstone experience and allow a more seamless understanding of how our students achieve the student outcomes required of the capstone experience.

3.1. Research questions

The following questions represent three phases of investigation that this research seeks to explore. The current paper is meant to present the overall approach and set-up prior to collects results in each of the three sequential phases.

1. Using a 2-part questionnaire to narrow and then classify capstone experiences using rubrics, is it possible to establish a common framework for characterizing the full breadth of capstone experiences at USAFA?
2. Is there a relationship between specific capstone characteristics and student performance (with respect to capstone course student outcomes)?
3. How can the established framework and observed relationships be used to affect capstone offerings and placement of students in capstones to improve the student outcomes of capstones?

3.2. Research design & assessment strategy:

The first research question will be addressed in the creation of a framework for capstone characteristics. This framework will form the foundation of the research and will be created with inputs of the many capstone faculty advisors. Initial discussion with the capstone faculty yielded dozens of characteristics that capstones exhibit (e.g. large team, externally funded, project level, formal, iterative, open-ended, highly-constrained, step-wise, homogeneous team members, etc). The lead author of this paper is in a uniquely suited position as the "USAFA System Engineering Capstone Coordinator." In this role, he has direct exposure and understanding of all 30+ capstone projects currently being administered at USAFA. Many of the characteristics identified by faculty advisors were observed as contrary to each other; forming dichotomous pairs that fell within a generalized spectrum (e.g. the spectrum of "degree of constraints" would include possible characteristics of "open-ended" or "highly-constrained"). From an initial list of 19 characteristic spectrums, the list will be narrowed by way of a poll to the capstone faculty at large. This subset of characteristics will then be further developed with rubrics to establish the spectrum of characteristics between the extremes. See section 4 for examples of these selected and developed characteristic spectrums.

These spectrum rubrics will then be used by faculty advisors to self-assess each of the 30+ current capstone projects in order to classify the projects against all of the chosen aspects. The authors and a few others with broad knowledge of the current capstones will also assess the current capstones according to the developed rubrics. This classification effort and its initial results will form a constructivist solution to the first research question.

For the second research question, performance data for the students in the 2015 year group who are members of a capstone projects will be used along with faculty assessments to determine attainment of capstone student outcomes. Final projects, final grades, and an end-of-course student survey will be used to establish the student attainment of the capstone outcomes. Also, a capstone faculty mentor survey similar to one given in previous years to advisors of systems engineering-supported capstones will be used for a faculty performance assessment of the students. This performance data will then be compared with the scores of the relative capstone characteristics to determine if correlation relationships exist. One significant challenge exists if only final project grades are used for comparison due to the many factors that go into these (e.g. technical solution success, grade distribution within a team of several separate majors, instructor grading approaches, hosting department grading approaches, and other nuanced differences between projects). Therefore, the final project grades will be carefully considered in concert with the student and faculty survey results which will represent more direct reflection of outcome attainment.

The presence of correlation, no correlation, or in-conclusive correlation will be evaluated and discussed for possible causes and potential for exploitation to improve the capstones. For example, if the study concludes that there is high correlation of outcome success for projects that are assessed at the "open-ended" side of the "degree of constraints" spectrum, future projects will be encouraged to remove as much early problem definition as feasible while balancing project progress. Or, if it is shown that no correlation exists between outcome success and the "size of team" characteristic, then capstone mentors can be advised to not worry so much about adherence to team size constraints and will be encouraged to enhance their capstones in other ways. These two examples are only illustrative of potential use of possible conclusions and should not be viewed as actual conclusions at this stage of research.

The third research question will be addressed by the comparison of performance in capstones data between the 2015 and 2016 year groups where application of the capstone characteristic correlations have been developed and applied in the capstone development for the 2016 year group. Application of the conclusions from the first two research questions may take the form of information sharing among the capstone mentors for their awareness, adjustment of specific project characteristics where there is clear opportunity to align with the desired capstone characteristics, and possibly down-playing emphasis on certain characteristics where success of outcomes is neutral (no correlation established). Application methods will depend on what the conclusions from research questions one and two are and the receptiveness of the various hosting departments to input for capstone experience improvement. Similar to data collection for question two, the data will consist of final projects, final grades, and an end-of-course student survey will be used to establish the student-based attainment of the capstone student outcomes. Also, a capstone faculty mentor survey similar to one given in previous years to advisors of systems engineering-supported capstones will be used for a faculty performance assessment of the students.

With the above research plan in place, the next steps were to develop the characteristics that would be investigated for this research.

4. A proposed framework of capstones

The following sections introduce the framework foundation that will be used for the future research. Assessment of student outcomes, correlations and conclusions of all future research will be based largely on the framework that is developed below.

4.1. Capstone characteristics

The first step in developing a framework for understanding capstones was to understand the various characteristics that capstone instructors use to describe their projects. These characteristics have several related descriptions that are most often mentioned when instructors attempt to place their project in context with other projects or to external visitors (e.g. "My project is *externally-funded* and is looking at the *novel generation* of a *system-level* solution to a *highly-constrained* problem. I'm also promoting design tool usage *as-needed* in a very *informal* way."). While this is what a typical instructor may say, what they are doing is assessing placement of their project on several characteristic spectrums, or dichotomies.

In order to focus in on the characteristics that are important to describe and understand a capstone, the following characteristics were gathered from the lead author's exposure to all 30+ USAFA capstone.

- Funding source (e.g. internal/external/none)
- Degree of constraints (e.g. open-ended, highly constrained)
- Starting point for requirements refinement (e.g. ill-defined, existing requirements)
- Agility of design process (e.g. step-wise, as-needed)
- Diversity of team member major/skillset (e.g. homogeneous, multidisciplinary)
- Scope of programmatic concern (e.g. project team, program office)
- Reflection of DoD development process (e.g. DoD 5000, rapid capability, industry innovation)
- Customer involvement (e.g. internal, external)
- Team size (e.g. number)
- Novelty of project (e.g. original problem/solution, existing project framework)
- Formality (e.g. relative number of formal briefs/ reports)
- Potential for publishing work (e.g. expectation, exception)
- System level (e.g. consumer-level product design, system-level design, system of systems)
- Course maturity (e.g. new CD/offering, years of refined offering of similar capstones)
- Knowledge use (e.g. much new knowledge required, application of previously learned material)

- Other faculty involvement (e.g. single instructor, team of instructors)
- Team selection (e.g. volunteer filled, directed)
- Competitive (e.g. sole-source, internal/external USAFA competition)
- Mission linkage (e.g. military need, general application)

The example terms provided in each line were what faculty advisors used to explain their projects. By pairing the related terms, the more general name for a characteristic spectrum was achieved as an initial step. It is suspected that not all characteristic spectrums will be of use in describing all current capstones. This is another way to say that there is a relative utility of description in the list of characteristics listed above. For this reason, a follow-on step to this paper will be to poll the capstone advisors for their preferred subset of the characteristic spectrums above. This will represent the first part of the two-part questionnaire referenced in research question one in section 3.1

4.2. Dichotomies of characteristics

In preparation for the second part of the two-part questionnaire referenced in research question one in section 3.1, rubrics were developed for each characteristic spectrum. Each spectrum was evaluated for the two extreme characteristics a project could exhibit in that aspect. With these extremes established, the adjacent positions of the rubric were populated with example characteristics appropriate for the relative location on five-position rubrics. These rubric descriptions were developed by the authors based on direct observation of the spectrum of characteristics present. The resulting rubrics are displayed in the following tables.

Table 1. Rubric characterizing the "funding source" spectrum

External				Internal
Sourced primarily external to Government funding	Sourced primarily from a Government agency	Shared mix of sources internal and external	Primarily sourced from USAFA budget	Sourced solely from the hosting department's standard course O&M budget

Table 2. Rubric characterizing the "degree of constraints" spectrum

Open-ended				Highly-constrained
Syllabus topics, schedule, deliverables and other aspects of the project are all highly fluid and largely student-led based on progress and needs	Syllabus topics, schedule, deliverables and other aspects of the project are provided in a rough framework	Syllabus topics, schedule, deliverables and other aspects of the project are defined, but regular updates are made by faculty and students as needed	Syllabus topics, schedule, deliverables and other aspects of the project are all highly defined and but can be tailored for certain cases	Syllabus topics, schedule, deliverables and other aspects of the project are all highly defined and very rarely deviated from in the course of the capstone

Table 3. Rubric characterizing the "starting point for requirements" spectrum

Ill-defined				Existing requirements
Problem statement known	Initial customer needs known	Customer needs and requirements already known	Requirements, interfaces and some components already established	Requirements, interfaces, and entire subsystems already established with several other constraints. System modification to a well-defined/highly constrained system

Table 4. Rubric characterizing the "agility of design process" spectrum

Step-wise				As -needed
Syllabus of design topics established and followed rigorously	Syllabus of design topics established, but can be adjusted in certain cases	Syllabus of design topics/tools is mostly defined, but adapted regularly to the project progression	Basic design topics/tools are presented and then augmented as-needed	Design topics/tools introduced only as needed

Table 5. Rubric characterizing the "skill diversity of team" spectrum

Multi-disciplinary				Homogeneous
No one particular major holds a clear higher concentration than another	Multiple majors present, but a concentration of one particular major exists	Several members are from a different major than the majority	All but 1-2 members are of the same major	All members are of the same major

Table 6. Rubric characterizing the "scope of concern" spectrum

Project team				Program office
Team is primarily concerned and responsible for only the technical success of the design	Team is responsible for the technical design success within cognizance of basic cost and schedule constraints	Team is responsible to balance performance, cost and schedule for their design	Team is responsible for most programmatic concerns in a typical development office as part of a company	Team is responsible for all programmatic aspects of running a typical development office or company

Table 7. Rubric characterizing the "reflection of the DoD development process" spectrum

DoD Acq				Rapid/innovation
Team is required to largely follow the DoD acquisition process and related deliverables	Team is required to follow some steps or produce some deliverable that are defined in DoD acquisition	Team is aware of DoD general acquisition process, but are allowed to highly tailor deliverables without adherence to DoD standards	Team follows a general system development process without linkage to DoD acquisition	Team follows a novel, industry, or innovative approach to system development

Table 8. Rubric characterizing the "customer involvement" spectrum

Internal/ academic customer				External customer
Customers are the faculty administering the course and completely controls the design success criteria	Customers are largely faculty, but an external customer is involved minimally. Design success criteria are largely driven by the faculty	Customers are an equal combination of faculty and external members. Design success criteria are developed in a balanced manner between the two types of customers	Customer is from an external agency and drives the majority of the design success criteria	Customer is from an external agency and completely controls the design success criteria

Table 9. Rubric characterizing the "team size" spectrum

Small				Large
1-2 members	3-5 members	6-10 members	11-20 members	21-40 members

Table 10. Rubric characterizing the "novelty of project" spectrum

Original design				Modify an existing design
Project framework, topic, and expectations are new and not previously offered	The project framework, topic and expectations are mostly new, but may be slightly based on previous research offerings	Either the project framework or topic has been used before, but the other is new for this offering	The project framework, topic and expectations have been mostly used before, but there is some small twist added to this offering	Project framework, topic, approach, and expectations already exist. Project has been completed mostly in its current form before

Table 11. Rubric characterizing the "process formality" spectrum

Formal				Informal
High number of formal and defined deliverables required	Several key milestone deliverables required and expectation of regular, prepared status briefs	Informal status briefs, but several key milestone deliverables required	Minimal formal milestone deliverables, status briefs only as needed	Only final report/briefing expected as a deliverable

Table 12. Rubric characterizing the "potential for publishing" spectrum

Expected				Exception
Publication in external, peer-reviewed products are explicitly expected and regularly occurs	Publication of results is suggested and expected for a majority of projects	Publication of results happens half of the time	Publication of results may be expected and happens only occasionally	Final reports and briefings to faculty are sufficient. Publishing results is not suggested or expected & happens by very rare exception

Table 13. Rubric for characterizing the "system level" spectrum

Product				System of systems
A consumer-level product being developed as a stand-alone item	A family of related products or a single product being developed with its associated logistics, maintenance, and other areas well-considered	A major subsystem of a highly complex system is being developed. Or, a small, but complete system-level solution is developed that considers its full context, interfaces and relation to other system issues	A system-level solution being developed completely to address organizational-level problems with cognizance of related systems	A suite or family of systems being developed and integrated to address a full, complex national or global-level problem

Table 14. Rubric characterizing the "course maturity" spectrum

New construct				Mature offering
Project, instructor, and course structure are brand new	Two of the following are new: project, instructor, or course structure	Only one of the following are new: project, instructor, or course structure	Project, instructor, and course structure are established and have been offered at least once before	Project, instructor, and course are established and have been offered many times before

Table 15. Rubric of characterizing the "knowledge use" spectrum

New knowledge				Applying knowledge

Team is essentially viewed as completely unlearned to the problem and domain	Large amounts of instruction and research needed to understand major parts of the problem and domain	Additional instruction/research required to understand a major component, function, or customer requirement for the project to be a success	Additional research required to understand some subsystem or function of the project	Only small amounts of new knowledge are required. Project is mostly application of previously acquired knowledge to a problem well-within one's domain or application discipline

Table 16. Rubric characterizing the "other faculty involvement" spectrum

Single-instructor				Team of instructors
A single instructor leads the project largely autonomously	A single instructor leads the project with help/input from one of two others	A pair of instructors co-lead the project	A few instructors are used with project lead and instruction sharing	Several instructors are used to lead the project with input and coverage from many

Table 17. Rubric characterizing the "team selection" spectrum

Volunteer				Directed
Team is fully staffed by volunteer students to a specific project	Team is staffed mostly with volunteers to the specific project	Team is staffed with students who have chosen a project domain, but not the specific project assigned	Team is staffed mostly with non-voluneers	Team is fully staffed by non-volunteer students to the domain and project

Table 18. Rubric characterizing the "competitive" spectrum

Sole-Source				Competition
Project has no other known competitors	Project has theoretical competition in the open market for the developed solution, but there is no reflection of that competition in the course	Project has competition through understanding and analysis of the open market for their solution	Project has similar, competing teams within USAFA	Project has similar, competing teams at external organizations

Table 19. Rubric characterizing the "mission linkage" spectrum

Military-need				General application
Problem statement uniquely aligned with operational military use	Problem is within the broad, support domain of the military	Solution to problem is considered a dual-use technology problem	Problem is defined in general societal need terms, however, military application is possible	Problem statement is applicable to general society

5. Discussion

The absence of a broad, multi-dimensional approach to characterizing capstone experiences is currently missing. Before assessments can be made about many, varied capstone projects, a framework for describing and understanding them is required. With the rubrics established in section 4.2 the next phases of research can begin. As described in section 3.2, capstone faculty will now be asked to narrow the characteristic spectrums of interest and then self-evaluate their capstone projects according to the chosen spectrums.

It is the goal of this research to inform others in a common-language, effective method of evaluating different projects against common outcomes. With the foundation of this paper and subsequent research effort in this vein, much can be shared across institutions that promote interdisciplinary capstone experiences. Much of the framework described can be easily applied to other schools and even within companies that must assess relative performance of multiple project divisions.

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Biographies

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Dr. Joseph Fulton is currently an Assistant Professor of Systems Engineering and Director of Assessment and Accreditation for the SE Program at USAFA. He holds a PhD and MS in Astronautical Engineering from the University of Colorado and the Air Force Institute of Technology respectively. He has held various developmental engineering and program management positions in the US Air Force, to include Deputy Group Commander of Wideband Satellite Communications, Chief Engineer of Wideband Global SATCOM (WGS) satellite constellation and Program Manager of the Defense Satellite Communications System (DSCS) at the Space and Missiles Systems Center in Los Angeles, California. In addition, he served as the Deputy Head of the Department of Astronautics at USAFA and as a Flight Commander and Instructor for Intercontinental Ballistic Missile (ICBM) operations at Malmstrom Air Force Base, Montana.

Captain JJ Homan is currently the Deputy Director and Instructor of Systems Engineering for the SE Program at USAFA. He holds a MBA and MS in Systems Engineering from the University of West Florida and the Air Force Institute of Technology respectively. He has been the lead analyst and deputy test director to several multi-billion dollar air armament and electronic warfare acquisition programs in Eglin Air Force Base, Florida. While residing in Tucson, Arizona, he has also served as both Chief of Assessments and Deputy Chief for Operational Plans and Joint Matters; responsible for planning and assessment of engagements and exercises with South American partner nation militaries.