THE FUTURE OF A MASTER'S IN SYSTEMS ENGINEERING

FINANCIAL AID EQUITY IN PROFESSIONAL EDUCATION

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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The world of Systems Engineering came to fruition during the second World War, when immense pressure coerced military organizations, especially the United States of America, to optimize mission practices (Brown & Scherer, 2000). The notion of braving an efficiency against daunting systems of complex military material, personnel, and data was no easy feat (Brown & Scherer, 2000). However, due to the necessity of the time, and the benefits that systems methodology had on military implementation, much literature regarding systems analysis has blossomed since. An unfortunate habit that has nonetheless surfaced with the upbringing of systems engineering, however, has been the external view that data management and analytics, large features of systems analysis, are a “black box of obeisance-demanding oracles” (Lane, 2000, p. 16). Contrary to this, in proper systems methodology, the interworkings of a system should be aired and understood by all stakeholders, to the extent that when each feedback loop reaches a decision, all stakeholders would have felt an active role in the negotiation (Lane, 2000).

The motivation for this research is to come to a universal understanding of systems engineering, especially in the professional education space. Specifically, this is regarding the terminology used, the implications of systems analysis in corporate and professional spaces, and reestablishing the extent of systems analysis that can suffice in professional settings where it previously lacked.

The goal is to reimagine what features of modern day learning can add to a program to make it state of the art, competitive, and robust against other professional degree offerings. Additionally, this research expands to critique the level of accessibility a prestigious degree such as this has for low income students through an Actor Network Theory of analysis (Edwards, 2010, p. 3).

Thus, the two, tightly coupled, topics explored in this research are understanding the components of a renovation to a Master's degree in Systems Engineering, as well as, the more generalized accessibility that Master's level education has for modern day, lower income students. Methods to make such programs as affordable and equitable as possible are also involved in the study.

The personnel responsible for this research include both faculty and students at the University of Virginia. William Scherer, Professor of Systems Engineering in the Department of Engineering Systems and Environment, as well as, myself, Mia Varghese, Salem Keleta, TJ Gwilliam, and Vinay Vangala, all fourth year undergraduate students in the School of Engineering and Applied Science's Department of Engineering Systems and Environment. Together, the following chart of Figure 1 has been developed to outline the deadlines for each component to the research project.

Tasks	**Assigned to**	**Start Date`**	**End Date**	**Status**
Prospectus Research Timeline	Maggie Salomonsky	10/01/2022	03/01/2022	In Progress
Determine logistics of cohort based model	Maggie Salomonsky	09/01/2022	10/31/2022	In Progress
Decide Major Curriculum and Concentrations Available	Maggie Salomonsky	09/01/2022	11/30/2022	Not Started
Marketing Plan	Maggie Salomonsky	10/25/2022	03/01/2022	In Progress

Figure 1: Timeline of Prospectus Research Project Deliverables and Tasks. This figure breaks down the time frame associated with each task in the technical and STS research project. (Salomonsky, 2022).

THE FUTURE OF SYSTEMS EDUCATION

The focus of a Master's in Systems Engineering is a development aimed to fill the many gaps in professional education that do not simultaneously account for business methods, technology management, systems engineering, data analysis, and professional connections all in one program. Systems dynamics incorporates all of these features, however, it is often critiqued as unwelcome to decision making because of the misconception of it being a "servo-mechanist theory," (Lane, 2000, p. 1) reling heavily on computer simulations, therefore not allowing as much freedom for debate. Debate is, actually, a large component to systems analysis (Lane, 2000).

As such, the skills learned in a reenvisioned Master's of System Engineering are not based on obiesant computer simulations, but can be immensely versatile, covering almost all industries with proficiency in many areas of the technology management lifecycle. This versatility is a product of a concept quoted by Lane where he says, "all things, including will, have causes" (p. 7), and thus, there is no dimension of professional work that is waived of the theme that its problems have root causes, and that those root causes can be discovered in systems analysis. Only by solving at the root will other extraneous issues fall, it is just a matter of having the proficiency to get there.

In contrast to many current professional programs similar to a Master's in Systems Engineering, there needs to be more intensive and community oriented learning activity than the passive, yet innovative, discussion boards and problem sets commonly assigned to students (Wynne & Sholes, 2021). A cohort model achieves just this, moreso than any other academic structure. However, a cohort model is not as popular with many competing professional degree programs, eventhough student performance in cohorts is proven to surpass the national average for graduate business programs, and others alike (Wynne & Sholes, 2021). Figure 2 below offers an example of Wynne's study in the *Business Education Innovation Journal* (2021) comparing a variety of business programs' success to that of similar, but cohort-based, programs. The asterisks represent a significance in difference of performance between the three non-cohort based models and cohort programs. This chart depicts the intensive and engaging nature of cohort style learning, being that it is more promising for successful performance than individualized, traditional structures (Wynne, 2021).

Table 11: Cohort Programs vs National Average

	Mean Difference	Variance	t-statistic
MS Finance	0.238	3.184E-05	42.18***
EMBA	0.123	5.425E-05	16.72***
Fast-Track MBA	0.37	8.966E-06	123.56***

Notes: p-value results: *,**,***Significant at 0.10, 0.05, and 0.01 levels, respectively

Figure 2: Table 11: Cohort Programs vs National Average. This is the concluding table of Wynne's research in proving the efficacy of cohort structured programs. (Wynne, 2021)

The overall objective of the technical research is to thus analyze which features of systems education can provide an innovative, creative, and competitive Master's level degree. This objective will be achieved through discussion of various realms within the Systems undergraduate curriculum, Systems engineering in the graduate level at competing universities, and through interviews with employers of UVA Master's of Systems Engineering alumni to evaluate what skills are needed in the field today.

The resources available for this research include a previous Accelerated Masters of Systems Engineering Program (AMP) (UVA, 2022) that can be considered the UVA predecessor to this reenvisioned project. Methods of reflection with these alumni will be conversations that reveal modern needs, and steer the designed toward the current technology profession audience.

For context, there are about 700 people in the AMP alumni network, where a sample of students are planned to be interviewed on their experience, the changes they would make, and for voicing their opinions on the proposed structure of the new program. The Department of Engineering Systems and Environment is also providing funding for the creation of this program, including the lecture space, faculty salaries, and materials for students. The space needed will specifically be located in the Northern Virginia area, either at UVA Darden in Rosslyn, Virginia (Darden, 2022), the Northern Virginia Campus (UVA, 2022), or rented lecture space in a previous AMP alum's corporate office. Regarding materials, computers with analytic packages and, likely, minimal use of textbooks will be required. Systems engineering is largely reliant on long term perspective or iterative analysis, which places a large need on computer capability in the classroom. It is stated by Whitehead that humans "lack the cognitive ability to deduce behavior… without the assistance of computers" (Whitehead, 2014, p. 1119). Although this is not always true, systems methodology is greatly eased with computer assistance (Whitehead & Scherer, 2014). The topic of computer and material access will be discussed further regarding the second area of research in this paper.

The anticipated outcomes for designing a new Master's of Systems Engineering at UVA Northern Virginia is that a common language and analytical understanding can develop the future of systems engineering. Often internal systems lack a universal language set due to mergers and other independently developed initiatives, so conversations regarding different aspects of a shared system are referred to with different terms, personnel, and even timeline sensitivity, depending on how the projet analysis is interpreted. This goal is to relieve that discrepancy and promote a universal sense of analysis. Universal conversation can greatly increase the effectiveness of the later determined conclusions, and pitched advice (Whitehead, 2014). This program also being competitive against schools that offer similar programs, such as a Master's of Science in Data Science, Master's of Business Administration, or Master's of Science in Engineering Management, is a hope to this research. The classroom teaching structure is ideally planned to have a cohort style that allows for close relations to faculty and fellow students. Students thus should attend in person class sessions on various weekends throughout the year, about 70% of the time, and spend the other 30% of weekend time in virtual learning environments.

The conclusion of this technical research will be presented to The Institute of Electrical and Electronics Engineers' Systems and Information Engineering Design Symposium (SIEDS) in the form of a conference paper (IEEE, 2022).

Financial Aid Equity in Postsecondary Education

The significance of financial aid equity in professional education is an area of heated controversy and a platform for injustice in the academic world. Acquiring financial aid not only requires a certain level of income to not be surpassed, but also insinuates that many people who may need financial aid have some of the most scarce resourcing to help them acquire it. Resources that include things such as form processing assistance, financial literacy, and proficient understanding of the required documentation (Greenfield, 2015, p. 317).

An unsurprising trend is that students of color who understand that college can be affordable and know how to make it affordable, are more likely to "aspire college, apply for financial aid, and enroll at a university" (Greenfield, 2015). However, it is also in parallel that students of color can come from underrepresented communities that "overestimate the cost of college and underestimate the availability of financial aid" (Greenfield, 2015).

The efficacy a family and student feel about their financial literacy is thus a huge proponent, or deterrent, to college access. Furthermore, the effect of various forms of financial aid can have different affects on different student groups (Kim, 2004). The beginngings of Kim's research can be seen in Figure 3 below, where an analysis of White, African American, Asian American, and Latino students were surveyed to identify which attended their first choice college and if there was an affect on this decision based off of financial aid options.

	White ($N = 4{,}382$)	African American ($N = 331$)	Asian American ($N = 251$)	Latino ($N = 172$)	Chi-Square
Choice of College					
First choice	79.3	68.1	54.8	71.8	95.388; $df = 3$;
Not first choice	20.7	31.9	45.2	28.2	$p \leq .000$
Types of Financial Aid Students Received					
Nothing	25.8	16.9	34.7	15.7	41.328; $df = 9$
Loans only	6.4	9.4	14.1	6.4	$p \leq .000$
Grants only	26.8	28.7	14.4	23.3	
Loans and grants	41.0	45.0	35.9	54.7	

Figure 3: Attending First-Choice Institution and Types of Financial Aid Received by Racial Groups (percentages). This chart shows the affect of types of financial aid offerings and whether or not students choose their first choice schools, for four different racial categories. (Kim, 2004, p. 52)

In addition to financial aid packages, data has proven that for middle and upper class families, tax credits, forms of tax deductions, and other financial incentives regardless of monetary amount, will not ultimately deter their children form attending post secondary education in some way or another (Greenfield, 2015). This conclusion was also evident in Kim's research regarding White students, where the difference in first choice or not with financial aid or without, was only a change of 4% (p. 60), whereas Asian Americans were 32% more likely to attend their first choice institution (Kim, 2004, p. 60). However, if understanding these tax documents or the means to acquire financial aid in the first place, is not understood then it is hard to say that the “thicket of paperwork” required will certainly aid a student in attending post secondary education (Greenfield, 2015, p. 320).

In the case where forms are understood, the struggle does not always stop. The process of receiving aid can be inconveniently time consuming. For example, tax credits are often not liquid enough to have a relieving impact on semester payouts, because benefits take up to 15 months to process (Long, 2008). Financial aid equity is thus an important area of interest for this aspect of research, in order to make a Master’s of Systems Engineering equitably accessible, given tuition sensitivities can be vastly different from one another.

The objective of the research on financial aid equity is to ultimately understand the most effective ways of offering financial aid and methods of understanding its documentation, in order to create a more equitable trial for each family at receiving aid. Equity and efficiency in education often oppose eachother in common policy, something Nelson refers to as “our biggest tradeoff,” (p. 516) but the research implores itself to demystify that opposition, and show how the two can both thrive in the same program (Nelson, 1981).

This research will follow an Actor-Network Theory of analysis, due to the nature of the mechanism that is higher education, professional workers and families, and institutionalized financial aid (Edwards, 2010, p. 3). The unique feature of Actor Network analysis is that the interaction of intangible systems, power dynamics, people and possessions all pull at the outcome of a design. As such, given that in this case the Actor-Network is composed of people, monetary funds, sources of distribution, distribution policy, and other components, it is important to expand the analysis to the most broad array of interactions influencing financial aid availability.

The anticipated outcomes of this research are to determine which financial aid offerings can be considered for the UVA Master's of Systems Engineering at the Northern Virginia campus. This motivation is implored through an aspiration to build pride within the UVA program. Despite the unavoidable and increasing costs of professional education, financial barriers can achieve a competitive level of minimization, as shown in the following chart.

	UVA Masters in Systems Engineering	**Georgia Tech**	**Darden's MBA/ MS Business Analytics**	**John Hopkins**	**George Mason**	**UMichigan**	**G.W**
Price	~36k	**<10k**	MSBA: ~66.7k MBA: ~72k	~$47k	~19k(in) ~42k(out)	1.3K - 3.5K	~38.7k
Structure	**-cohort model -70% in person, 30% online -12 month**	-100% online -24-72 months	MSBA: 1year, hybrid MBA: 2 years, in person	-hybrid,online option -up to 5 years to complete	-100% online, hybrid	-online with campus option -1-2 years	2-3 years 100% online
Content	Systems thinking, analytics and data, technology leadership	data analytics, business analytics, data science	MBA: financial, management MSBA: analytic, business and leadership	-management systems, architecture -wide range of electives	- sys design, management, modeling/cost modeling	- human centered engineering, lean systems engineering, risk management	Systems and architecture analysis, risk, large-scale systems

Figure 4: Competitive Advantage of UVA Master's in Systems Engineering. This visual shows the UVA Master's in Systems Engineering features in comparison to the leading competitors in the United States for similar degree programs. (Keleta, 2022)

The style of proposal for this paper will be in the form of a recommendation statement to the UVA Master's of Systems Engineering at Northern Virginia program, and will specifically surround facts of tuition resolutions with predicted tradeoffs in the program in relation to other competitor schools.

REVISITING THE OBJECTIVE

The future of Systems engineering has come a very long way from its birth in the militia space, to now being a profound tool of optimzation from many aspects of the consumer and commerical technological world. This research will explore how to make a new leading program with a Master's in System's Engineering and well as challenging the components of cost and affordability. The goal is to renovate the traditional curriculum with a creative and inclusive price.

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