GROVE CITY COLLEGE

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TO: Rich Savage, John Inman

FROM: Mike Bright (on behalf of the Dept. of Electrical and Computer Engineering)
Christy Crute, Director of Graduate and Online Programs

DATE: April 15, 2020

SUBJECT: Proposal for a Master of Engineering in Systems Engineering and Technology Management

Section I: Rationale and Overall Description of Proposal

Rationale

This proposal contains the details of a Master of Engineering in Systems Engineering and Technology Management program. This program would initially be offered as a 4+1 program to existing students. This program allows Grove City College to focus efforts on a single 4+1 engineering graduate program which will appeal to students from all three ABET-accredited programs: Mechanical Engineering, Computer Science, and Electrical Engineering. It is expected that this will:

- Enhance our reputation as an institution of higher education and further distinguish us from several of our key competitors through the offering of an engineering graduate program in a growing field of study.
- Aid in recruiting bright and eager undergraduates who may already be thinking of graduate school
- Provide additional revenue through both higher graduate tuition and room/board
- Equip our students to better serve society as technical leaders in their industry

This program is designed to be professional practice oriented, and thus is a coursework and project Master of Engineering program (rather than a Master of Science). Initially, we expect 100% of the students to be from the current GCC undergraduate ranks. If we expand to a part-time online program, we expect 80% of the students to be GCC graduates given our regional status.

The Program Objectives are to enable our students to be effective technical leaders 3-5 years after graduation. These leaders would (adapted/excerpted from MITRE's Systems Engineering Competency Model[1]):

- Apply systems thinking to create strategies, anticipate problems, and provide short- and long-term solutions to systems of societal importance.

[1] L. Metzger and L. Bender. 2007. MITRE Systems Engineering Competency Model. v1.13E. Bedford, MA, USA. The MITRE Corporation. Available at: https://www.mitre.org/publications/technical-papers/systems-engineering-competency-model

- Adapt to change and uncertainty in the project and program environment, and assist the sponsor, customer, and other stakeholders in planning for and reacting to these.
- Propose a comprehensive, integrated solution or approach that:
  - Contributes to achieving the sponsor's, customer's and other stakeholders' strategic mission objectives in a changing environment.
  - Can be feasibly implemented within the sponsor's and customer's political, organizational, operational, economic, and technical context.
  - Addresses interoperability and integration challenges across organizations.
  - Addresses ethical concerns with the highest integrity
- Cultivate partnerships with sponsors and customers to work in the public interest.
- Bring their own and others' expertise to provide sound, objective evidence and advice that influences the decisions of our sponsors, customers, and other stakeholders.

The Learning Outcomes designed to achieve these Program Objectives and their mapping to courses in are provided in Section VII and VIII.

Summary of Need

The complexity of many critical systems serving the world continues to grow and so Engineers and Computer Scientists who can design, analyze, and manage complex systems are in increasing demand. Systems engineering is a growing multi-disciplinary field that provides tools and methods to think about complex systems whose individual components span more traditional engineering disciplines. The proposed new Master of Engineering in System Engineering and Technology Management program at GCC is designed to equip students to take on these critical technical leadership positions in any industry.

A survey was sent to all Freshmen, Sophomore, and Junior students in the departments of Computer Science, Mechanical Engineering, and Electrical Engineering (313 in total) on Tuesday, March 24th, 2020 by the Dean's office. Ninety-six (96) responses were received by noon on the 27th, a 30.7% response rate. The vast majority of students are excited about a career as a systems engineer (70%). About a third (34%) would consider enrolling in this graduate program at GCC and most of these prefer full-time (58%), which suggests that we can expect around 35 applicants for this graduate program annually with 20 wanting to stay on campus for a full-time 4+1 program. Interest in the three proposed elective course areas is spread across the three departments as intended and student interest is high. Finally, there is strong interest from Freshmen, suggesting that a 4+1 program might also be beneficial for recruiting students

The majority of Systems Engineering degrees are at the Master's level (64% regionally). Systems Engineers enjoy high mid-career salaries (avg. $100k), ample opportunities (there are over 75k active postings on GlassDoor) and therefore low unemployment (2%). Systems engineering graduates are recruited to work in various technical leadership roles across industries. Growth in these roles is expected to grow faster than other engineering disciplines both regionally and nationally.

The demand for systems engineering professionals is growing faster than supply: despite it being the fastest growing engineering Master's (+28% in the last 3 years), there are still relatively few institutions offering Systems Engineering programs. By creating a high-quality, Masters of Engineering in Systems Engineering and Technology Management, GCC will increase availability for this critical skill throughout the region. For the general field of Industrial and Systems Engineering, Pennsylvania is a high-demand area as are surrounding states.

Competitor Analysis

A brief curriculum review was done of seven of the leading institutions to inform this program proposal: Johns Hopkins University, Pennsylvania State University, Georgia Institute of Technology, Rensselaer Polytechnic Institute, University of Michigan, and the University of Pennsylvania.

Liberty University and LeTourneau University are currently the only other faith-based engineering Master's programs. Both programs are a general MS/MEng in Engineering consisting of all electives.

SECTION II: Statement of Coordination and Impacts

This program was developed in consultation with the Graduate Program Director, the Business, Marketing and Management, and Computer Science departments, as well as several administrative units on campus, including office of the Provost, and the office of Finance. The Career Center and Admissions will become involved after the program progresses through the faculty approval process.

The Graduate Program Director will supervise graduate programs and will continue to collaborate with these academic and administrative units during and after the program development phase.

SECTION III: COURSE DELETIONS

None

Section IV: COURSE ADDITIONS

Summary of Program Coursework (see Course Offering Syllabi)

Required Courses for M.Eng Include:

- SYSE 501 Foundations of Systems Engineering*
- SYSE 502 System Uncertainty Models
- SYSE 503 Linear Optimization Methods*, **
- SYSE 582 Project

Elective Courses for M.Eng. include:

- Systems Modeling and Optimization:
  - SYSE 521 Systems Simulation *
  - SYSE 520 Advanced Optimization*
  - SYSE 522 Stochastic Systems
- Technical Management:
  - SYSE 530 Decision Analysis*
  - SYSE 531 Technical Program Management
  - SYSE 532 Cost Accounting for Engineers
- Data Analytics:
  - MNGT 512 Forecasting Models**
  - MNGT 542 Ethically Architecting Information**
  - MNGT 550 Visualizing and Presenting Data**
  - COMP 544 Database Management Systems **
  - DSCI 546 Introduction to Big Data**
- Courses requested for future use:
  - SYSE 560 Independent Study
  - SYSE 570 Independent Research
  - SYSE 590 Special Studies

Notes:

* indicates an existing topics course (ENGR 390) that will be renumbered and refactored as needed for the proposed program

** these courses will be common between the MEng Sys Engineering and MS Business Analytics.

SECTION V: COURSE COVERAGE

Several existing engineering, management, and computer science faculty are qualified to teach the various new courses in this curriculum. However, both the Department of Management and Marketing and the Department of Computer Science have conditioned their approval of this proposal on the promise of an additional faculty member in each department. Each department currently have faculty who are fully loaded, with several either teaching on an overload basis and/or teaching during intersession and summer periods. Similarly, Electrical and Computer Engineering and Mechanical Engineering would need some adjunct faculty to backfill some undergraduate courses or add additional sections as needed. Exactly who would be assigned to teach which course would await knowing the qualifications and interests of new faculty members, as well as satisfying the demands of newly approved B.S. programs in some of these departments.

SECTION VI: CHANGES TO MAJOR REQUIREMENTS

Not applicable (new program proposal)

SECTIONS VII and VIII: NEW COURSE INFORMATION AND DRAFT SYLLABI

The *Learning Outcomes* for this program were adapted from the Graduate Reference Curriculum for Systems Engineering (GRCSE v1.1[2]) and are:

1. The student will demonstrate an understanding of systems terminology, definitions, and the design process.
2. The student will demonstrate critical analysis skills by applying tools, methodologies, and procedures specified during the course to solve selected systems engineering problems.
3. The student will demonstrate an understanding of systems engineering processes involved in developing effective systems solutions for large-scale systems.
4. The student will demonstrate the ability to analyze existing (and proposed) processes and/or products to support safe, efficient, and reliable human-centered designs.
5. The student will demonstrate a knowledge of systems engineering terminology as it applies to the design, operation, maintenance, and support of modern technological systems.
6. The student will demonstrate an understanding of the positive aspects and limitations associated with using derived and embedded constraints while attempting to satisfy customer requirements.
7. The student will be able to employ systems engineering analytical tools, techniques, methodologies, and processes to assist development teams in designing efficient and cost effective design solutions.
8. The student will demonstrate the ability to consider ethical implications of system design.

[2] Pyster, A., D.H. Olwell, T.L.J. Ferris, N. Hutchison, S. Enck, J. Anthony, D. Henry and A. Squires (eds.). 2015. Graduate Reference Curriculum for Systems Engineering (GRCSE™) V1.1. Hoboken, NJ, USA: Trustees of the Stevens Institute of Technology. Available at: www.bkcase.org/grcse/

	CORE				DATA ANALYTICS					SYS MODELING AND OPT			TECH MANAGEMENT			400-LEVEL
Learning Outcomes	*Foundations of Systems Engineering*	*System Uncertainty Models*	*Linear Optimization Methods*	*Project*	*Forecasting Models*	*Ethically Architecting Info*	*Visualizing and Presenting Data*	*Database Managmenet Systems*	*Intro to Big Data*	*Advanced Optimization Methods*	*Systems Simulation*	*Stochastic Systems Models*	*Decision Analysis*	*Technical Program Management*	*Cost Accounting for Engineers*	*All 400-level Courses*
1	x			x												
2			x	x			x	x	x	x	x	x	x		x	x
3	x			x	x							x	x	x		
4	x	x		x			x				x					
5	x			x									x	x		
6	x		x	x						x			x			
7				x											x	
8				x		x	x				x		x	x		

The draft course descriptions for the proposed courses follow (note that it is expected that these will be refined with involved faculty after the program is approved)**.** The last two pages provide a draft course schedule and a rough draft of a status sheet for the program.

Required Courses:

SYSE 501 Foundations of Systems Engineering: This course introduces the fundamental principles of model-based systems engineering and the application to complex systems design. Topics include Agile development framework, requirements definition and analysis, systems architectures, and validation & verification. Prerequisites: Graduate standing or permission of instructor. 3 credits.

SYSE 502 System Uncertainty Models: All systems are exposed to uncertainty during the planning, development, deployment, and retirement phases. This course will advance the student's knowledge of probability theory, statistics (inference and design of experiments), and some basic stochastic processes (e.g., Markov processes, Brownian motion). Prerequisites: Graduate standing, or ENGR 274 or equivalent and permission of instructor. 3 credits.

SYSE 503 Linear Optimization Methods: The use of mathematics to describe and analyze large-scale decision problems. Allocation of resources, making decisions in a competitive environment, and dealing with uncertainty are modeled and solved using suitable software packages. Topics include solving linear programming problems via the Simplex Method (including sensitivity analysis), integer programming, transportation problems, and other important Optimization models Prerequisites: Graduate standing, or ENGR 274 or equivalent and permission of instructor. 3 credits.

SYSE 582 Project: Students will have a final systems design experience which involves: stakeholder identification and needs analysis, derived system requirements (with full traceability), design and evaluation of at least 2 alternative system architectures, and the iterative development of model-based requirements artifacts (e.g., using SysML or OPM). Prerequisites: Graduate standing, SYSE 501. 3 credits. (note that this course may be taken multiple times as needed to complete the project in 1-credit increments)

Systems Modeling and Optimization Electives (students must take at least one):

SYSE 520 Advanced Optimization: A second course in the use of mathematics to describe and analyze large-scale decision problems. Advanced programming systems and game theory models are developed and solved using suitable software package. Prerequisites: SYSE 503. 3 credits.

SYSE 521 Systems Simulation: This course introduces the fundamentals and techniques for designing simulation models of existing or proposed systems and using them to predict future behavior of the system. Applications include healthcare, transportation, manufacturing, and computing systems. The course topics include discrete-event modeling and simulation of systems, statistical analysis of system data, model fitting

techniques, Monte Carlo simulations, queueing models, random number and random variable generation, variance reduction techniques, and model validation. Prerequisites: Graduate standing or ENGR 274 or equivalent, some programming (e.g. ENGR 120 or COMP 141) and permission of instructor. 3 credits.

SYSE 522 Stochastic System Models: This course will introduce students to fundamental stochastic system models which are commonly used in the evaluation of system architectures and process design. Topics include reliability and queueing models, design optimization, and fitting models to system data. Prerequisites: SYSE 502. 3 credits.

Technology Management Electives (students must take at least one):

SYSE 530 Decision Analysis: The objective of this course is to introduce students to systems engineering, especially from a decision-focused perspective. System concepts, methodologies, models, and analysis are covered in relation to a system's design, development, test, evaluation, and operation. Decisions concerning a system's reliability, maintainability, usability, disposability, and affordability are systematically considered. A range of systems, including service systems, are considered. Specific topics include how to structure a model with decisions, uncertainties and consequences; how to build graphical models of decision problems and exploit them to solve problems, including the use of sensitivity analysis; how to apply probabilistic methods for uncertainty and risk analysis; the use of basic queueing models; and how to estimate reliability and risk associated with complex systems. Prerequisites: Graduate standing or ENGR 274 or equivalent and permission of instructor. 3 credits.

SYSE 531 Technical Program Management: Students will learn strategies for managing technical development teams and products. Topics will include waterfall and agile program management, multi-generation technology/product planning and strategy, competitive analysis, and introduction to intellectual property. Prerequisites: Graduate standing or permission of instructor. 3 credits.

SYSE 532 Cost Accounting for Engineers: This course provides a foundation for systems engineers to engage in critical business decisions affecting system development, deployment, and maintenance. Topics include basic cost accounting (gross/net margin, direct/indirect cost, capex/opex, standard cost, labor rates, depreciation), designing and using chart of accounts, balance sheet, P&L, and an understanding of service/warrantee contracts. Prerequisites: Graduate standing or permission of instructor. 3 credits.

Data Analytics Electives (students must take at least one; note that these courses overlap with the MS Data Analytics program and are included here for completeness):

MNGT 512 Forecasting Models: An introduction to creating, solving, analyzing, and interpreting real-world time-series and forecasting models. Topics include linear, autoregressive, moving average and other forecasting and time-series techniques, transfer functions, multivariate model building, stationary, and nonstationary techniques. Applications include all areas where forecasting is required including transportation, finance, scheduling, networks, and supply chains. Appropriate software tools for analyzing forecasting models including SAS and spreadsheet software. Prerequisites: SYSE 502. 3 credits.

MNGT 542 Ethically Architecting Information: Practical guidance on how to implement information management. This course explores the fundamental elements of ethics and provides practical methods for organizations to embed ethical principles and practices into the management and governance of the organization's information. Will explore the business case for ethical business practices. Prerequisites: Graduate standing or permission of instructor. 3 credits.

MNGT 550 Visualizing and Presenting Data: Introduction to the key concepts and technologies for graphing and other visual ways to present data. This course covers modern techniques and software used to

understand and explain data quickly through visual presentation. Prerequisites: SYSE 502 or MNGT 202. 3 credits.

COMP 544 Database Management Systems: A graduate level course in database management systems emphasizing the relational model. Topics include data manipulation languages (SQL, QBE); database design (intuitive design, normalization, and E-R design model); three-tier and multi-tier architecture; database security; and database integrity. Prerequisites: Graduate standing, or COMP 220 and permission of instructor. 3 credits.

DSCI 546 Introduction to Big Data: The objective of this course is to introduce key concepts and technologies of big data management. This course covers big data characteristics, storage, and processing. Students learn how to use multiple big data technologies, such as stream processing, in-memory databases, Hadoop MapReduce, NoSQL, and NewSQL systems. *Prerequisites*: COMP 544. 3 credits.

Advising Form & Status Sheet

One Year FT: Semester I (Summer)		
SYSE 501	Foundations of Systems Engineering	3
SYSE 502	System Uncertainty Models	3
	Total:	6

One Year FT: Semester II (Fall)		
SYSE 503	Linear Optimization	3
Elective		3
Elective		3
Elective		3
	Total:	12

One Year FT: Semester III (Spring)		
Elective		3
Elective		3
Elective		3
SYSE 582	Project	3
	Total:	12

Grove City College Status Sheet

Status Sheets are provided as a convenience for the student and may be helpful for recording completed courses. However, the College Bulletin is the controlling authority on all requirements. Questions should be directed to your academic advisor or the Office of Graduate and Online Programs.

M.Eng. in Systems Engineering and Technology Management
Entering in 2021

(REVISED 03-27-20)

Name: _____

ID# _____ **Date:** _____

Year of Anticipated Graduation: _____ **Advisor:** _____

TOTAL HOURS REQUIRED FOR THIS DEGREE---------- 30 HOURS

Minimum CQPA and MQPA required for graduation----------2.50
MQPA Courses----------ELEE; SYSE; COMP; MECE; MGNT; DSCI
Major Requirements----------30 HOURS

PROGRAM PREREQUISITES

ABET-accredited undergraduate degree*
Relevant internship experience

* Or similar technical undergraduate degree

SYSTEMS ENGINEERING CORE---------- 12 HOURS

		Cr.	Sem. Taken	Grade
SYSE 500	Foundations of Systems Engineering	3		
SYSE 510	System Uncertainty Models	3		
SYSE 520	Linear Optimization Methods	3		
SYSE 582	Project	3		

Data Analytics Electives (choose at least one) ..... 3-9 HOURS

MNGT 512	Forecasting Models	3		
MNGT 542	Ethically Architecting Information	3		
MNGT 550	Visualizing and Presenting Data	3		
COMP 544	Database Management Systems	3		
DSCI 546	Introduction to Big Data	3		

Systems Modeling and Optimization Electives..... 3-9 HOURS

SYSE 520	Advanced Optimization	3		
SYSE 521	Systems Simulation	3		
SYSE 522	Stochastic System Models	3		

Technology Management Electives..... 3-9 HOURS

SYSE 530	Decision Analysis	3		
SYSE 531	Technical Program Management	3		
SYSE 532	Cost Accounting for Engineers	3		

Other Technical Electives..... up to 6 HOURS

Choose up to two courses from:

ELEE 421, 422, 431, 432, 441, or 442
COMP 447, 448, or 475
MECE 407, 414, 416, 418, or 428