A Proposal for a Masters of Engineering Degree in Systems Engineering Taught Using Distance Learning (DL MEng in SE)

1. Purpose

The purpose of this proposal is to gain approval to award the Master of Engineering (Systems Engineering) degree, an existing graduate degree, on the basis of courses taken in a distance-learning format, along with a small but critical face-to-face component.

2. Background and Motivation

There are approximately 73,000 Bachelor’s degrees in engineering awarded in the U.S. annually, and about one-half as many Master’s degrees. However, the Master’s degree is increasingly viewed as the requirement for effective professional practice in engineering. In recent years, this position has been espoused very directly by several of the major engineering professional societies. For example, the American Society of Civil Engineers has adopted Policy Statement 465, which states, in part, “The ASCE supports the concept of the Master’s degree or equivalent as the first professional degree for the practice of civil engineering at the professional level.” The National Academy of Engineering Committee on the Engineer of 2020, Phase II also views the baccalaureate degree as a “pre-engineering” degree. They challenge the engineering profession to recognize and reward the distinction between entry level engineers and engineers who have “mastered an engineering discipline through further formal education.” They state specifically, “Adequate depth in a specialized area of engineering cannot be achieved in the baccalaureate degree.”

As more and more engineers pursue Master’s level education, the demand for Master’s programs is increasing and will rise dramatically in the coming years. Many of those prospective Master’s degree students are engineers who already have professional jobs, and who want to pursue a professional Master’s program without leaving their employment. For these mature students, part-time study, often based on distance learning, is a necessity.

Systems Engineering is a valuable discipline for Master’s level study because many engineers from various undergraduate disciplines find that they are deeply involved in designing and implementing complex systems. Master’s level study in that area can support their career goals and give them tools for continued improvement of professional skills. Thus, the Master of Engineering (Systems Engineering) degree program is an important place for Cornell to begin its offerings of distance learning based professional Master’s study.

There is strong interest in this initiative from local companies that have international operations. For example, Steven Betza, the Director of the Engineering Leadership Development Program at Lockheed Martin in Owego, strongly supports this initiative (see attached letter). Companies like Lockheed Martin have a global perspective with engineers working in many different facilities around the world. To be an effective
partner with such companies, Cornell also needs to have a global view of educational opportunities and offerings. Distance learning is a vital element of meeting their needs.

In addition to strategic partnering opportunities with major companies that employ thousands of engineers, there is also substantial evidence of demand for distance learning based Master’s study by individual engineers in various locations around the U.S. and the world. This fall alone, we have received inquiries from more than 100 engineers looking for a distance learning Master’s program in Systems Engineering. At present, we are forced to respond that we do not offer such a program. We believe it is in the University’s interests to respond more positively to the demand for this type of Master’s study. Furthermore, we believe that this type of program can be created in a way that has the full rigor and educational value of the on-campus offerings.

3. Cornell Systems Engineering Program History

The Cornell Systems Engineering Program is designed to promote an understanding of the Systems Engineering process throughout an organization enabling our students to better design and manage complex systems that will evolve over their life cycle. The program is designed to help engineering professionals make trade-off decisions in high-risk environments and to make the transition from managing independent engineering projects to creating globally optimized integrated solutions to meet customer needs.

Founded in 1999, the Cornell Systems Engineering Program grew out of strong corporate interest from General Motors, the Xerox Corporation, Applied Materials, and Lockheed Martin. Based on continued feedback and input from industry, our course content and curriculum continue to evolve and are designed to be highly responsive to industry needs.

The Systems Engineering Program quickly developed two courses in systems engineering and made these available to the sponsoring companies via distance learning. In particular, the commitment of General Motors to these initial offerings was critical to their success. In 2001, the Program instituted an on-campus Master of Engineering degree program. In 2003, the Program created a one-week short course in systems engineering fundamentals. In 2004, the Program created a Minor in Systems for M.S. and Ph.D. students. In 2006, the program started offering a third course in systems engineering, emphasizing the role of reliability in the design and operation of complex systems. Since 1999, over 800 students have had significant exposure to the concepts of systems engineering through these offerings.

4. The Systems Engineering On-Campus Degree Program

The Systems Engineering Program emphasizes the fundamentals of requirements analysis, systems architecture, product development, project management, operations research, optimization, simulation, systems analysis, integration and verification. The program’s strength in these areas helps promote an understanding of the systems process throughout an organization and prepares students to transition from designing and managing independent engineering projects to creating integrated solutions that meet customer needs. Courses are offered via traditional in-classroom delivery as well as
distance learning and online options--all designed to meet a student’s particular needs for enhanced learning.

The Master of Engineering (Systems) is designed for students who want to specialize in Systems Engineering. It presently requires a minimum of thirty credit hours. Students must complete the following required (“core”) courses:

- Applied Systems Engineering (3 credits)
- Systems Architecture, Behavior, and Optimization (3 credits)
- Project Management (4 credits)
- Systems Engineering Project (6 – 8 credits)

Approved electives account for the remaining credits to reach the minimum of 30 credits required for the degree and are to be chosen from the following areas:

- Systems Modeling and Analysis (at least 1 course): Courses that enrich the understanding of generic methods to design and analyze systems including courses in simulation, feedback and control, decision-making, reliability analysis, and risk analysis.
- Systems Applications: Courses that provide depth in the design and operation of specific systems such as power, communication, software, manufacturing, and transportation.
- Systems Management (at most 1 course): Courses that enhance student understanding of the management activities and processes which are necessary to successfully design and operate systems.

5. Suitability of the Systems Engineering Curriculum for Distance learning

The Systems Engineering core courses are well suited to being taught in a distance-learning format. There are no laboratory experiences requiring specialized equipment and no computer experiences requiring site-licensed software. Much of the material is methodology-oriented and lends itself to traditional lecture-style presentation. These lectures can be recorded and transmitted asynchronously.

Delivery of Systems courses via distance learning does pose a few challenges. There are experiential exercises in the Project Management course that cannot be taught through distance learning. However, by reorganizing the curriculum, these course components can be delivered using face-to-face short courses. There are also required collaborative experiences, such as the Systems Engineering Project, that are more difficult to replicate for off-campus students. However, the College of Engineering has already surmounted this challenge by pioneering the facilitation of geographically dispersed teams and providing the technology to support collaborative workgroups in real-time.

6. Target Population

6.1. Need, nature, and extent

The target population for this degree program are young working professionals who satisfy the admission criteria for the MEng in Systems Engineering but who cannot afford to interrupt their careers for full-time, on-campus graduate study. These are
typically mature students who have at least one year of work experience when they begin their graduate work. We have many years of experience in working with such students through our relationship with Lockheed Martin – Owego. Our initial target geographical area is New York State but there is already interest from Lockheed Martin for us to consider an international audience consisting of facilities in Canada and the UK reporting to the Owego site.

6.2. Demonstrated interest

Steven Betza, Director of Engineering Leadership Development for Lockheed Martin Systems Integration – Owego, has written a strong letter of support for this proposal. We currently have 260 inquiries on file from students seeking to find a distance learning Master’s degree program in Systems Engineering. There are 100 inquiries in the past three months alone.

7. Technology and Facilities

By distance learning, we refer primarily to the transmission of on-campus lectures to remote sites, and the facilitation of faculty-student interaction by electronic means. There are numerous proven technologies to support distance learning and new technologies continue to evolve. The SE Program currently offers courses with both synchronous (two-way live audio and video) and asynchronous (web-based video-streaming) delivery methods. Web-based course administration tools (the Blackboard course management system) are used extensively. Courier services are used for the timely delivery of dated confidential materials such as exams.

The University has invested in excellent distance learning facilities in Ives Hall. These facilities are well staffed and, currently, are adequate to support a limited distance learning degree program.

8. Face-to-Face Instruction

The distance learning degree program shall include a minimum of two weeks (ten days) of face-to-face interaction with classmates and Cornell faculty. The two weeks are not required to be contiguous. They may be conducted on-campus or at a remote site. The purposes of this requirement are to:

- initiate new students into the program,
- facilitate the networking and bonding of classmates within a cohort,
- establish standards for performance,
- create a sense of identification with the institution of Cornell University,
- complete the team-based experiential learning components of the on-campus program, and
- conduct project presentations and project evaluation.

The face-to-face instructional component shall be designed to satisfy two credit hours of the degree program.
9. Equivalence

9.1. Equivalence of Rigor and Quality

All distance learning courses offered by Cornell for academic credit shall meet the same standards for rigor and quality as on-campus courses and shall be taught by Cornell faculty.

Distance learning degree students seeking academic assistance in their courses shall have access to teaching assistants and faculty comparable to their on-campus counterparts.

9.2. Equivalence of Respect

Distance learning degree students shall be considered to be fully matriculated graduate students of Cornell University, with full student privileges, rights, and responsibilities.

All credit-bearing distance learning courses shall be viewed as equivalent to on-campus versions of the same course. Graduate degrees granted shall not bear any distinction as to the manner in which credits were earned (distance learning or on-campus).

10. Assurance of Academic Integrity

The SE Program shall obtain third party verification of academic integrity observed by the student in the off-campus completion of exams or major assignments for each Cornell course in the degree program.

11. Admission and Enrollment Criteria

The basic admission criteria for the on-campus and distance learning degree programs shall be the same; however, applicants must document at least one year of work experience in a relevant field to be eligible to enroll in the distance learning degree program. All successful applicants will have, as a minimum, a baccalaureate degree in engineering, mathematics, or science, conferred by an accredited college or university. Additional selection criteria may apply for enrollment in the distance learning degree program.

The SE Program reserves the right to restrict distance-learning enrollments based on program capacity, the geographical location of the student, and the technical or administrative capability of the program to provide adequate service to the student.

Students eligible to enroll in the distance learning degree program shall be admitted into the degree program using the same process as on-campus MEng applicants and may opt to enroll in either the distance learning program or the on-campus program. With sufficient advance notice, matriculated distance learning degree students may also transfer into full-time on-campus study at the beginning of any semester of their study.
12. Distinctiveness (from on-campus and undergraduate instruction)

It is understood that the residential experience is central to the Cornell undergraduate degree. There is no intent to replace or erode the undergraduate residential experience with this proposal.

On-campus undergraduate students are excluded from core SE courses except by permission of the instructor. The pre- or co-requisite for enrollment in a core SE course is a significant experience in a team-based project. There are a small number of seniors who satisfy this requirement and are admitted to these courses. Undergraduates shall not be permitted to register for the distance learning versions of these courses.

Lecture attendance and class participation is required of all on-campus students in core SE courses. Typically, a portion of the grade is reserved for class participation. An exception is granted for graduate students pursuing the Minor in Systems Engineering who experience course conflicts between classes in their home department and core, non-experiential courses (SYSEN 510, SYSEN520) required for the minor. In this case, and with the written permission of the student’s graduate committee chair and the instructor, the student is allowed to participate in the distance-learning course.

13. Policy on Re-use of Recorded Lectures

Recorded lectures are intended for use by students only within the semester in which they are delivered. At the end of each semester, distance-learning students shall be required to delete or dispose of any copies of lectures they may have made during the semester.

Recorded lectures, or portions thereof, may be used in other graduate courses with the approval of the originating faculty member.

14. Ownership of Course Materials

Course materials developed for use in a distance learning course shall be subject to the same ownership policy as materials developed for use in traditional on-campus courses.

15. Tuition and Fees

All students in the Systems Engineering degree program, both the on-campus and the distance learning variants, shall enroll and be registered in the Graduate School as fully matriculated students in the MEng degree program.

Students in the distance learning degree program shall pay tuition and fees prorated on a per-credit hour basis and shall be enrolled for a minimum of three credit hours per semester. The distance-learning student is expected to complete the degree requirements within five years. In special circumstances, the student may request a leave of absence. The degree requirements must be satisfied within seven years.

Students in the distance learning degree program shall be charged tuition and fees at a College of Engineering Special Program rate. This rate shall include a distance learning technology and administration fee.
Distance learning students shall be exempt from the requirement of purchasing health insurance.

16. Faculty Professional Development in Distance learning

The University shall provide resources sufficient for faculty to develop their teaching skills and adapt their curricular materials to succeed in distance education.

16.1. Course Development Support

The SE Program typically provides teaching assistant support to a faculty member in the field of Systems to assist in creating a distance-learning course or in converting an existing on-campus course to support distance learning. This support is provided at least one semester in advance of the first scheduled distance-learning offering.

16.2. Faculty Rewards and Compensation

Teaching a distance-learning course is more demanding of the faculty member than teaching the same course on-campus without the distance component. Course administration is more complicated and an extra effort is required to keep off-campus students as engaged in the learning process as on-campus students. For this reason, it is typical for the SE Program to provide faculty in distance learning courses with support and/or compensation in excess of that provided to other faculty. This support or compensation may consist of (and is not limited to):

- Team teaching assignments or a lighter course load;
- Support for graduate students;
- Extra salary compensation.

In addition, there exist numerous other opportunities for faculty to enhance their skills and to mount new distance learning courses. These include support from the School of Continuing Education and Summer Sessions and from Faculty Innovation Grants.

16.3. Cornell SCE Support

Faculty developing distance learning courses for the SE Program will be supported by the Cornell School of Continuing Education and Summer Sessions with a range of support services:

- determining technological needs,
- organizing non-academic production components of the course,
- resolving copyright issues,
- creating a marketing plan, and
- coordinating resources for the improvement of online teaching skills.

16.4. Cornell Faculty Innovation Grants

“The Faculty Innovation in Teaching (FIT) program is part of a larger distributed learning initiative supported by the President and the Provost. The program is designed to allow faculty to develop innovative instructional technology projects that have the
potential to improve the educational process. The program provides faculty with the technical staff and other resources necessary to plan and implement their projects, thus allowing faculty to focus on their pedagogical objectives.

The Provost has funded a number of staff within CIT’s Academic Technologies & Media Services division whose explicit focus is to support these innovation projects. Project support comes primarily in the form of the development services required to turn faculty ideas into reality. These services are coordinated by CIT’s Academic Technologies & Media Services staff in collaboration with campus partners, such as the Library and the Center for Learning and Teaching. Funds have also been made available for the purchase of hardware, software, and other technical services/assistance that might be required. Support is also available for faculty release time.

It is a goal of the Faculty Innovation in Teaching program to support the cycle of innovation beyond implementation of individual projects. Faculty will be encouraged to participate in program activities that promote scholarly discussion of the relationship between pedagogy and technology, and to share information with the larger Cornell teaching community.

Scheduled Special Interest Groups and other avenues of communication are intended to support faculty in identifying best practices and technology solutions that merit further exploration. These and other forums will be available for faculty to share their experiences, explore evaluation findings and make recommendations regarding the future direction of instructional technology at Cornell.”

Source: http://www.innovation.cornell.edu:5000/fig/content/about
A. Appendix: Benchmarking

1. Johnson Graduate School of Business

Boardroom Executive MBA Program

“The Cornell Boardroom Executive MBA program is delivered over 17 months in a combination of residential sessions and videoconferencing-based boardroom sessions. The three residential sessions are each between 10 days and two weeks in length and held on the campuses of both Cornell University in Ithaca, NY, and Queen's University in Kingston, Ontario. In addition to these residential sessions, the international collection of Boardroom Learning Teams is connected via a multi-point, interactive videoconferencing network for boardroom sessions. These are held on sets of three consecutive Saturdays with the fourth Saturday off…. The Global Business Project's one-week field study rounds out this learning experience.”

“Program participants within one city are organized into Boardroom Learning Teams, typically comprised of six to eight individuals. Each team is assigned a boardroom location in its home city, and these teams stay together for the entire length of the program.”

“For the class starting in July 2006, we are targeting selected sites in New York State, Ohio, Washington State, and Washington, D.C. for Boardroom Learning Teams.”

“The bottom line: this team-based, technology supported program allows you to earn prestigious dual degrees in just 17 months - without sacrificing the quality of the learning experience and without interrupting your job or life.”

Source: http://www.johnson.cornell.edu/academic/boardroom/format.html

2. Stanford University

Masters Programs at Stanford

“The Honors Cooperative Program (HCP) is the only part-time graduate program offered by Stanford University. It allows working professionals an opportunity to earn a graduate engineering degree through SCPD [Stanford Center for Professional Development] while maintaining employment.

“HCP students apply to the department in which they would like to pursue a graduate degree through the normal graduate admissions process, and compete with all other applicants for admission to the program. Once admitted, the HCP students implement degree study on a part-time basis through SCPD. HCP students are fully matriculated graduate students of Stanford University, with full student privileges, rights, and responsibilities.

“HCP students must complete the 45 units of master's degree study in five years. They file study plans for their degree program, and are tested and graded to the same standards as on-campus students. Eighteen units may be transferred from the Non-Degree Option (NDO) to the HCP program.

To participate, industry students must have the support of their employer as a member company of the Stanford Center for Professional Development.”

Source: http://scpd.stanford.edu/scpd/programs/mastersDegree.htm
Member Companies Benefits

“The opportunity to participate in Stanford engineering classes for credit on a part-time basis is available to students whose employers are members of the Stanford Center for Professional Development (SCPD). [Membership benefits include:]

- SCPD provides an easily accessible gateway to School of Engineering (SoE) education by world-renowned faculty, to state-of-the-art research, and to emerging interdisciplinary programs.
- Access to Stanford courses supports technology transfer, and recruitment and retention efforts at member companies.
- SCPD is positioned to garner resources and support for newly emerging educational delivery technologies, coupled with the interests of faculty and customers, to improve engineering and technology management education.
- By outsourcing education and training administration to SCPD, companies reduce burdensome administrative tasks.”

Source: http://scpd.stanford.edu/scpd/members/companies/

Annual membership fees range from $1000 to $3000 depending on the number of employees in the company. Member companies agree to appoint an education manager and an administrative coordinator. Member companies also agree to provide exam monitors of suitable rank.

Stanford Departments Offering Masters Degrees

- Aeronautics and Astronautics
- Applied Physics
- Biomedical Informatics *
- Chemical Engineering
- Civil and Environmental Engineering
- Computer Science *
- Electrical Engineering *
- Management Science and Engineering *
- Materials Science and Engineering
- Mechanical Engineering *
- Statistics

* Departments offering master's degrees that may be completed entirely online.

Other departments offer a range of courses that are broadcast, but still require some attendance on campus for degree completion:

- BioMedical Informatics
- Computational and Mathematical Engineering
- Education - Learning Design and Technology

Stanford Delivery Technology

“In order to meet the varying locations and scheduling needs of its students, SCPD delivers its courses in a variety of formats, including the following:

- “Stanford Online: delivered over the Internet via streaming media, courses are posted online within two hours of the live Stanford University course concluding.”
• Broadcast: transmitted through microwave technology, SITN broadcasts up to 75 courses a quarter, both live and tape-delayed.
• Two-way Video: using videoconferencing technology, students can participate in two-way compressed video
  “Member companies within an approximate 35-mile radius, ranging from San Francisco to San Jose, may receive the broadcast signals with the use of a simple roof-mounted antenna.
  “A frequency-changer must be installed on the company's premises. It converts the microwaves to VHF TV frequencies and enables students to view the classes on standard television receivers.”
Source: http://scpd.stanford.edu/scpd/about/delivery/

**Tuition and Fees**

Students in the Honors Cooperative Program pay $1,240 per unit (3 unit minimum) for the 2006-2007 Academic Year. HCP students must enroll for a minimum of 3 units of coursework each quarter, unless they have been granted a Leave of Absence. There is an additional one-time $80 document fee and a per-quarter Associated Students of Stanford University fee of $30. Total tuition and fees for 45 units is estimated to be $56,330.

**3. University of Southern California**

**DEN (Distance Education Network)**

“Established in 1972, the USC Viterbi School of Engineering's Distance Education Network was a pioneer in the distance learning arena, utilizing the most cutting-edge technology to enable professional engineers to take USC engineering courses for graduate degree credit without having to set foot on the campus.”

“DEN offers over 30 Master of Science degrees to choose from - more than that of any leading research university.”
Source: http://den.usc.edu/prospectives/overview.htm

“DEN strives to meet the needs of engineering professionals, providing the opportunity to advance your education while maintaining your career and other commitments. By breaking down geographical and scheduling barriers, DEN allows you to take your classes anytime and anywhere.

**How DEN Works**

• “Courses are transmitted from studio classrooms at the USC campus via an Internet-delivery system. DEN students are viewing the same lecture as on-campus students.
• Students can view the courses live, or later at their convenience. Lectures are archived for the entire semester and can be downloaded.
• Live instruction is interactive - students can call by a toll free phone line to ask the professor questions, or use threaded online chat.
• Professors' in-class notes are digitized and posted so students can print them and watch the lecture.
• Homework is submitted by email or fax to the DEN Document Center.
• Exams are proctored at local testing centers (with the exception of Los Angeles based students, who are required to come to campus for their exams).”
Source: http://den.usc.edu/prospectives/howdenworks.htm

**USC Master of Science Degree Programs – Online**

“Each degree program [below] can be completed entirely online.

- Aerospace & Mechanical Engineering
- Astronautics and Space Technology Division
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering
- Computer Science
- Electrical Engineering
- Industrial & Systems Engineering
- Materials Engineering
- Petroleum Engineering”
Source: http://den.usc.edu/programs/degreeprograms.htm

**Tuition and Fees**

Off-campus students pay $1,151 per unit, plus a $500 DEN fee per course and $43 in student fees per semester, for the 2006-2007 Academic Year. There is an additional fee of $25 per exam taken at a certified testing center. Total tuition for 30 units is estimated to be $34,530. Fees for a five-year program are estimated to add $6,180 to this for a total degree cost of $40,710.

**Corporate Partners**

USC lists several corporate partners. In particular, “The Boeing Company has selected the team of the University of Southern California (USC) and the University of Missouri-Rolla (UMR) to provide its engineering employees with an opportunity to enroll in a graduate program in Systems Engineering.

“Boeing employees and its suppliers worldwide have the opportunity to earn a Master of Science degree or Graduate Certificate in Systems Architecture & Engineering.”
Source: http://den.usc.edu/programs/boeing/index.htm
Dear Dr. Jackson:

I am writing to express Lockheed Martin’s support for a proposal to award the Master of Engineering in Systems Engineering degree (an existing graduate program) through courses taken in a distance learning format, supplemented by a small, but well selected, face-to-face component.

Since 2000, Lockheed Martin Systems Integration – Owego has enrolled over eighty (80) students in the Cornell MEng Systems Engineering program, and it is the cornerstone of our Engineering Leadership Development Program (ELDP). The quality of the Cornell SE degree is outstanding, as it: (1) builds a superior base in the theory and practice of Systems Engineering, (2) allows students to gain additional depth in their core discipline (e.g. ECE, MAE, etc.) through electives, and (3) includes an invaluable two-semester design project which we have tailored to model a real-world, full-lifecycle engineering program.

In recent years, Lockheed Martin has welcomed the addition of new courses and electives offered through distance learning (both synchronous and asynchronous), and the significant benefit that this has provided to our graduate students who balance a full-time professional work schedule with the completion of the MEng degree over a regimented three-year time period. These courses have allowed our students to participate in a “virtual” classroom with no compromise to course quality.

Awarding the Master of Engineering in Systems Engineering through distance learning (and a well chosen face-to-face component) is of mutual benefit to both Cornell and Lockheed Martin, including:

- The ability to expand our ELDP program to students in LM Canada and LM United Kingdom who organizationally report to Lockheed Martin Systems Integration – Owego.
- The ability to offer the Cornell MEng program to high achieving ELDP students across Lockheed Martin, with over 250 new Lockheed Martin employees selected for this program each year.
- The ability to offer a more flexible MEng program to non-ELDP Lockheed Martin employees who enroll and complete the program on a self-paced basis each year.

In summary, I would like to offer Lockheed Martin’s highest recommendation for approval of this proposal to the Master of Engineering Committee and Cornell Senior Administration. This is a high-priority initiative for us, and a great opportunity to further expand our already successful academic-industry partnership. If I can be of further assistance in your evaluation, please do not hesitate to contact me at (607) 761-7353.

Sincerely,

(Signature on File)

Steven J. Betza
Director, Engineering Leadership Development
Lockheed Martin Systems Integration – Owego