

University of South Carolina

**New Degree Program in
System Design**

MS in System Design

College of Engineering and Computing

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Date of Submission

June 12, 2013

Revised and Resubmitted

Harris Pastides, President

Commission on Higher Education Full Program Proposal

Name of Program: System Design

Concentrations, options, and tracks: Secure Communications and Power, and Power
Electronic Systems

Academic Unit in Which the Program Resides: College of Engineering and Computing

Level of Degree: Master of Science

If undergraduate, designation as four- or five-year program: N/A

Proposed date of implementation: Fall 2014

CIP Code: 14.2701

Site: University of South Carolina – Columbia Campus

**Program qualifies for supplemental Palmetto Fellows Scholarship/LIFE
Scholarship awards:** No

Delivery Mode: Traditional and distance

Inter-Institutional Approvals

A. Five Departments

Chemical Engineering 9/17/2012

Civil and Environmental Engineering 9/17/2012

Computer Science and Engineering 9/17/2012

Electrical Engineering 9/17/2012

Mechanical Engineering 9/17/2012

B. College of Engineering and Computing 9/18/2012

C. Graduate Council 11/26/2012

D. University Provost 2/13/2013

E. USC President 2/18/2013

F. USC Board of Trustees 4/17/2013

Purpose Statement

The proposed degree program will help engineering and computer-science professionals to become proficient in the ever changing field of system design. As discussed in the section on justification, this is a new and emerging field involving the development of new processes that are inter-disciplinary and focus on the design and management of complex projects at the design phase and throughout the life of the projects.

The program would be beneficial to a wide range of industries including defense organizations (communications, weapon systems), power generation and control (nuclear power stations and grid control), manufacturing systems, automotive and aerospace.

Currently, no other institution in our state offers a Master's of Science in this area, the closest being Clemson's Master of System Engineering, which does not require a thesis and has a different focus (see section on duplication in state).

Justification

The planning, design, construction, production or manufacturing, and operation of complex projects and systems requires input and participation from different engineering disciplines and may involve design and test phases that span many levels of hierarchy and abstraction. Traditionally, and within specific domains, design and test processes at the level of individual components or sub-systems are well-understood, and sound methodologies and tools are presently available. However, comprehensive design at the networked system-of-systems or infrastructure level remains largely *ad hoc* in nature. Far reaching design decisions are made early on with little or no analysis, and major flaws are often not discovered until final integration testing or system deployment. Typically such an approach results in a system that is inefficient or not cost effective and many times leads to enormous cost increases or complete project failures. Recent examples include the Airbus A380 and Boeing 787. The production of these aircraft was delayed over a year due to integrated design failures between the electrical and mechanical systems. Given exponentially rising complexities, such an approach to system design will not be feasible in the future, and an optimum design will require a comprehensive approach where an entire system is considered as a whole rather than individual components or sub-systems.

For this purpose, new processes in system design are being developed which are inter-disciplinary and focus on the design and management of complex projects primarily at the design phase as well as over a project's lifespan. The incorporation of these processes requires coordination and management of teams, scheduling processes, tools and facilities to optimize costs and resources, to reduce risk, to meet deadlines and schedules, and to combine knowledge of both technical and human-related activities and interactions. In addition to technical knowledge and expertise in the related area of specialization, these activities require a multi-disciplinary approach utilizing knowledge of modeling, simulation and visualization, optimization, risk and reliability analysis, design, development, production and operation of physical systems, operations research, and other system design and management skills.

Almost all undergraduate engineering programs in the United States concentrate mainly on technical subjects in the area of specialization. However, the topics listed above that are necessary for system design are usually not covered in typical undergraduate curricula. Thus, a

significant number of engineers lack suitable training and learn by trial-and-error once they are on the job. As one might expect, this can have disastrous consequences for a project.

Several educational institutions in the United States now offer an MS degree in Systems Engineering, which is different from system design. To date, systems engineering has been mainly focused on structuring the *management* aspect of the manufacturing, test and lifecycle processes, such as tools for documentation and planning at the block diagram level. Furthermore, many system level approaches are limited to specific domains in areas such as automotive or aerospace, but still do not encompass the totality of the system. While cross-disciplinary approaches such as Mechatronics, Micro Electrical Mechanical Systems (MEMS) or cyber-physical systems (CPS) have begun to emerge in recent years, truly holistic approaches are lacking. Systems of the future will increasingly consist of heterogeneous, intelligent, autonomous and distributed electronic, mechanical or biological subsystems deeply immersed and embedded within their environment. Individual subsystems will sense, act and interact through combinations of electric, Radio Frequency (RF), optical, electromechanical, electrochemical and other interfaces. Due to their entrenched nature, a key aspect of future systems will be the development of non-traditional, natural and intuitive human-computer interfaces (HCI), such as direct brain-machine connections. The proposed program will incorporate study of the latest such developments in the field of system design.

No other institution in South Carolina offers a program for engineers and technical personnel that leads to a Master of Science degree in System Design. We note that Clemson University started a recent graduate certificate program in Systems Engineering, and launched a Master of Engineering in Systems Engineering in Fall 2012. Our proposed MS program has a significantly different focus than that of Clemson's ME program, as discussed in the section below on duplication of programs.

The proposed program is also distinct from, yet complementary to, existing programs in the College of Engineering and Computing. It will build upon expertise already present in the College, as well as mesh with the strategic direction of both the College and University. Graduates of the program will be equipped to move into range of industries already in the State of South Carolina, including defense organizations (communications, weapon systems), power generation and control (nuclear power stations and grid control), manufacturing systems, automotive and aerospace industries. With the skills acquired in the proposed program, graduates will contribute to the reduction of flaws in the design of software and hardware used in communication systems, enabling them to help prevent inadvertent data releases or data corruption based on software defects (susceptibility to cyber-attacks), or hardware defects (inadvertent electromagnetic losses or emissions). The proposed program also allows the College to teach radically new approaches for contemporaneous collaborative design of multidisciplinary systems, such as power and energy conversion systems for aerospace or terrestrial applications, which will lead to improved energy efficiency and effectiveness, and reduced project costs.

The proposed program is a natural extension of the work currently in place in the College of Engineering and Computing and brings together technology and research in a way that benefits SC engineering and computing industries, e.g., aerospace, power generation and control, and automotive manufacturing. The Power and Energy Systems group within the Department of Electrical Engineering has led research involving the development of software for the collaborative design of naval systems. The Office of Naval Research is funding this research at a level of approximately 40 million dollars over a ten year period. This project and the software it

has produced have advanced the concepts of system design. The development team for this research has included members from MIT, University of Texas, Purdue, Florida State University, Mississippi State University, US Naval Academy, and the Naval Postgraduate School. At least one private company in Columbia emerged as a spin-off of this research to commercialize the developments that evolved in the establishment and application of the project. Formal class work in system design would greatly benefit the ongoing research activity and the resulting statewide activities in the discipline.

Anticipated program demand and productivity

The proposed program will be of interest to a wide group of engineers whose career goals are to assume technical managerial positions or coordinating roles. Its graduates will be prepared to work in all engineering disciplines (chemical, civil, electrical, mechanical, and nuclear engineering), and therefore the program is expected to draw students not just from South Carolina but also from the neighboring states of North Carolina and Georgia. The proposed program will be offered each semester as an executive program in synchronous delivery mode, as well as in an asynchronous distance education format (APOGEE - A Program of Graduate Engineering Education) nationally and internationally, to make it attractive to practicing engineers employed full-time, and to US citizens on overseas deployment.

The College of Engineering and Computing has been running successful distance-education graduate programs (APOGEE) since the late sixties. The proposed program in System Design will be a good addition to the existing distance-delivered programs, and will provide additional options to other graduate students in the College.

Once the proposed program is fully developed, we anticipate approximately 20 on-campus and 10 distance education students. Preliminary discussions have been held with a number of companies within the state who have shown significant enthusiasm for the proposed program. The rationale and basic content of this proposed course has been developed over time and in direct discussion with a number of national-level companies including Boeing, Lockheed Martin, Raytheon, NASA, Naval Undersea Warfare, Spawars, SAIC, and L-3 Communications.

Employment Opportunities

The graduates of this program will have ample opportunities for high ranking jobs within the private sector, consulting engineering firms, and industry as well as in local, state and federal government agencies. Employment opportunities include jobs in in-state organizations as well as nationally and internationally. Evidence of the demand can be seen in the many similar new programs being developed in Tier 1 institutions during the last few years in the southeast (enrollment and graduation data available in Table 1).

Table 1

2012 Enrollment and Graduation Rates of Similar Programs in the Southeast

Institution	Degrees	Enrollment (2012)		Degrees Awarded (2012)
		PT	FT	
Auburn University	MS, MISE	25	48	37
Florida Institute of Technology	MS	45	11	25
George Mason University	MS	69	12	31
George Washington University	MS	423	82	187
Old Dominion University	ME	37	5	12
Southern Polytechnic State University	MS	42	4	16
University of Alabama Huntsville	MSE	87	7	34
University of Florida	MS, ME	23	193	116
University of Virginia	MS, ME	30	42	51

Source: American Society for Engineering Education

Program Relationship to Mission

The mission of this program aligns with that of the University of South Carolina, which states

USC Columbia's mission is twofold: to establish and maintain excellence in its student population, faculty, academic programs, living and learning environment, technological infrastructure, library resources, research and scholarship, public and private support and endowment; and to enhance the industrial, economic and cultural potential of the state.

In particular, this program is designed to produce engineers and other technical personnel who will contribute to the economic development of the state. Such contributions will include developing and efficiently utilizing available natural and human resources, attracting new businesses nationally and internationally, exporting products, and providing technical services inside and outside the state.

Assessment of extent to which the proposed program duplicates existing programs in the state

There is no other program in the state leading to a Master of Science degree in System Design. In the fall of 2012, Clemson started a Master of Engineering degree in System Engineering which does not require a thesis, and which is related to ecology, environmental engineering and science, transportation, and information technology, as indicated in their CHE proposal. Our proposed program, which does require a thesis, will focus initially on energy, aerospace,

computer architecture and cyber-security. The initial concentrations proposed for this degree include Secure Communications and Power, and Power Electronic Systems. We anticipate adding interdisciplinary concentrations to the program in the future.

Relationship of the proposed program to existing programs at the proposing institution

The proposed program will significantly add to the educational and research activities of the McNair Aerospace Institute and will complement the management and aerospace programs of the College of Engineering and Computing. The proposed program will complement the existing graduate programs of the College of Engineering and Computing by making eventual additional graduate courses available to the full-time graduate students as well as those enrolled in the distance education program. This MS program in System Design offers courses on system design, projects and processes, modeling and simulation, planning and scheduling, and other related areas. Existing courses in the recently approved MS program in Engineering Management are available to the proposed program – the interdisciplinary nature of the proposed degree means that there are a significant number of classes already in place. The recent faculty hiring in the College of Engineering and Computing also opens the opportunity for classes in new areas to be developed for eventual additional interdisciplinary concentrations.

The University of South Carolina has several nationally recognized programs, among them management techniques and supply chain management (housed in the Moore School of Business), and psychology/human factors (College of Arts & Sciences), that offer the potential for cross-disciplinary collaboration. The prestige of these related programs will enhance the attractiveness of the proposed program to quality graduate students.

Relationship of the proposed program to other institutions via inter-institutional cooperation

An MOU for collaboration between the Colleges of Engineering and Computing of USC and the Citadel has been signed that will allow students to take courses at the partner institution (copy attached). Our proposed program will complement the Project Management program at the Citadel. Discussions with Clemson University for developing similar collaboration have been planned.

Enrollment

Admission Criteria

The admission criteria will conform to those currently required by the USC Graduate School. An applicant must have a baccalaureate degree or its equivalent in engineering, computer science or a related field from an accredited institution. Admission will be based on the applicant's GRE score, letter of recommendation, GPA and quality of the applicant's prior education and experience.

Projected Total Enrollment

Table 2 lists the estimated headcount in the program during the first five years. As is typical for new Engineering programs, the enrollment is expected to grow at a faster rate during the first

three years and then level off as it reaches the limit of available qualified students. Almost all of the students will be new students with just a few as transfers from other programs.

For the credit hours listed in Table 2, it is assumed that the full-time student will be enrolled in a minimum of nine hours during the fall and spring semesters and during the summer. Part-time students will take three credit hours during each semester and during summer.

Table 2
Projected New Enrollments: Headcount and Credit Hours

Year	Fall				Spring				Summer			
	Headcount		Credit Hours		Headcount		Credit Hours		Headcount		Credit Hours	
	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT
2013-2014	5	3	15	27	6	4	18	36	4	4	12	36
2014-2015	8	4	24	36	10	5	30	45	8	5	24	45
2015-2016	12	6	36	54	15	8	45	72	12	8	36	72
2016-2017	20	10	60	90	20	10	60	90	15	10	45	90
2017-2018	20	10	60	90	20	10	60	90	15	10	45	90

Curriculum

The program will be housed in Electrical Engineering with other departments providing graduate courses that students enrolled in this program may take, as is presently done for other Master’s programs within the college.

Six hours of MS thesis are required with a final oral examination for thesis defense. Student achievement of program objectives will be assessed based on the successful thesis project and defense.

The program will initially concentrate in two areas: Secure Communications and Power, and Power Electronic Systems. Additional courses will be developed later for each area as needed and based on the availability of faculty, without adversely affecting other program areas. It is anticipated that the program may add interdisciplinary concentrations which may also tie in to our other engineering programs.

Course Requirements

All courses listed in this proposal are existing courses. Additional new courses may be developed later as needed, if further concentrations are proposed in the future.

A total of 30 credit hours are required, with a maximum of 12 credit hours of 500-level courses.

Thesis: six credit hours.

Core courses: nine credit hours.

Choose any three from the following courses:

- CSCE 716 -- Design for Reliability
- CSCE 758 -- Probabilistic System Analysis
- CSCE 512 -- System Performance Evaluation
- CSCE 563 -- Systems Simulation

Twelve credit hours are required in a research area which must be directly related to thesis research from the courses listed below.

Three credit hours of complementary coursework must be chosen with the advisor's consent.

Course List

Electrical Engineering

- ELCT 521: Introduction to Microwaves
- ELCT 530: Industrial Controls
- ELCT 531: Digital Control Systems
- ELCT 551: Power Systems Design and Analysis
- ELCT 553: Electromechanical Energy Conversion
- ELCT 561: Advanced Electromagnetics
- ELCT 562: Wireless Communications
- ELCT 563: Semiconductor Electronic Devices
- ELCT 564: RF Circuit Design for Wireless Communications
- ELCT 566: Semiconductor Optoelectronics
- ELCT 572: Power Electronics
- ELCT 573: High Speed Digital Systems
- ELCT 751: Advanced Power Systems Analysis
- ELCT 752: Power System Grounding & Transients
- ELCT 753: Electrical Drives
- ELCT 761: Fundamental Electromagnetics
- ELCT 762: Signal Integrity in High Speed Circuits
- ELCT 771: Optical Communications: Devices & Systems
- ELCT 772: Advanced Power Electronics
- ELCT 782: Power Semiconductor Devices
- ELCT 837: Modern Control Theory
- ELCT 838: Optimal Control & Estimation
- ELCT 861: Advances in Electromagnetics
- ELCT 862: Antennas & Radiation
- ELCT 863: Computational Electromagnetics
- ELCT 864: Microwave Devices & Circuits
- ELCT 865: Signal Integrity on System Bus Technology
- ELCT 883: Power Systems Stability & Control

Computer Science and Engineering

- CSCE 512: System Performance Evaluation
- CSCE 513: Computer Architecture
- CSCE 516: Computer Networks
- CSCE 520: Database System Design
- CSCE 522: Information Security Principles
- CSCE 561: Numerical Analysis (Cross-listed as MATH 527)
- CSCE 563: Systems Simulation
- CSCE 711: Advanced Operating Systems
- CSCE 713: Advanced Computer Architecture
- CSCE 716: Design for Reliability
- CSCE 717: Computer System Performance and Reliability Analysis
- CSCE 741: Software Process
- CSCE 742: Software Architectures
- CSCE 758: Probabilistic System Analysis
- CSCE 760: Numerical Analysis I
- CSCE 761: Numerical Analysis II (Cross-listed as MATH 727)
- CSCE 846: Software Reliability and Safety
- CSCE 790: Topics in Information Technology

Faculty

It will be possible to offer this program with the present facilities and staff and with the existing faculty, including the three new faculty members in this area who joined the college in Fall of 2012. No additional resources are required. There will be no changes in the assignment of current faculty. As indicated in Table 3, the number of existing faculty who will participate in the proposed program increases with the increase in enrollments.

Table 3

Rank and Academic Qualifications of Faculty in Program

Rank	Highest Degree Earned	Field of Study	Teaching in Field
Professor #1	Ph.D.	Computer Science and Engineering	Yes
Professor #2	Ph.D.	Electrical Engineering	Yes
Associate Professor #1	Ph.D.	Computer Science and Engineering	Yes
Associate Professor #2	Ph.D.	Electrical Engineering	Yes
Associate Professor #3	Ph.D.	Mechanical Engineering	Yes
Assistant Professor #1	Ph.D.	Computer Science and Engineering	Yes
Assistant Professor #2	Ph.D.	Electrical Engineering	Yes

Proposed Changes in Assignment for Current Faculty

There will be no change in the assignment of current faculty.

Institutional Plan for Faculty-Development

The existing faculty members are involved in teaching, research, and service activities and institutional processes and procedures are in place for faculty-development at the department, college and university levels. Any new faculty hired according to previously approved plans will be mentored by the senior faculty for their career development.

Table 4

Overall Headcount and FTE of Faculty, Administrators and Staff for the Program

Year	New		Existing		Total	
	Headcount	FTE	Headcount	FTE	Headcount	FTE
Administrators						
2013-2014	0	0	1	0.15	1	0.15
2014-2015	0	0	1	0.15	1	0.15
2015-2016	0	0	1	0.15	1	0.15
2016-2017	0	0	1	0.15	1	0.15
2017-2018	0	0	1	0.15	1	0.15
Faculty						
2013-2014	0	0	8	0.75	8	0.75
2014-2015	0	0	10	1.25	10	1.25
2015-2016	0	0	12	2.00	12	2.00
2016-2017	0	0	12	2.00	12	2.00
2017-2018	0	0	12	2.00	12	2.00
Staff						
2013-2014	0	0	1	0.25	1	0.25
2014-2015	0	0	1	0.25	1	0.25
2015-2016	0	0	1	0.25	1	0.25
2016-2017	0	0	1	0.25	1	0.25
2017-2018	0	0	1	0.25	1	0.25

Physical Plant and Equipment

No additional physical space will be needed for the proposed program. Existing lab space is sufficient to accommodate the program.

Supporting Resources

Present facilities will be sufficient.

Equipment

Other than existing teleconferencing facilities for distance education, no specialized equipment or facilities will be needed for the proposed program.

Library Resources

USC Libraries

The current library holdings are more than adequate for up-to-date research and teaching for the proposed program. The College of Engineering and Computing's allocated amount for periodical subscriptions is \$228,504 and \$10,800 for books. As the program enrollments increase and as the number of faculty who are involved with the program increases, college representatives on the library committee will be asked to make a request for allocation of library funds for journals (approximately \$1000 per year) and books (approximately \$500 per year) as needed.

Accreditation

The institution will not seek accreditation for the proposed program.

Table 5
Costs to the Institution

Estimated Costs By Year						
Category	1st	2nd	3rd	4th	5th	Total
Program Administration	5,000	5,000	5,000	5,000	5,000	25,000
Faculty Salaries	67,500	112,500	180,000	180,000	180,000	720,000
Graduate Assistants	0	0	0	0	0	0
Clerical/Support Personnel	10,000	10,000	10,000	10,000	10,000	50,000
Supplies & Materials	5,000	5,000	5,000	5,000	5,000	25,000
Library Resources	1,500	1,500	1,500	1,500	1,500	7,500
Equipment	0	0	0	0	0	0
Facilities	0	0	0	0	0	0
Other/Operating	0	0	0	0	0	0
Total	89,000	134,000	201,500	201,500	201,500	827,500

Sources of Funding

Sources of Funding						
Source	1st	2nd	3rd	4th	5th	Total
Estimated Revenue Generated from Tuition	92,160	130,560	201,600	278,400	278,400	981,120
Other State Funding	0	0	0	0	0	0
Reallocation of Existing Resources	0	0	0	0	0	0
Total	92,160	130,560	201,600	278,400	278,400	981,120

The revenue from tuition is estimated at \$470 per credit hour for South Carolina residents (based on the credit hours shown under the projected enrollment and an APOGEE executive fee of \$170 per credit hour. All tuition goes to the University's general fund; allocation back to the College of Engineering and Computing is determined by the annual strategic planning budgeting process.