Graduate Faculty Meeting
Monday December 5, 2005

The graduate faculty meeting was called to order at 3:05 pm in the St. Pat's Ballroom of the Havener Center. The first item of business was approval of the list of graduate degree recipients for the December 2005 commencement ceremony. The list provided by the registrar's office was approved unanimously with no additions or deletions.

The PhD program in Systems Engineering was described by Prof. Dagli and then considered for approval by the graduate faculty. A motion to approve the PhD degree program in Systems Engineering was introduced by Dean Krishnamurthy and, with subsequent amendments, became a motion "to approve the PhD degree program in systems engineering as submitted on the new program proposal form NP. The residency and research requirements described in this document are approved only for the PhD in Systems Engineering." The motion was seconded by Prof Dagli and after some brief discussion was approved by a vote of the graduate faculty with 21 votes in favor, 0 votes opposed, and 5 abstentions. For the purpose of providing a complete record of this meeting the NP form referenced in the motion will be included with these minutes.

Prof. Liou introduced a proposal to change the requirements listed in the graduate catalog for the master of engineering program. A motion was brought before the graduate faculty to approve changes to the requirements in the Master of Engineering program as described in the attachments to the agenda for the FS05 Graduate Faculty Meeting. The attachments referenced in the motion are included at the end of these minutes. The motion was approved by a vote of 15 in favor, 5 against, and 5 abstentions.

At the request of Roberta Cox the graduate council was asked to consider very slight changes in graduate form VII—the comprehensive exam report. The purpose of the changes was to replace the wording "date of final examination" with "date of completion of the comprehensive exam." The purpose of the proposed changes was to eliminate confusion and ambiguity in the wording on this form. A motion was made by Prof Ragsdall to make these changes on Gradaute Form VII and the motion was approved unanimously by the 19 graduate faculty members still present.

The recommendation of the Graduate Council to accept a minimum score of 80 on the IBT (internet based testing) TOEFL was cast as a motion and approved unanimously.

The graduate faculty membership committee was recognized for its service to the graduate faculty and new members (one representative from each school or college) will be selected. Any member of the graduate council wishing to serve on this committee should contact the chairman of the graduate faculty.

The meeting was adjourned at 4:05 pm.
Respectfully submitted,

Richard E DuBroff
Chairman, Graduate Faculty

1. NEW PROGRAM PROPOSAL

Form NP

Sponsoring Institution: University of Missouri-Rolla
School of Engineering

Program Title: Systems Engineering

Degree: Doctor of Philosophy (PhD) in Systems Engineering

Options: No options

Delivery Sites: University of Missouri-Rolla

CIP Classification: 14.2701

Implementation Date: Fall 2006

Cooperative Partners: No Partners

Expected Date of First Graduation: May 2007

AUTHORIZATION

____

Name/Title of Institutional Officer | Signature | Date

Cihan H. Dagli, PhD | (573) 341-4374

Person to Contact for More Information | Telephone

2. NEED

In the late 1990s, UMR responded to The Boeing Company's "Request for Proposals" (dated 12/1/98) to provide a Systems Engineering MS degree to Boeing engineers and its contractors worldwide. As a result, a joint effort was formed between the University of Southern California (USC) and the University of Missouri-Rolla (UMR). The UMR and USC team proposal was selected by The Boeing Company from among 15 competing proposals that included submissions from Ivy League universities. In 2000, the MS degree in Systems Engineering was approved by CBHE. During the December 2000 commencement ceremony, three students received their MS degrees in Systems Engineering as the first graduates of the UMR program. Currently, the program has over 238 students and has graduated over 130 students as of the Spring 2005 semester. The Systems Engineering program is considered as one of the best programs in the nation. It is attracting students from diverse companies and laboratories, such as the U.S. Air Force, U.S. Army, National Geospatial-Intelligence Agency (NGA), Los Alamos National Laboratories, General Motors, Lockheed Martin, Raytheon, Sprint, Brewer Science, Briggs and Stratton, University of Missouri System, Hollister Corporation, and Singapore Airlines. Nonetheless, The Boeing Company still remains the major source of students, and the cooperation and competition between UMR and USC for students from The Boeing Company is still healthy. UMR and USC continue to be the major suppliers of systems engineers for The Boeing Company as stated clearly in the following quotation by John Tracy, Vice President of Engineering of Boeing Integrated Defense Systems (IDS):

"Systems Engineering is very important to IDS and is becoming more so. It is a necessary way of doing business not only for the understanding and implementation of the most modern practices of systems engineering, but also for advancing our competitive posture in areas such as decision making, modeling and interdisciplinary integration. Systems Engineering is a foundational element in meeting our customer needs. USC and UMR have a contract with Boeing to provide a systems engineering graduate program – available over the Internet – for all Boeing employees. I encourage the engineers of Boeing to participate in this program. It will be beneficial for them and it is necessary for Boeing."

The current MS degree program will provide a sound foundation for the proposed PhD program in Systems Engineering.

2.1 Student Demand
Form SE: Student Enrollment Projections

YEAR	0	1	2	3	4	5
Part time (off-campus)	8	12	16	20	24	26
Full time (on-campus)	6	10	12	14	16	18
Total	14	22	28	34	40	44
Graduates	0	1	4	6	8	12

The American Society for Engineering Education (ASEE) web site lists 22 universities that have MS degree programs in Systems Engineering. Every year new universities are being added to this list. Nationwide, 782 MS degrees were awarded in Systems Engineering in 2003 and this number jumped to 970 in 2004. These programs generally use practicing Systems Engineers as adjunct faculty, often with limited full time faculty. Hence, there is a great need for faculty with a PhD in Systems Engineering to teach graduate courses in Systems Engineering. Their responsibility will be to create the new body of knowledge in this field through research to help find solutions to the engineering problems in the design and operation of both defense and commercial complex network centric systems-of-systems and family-of-systems of the future.

However, there are a limited number of PhD degree programs in USA universities. The four basic programs at Massachusetts Institute of Technology, University of Virginia, Stevens Institute of Technology, and University of Arizona, along with a DSc program at The George Washington University and a closely related PhD degree program at George Mason University, are not sufficient to meet this demand. UMR's strong foundation in the MS degree program in Systems Engineering is an asset in starting the PhD program. There are currently 14 students in the Engineering Management PhD program who are conducting Systems Engineering related research. These students are listed in the Student Enrollment Projection Table under Year 0. Graduates of the Systems Engineering MS degree program will be the primary source of students for this new program. Defense industries such as The Boeing Company will be the initial primary source for students, as well as the funding entity for the program through tuition reimbursement during the first five years of the program. On-campus students will be funded through research grants from industry and federal agencies.

The estimates of student enrollment assume that the major part of the student body will be from The Boeing Company, primarily from St. Louis. It will take approximately six years for a part time student and three years for a full time student to complete the degree after successful completion of their MS degree in Systems Engineering.

2.2 Market Demand

Systems Engineers are responsible for the design and management of complex systems. There is a need for engineers who are concerned with the whole system and can take an interdisciplinary and top down approach, who are problem definers, not just problem solvers, and who are involved with a system throughout its life cycle from development through production, deployment, training, support, operation and disposal. The systems architecture is often arbitrary for these systems and interfaces are very significant and are generally unknown. Technical and domain expertise is important.

Systems engineering is non-linear journey from cradle to grave that result in a non-analytic top down design process. Solution concepts are not unique, global optimization is often not possible, and balance is sought. Societal factors are important and are sometimes difficult to predict. There is a need to iterate between form and function experimentally.

These characteristics necessitate engineers with diverse backgrounds of technical and domain specific experience. Companies have realized this need and have trained their engineers accordingly. However, this has not been sufficient to fulfill the educational need and has created a huge demand to provide an education to engineers so that they could receive their MS in Systems Engineering while working.

These recent changes have created the following two basic needs:

- Availability of full time faculty to teach Systems Engineering courses in the universities that offer PhD degrees in Systems Engineering. The current practice is to use practicing Systems Engineers from industry as adjuncts professors to teach courses in these programs.
- Creation of a new body of knowledge in Systems Engineering to respond to new engineering challenges of tomorrow, along with the immediate transfer and creation of this knowledge within industries. This knowledge pushes the envelope of technology in a timely manner, while respecting proprietary information of the involved companies and providing for the education of a new generation of Systems Engineering faculty.

The tremendous success of UMR's Systems Engineering MS degree program over the last six years, along with its strong ties to The Boeing Company both nationally and internationally, uniquely positions UMR to respond to this need. The proposed PhD program will serve the needs of the State of Missouri and the nation in a timely manner. It will also maintain the lead of UMR, and in turn the State, in Systems Engineering Graduate Education.

2.3 Societal Need

We are increasingly becoming a networked society. This is true in state, local and federal government, industry, and with individuals. Society is increasingly dependent on these networks. These new engineering systems are generally described as Mega Systems. Figures 1 and 2 provide operational concept views for some of these systems.

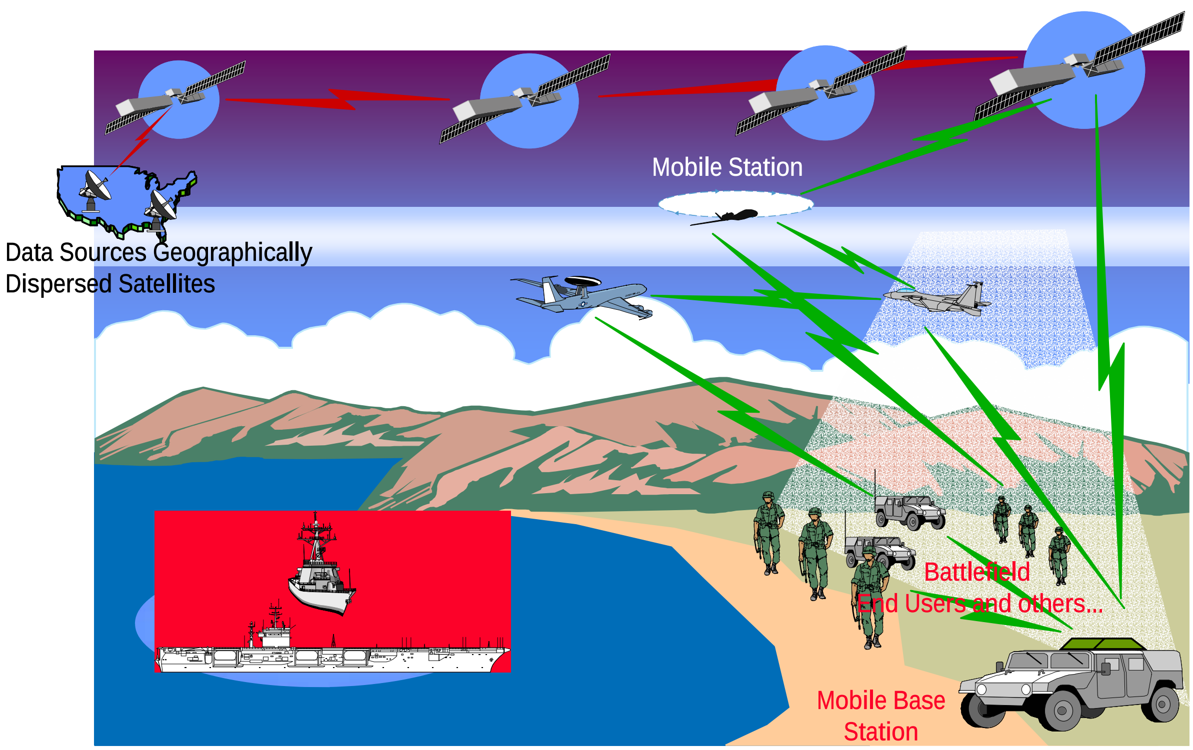

Figure 1: Military Mega-Systems

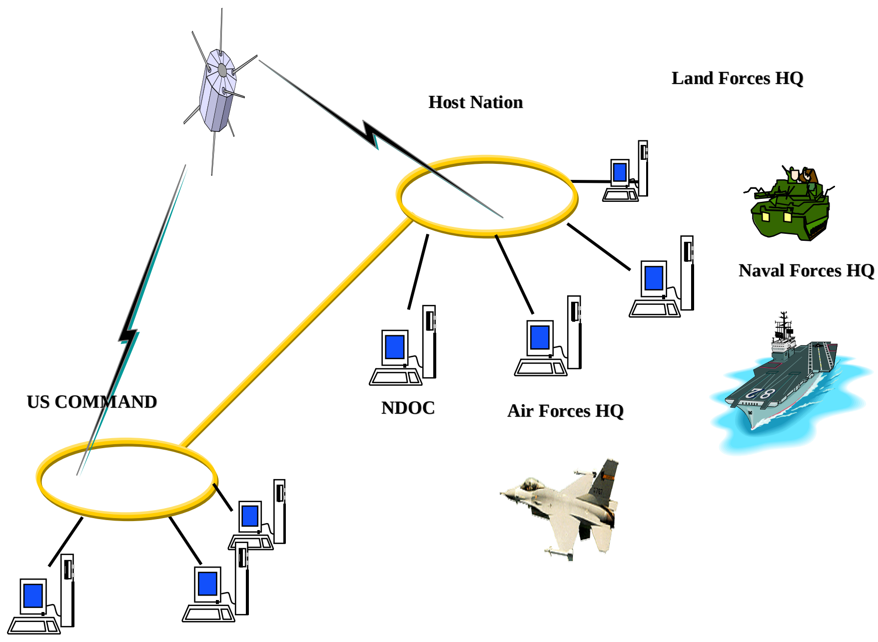

Figure 2: Trans-National Military Mega-Systems

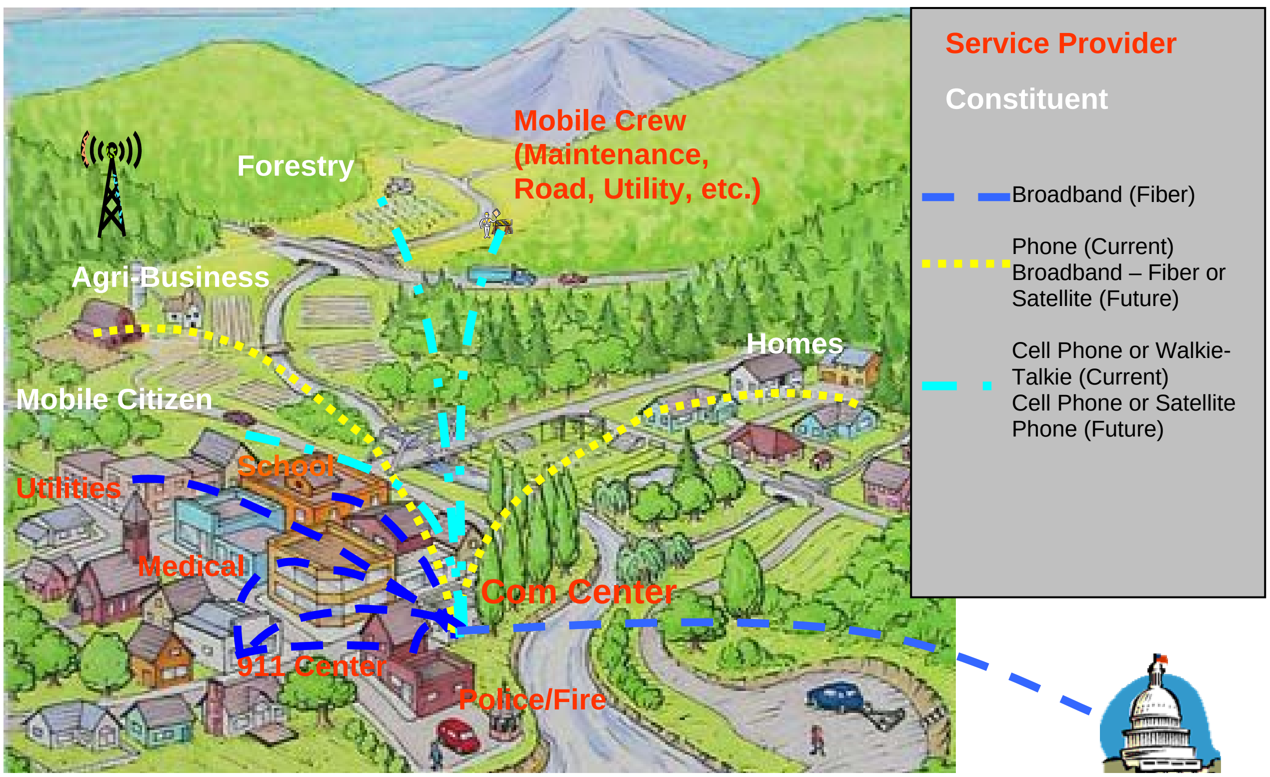

Figure 3: OV-1 High-Level Operational Concept Graphic Rural Country Management

It is possible to combine these systems and make them trans-national in responding to dynamically changing needs imposed by global events by creating system architectures that will be in effect for the duration of the event, thereby creating a need to develop new systems architecture for the next mission or the event. This fact is important as it complicates the systems architecting activities and also eliminates the static structure of classical architecting approaches. Hence, the architecture becomes a dominating but confusing concept in capability development. The same concepts can be applied to managing a rural country as well. Figure 3 (Charles J. Bryan SysEng 419 Fall 2004 course project) depicts the concept of operations for such a system.

These systems need to evolve in time to accommodate changes in technology and requirements. Hence, systems engineers need to monitor, evolve, and adapt systems architectures in time. This eliminates the classical concept that is used in the past, namely, that architectures are static. Figure 4 demonstrates this concept. These systems evolve by adding components, as in the case of electrical utilities creating a potential for hidden robustness (for example, load sharing across electric utilities), and also give rise to a potential for cascading failures as well, as in the case of August 14, 2003 blackout in Northeast U.S. Individual systems within the Systems-of-Systems (SoS) may be developed to satisfy the peculiar needs of a given group. The information they share is so important that the loss of a single system may deprive other systems of their data needs to achieve even minimal capabilities.

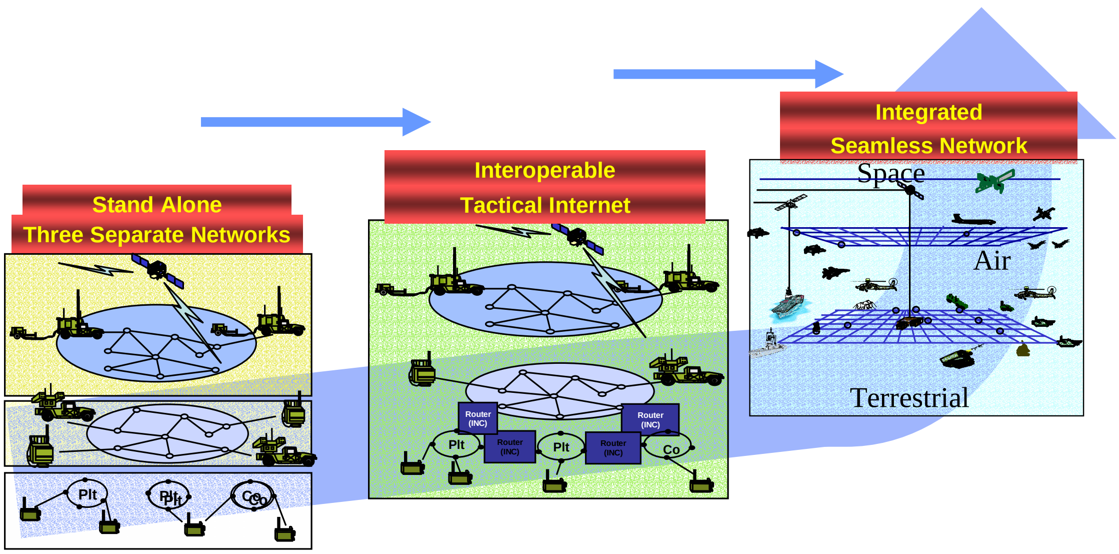

Figure 4: An Example of the Evolution of Systems-of-Systems

It is also possible to define a Family-of-Systems (FoS) as a set or arrangements of independent systems that can be arranged or interconnected in various ways to provide capabilities. The mix of systems can be tailored to provide desired capabilities, depending on the situation. Although these systems can independently provide useful capabilities, in collaboration they can more fully satisfy a more complex and challenging capability. The SoS created from Network-Centric Operations (NCO) is a "super-system" comprised of elements that are themselves complex, independent systems that interact to achieve a common goal.

Unfortunately, the current body of knowledge in Systems Engineering is not sufficient for effective design and operation of these systems. There is a need to push the boundaries of technology and Systems Engineering and Systems Architecting research both in industry and research universities to meet the challenges imposed by these systems, as there is increased uncertainty about systems requirements coupled with continuous changes in technology and organization structures. A diverse spectrum of missions and operations requires development of system architectures that can adapt and evolve. This is possible through extensive collaborative research with industry and academia in Systems Engineering and Systems Architecting to answer the following questions for these emerging new engineering systems:

- How can we assure trustworthiness, interoperability, large-scale design, test and evolutionary growth?
- How can we deal with hidden interdependencies?
- How can we guard against cascading failures?
- How can we deal with complexity?

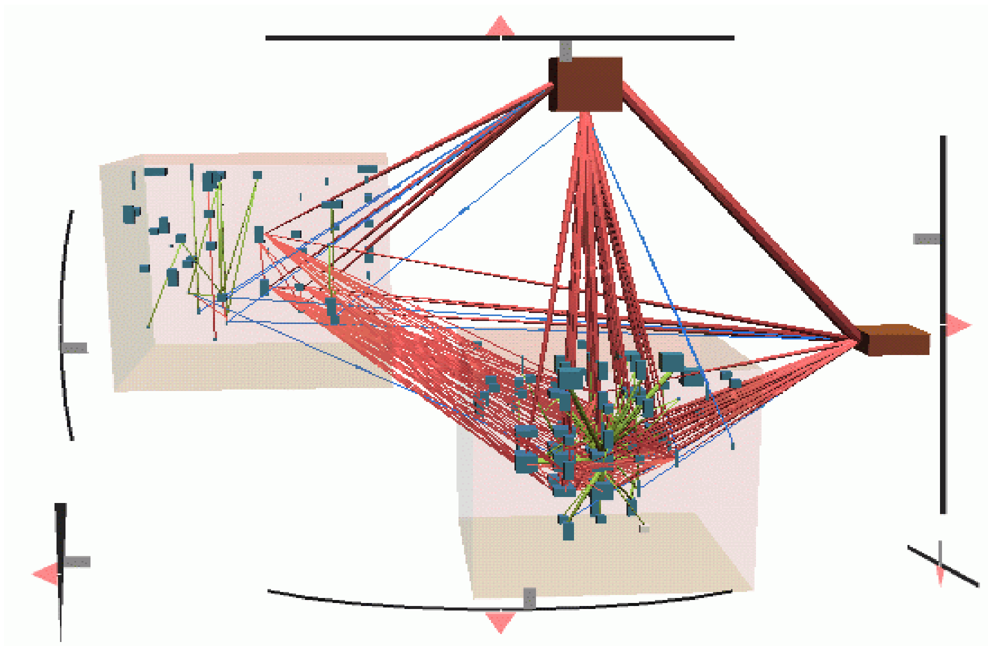

Figure 5: A graph representing almost 6 million lines of computer code. The graph contains approximately 33,000 nodes and 34,000 relations. Source: NATO Report on Visualization, 1999.

The four current PhD programs in the nation are not sufficient to meet this research challenge that requires extensive collaboration with industry. There is also a need to restructure the classical PhD program structure to meet these new research demands, as it is impossible to bring these systems to a university laboratory.

The tremendous success of UMR's Systems Engineering MS degree program over the last six years, and strong ties of this program to The Boeing Company, both nationally and internationally, put UMR in an excellent position to respond to this need. We believe that the availability of such a program will have a positive impact on the state's economy in the future.

3. DUPLICATION AND COLLABORATION

UMR is the sole provider for the program. At the present time, no other institution of higher education in the State of Missouri offers programs that are similar to the proposed program.

4. PROGRAM STRUCTURE

4.1 Basic Structure

The proposed PhD program in Systems Engineering will depend heavily on the MS degree program and maintain the same diversity among various disciplines by cutting across all four schools and colleges at UMR. As indicated in an earlier section, it is not possible to generate the body of knowledge required in designing and operating and disposing the System-of-Systems of this century without integrating several engineering and scientific disciplines. Using the idea of Integrated Product and Process Development Teams (IPPD) that worked very well in the defense industry for several decades, faculty from different schools and departments are grouped together into different research areas within the Systems Engineering field, forming an interdisciplinary team that cuts across departments and schools. This diverse faculty will be involved in all aspects of the program under the leadership of Dr. Cihan H Dagli, who is the director of the Boeing Systems Engineering Graduate program, Professor of Engineering Management and Systems Engineering at UMR, and Director of the Smart Engineering Systems Lab.

The total credit requirements for graduation are 60 credits after successful completion of MS degree in Systems Engineering and 90 credit hours after a BS degree. Actual courses to be taken will be determined by the candidate's committee and his program of study. The student will be expected to complete all requirements listed in the UMR Graduate Catalog.

Form PS

A. Total credits required for graduation: 90

B. Residency requirements, if any:

The program will follow the residency requirements listed in the UMR Graduate Catalog under the section entitled ***Doctor of Philosophy Degrees***. Distance students can satisfy the current two-semester residence at UMR requirement by meeting the following guidelines.

- The qualifying exam must be taken on-campus during the first year of enrollment.
- The student is expected to have at least two Internet video conference meetings per month with their advisor or committee member that they sign up with for the SysEng 490 research course.
- The student's PhD committee must include one member from the student's professional work location. This individual must have a PhD degree and be familiar with the chosen research area of the student.
- The student will be expected to meet with his PhD committee on a regular basis as established by the committee through campus visits or internet video conferencing with a minimum of two meetings each semester.

- During any one year period, the student is expected to be on campus for a minimum of 16 days spread over at least four visits while taking courses toward the PhD.
- The student is expected to participate in all graduate courses synchronously with the class sessions based on the communication technology available in the classroom. Full participation in class activities is expected within the limitations of the communication technology. Asynchronous participation may be allowed only on an exceptional basis for individual class sessions.
- The PhD comprehensive exam must be taken on campus.
- The student has the option of selecting a dissertation topic in an area directly related to and beneficial to his/her professional work, and can carrying out the associated research at the student's worksite. It is essential that the student's employer fully support the doctoral program.
- Defense of the dissertation must take place on campus.

C. General education: Total credits: 0

D. Major requirements: Total credits: 24 hours

Core Curriculum

- SysEng 368 Systems Engineering Analysis I (3 hours)
- SysEng 468 Systems Engineering Analysis II (3 hours)
- SysEng 469 Systems Architecting (3 hours)
- SysEng 4xx Economic Analysis of Systems Engineering Projects (3 hours) (to be developed)
- SysEng 4xx Systems Engineering Management (3 hours) (to be developed)
- SysEng 4xx Complex Engineering Systems Project Management (3 hours) (to be developed)
- Courses in Systems Engineering Process Tools, Optimization and Statistics
    - SysEng/CpE 419 Network-Centric Systems Architecting and Engineering (3 hours)
    - SysEng 479 Architectures for Smart Engineering Systems (3 hours)

E. Free elective credits: 66 hours

Systems Engineering Process Tools, Optimization and Statistics elective courses (12 hours)

Research Specialization Areas courses (24 hours)

- Network Centric Systems
- Systems Architecting, Systems Engineering Process and Design
- Distributed Systems Modeling
- Structures
- Network Centric Manufacturing and Control
- Risk Modeling and Assessment
- Modeling and Simulation
- Computational Intelligence

Research SysEng 490 (30 hours)

(Sum of C, D, and E should equal A.)

F. Requirements for thesis, internship or other capstone experience:

Students will conduct original research demonstrated by journal or refereed proceedings publications under the supervision of a doctoral advisor, and communicate their findings, write a dissertation on research conducted, and provide satisfactory defense of their dissertation in a final oral examination.

G. Any unique features such as interdepartmental cooperation:

This interdisciplinary degree program cuts across all four schools and colleges within UMR. Courses for the degree will be taught mainly by engineering faculty. However, the 30 plus faculty who have agreed to participate in the Systems Engineering PhD degree program together bring a combined 130 years of distance teaching, 400 years of graduate teaching, and 160 years of industrial experience. Their joint contribution to the literature is over 2,500 scholarly articles. The 30 plus faculty represent membership at different levels in over 30 different professional societies and bring the level of diversity required in designing and operating the Systems-of-Systems of today. The open architecture concept used in designing both the MS and PhD graduate program in Systems Engineering enables the aggregation of this strong faculty for the program. This capability can be expanded even further by transferring courses from USC. Inclusion of Boeing researchers with a PhD to dissertation committees and selecting research topics from Boeing that push the boundaries of knowledge and technology will make this new degree program one of the best in the world.

This level of cutting edge research is already happening with students who are currently in the Engineering Management PhD program and who are doing Systems Engineering research. The strong foundation of the MS degree program and excellent support from The Boeing Company will make this new program a success. It will only be a matter of time that UMR will see similar support for this program from other defense and commercial companies. This is already happening in the Systems Engineering MS degree. This support will continue as long as courses are updated, new courses are developed, and new knowledge produced through research in the PhD program is disseminated to MS degree courses. Currently, research focus in the Systems Engineering PhD program is concentrated in eight areas, namely, network centric systems, systems architecting, systems engineering process and design, modeling and simulation, structures, computational intelligence, risk modeling and assessment, distributed system modeling, and manufacturing and control. These clusters will change in time. For example, the network-centric research cluster is discussed here in more detailed.

Network-centric systems comprise a diverse category of large and complex systems whose primary purpose is to provide distributed, network-type services. Infrastructures such as the electric power grid, oil and gas distribution systems, pipelines, financial networks, and corporate intra-nets are commercial examples of network-centric systems. Military examples include command and control systems, communications systems, and information fusion intelligence systems. These are multi-tiered systems, ranging small devices such as sensors to large-scale servers and computers and are themselves frequently “a system-of-systems”. Our society is greatly dependent on such systems since the networked components yield a system that is truly greater than the sum of the parts, offering increased effects and robustness. However, a failure in one node can have a rippling effect, resulting in cascading failures throughout the system. The failure could be caused by a natural disaster, human error, or a malicious attack. The research emphasis in this area spans the entire life cycle from system concept through maintenance and phase-out, with special interests in architecture, assurance, reliability, and security of network-centric systems.

4.2 Faculty Research and Teaching Experience

The faculty characteristics representing these research clusters are provided in Table I.

Table I: Faculty Research and Teaching Experience

Faculty	Distance Teaching Experience	Graduate Teaching Experience	Industrial Experience	Professional Societies	Highest Degree and University	Number of Publi-cations
Venkat Allada	3	11	1	SME, IIE	PhD, University of Cincinnati	80
S. N. Balakrishnan	1	19	N/A	AIAA	PhD, The University of Texas Austin	100+
Abdeldjelil Belarbi	1	14	1	ASCE, ACI, ASEE, PCI, NEES, TMS, TRB, EERI, Sigma Xi	PhD, University of Houston	85+
K. Chandrashekhara	4	20	2	ASME, SAMPE, AIAA, ASEE	PhD, Virginia Tech	150+
Minsu Choi	3	3	N/A	IEEE, Sigma, Xi	PhD, Oklahoma State University	35
Cihan H. Dagli	15	26	15	INCOSE, IEEE, IIE, INNS, INFORMS, ASEM, ASEE	PhD, University of Birmingham, England	250+
Lokesh R. Dharani	5	23	9	AIAA, ASME, ASEE	PhD, Clemson University	193
Xiaoping Du	0	11	2	ASME, AIAA, ASEE	PhD, University of Illinois at Chicago	50+
David Enke	5	8	5	AFA, ASEM, ASEE, FMA, GARP,IAFE, IIE, PRMIA	PhD, UMR	50+
Kelvin Erickson	0	18	1	IEEE, ISA	PhD, Iowa State University	40+
Barry Flachsbart	6	38	35	ACM, IEEE, ASCE	PhD, Stanford	40+
Scott Grasman	4	5	3	ASEE, ASEM, DSI, IIE, INFORMS	PhD, Univ. of Michigan	30+
Isaac Kakkattukuzhy	2	5	5	AIAA, Combustion Institute, ASME	PhD, Virginia Tech	100+
K. Krishnamurthy	1	18	1	ASME, IEEE, SME	PhD, Washington State University	50+
Robert G. Landers	5	12	0	ASEE, ASME, IEEE, SME	PhD, University of Michigan at Ann Arbor	50+
Jennifer Leopold	2	3	12	IEEE, ACM	PhD, University of Kansas	16
Frank W. Liou	6	18	2	ASME, SME, ASEE	PhD, University of Minnesota	100+
Frank Liu	6	11	0	IEEE	PhD, Texas A&M Univ.	50+
Ronaldo Luna	3	10	7	ASCE, EERI, GI, NSPE, MSPE, ASEE, ISSMGE	PhD, Georgia Institute of Technology	55+
Sanjay Kumar Madria	4	10	0	IEEE	PhD, IIT, India	100+
Ann Miller	8	19	13	IEEE, ASEEE	PhD, Saint Louis University	70+
John Myers	1	6	10	ACI, ASCE, PCI, NSPE, TMS, SEI, AEI	PhD, University of Texas-Austin	60+
Kenneth M Ragsdell	32	33	6	ASME, ASEE	PhD, The University of Texas, Austin	100+
Sreeram Ramakrishnan	2	2	4	ASEE, ASEM, SME	PhD, Penn State University	25+
Jagannathan Saranapani	3	9	7	IEEE, CS, Control, INNS, ASEE, Sigma Xi and Eta Kappa Nu	PhD, University of Texas - Arlington	130+
Can Saygin	1	8	0	SME, ASEE, ASEM, IIE	PhD, METU, Turkey	50
R Joe Stanley	2	4	2	IEEE, ASEE, NAFIPS	PhD, University of Missouri-Columbia	37
Daniel Tauritz	1	3	1	ACM SIG, IEEE	PhD, Leiden University	9
Chung-Li Tseng	1	7	3	INFORMS, IEEE, ASCE	PhD, University of California Berkeley	27
Ganesh Kumar Venayagamoorthy	0	6	3	IEEE, ASEE, INNS	PhD, University of Natal, Durban, South Africa	120+
Donald C Wunsch II	1	12	10	IEEE, INNS, ASEE, Phi Kappa, Phi, Eta Kappa NU	PhD, University of Washington	245+
Franck Xia	4	5	6	IEEE	PhD, University of Paris	40+

4.3 Financial Projections

Form FP

The new degree proposed will not bring an extra cost burden to the university as it primarily uses existing courses and laboratories and brings in significant tuition revenue.

The interdisciplinary nature of the PhD program, the configuration of the students (namely, part time students working on projects for their dissertation for The Boeing Company or other corporations pushing the boundaries of technology and knowledge, on campus students working at various research units), and the diversity of specialization areas create a different laboratory need for this degree program. Hence, it will not be possible to identify a single laboratory.

The number and location of laboratories will depend on the dissertation topics. Excellent infrastructure for distance education and recent developments in communication technology, such as the availability of collaboration software like WebEx and the Internet, will provide the needed communication structure among laboratories, faculty, and students. However, most of the research work will be abstract and algorithm based. The Smart Engineering System Laboratory in Engineering Management and Systems Engineering Department will serve as the prime laboratory. The Department established the Smart Engineering Systems Lab (SESL) to develop approaches in building complex systems that can adapt to changes in the environments in which they operate.

The focus of the SESL is in developing smart engineering architectures that integrate and/or enhance current and future technologies necessary for developing smart engineering systems while illustrating the real-life application of these architectures.

Current research topics include data mining, artificial life, evolutionary robotics, internet-based pattern recognition, and systems architecture assessment based on the Department of Defense Architecture Framework (DoDAF). Capabilities of the developed computational intelligence models are demonstrated physically in the lab through mini-autonomous research robots.

The Engineering Management and Systems Engineering Department also has been providing a forum for international researchers by hosting the ANNIE (Artificial Neural Networks in Engineering) conferences, held every year in St. Louis, Missouri since 1991. The Conference is an international gathering of researchers interested in Smart Engineering System Design.

The theme of this year's fifteenth ANNIE conference is ***Computational Intelligence and Systems Engineering***. The research papers presented at the ANNIE conferences by interdisciplinary engineering and scientific teams enhance the engineering tools and algorithms that can be used in building today's complex System-of-Systems and Family-of-Systems.

This is in line with the current research focus in the SESL laboratory that involves developing solutions to the research challenges in Systems Engineering that are imposed by today's complex, adaptive, distributed, cooperative and dynamically changing engineering systems.

4.3.1 Expenditures and Revenue

	Year 1	Year 2	Year 3	Year 4	Year 5
<u>1. Expenditures</u>					
A. One-time					
Course Development (3)	$ 24,000				
Total for One-time Expenditures	$ 24,000				
B. Recurring					
Faculty	$ 35,000	$ 35,000	$ 70,000	$ 70,000	$ 70,000
Staff	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000
Benefits	$ 16,500	$ 16,500	$ 27,000	$ 27,000	$ 27,000
E&E	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
Library (Electronic Journals)	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Distance Education and Technology Costs	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Total for Recurring Expenditures	$156,500	$156,500	$202,000	$202,000	$202,000
TOTAL EXPENDITURES (A+B)	**$180,500**	**$156,500**	**$202,000**	**$202,000**	**$202,000**
<u>2. Revenues</u>					
State Aid – CBHE					
State Aid – DESE					
Tuition/Fees					
Off-campus enrollment	$136,872	$182,496	$228,120	$273,744	$296,556
(# off-campus students @ $11,406/yr)	(12)	(16)	(20)	(24)	(26)
On-campus enrollment	$ 49,150	$ 58,980	$ 68,810	$ 78,640	$ 88,470
(# on-campus students @ $4,915/yr)	(10)	(12)	(14)	(16)	(18)
Institutional/Other Resources					
TOTAL REVENUES	**$186,022**	**$241,476**	**$296,930**	**$352,384**	**$385,026**

4.3.2 Budget Justification

The budget includes one-time and recurring costs. The one-time cost will be for developing three new courses during the first year of the program. These three new courses will be at the 400-level and will cover the main topic of complex engineering systems management for the systems-of-systems and family-of-systems of today. Currently, there are no courses at UMR that cover these topics. Recent natural disasters such as Hurricane Katrina and other man-made disasters are a testimony for the need of such courses.

The recurring costs are for salaries and operating expenses for the degree program. The salaries include the position of a faculty member at 50% during the first two years and increasing to 100% thereafter to support the increased enrollment, and a secretary to help with the promotion and administration of the degree program. Benefits are calculated at 30% of the salaries. Other recurring expenses include E&E, electronic journal subscription by the library, and distance education delivery and technology costs.

Revenue for this degree program will be generated by tuition paid by off- and on-campus students. The current rate approved by the Board of Curators is $3,802 and $983 per three hour course for off- and on-campus students, respectively. Each off-campus student will take at least three courses per year on average (the present average for the MS program in Systems Engineering is above this number). It is estimated that the average on-campus student will pay tuition for five courses per year on average (due to our tuition waiver policy for students with support, there will normally be two courses each academic semester and one course summer with paid tuition). It should be noted that the M.S. program in System Engineering brought in $1,657,305 in tuition from off-campus students during FY 2005 (FS 04, SP 05 and SS 05). This source of revenue is used for course delivery at the graduate level.

5. PROGRAM CHARACTERISTICS AND PERFORMANCE GOALS

FORM PG

Institution Name: The University of Missouri-Rolla

Program Name: Doctor of Philosophy in Systems Engineering

Date: September 2005

5.1 Student Preparation

Admission to the graduate program in Systems Engineering is limited to applicants with BS degree in engineering and certain physical sciences, such as mathematics or computer science. Students must also have a superior academic record. Applicants are required to submit the Graduate Record Examination (GRE) scores for admission evaluation. Applicants whose native language is not English are also required to take the Test of English as a Foreign Language (TOFEL).

Admission standards for a PhD in Systems Engineering include the following:

- BS in engineering or hard science and MS in Systems Engineering or related field with a 3.5 GPA.
- Minimum three years experience is recommended.
- All students must submit GRE scores. (Verbal plus Quantitative greater than 1150 and Analytical Writing greater than 4.5)
- All international applicants must submit TOFEL score. (237 or higher)
- All applicants must submit a statement of purpose.

Current engineering management PhD students whose research area is in systems engineering and who have passed their qualifying or comprehensive exam can transfer to the Systems

Engineering PhD program if it is approved by their advisor and committee during the initial transition period.

A candidate for the PhD in Systems Engineering must complete the equivalent of at least three years of full time-time work beyond the Bachelor's degree. The content of all PhD programs is individually structured by the student in consultation with and approved by the student's advisory committee. All requirements for the degree must normally be completed within an eight-year period. At appropriate points in their program, PhD students must pass both a qualifying examination and a comprehensive examination. Off-campus students are expected to complete all requirements listed in the UMR Graduate Catalog under the section entitled ***Doctor of Philosophy Degrees*** and follow all procedures listed under the ***Procedures for PhD Candidates*****.**

5.2 Faculty Characteristics

This interdisciplinary degree program cuts across all four schools and colleges within UMR. Courses for the degree will be taught mainly by engineering faculty. It is required that the faculty who will be teaching in this graduate program should have PhD degree in engineering or hard science. The 30 plus faculty who agreed to participate in the Systems Engineering PhD degree program fulfill this requirement. This faculty brings a combined 130 years of distance teaching, 400 years of graduate teaching and 160 years of industrial experience. Their joint contribution to the literature is over 2,500 scholarly articles. It is expected that 85% of credit hours will be assigned to full-time faculty.

5.3 Enrollment Projections

It is estimated that there will be 44 PhD students in the program at the end of five years. Approximately 60% of the student body will be part time and 40% will be full time students.

5.4 Student and Program Outcomes

Annual graduation rates at the end of three and five years are 6 and 12, respectively. These numbers may increase, based on the pool of MS degree students in Systems Engineering. There will be feedback loops that require input from the students, as well as stakeholders, incorporated in the educational program.

5.5 Program Accreditation

No discipline specific accreditation will be sought at the Ph.D. level since engineering accreditation is granted at the BS or MS level.

5.6 Alumni and Employer Survey

Three years after a student completes a degree program, he or she will be supplied with a questionnaire to evaluate the benefit of the program for their needs. This will include questions such as, "Which class or classes were the most useful to you and were there any impediments in the medium of instruction and learning format that need to be addressed to improve your education?" The results obtained will be summarized and used as feedback to improve the program. This type of evaluation is already being done for the MS degree program in Systems Engineering. The research quality of the program will be measured by the number of research grants and projects secured, achievable journals and papers published, and the number of graduates in getting faculty appointments and research jobs in industry and federal laboratories.

(From Current Graduate Catalog)

Master of Engineering Degree

The Master of Engineering degree is a practice oriented program designed for full-time students with the possibility of completion of degree requirements in one year, and for students working in industry through distance education. The choice of this degree program is made in consultation with the student's advisor and with the approval of the program director. Currently, the Geotechnics, Manufacturing Engineering and Mining Engineering programs offer a Master of Engineering (M. Eng.) degree.

General Requirements

The master of engineering program with project shall consist of a minimum of 30 semester hours of graduate credit over and above the prerequisites. At least six semester hours of the required work be from the group of lecture courses bearing numbers in the 400 series, and it is recommended that at least three semester hours will be devoted to courses outside the major department. A maximum of six hours of 200-level courses can be accepted in the M.Eng. program. Credit for research and development work conducted in preparation for the practice oriented project is counted in terms of hours making up the total credit hours by mastering and improving at least one manufacturing process or system, but not less than 3 hours. A minimum of six hours must be devoted to Graduate Research, Course 400. (Depending on the advisor's affiliation, course 400 credit is registered under the department involved.) Project work can be conducted on the UMR campus or in industry with the approval of the advisor. Such industrial projects must be supervised by an industrial supervisor and have prior written approval (Graduate Form " Application to Do Non-resident Research") of the student's graduate advisor and program director. Care must be taken to provide an industrial project that promises results equivalent to or superior to that which might be expected at UMR.

For more effective use of the committee, the candidate is encouraged to: (1) submit a written description of the proposed project to the members of the committee as soon as the topic is decided, and (2) obtain written approval of the committee indicating that the proposed project is of M.Eng. caliber.

Project Report

The findings and results of the practice oriented project undertaken by the candidate for a master of engineering degree must be presented in a report. A minimum on one (1) original and three (3) copies normally will be prepared following a format approved in advance by the advisor. After examining the report, the advisor will authorize the student to conduct an oral presentation of the project.

Oral Presentation

The student will distribute copies of the report to the project committee and arrange a time and place for the presentation of the project. The student must be enrolled at the time of the presentation in accordance with UMR Policy Memorandum Number II-20. Such presentations are normally scheduled only when the school is officially in session. Each committee member should be allowed to examine the report for at least three days before the oral presentation. During the presentation, the candidate should exhibit an acceptable knowledge of a professional area as defined by the program.

In order for the candidate to pass the project requirement, all the project committee must vote affirmatively. If a majority of the committee votes not to pass the candidate, the program director shall appoint a new project committee on which the dissenting member may be replaced, and the new committee will administer a second presentation. A student who fails a second time will no longer be eligible for a master of engineering degree.

Immediately following the presentation, the chair of the committee will report the action of the committee to the program director.

Procedure for Master of Engineering Candidate

1. 1. Go to steps 1 through 4 for regular graduate students.[1]
2. 5. Submits report;
3. 6. Advisor authorizes presentation;
4. 7. Candidate distributes copies of the report to project committee at least three days before the oral presentation;
5. 8. Arranges a date, time and place for the oral presentation of the project (the student must be enrolled at the time of the examination);
6. 9. Chair of examining committee reports the action of the committee to the program director;
7. 10. If all requirements are met, student receives degree, granted by the Board of Curators upon the recommendation of the graduate faculty.

[1]M.E. Form I for SoMEER no longer required.

Specific Requirements

The candidate must complete at least 30 semester hours. A minimum 3-hour practice oriented project is required. The course requirement includes 12 credit hours from the Manufacturing Core Curriculum (3 credit-hour core course from each area); 6 credit hours of 400-level courses in manufacturing; 3 credit hours of approved Mathematics or Computer Science from approved course list, and 6 credit hours of graduate courses in manufacturing.

(Proposed)

Master of Engineering Degree

The Master of Engineering degree is a practice-oriented program designed for full-time students with the possibility of completion of degree requirements in one year, and for students working in industry through distance education. The choice of this degree program is made in consultation with the student's advisor and with the approval of the program director. Currently, the Geotechnics, Manufacturing Engineering and Mining Engineering programs offer a Master of Engineering (M. Eng.) degree.

General Requirements

The master of engineering program with project shall consist of a minimum of 30[1] semester hours of graduate credit over and above the prerequisites. At least six semester hours of the required work must be from the group of lecture courses bearing numbers in the 400 series in the major field of study.[2] A maximum of six hours of 200-level courses can be accepted in the M.Eng. program.[3] Credit for research and development work conducted in preparation for the practice-oriented project is counted in terms of hours making up the total credit hours by mastering and improving the knowledge of a professional area as defined by the program, but not less than 3 hours is required in one of the selected courses. Care must be taken to provide an industrial project that promises results equivalent to or superior to that which might be expected at UMR.

Project Report

The findings and results of the practice-oriented project undertaken by the candidate for a master of engineering degree must be presented in a report. Specific program may require oral presentation.

Procedure for Master of Engineering Candidate

1. Go to steps 1 through 4 for regular graduate students.[4]
(Note: In step 2, the student's advisor is assigned, and no committee is formed)
2. Submits report; Specific program may require oral presentation.
3. Advisor reports the action to the program director;
4. If all requirements are met, student receives degree, granted by the Board of Curators upon the recommendation of the graduate faculty.

Specific Requirements

The candidate must complete at least 30[1] semester hours. A minimum 3-hour practice-oriented project is required in one of the selected courses. The course requirement includes satisfying the program core curriculum; 6 credit hours of 400-level courses in the major field of study[2]; no more than 6 credit hours of 200-level courses; and 6 credit hours of graduate courses in the major field of study. Check specific department for additional requirements.

[1] 33 semester hours in the Mining Engineering program
[2] Not required in the Mining Engineering program
[3] Geotechnics program do not accept 200-level courses
[4] M.E. Form I for SoMEER no longer required. Form I is supplanted by the DARS report form.