PROPOSAL

GRADUATE CERTIFICATE IN SYSTEMS ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF ENGINEERING AND TECHNOLOGY

TO BE OFFERED AT

INDIANA UNIVERSITY – PURDUE UNIVERSITY INDIANAPOLIS
Indiana University Purdue University Indianapolis
Request for a New Graduate Certificate Program

Campus: Indianapolis (IUPUI)

Proposed Title of Graduate Certificate Program: SYSTEMS ENGINEERING

Department/Program and School Proposing Certificate: Department of Mechanical Engineering (ME), Purdue School of Engineering & Technology (ENGT)

Projected Date of Implementation: Spring 2008

I. GRADUATE SCHOOL AFFILIATION OF CERTIFICATE: (check one)

✓ PURDUE UNIVERSITY — These certificates meet the general requirements of Purdue and are approved by the Purdue Graduate School, after approval at IUPUI

☐ INDIANA UNIVERSITY — These certificates are proposed by units that are subject to the authority of the IU Graduate School, meet the general requirements of IU, and are approved by the IU Graduate School, after approval at IUPUI

☐ INDIANA UNIVERSITY — These certificates are proposed by units that are not subject to the authority of the IU Graduate School and are referred directly to the Academic Leadership Council after approval at IUPUI

II. TYPE OF CERTIFICATE: (check one)

☐ AREA CERTIFICATES — These are specialty certificates, often interdisciplinary, which are awarded concurrently with or subsequent to a baccalaureate, masters, or doctoral degree. In one sense, they are like an additional major or minor, and their content may or may not be related to the degree.

✓ REGULAR CERTIFICATES — These programs generally require one semester to one year of academic work. They are structured programs which utilize regular academic credit courses. This type of certificate program corresponds with the ICHE definition of certificate programs.

☐ UNIT AWARDED CERTIFICATE — These are granted by sub-units of the university for certain kinds of specialized training or education. They are not recognized as being university awarded but rather unit awarded, and may not only utilize credit bearing courses.
III. Why is this certificate needed? (State the purpose and rationale of the program)

Background
Systems Engineering is a multi-disciplinary field that aims at integrating the engineering and management functions in the development and creation of a product, process, or service. The definition given by International Council on Systems Engineering (INCOSE) is a good description of what SE encompasses: “Systems Engineering is concerned with the overall process of defining, developing, operating, maintaining, and ultimately replacing quality systems. While other engineering disciplines concentrate on the details of individual aspects of a system (electronics, mechanics, ergonometics, aerodynamics, software, etc.), Systems Engineering is concerned with the integration of all of these aspects into a coherent and effective system. Systems engineers concentrate their efforts on the aspects of the engineering process (requirements definition, top-level functional designs, project management, life cycle cost analysis,...) that serve to organize and coordinate other engineering activities. The systems engineer is the primary interface between management, customers, suppliers, and specialty engineers in the systems development process.” Based on this description, all engineering and manufacturing firms, and many other complex institutions, need Systems Engineering to improve productivity and quality.

The following schematic shows how Systems Engineering typically forms a link for all the other disciplines and functions in a broad engineering organization. Similar schematics may be developed for institutions in specialized fields.

![Diagram of Systems Engineering]

Need in Central Indiana
The Purdue School of Engineering and Technology (ENGT) was advised by its Dean’s Industrial Advisory Committee (DIAC) that there is an unfulfilled need among companies in central Indiana for training and supply of qualified systems engineers.

An ad hoc DIAC Committee on Systems Engineering was appointed by the Dean of ENGT, and after a careful study, the committee members agreed that there is a need from local companies for employee education in the discipline of Systems Engineering. Industry members on the
committee pointed out that it is difficult for local industry to find candidates with the specific training in SE. Companies typically have to rely on on-the-job training to give engineers the necessary knowledge to work in the Systems Engineering area. ENGT also receives inquiries about course and degree offerings in Systems Engineering.

A recent seminar offered by the Central Indiana Section of INCOSE was filled to capacity by employees from local companies. About 45 people attended the INCOSE seminar, representing all the major companies in Central Indiana, including Rolls Royce, Raytheon, Delphi, Cummins, and Lilly. According to a seminar organizer, many others who wanted to attend were left out because of the overwhelming response. During a discussion at the ICSE seminar, representatives from industry made it clear that there is a need for a graduate level program in Systems Engineering in Central Indiana.

In February 2006, an INCOSE education fair was held at IUPUI, with presentations by several Indiana schools about programs in Systems Engineering. This was also well attended, and it was clear that other schools are forging ahead with similar programs in the Fort Wayne and Terre Haute areas, but there is no Systems Engineering program in the Indianapolis area yet. From a survey conducted during this meeting, it appears that there is significant interest in either a certificate or a masters' level program in Systems Engineering.

In Spring 2007, the Department of Mechanical Engineering offered a new experimental graduate course ME 597 TOPICS: Introduction to Systems Engineering, which is essentially equivalent to the first course in the proposed program. The course was taught by an associate faculty member, and had an above average enrollment of 8 students, despite late announcement and limited publicity.

The above cited studies are the basis for the proposed Systems Engineering Certificate Program to be offered by ENGT at IUPUI.

IV. List the major topics and curriculum of the certificate. A course list including course descriptions is required. If new courses are proposed for the program, include copies of the paperwork for course submission.

There will be two required courses, and two elective courses.

The following are required courses for the Systems Engineering Certificate program:
  a. SE 5xx Introduction to Systems Engineering Principles
  b. SE 5xx Systems Modeling and Analysis

Elective courses will be selected from the following list of courses that may be offered. The SE5xx courses will be developed when justified by student interest and resources. At least one of the elective courses must be from the Systems Engineering program, i.e. SE courses. The other elective may be selected from among the listed ME, ECE, or STAT courses.
c. SE 5xx Safety and Reliability Engineering  
d. SE 5xx Systems Architecting  
e. SE 5xx Project Management & Risk Analysis  
f. SE 5xx Requirements Elicitation and Requirements Management  
g. SE 5xx Human Factors in System Performance  
h. SE 5xx Systems Financial and Contract Management  
i. SE 5xx Health Care Management using Systems Engineering  
j. SE 5xx Supply Chain, Logistics and Transportation Systems  
k. SE 5xx Concurrent Engineering and Integrated Product Development Systems  
l. SE 5xx Product Lifecycle Management  
m. ME 575 Theory and Design of Control Systems  
n. ME 581 Numerical Methods in Mechanical Engineering  
o. ME 597 Advanced Mechanical Engineering Projects I (3cr)  
p. ECE 536 Introduction to Computational Intelligence  
q. ECE 565 Computer Architecture  
r. ECE 515 Software Engineering Methodology  
s. ECE 580 Optimization Methods for Systems and Control  
t. ECE 602 Lumped System Theory  
u. ECE 680 Modern Automatic Control  
v. STAT 511 Statistical Methods I  
w. STAT 512 Applied Regression Analysis  
x. STAT 514 Designs of Experiments

Course descriptions are given in the Appendix. Elective SE courses will be described as resources become available to develop these courses.

V. What are the admission requirements and admission procedures?

To be admitted to the proposed Certificate Program a candidate should meet the following requirements:

1. A bachelors degree in an engineering field from an ABET accredited or equivalent recognized institution, or in a field of science or technology with strong mathematical background, from an accredited or recognized institution.
2. An undergraduate GPA above 3.0 on a 4.0 scale.
3. For international students, a minimum TOEFL score of 550 or higher on the paper-based test, 213 or higher on the computer-based test, or 77 or higher on the Internet-based test (iBT) for applicants whose native language is not English, with the possibility of allowing exceptions, including substitution of alternate criteria. Applicants who take the TOEFL iBT must achieve the following minimum test scores, in addition to the overall required score of at least 77: reading, 19; listening, 14; speaking, 18, and writing, 18. Applicants taking the IELTS must score at least 6.5 on the Academic Module.

Students admitted into any of the engineering graduate degree programs are also eligible for the SE Certificate Program.

VI. List the major student outcomes (or set of performance based standards) for the proposed certificate. Completion requirements should be clearly stated, along with procedures for audit and certification.
The major outcome of this program is that the students will gain a good understanding of Systems Engineering principles, practices, and methods. This will enable them to apply the systems approach in advanced manufacturing, life sciences, and other fields where complex systems and high-tech products are developed, and diverse performance and regulatory requirements apply.

The graduate level Systems Engineering Certificate will be awarded when the student has fulfilled the following requirements:

1. Completed 12 credit hours of graduate course work, taken for letter grades, chosen from the list of courses listed in Section IV above, with a C or better grade.
2. Received an overall GPA of 3.0 or higher.

The following restrictions apply:
1. A maximum of 3 credit hours of equivalent coursework may be transferred from another institution.
2. A maximum of 6 credit hours earned prior to enrollment in the program, including work at other institutions, may be applied towards the certificate program.
3. No undergraduate courses may be used for the graduate certificate program.
4. A maximum of 4 years is allowed for the completion of the certificate program. Exceptions may be approved by the ENGT Graduate Education Committee.
5. The courses earned for the SE Certificate Program cannot be used for another certificate program within ENGT, but may be used towards a graduate degree program.

VII. Explain how student outcomes will be assessed (course-embedded assessments, graduate follow-up, employer survey, standardized tests, etc.).

The program outcomes will be assessed by surveys of employers of SE graduates, self-assessment of graduating students, and a follow-up survey of alumni after graduating significant number of students.

Course outcomes will be written for each course. The outcomes will be measured using multiple methods, including student performance on assigned tasks, examinations, and projects, self-assessment surveys, and juries of faculty and industry representatives.

VIII. Describe procedures for program evaluation including the criteria for success

The program will be evaluated based on the level of enrollment, satisfaction of employers, and the success of graduates from the program.

IX. Describe student population to be served, including evidence of need and what proportion of students are expected to be concurrently working toward a graduate degree at IUPUI.
The SE Certificate Program aims at helping local industry to train qualified engineers to work in the area of Systems Engineering. The primary targets are practitioners in the industry who are either working in the area but have not had any formal training in the area, or are interested in moving into the SE area.

As has been mentioned in Section I, local industry currently has not been able to hire directly candidates with a formal education in SE and often have to rely on on-the-job training to move engineers from other disciplines into the positions of systems engineers. There is a clear need in industry, especially in central Indiana, for an educational program to help train employees in this area.

Some SE students may also be working towards graduate degrees in Engineering, Technology, Science, Medicine, Health Sciences, Management, Public Policy, Informatics, or other fields of study at IUPUI, and may also use SE credits towards such degrees, as allowed by those programs.

X. How does this certificate complement the campus or departmental mission?

This certificate program is consistent with the missions of IUPUI, the School and Department. The Department mission includes service to local engineering needs, and the School mission emphasizes the provision of high-quality, well-rounded educational experiences in an urban environment. It is expected that the degree will fulfill the IUPUI mission to provide its constituents with excellence in learning in an urban university, characterized by collaboration across and within disciplines and within the community.

The SE program is inherently multi-disciplinary and requires strong collaboration among engineering departments. In addition, it will complement existing dual degree programs that ME has with the Department of Physics and the School of Business.

XI. Clarify the relation of the proposed certificate to relevant existing or proposed undergraduate, graduate, or certificate programs, if any, at IUPUI or elsewhere at Indiana University.

The program is being developed collaboratively by faculty in the engineering departments of the Purdue School of Engineering and Technology, IUPUI. There is no known similar program at IUPUI or IU. When the Systems Engineering certificate program is mature and stable, it may grow into a graduate degree program, or lead students to graduate degrees in other engineering disciplines: industrial, mechanical, electrical, computer, biomedical.

It is intended that the program eventually form the case of a masters’ program in Engineering Management, which will be developed as the SE certificate program becomes established with sufficient new resources as described below.

Some SE students may also be working towards graduate degrees in Engineering, Technology, Science, Medicine, Health Sciences, Management, Public Policy, Informatics, or other fields of
study at IUPUI, and may also use SE credits towards such degrees, as allowed by those programs.

XII. List and indicate the resources required to implement the proposed program. Indicate sources (e.g., reallocations or any new resources such as funding, space, personnel, library holdings, equipment, etc.).

The most important resources needed are personnel: faculty members qualified to conduct the program and teach courses. At present, there are no faculty members at IUPUI with qualifications specifically in Systems Engineering. Competing schools have hired such faculty, and IPFW has hired a senior professor into an endowed Systems Engineering chair position created for their new program.

The Department of ME needs to hire two tenure-track faculty members with research expertise in Systems Engineering and Engineering Management to become the champions and experts of this program. The base funding for these positions will be an essential requirement for creating this program. These faculty will also develop the MS program in Engineering Management, with input from the other engineering departments and local industry. In the short term, approval of the program will allow courses to be offered by experienced associate faculty from industry.

It will also be necessary to provide release time for current engineering faculty to develop related courses. Industry practitioners in Systems Engineering will be invited to teach some of the courses listed above.

XIII. Describe any innovative features of the program (e.g., involvement with local or regional agencies, or offices, cooperative efforts with other institutions, etc.).

The program will involve local industry very closely in setting guidelines for the curriculum, participation of adjunct faculty from industry, and student recruitment. The program is multidisciplinary, involving courses and faculty from multiple engineering departments, as well as Mathematical Sciences.

XIV. What is the plan for attaining steady-state enrollment. Include the number of students expected to participate in the program in the first year and an enrollment projection for the year in which steady-state enrollment is expected.

The industry members predicted that there might be 10 to 15 employees interested in taking SE courses at the beginning when such courses are offered at IUPUI, but the numbers may decrease after the initial demands were met. However, they also pointed out that if ISO would require certification on the industrial standards of ISO15288, then the demand for SE may see a tremendous surge.

XV. Describe the administrative structure of the certificate program.
Who is the designated program head?  
What faculty are initially involved in the program (include their credentials)?  
Describe any oversight or consulting committees overseeing the program.

The SE Certificate Program will be housed in the Department of Mechanical Engineering, but will be jointly offered by all the engineering departments within ENGT.

The Associate Dean for Graduate Programs at ENGT shall be the head of the program. The program will be administered by a Systems Engineering Graduate Committee (SEGC) with correspondingly broad representation. The Department Chair and Graduate Chair of the Department of Mechanical Engineering will be ex-officio members of the SEGC. The SEGC will have responsibility for decisions on Program and course content, admission of students, auditing, and certifying of completion.

A program code will be setup with the registrar’s office for the purpose of admitting students. Upon a student’s completion of the program, ENGT Graduate Office will notify Purdue Graduate School, who will issue the Graduate Certificate to the student.

The following faculty members will participate initially in the development of the program.

1. Hasan Akay, PhD, Professor of Mechanical Engineering
2. Jie Chen, PhD, Professor of Mechanical Engineering
3. Andrew Hsu, PhD, Professor of Mechanical Engineering
4. Anwar Sohel, PhD, Assistant Professor of Mechanical Engineering
5. Razi Nalim, PhD, Associate Professor of Mechanical Engineering
6. Yaobin Chen, PhD, Professor of Electrical Engineering
7. Stanley Chien, PhD, Professor of Electrical Engineering
8. Jose Ramos, PhD, Assistant Professor of Electrical Engineering
9. Sarah Koskie, PhD, Assistant Professor of Electrical Engineering
10. Edward Berbari, PhD, Professor of Biomedical Engineering
Appendix A

Course Descriptions of Existing IUPUI Courses

Course Descriptions of Proposed New Core Courses
Appendix

Course descriptions of existing IUPUI courses

ME 575 Theory and Design of Control Systems (3 cr.) Class 3. P: consent of instructor. Modern control techniques, state space representations, performance evaluation, controllability, observability, and observer design are introduced. The Bond graph is developed as a versatile computer-aided method of modeling coupled systems.

ME 581 Numerical Methods in Mechanical Engineering (3 cr.) Class 3. P: 314, 372, and ENGR 197 or its equivalent. The solution to problems arising in mechanical engineering using numerical methods. Topics include nonlinear algebraic equations, sets of linear algebraic equations, eigenvalue problems, interpolation, curve fitting, ordinary differential equations, and partial differential equations. Applications include fluid mechanics, gas dynamics, heat and mass transfer, thermodynamics, vibrations, automatic control systems, kinematics, and design.

ME 597 Advanced Mechanical Engineering Projects I (1-6 cr.) Sem. 1 and 2. Summer Session. (May be repeated for credit). P: master’s standing. Projects or special topics of contemporary importance or of special interest that are outside the scope of the standard graduate curriculum can be studied under the Mechanical Engineering Projects courses. Interested students should seek a faculty advisor by meeting with individual faculty members who work in their area of special interest and then prepare a brief description of the work to be undertaken in cooperation with the advisor.

ECE 536 Introduction to Computational Intelligence (3 cr.) Class 3. P: C programming skills; graduate standing or permission of instructor. Basic concepts in theory and paradigms for neural networks, evolutionary computation, and fuzzy logic; algorithms and applications for hybrids of these tools known as computational intelligence are explored. Topics include artificial neural networks, fuzzy systems, and evolutionary computation. Implementations of a number of paradigms are presented, including particle swarm optimization. Applications to various areas such as biomedical engineering and non-linear control are examined.

ECE 565 Computer Architecture (3 cr.) Class 3. P: 365 or graduate standing. An introduction to problems of designing and analyzing current machine architectures. Major topics include performance and cost analysis, pipeline processing, vector machines and numerical applications, hierarchical memory design, and multiprocessor architectures. A qualitative approach allowing a computer system designer to determine the extent to which a design goal is emphasized.

ECE 515 Software Engineering Methodology (3 cr.) Class 3. P: 359 or equivalent. Life-cycle models, software planning, software analysis, software design including data flow and data structure design, software testing methods, and software documentation. Software design project required.
ECE 580 Optimization Methods for Systems and Control (3 cr.) Class 3. P: consent of instructor or graduate standing. Introduction to optimization theory and methods, with applications in systems and control. Nonlinear unconstrained optimization, linear programming, nonlinear constrained optimization, various algorithms and search methods for optimizations, and their analysis. Examples from various engineering applications are given.

ECE 602 Lumped System Theory (3 cr.) Class 3. P: 301. P or C: MATH 511 or consent of instructor. An investigation of basic theory and techniques of modern system theory, emphasizing linear state model formulations of continuous- and discrete-time systems in the time and frequency domains. Coverage includes notion of linearity, time invariance, discrete- and continuous-times state models, canonical forms, associated transfer functions and impulse response models, the state transition matrix, the Jordan form, controllability, observability, and stability.

ECE 680 Modern Automatic Control (3 cr.) Class 3. P: 602 or consent of instructor. Theoretical methods in optimal control theory. Topics include the calculus of variations and the Pontryagin minimum principle with applications to minimum energy problems. Geometric methods will be applied to the solution of minimum time problems. Computational methods, singular problems, observer theory, and sufficient conditions for existence of solutions are also discussed.

STAT 511 Statistical Methods I (3 cr.) P: MATH 164. Descriptive statistics; elementary probability; random variables and their distributions; expectation; normal, binomial, Poisson, and hypergeometric distributions; sampling distributions; estimation and testing of hypotheses; one-way analysis of variance; correlation and regression.


STAT 514 Designs of Experiments (3 cr.) P: 512. Fundamentals, completely randomized design, randomized complete blocks. Latin squares, multiclassification, factorial, nested factorial, incomplete blocks, fractional replications, confounding, general mixed factorial, split-plot and optimum design. Use of existing statistical computing packages.

Catalog Course Descriptions of Proposed New Core Courses

SE 5xx Introduction to Systems Engineering Principles (3 cr.) P: graduate standing. Fundamental ideas of Systems Engineering, creation of diverse, complex engineered systems, defining system requirements, creating effective project teams. System life cycle and economics. Systems Engineering project.

Tentative syllabi for these courses are attached.

Course Descriptions and Syllabi to be developed by new faculty:
SE 5xx Safety and Reliability Engineering
SE 5xx Systems Architecting
SE 5xx Project Management & Risk Analysis
SE 5xx Requirements Elicitation and Requirements Management
SE 5xx Human Factors in System Performance
SE 5xx Systems Financial and Contract Management
SE 5xx Health Care Management using Systems Engineering
SE 5xx Supply Chain, Logistics and Transportation Systems
SE 5xx Concurrent Engineering and Integrated Product Development Systems
SE 5xx Product Lifecycle Management
IUPUI
Department of Mechanical Engineering

SE 5xx:
Introduction to Systems Engineering Principles

I. Instructor:

Dr. Dan Surber, CSEP
Phone: (317) 989-7974 (cell)
Email: dsurber@indy.rr.com (home)

II. COURSE DESCRIPTION AND RATIONALE:

Catalog Course Description:
This course offers a strategic examination of the principles of systems engineering and their application across the system life cycle. Special emphasis is given to concept exploration, requirements analysis, requirements development, analysis of alternatives, preliminary design, integration, verification, and system validation.

Course Rationale:
Systems engineering is a multi-disciplinary methodology for developing knowledge, goods and services that are based upon a total systems view of the customer/user stated need ands wants. This introductory course to systems engineering will explore the system life cycle, the principles of systems engineering, and how they are applied across the system life cycle. The student will establish a foundational understanding that will be used in the other certificate courses to be offered for a certificate in system engineering. This course will emphasize the "first things" of the systems engineering process: concept exploration, requirements analysis, requirements development, analysis of alternatives, verification and validation, and how these integrate into the rest of the product development phases: preliminary design, detailed design, integration, verification, and system validation. Practical in-class exercises, after-class readings, and a foundational text book will enhance student learning and application of the key principles.

Prerequisites: Senior or Graduate Standing

III. EDUCATIONAL OBJECTIVES:

Course Outcomes: After completion of this course, the students should be able to:

1. Define systems engineering, the system life cycle phases, and the product development life cycle phases.
2. Describe the general phase gates and reviews that comprise a product development life cycle, and how other disciplines contribute during this process.
3. Describe the four types of system requirements, how they are elicited and used by the systems engineer during concept exploration phase.
4. Write good requirements and explain the characteristics of a good requirement, a good requirement management process, and some enabling tools.
5. Define functional analysis, decomposition, and requirement allocation, and their relationship to concept exploration and the later phases of the product development life cycle.
6. Explain the similarities and differences between verification, validation, and their relationship to system integration.
7. Describe and apply a general methodology for trade study and analysis of alternatives.
8. Describe how integrated product teams and specialty engineering are used to achieve effective product development.
9. Explain how the principles of systems engineering interrelate to the principles of quality engineering and six sigma.
10. Demonstrate a basic ability to “walk through” a generic phase gate review checklist, and how it relates to technical project management and systems engineering principles.

IV. COURSE CONTENT:
1. Overview of the systems engineering domain; definitions key to systems engineering; the system life cycle, and the product development life cycle. (1.5 hrs)
2. Phase gate approach to product development enabled by application of systems engineering principles. (1.5 hrs)
3. Concept Exploration and the four types of systems requirements that must be extracted from the customer’s statement of want and needs. (1.5 hrs) Dual nature of validation, and its differences from verification. (1.5 hrs)
4. Requirement analysis, requirements development, and how these relate to planning for systems integration, verification and validation. (1.5 hrs)
5. Functional analysis, interface analysis, requirement allocation, traceability, and use of commercial tools to enable effective application of SE principles in an integrated team environment. (1.5 hrs)
6. Development of a master compliance matrix, a test and evaluation master plan, and use of technical performance measures in defining system performance. (1.5 hrs)
7. Use of trade study methods for system definition. Applying these methods in concept exploration and system definition. (1.5 hrs)
8. Modeling, simulation and systems analysis enable analysis of alternatives in concept exploration. (1.5 hrs)
9. Applying specialty-engineering disciplines by the system engineer throughout the product development life cycle, and the system life cycle. Gaining practical experience in the use of reliability, system safety and human factors engineering. (1.5 hrs)
10. Examining risk management concepts, techniques, and tools and their utility in the concept exploration phase, as well as carry-over utility into the later phases of the product development life cycle. (1.5 hrs)
11. Exploring the technical management responsibilities and functions of the systems engineer applicable to the entire system and product development life cycles. (1.5 hrs)
12. Examining the later stages of the product development life cycle after Concept Development and understand how knowledge development continues through the phases: preliminary design, detailed design, integration and test, system validation, full rate production. (1.5 hrs)
13. The ideas behind concurrent engineering, design for six sigma and total quality development as they apply to the systems engineering roles, responsibilities, and the development of high quality products in any market, industry or sector. (1.5 hrs)
14. Exploring the fundamentals of how an integrated product and process development system can enhance the application of systems engineering principles and what an engineer should look for in a company’s “people, methods, tools/processes, and environment (PMTE)”. (1.5 hrs)
15. Class project (in class work using principles from lectures).(13.5 hr)

V. REQUIRED AND RECOMMENDED TEXTS:
(This section should identify any required and/or recommended texts or other course materials (e.g., software, art supplies, etc.) that students will be expected to acquire in order to participate satisfactorily in the course.)

TEXTBOOK:


It is recommended that the students join the International Council on Systems Engineering for the Student Fee of $10.00, and thus gain access to the 3rd Edition of the INCOSE Systems Engineering Handbook, the Primer on Metrics, and all of the proceedings from the last 16 years of international symposia. These benefits are good for an entire calendar year.
[http://www.incose.org/]

REFERENCE:

VI. EVALUATION AND GRADING:

*Student participation during the in-class project, (which spans the semester), and participation during class discussions, which will include discussion of homework assigned and pop quizzes constitutes 45% of the overall grade. There will be one test on material covered in the first 5 weeks, a mid-term covering the first 9 weeks, a second test covering material from the mid-term to the 12th week, and a final covering the full semester. These tests constitute 55% of the overall grade.*

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<th>Points</th>
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<tr>
<td>Homework</td>
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<td>250 points</td>
</tr>
<tr>
<td>Pop Quizzes</td>
<td>10%</td>
<td>50 points</td>
</tr>
<tr>
<td>Test 1</td>
<td>10%</td>
<td>100 points</td>
</tr>
<tr>
<td>Mid Term</td>
<td>15%</td>
<td>200 points</td>
</tr>
<tr>
<td>Test 2</td>
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<td>100 points</td>
</tr>
<tr>
<td>Final</td>
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<td>300 points</td>
</tr>
<tr>
<td>In-class Project</td>
<td>20%</td>
<td>300 points</td>
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<td>TOTAL</td>
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Grading Scale:

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<td>D</td>
<td>61-70</td>
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<tr>
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Notes:
- In addition to HW assignments, students will be asked to conduct literature search and review of technical papers.
- Students are expected to fulfill all reading assignments prior to the class hours to get the most out of lectures.
- In-class contributions include coming to class prepared, asking good questions, answering questions well, attendance, quizzes, etc.
VII. BIBLIOGRAPHY:

The primary textbook (C. Wasson) has a bibliography, as well as listings of additional readings that will be used during the semester to broaden the student’s appreciation of the systems engineering domain. Blanchard’s book (reference) also has an entire appendix devoted to a topical bibliography. In addition, the instructor will use current events from various periodicals such as Aviation Week, Avionics, NASA Tech Briefs, and INCOSE publications to challenge class discussions and critical thinking skills.

Policy on Cheating and Plagiarism:
Cheating is Absolutely Not Tolerated at IUPUI
The IUPUI Code of Ethics is based on the need for trust in an academic community. IUPUI’s system is developed by and maintained for the welfare of its students, and all students should make sure that they read and understand the provisions outlined in the Student Handbook.
Any form of cheating on any test or final exam in the course will result in a zero score for the exam and also may result in an automatic "F" grade for the course. The case will be forwarded to the Dean of Students for appropriate disciplinary action.
· Any form of cheating/plagiarism on a homework or lab submission may result in both a zero score for the assignment, and a one-letter grade penalty in the course. The case may be forwarded to the Dean of Students for appropriate disciplinary action.
· Any form of cheating on a quiz will result in a zero score for that quiz. The case may be forwarded to the Dean of Students for appropriate disciplinary action.
· Cheating, or helping another student to cheat, are considered equal cases of academic dishonesty and will be dealt with as noted above.
· Giving another student access to your computer account, or negligently permitting another student to access your computer account constitutes cheating on your part if that other student copies any files that become implicated in a cheating case. Protect your account as if your academic career depends on it!
If you are confused as to the difference between helping each other (which is encouraged) and plagiarism (which will not be tolerated), please see your instructor. Please make sure that you are aware of the results of academic misconduct by reading the information from the Student Code of Rights, Responsibilities and Conduct at IUPUI.

AMERICANS WITH DISABILITIES ACT:

Disabilities Policy:
In compliance with the Americans with Disabilities Act (ADA), all qualified students enrolled in this course are entitled to "reasonable accommodations." Please notify the instructor during the first week of class of any accommodations needed for the course.

If you need any special accommodations due to a disability, please contact Adaptive Educational Services at (317)-274-3241. The office is located in CA 001E.
# Sample Teaching Schedule and Topics

**Instructor:** Dr. Surber  
**Course:** ME 597 Introduction to Systems Engineering

<table>
<thead>
<tr>
<th>Meeting Date</th>
<th>Week</th>
<th>Session per Week</th>
<th>Lecture Hrs</th>
<th>Gate Review</th>
<th>Course Content &amp; Class Project</th>
<th>Test Book</th>
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<td>8-Jan</td>
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<td>1</td>
<td>1.3</td>
<td></td>
<td>Overview of the systems engineering domain: definitions key to systems engineering, the system life cycle, and the product development life cycle.</td>
<td>Chapter 3, 4, 5</td>
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<tr>
<td>10-Jan</td>
<td>2</td>
<td>1</td>
<td>1.3</td>
<td>Concept Review</td>
<td>Class Project: Introduction to the SE tools used in class project.</td>
<td>Chapter 6, 7</td>
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<tr>
<td>15-Jan</td>
<td>3</td>
<td>1</td>
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<td>Phase gate approach to product development enabled by application of systems engineering principles.</td>
<td>Chapter 24, 54</td>
<td></td>
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<tr>
<td>17-Jan</td>
<td>4</td>
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<td>1.3</td>
<td></td>
<td>Class Project: Integrating the general system model into the project documentation.</td>
<td>Chapter 8, 9</td>
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<td>22-Jan</td>
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<td></td>
<td>Concept Exploration and the four types of systems requirements that must be extracted from the customer's statement of want and needs.</td>
<td>Chapter 10, 11, 12</td>
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<td>24-Jan</td>
<td>4</td>
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<td>Class Project: Using DOORS to capture system requirements.</td>
<td>Chapter 13, 14</td>
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<td>26-Jan</td>
<td>4</td>
<td>1</td>
<td>1.3</td>
<td>Dual nature of validation, and its differences from verification.</td>
<td>Chapter 25</td>
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<td>31-Jan</td>
<td>8</td>
<td>1</td>
<td>1.3</td>
<td></td>
<td>Class Project: Identifying and documenting risks.</td>
<td>Chapter 53</td>
</tr>
<tr>
<td>5-Feb</td>
<td>5</td>
<td>9</td>
<td>1.3</td>
<td></td>
<td>Requirement analysis, requirements development, and how these relate to planning for systems integration.</td>
<td>Chapter 32, 33</td>
</tr>
<tr>
<td>7-Feb</td>
<td>10</td>
<td>1</td>
<td>1.3</td>
<td>System Functional Review</td>
<td>Class Project: expand on requirements and conduct an requirements review with a generic checklist.</td>
<td>Chapter 35, 36</td>
</tr>
<tr>
<td>12-Feb</td>
<td>6</td>
<td>11</td>
<td>1.3</td>
<td></td>
<td>Functional analysis, interface analysis, requirement allocation, traceability, and use of commercially available tools to enable those principles to be effectively applied in an integrated team environment.</td>
<td>Chapter 37, 38</td>
</tr>
<tr>
<td>14-Feb</td>
<td>12</td>
<td>1</td>
<td>1.3</td>
<td></td>
<td>Class Project: Development of a master compliance matrix, a test and evaluation master plan, and use of technical performance measures in system performance.</td>
<td>Chapter 21, 22, 39</td>
</tr>
</tbody>
</table>
| 16-Feb       | 7    | 13               | 1.3         | TEST #1     | 20 Questions 5 points each  
Multiple choice and TRUE-FALSE  
1 Short answer paragraph for extra credit | | |
| 21-Feb       | 14   | 1                |             |             | Class Project: examine modules for specification and their content. | Chapter 41, 42 |
| 26-Feb       | 8    | 15               | 1.3         |             | Use of trade study methods for system definition. Applying these methods to the development and evaluation of system and system definition. | Chapter 57 |
| 26-Feb       | 16   | 1                |             | Preliminary Design Review | Class Project: complete allocation of requirement-function to HWCI and CSCI. | Chapter 23, 43 |
| 5-Mar        | 9    | 17               | 1.3         |             | Modeling, simulation and systems analysis enable analysis of alternatives in concept exploration.  
Applying specially-engineering disciplines by the system engineer throughout the product development life cycle, and the system life cycle.  
Gaining practical experience in the use of reliability, system safety and human factors engineering. | Chapter 20, 46, 50 |
| 7-Mar        | 10   | 18               | 1.3         |             | Class Project: Revise Allocated Baseline with specially requirements 50 questions 4 points each  
Multiple choice and TRUE-FALSE  
1 Short answer paragraph for extra credit | Chapter 32 |
| 19-Mar       | 19   | 1                |             | MID TERM EXAM | Class Project: Assess Reqm Compliances & Verification Matrix | Chapter 49 |
| 21-Mar       | 11   | 20               | 1.3         |             | Examining risk management concepts, techniques, and tools and their utility in the concept exploration phase, as well as carry-over utility into the later phases of the product development life cycle. | Instructor HANDOUT |
| 26-Mar       | 12   | 21               | 1.3         | Critical Design Review | Class Project: Detail Design on one HWCI, interfaces, and Integration | Chapter 24, 25 |
| 26-Mar       | 22   | 1                |             |             | Exploring the technical management responsibilities and functions of the systems engineer applicable to the entire system and product development life cycles. | Chapter 54 |
| 2-Apr        | 13   | 23               | 1.3         | Test Readiness Review | Class Project: Conduct test readiness on HWCI | Chapter 55 |
| 4-Apr        | 14   | 24               | 1.3         |             | TEST #2 20 Questions 5 points each  
Multiple choice and TRUE-FALSE  
1 Short answer paragraph for extra credit | | |
| 9-Apr        | 15   | 25               | 1.3         |             | Class Project: Examining the later stages of the product development life cycle after Concept Development and understand how knowledge development continues through the phases: preliminary design, detailed design, integration and test, system validation, full rate production. | Chapter 47 |
| 11-Apr       | 15   | 26               | 1.3         |             | | |
IUPUI
Department of Mechanical Engineering

SE 5xx:
Safety & Reliability Engineering

This is a prospective course for inclusion in the Systems Engineering Certificate offering envisioned by the ME and ECE departments. Instructor name is notional.

I. Instructor:

Dr. Dan Surber, CSEP
Phone/Email: SL 260A, cell: 317.989.7974, dsurber@iupui.edu

II. COURSE DESCRIPTION AND RATIONALE:

COURSE DESCRIPTION: This course will overview reliability and systems safety engineering and their relationship to systems engineering as two of its specialty engineering disciplines.

COURSE RATIONALE: Systems engineers are responsible for managing the systems engineering process, which includes determination of the specialty and design engineering disciplines necessary for the successful development of the system solution. Two of these specialties are systems safety and reliability engineering.

Prerequisites: Senior or Graduate Standing, and completion of either SExxx topic, Introduction to Systems Engineering, or Systems Engineering: Analysis, Modeling & Simulation.

III. EDUCATIONAL OBJECTIVES:

Course Outcomes: After completion of this course, the students should be able to:

1. Explain how reliability engineering integrates within the systems engineering process.
2. Explain how systems safety engineering integrates within the systems engineering process.
3. Understand reliability mathematics and models, and their application to design.
4. Explain systems safety hazard analysis methods and techniques that are most useful to systems engineering.
5. Explain how various types of failures modes and effects analyses are shared by reliability, safety and systems engineering in the systems engineering process.
6. Understand how reliability, availability and Maintainability are related.
7. Be able to perform basic reliability predictions for mechanical and electrical systems.
8. Be able to perform basic system safety hazard analyses for various types of system.
IV. COURSE CONTENT:

- Introduction to Reliability Engineering & Systems Safety (2.6 hrs) 2 class periods
- Examine the various System Safety Analyses (2.6 hrs) 2 class periods
- Examine reliability mathematics (1.3 hrs) 1 class periods
- Examine Probability Plotting (1.3 hrs) 1 class periods
- Review Load-strength Interference and Safety Margin (1.3 hrs) 1 class periods
- Examine Reliability Prediction & safety in Modeling (1.3 hrs) 1 class periods
- Reliability in Design & Failure Modes Analysis (2.6 hrs) 2 class periods
- FMEA, FMECA Contributions to Hazard Analysis (1.3 hrs) 1 class periods
- Design for Variation and Use of Six Sigma (2.6 hrs) 2 class periods
- Hazard Analysis and Systems Engineering Interoperability (2.6 hrs) 2 class periods
- Reliability of Mechanical Systems (1.3 hrs) 1 class period
- Reliability of Electronic Systems(1.3 hrs) 1 class period
- Software Reliability (2.6 hrs) 2 class period
- Reliability Testing (1.3 hrs) 1 class period
- System Safety relationship to Verification & Validation (1.3 hrs) 1 class period
- Analyzing Reliability Data (1.3 hrs) 1 class period
- Reliability in Manufacturing (1.3 hrs) 1 class period
- Maintainability, Maintenance and Availability (1.3 hrs) 1 class period
- Reliability Management and Systems Safety Management(2.6 hrs) 2 class periods

26 class periods (1.3 hours each)

V. REQUIRED TEXT:


REFERENCES:

FAA System Safety Handbook (free from FAA web site).
SAE/ARP-4761.

VI. EVALUATION AND GRADING:

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<th>Component</th>
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<th>Details</th>
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<td>Chapters 8-15 30 questions</td>
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7500
Grading Scale (no curve)

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<td>B</td>
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<td>D</td>
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<tr>
<td>F</td>
<td>≤ 59</td>
</tr>
</tbody>
</table>

VII. BIBLIOGRAPHY:

The text book contains an excellent bibliography at the end of each chapter which is up to date and relevant to reliability and safety engineering topics.

CHEATING AND PLAGIARISM:

Policy on Cheating and Plagiarism: Cheating is Absolutely Not Tolerated at IUPUI. The IUPUI Code of Ethics is based on the need for trust in an academic community. IUPUI's system is developed by and maintained for the welfare of its students, and all students should make sure that they read and understand the provisions outlined in the Student Handbook. Any form of cheating on any test or final exam in the course will result in a zero score for the exam and also may result in an automatic "F" grade for the course. The case will be forwarded to the Dean of Students for appropriate disciplinary action.
· Any form of cheating/plagiarism on a homework or lab submission may result in both a zero score for the assignment, and a one-letter grade penalty in the course. The case may be forwarded to the Dean of Students for appropriate disciplinary action.
· Any form of cheating on a quiz will result in a zero score for that quiz. The case may be forwarded to the Dean of Students for appropriate disciplinary action.
· Cheating, or helping another student to cheat, are considered equal cases of academic dishonesty and will be dealt with as noted above.
· Giving another student access to your computer account, or negligently permitting another student to access your computer account constitutes cheating on your part if that other student copies any files that become implicated in a cheating case. Protect your account as if your academic career depends on it.

If you are confused as to the difference between helping each other (which is encouraged) and plagiarism (which will not be tolerated), please see your instructor. Please make sure that you are aware of the results of academic misconduct by reading the information from the Student Code of Rights, Responsibilities and Conduct at IUPUI.
AMERICANS WITH DISABILITIES ACT:

Disabilities Policy:
In compliance with the Americans with Disabilities Act (ADA), all qualified students enrolled in this course are entitled to "reasonable accommodations." Please notify the instructor during the first week of class of any accommodations needed for the course.

If you need any special accommodations due to a disability, please contact Adaptive Educational Services at (317)-274-3241. The office is located in CA 001E.
IUPUI
Department of Mechanical Engineering

SE 5xx Topics:
Systems Modeling & Simulation

This is a prospective course for inclusion in the Systems Engineering Certificate offering envisioned by the ME and ECE departments. Instructor name is notional.

I. Instructor:

Dr. Dan Surber, CSEP
Phone/Email: SL 260A, cell: 317.989.7974, dsurber@iupui.edu

II. COURSE DESCRIPTION AND RATIONALE:

COURSE DESCRIPTION: This course will briefly review the systems engineering process and life cycle in order to set the framework for a discussion of useful analysis, modeling and simulation techniques that are useful to the engineering of systems.

COURSE RATIONALE: Most engineering disciplines have ample tools and techniques for analysis, modeling and simulation. The systems engineer needs to know which ones are likely to be most useful at the various points along the systems engineering process.

Prerequisites: Senior or Graduate Standing, SE xxx Introduction to Systems Engineering Principles

III. EDUCATIONAL OBJECTIVES:

Course Outcomes: After completion of this course, the students should be able to:

1. Explain the systems engineering process.
2. Explain systems analysis methods and techniques that are most useful to systems engineering.
3. Explain the difference between models, simulations, and their contribution to verification and validation.
4. Describe alternatives and use of models in decision making.
5. Apply economic evaluation techniques for single and multiple alternatives.
6. Understand optimization and its application to systems engineering.
7. Describe basic control concepts, methods, queuing theory and analysis methods.
8. Describe various aspects of design for operational feasibility and suitability using models.
9. Describe the uses of models and analyses to performance of systems engineering management.
IV. COURSE CONTENT:

- Brief Review of systems, systems engineering (2.6 hrs) 2 class periods
- The four stages of the systems design process (5.2 hrs) 4 class periods
- Useful applications of models to support analysis in these stages (2.6 hrs) 2 class periods
- Alternatives in Decision Making using Models (2.6 hrs) 2 class periods
- Economic Models and Evaluations (2.6 hrs) 2 class periods
- Optimization in Design and Operations (2.6 hrs) 2 class periods
- Queuing Theory and Analysis (2.6 hrs) 2 class periods
- Control Concepts & Methods (2.6 hrs) 2 class periods
- Design for Reliability (2.6 hrs) 2 class periods
- Safety Models and Hazard Analysis (2.6 hrs) 2 class periods
- Design for Maintainability (1.3 hrs) 1 class period
- Design for Usability (1.3 hrs) 1 class period
- Design for Supportability (1.3 hrs) 1 class period
- Design for Producibility & Disposability (1.3 hrs) 1 class period
- Design for Affordability (1.3 hrs) 1 class period
- Systems Engineering Planning (1.3 hrs) 1 class period
- Program Management, Control & Evaluations (2.6 hrs) 2 class periods

30 class periods (1.3 hours each)

V. REQUIRED TEXT:


VI. EVALUATION AND GRADING:

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<td>Chapters 12-19 50 questions</td>
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<td>Class Project</td>
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<td>4 design reviews @ 100 pts each</td>
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Grading Scale (no curve)

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<td>90-100</td>
</tr>
</tbody>
</table>

25
VII. Bibliography:

The textbook contains an excellent bibliography in Appendix G; this is most up-to-date and pertinent to systems engineering topics.

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Disabilities Policy:

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If you need any special accommodations due to a disability, please contact Adaptive Educational Services at (317)-274-3241. The office is located in CA 001E.
Appendix B

Curriculum Vitae for Dan Surber
DAN C. SURBER, Ph.D.
E-mail: dsurber@indy.rr.com, Ph: (317) 306-4114

EDUCATION

2004, INCOSE Certified Systems Engineering Professional, (CSEP)

2003, Raytheon Corporate Six Sigma Specialist Certification

1998-2001, Kennedy-Western University, Cheyenne, Wyoming
- Ph.D. Engineering Management, GPA 3.50 of 4.0 cum. (focus area: Systems Engineering)

1998, Certificate in Systems Engineering from JOG Systems Engineering, INC. (80 contact hrs)

1983-1984, University of Southern California, Norton AFB, California
- USAF System Safety Management and Accident Investigation Officer’s Course (10th of 50 graduates)

1981-1983, Embry-Riddle Aeronautical University, Daytona Beach, Florida
- M.S. Aeronautical Science - Graduated with Distinction (3.75 of 4.0 cum.) Concentration: Aviation Safety

- Staff operations, command and control of air and space power above wing level, tactics and strategy

1969-1974, United States Air Force Academy, Colorado Springs, Colorado
- B.S. History, (197 semester hours); Minors in: German & General Engineering (2.98 cum., 3.50 in major)

EXPERIENCE

2007 (January to present), Associate Faculty, Department of Mechanical Engineering, IUPUI
- Teaching a systems engineering course

2007 (June to present) Raytheon Technical Services Co., LLC, Indianapolis, IN
- System Architect for Ukraine Weapons of Mass Destruction Reduction Program
- Lead Systems Engineer for Biological Threat Reduction Program, Former Soviet Union
- Systems Engineer for Azerbaijan Bio Threat Reduction Program (in country 21 days)
- Senior Instructor for Raytheon “Principles of Systems Engineering”, team instructor
- Re-certified by INCOSE as Certified Systems Engineering Professional and Certification Application Reviewer

2005-2007 (through June) Raytheon Technical Services Co., LLC, Indianapolis, IN
• Lead Systems Engineer for Integrated Support Software Suite (ISSS) IPT, DDX Program
• Risk and Opportunity Manager for ISSS IPT, and Business Unit Risk & Opportunity Trainer
• Lead Systems Safety Engineer for DDX Support Segment Cross Product Team (CPT), DDX Program.
• Guest lecturer at Tennessee State University, graduate seminars in systems engineering
• International Council on Systems Engineering Member Board Representative for Region IV (NE USA)

2002-2005, Raytheon Technical Services Co., LLC, Indianapolis, IN
• Principal Engineer for Systems Safety, V-22 Avionics Support IPT, NAVAIR Detachment
• Certified Systems Engineering Professional (CSEP), INCOSE, 2004-2007 (first 50 in the world)
• Principles of Systems Engineering (PoSE) Instructor for RTSC-EPS Business Unit, 2004
• Small Projects Proposal leader/consultant on systems engineering and risk management for business unit
• Raytheon Six Sigma Specialist, 2003

2001-2002, Raytheon Technical Services Co., Indianapolis, IN
• Systems Engineer & production readiness assessment lead for Integrated Fire Control System (IFCS) Team
• On-site Team Leader for IFCS Installation and coordination with KADDB, Jordanian Army, 2001 (in country 90 days with 4-man team)
• Principal Engineer for Systems Engineering, V-22 Avionics Support, NAVAIR Detachment, 2002

• System Engineering Manager, Engineering Process Competency Center, Functional Engineering
• Developed Systems Engineering process flow, training, and delivered material globally (8 countries on four continents)

• System Integration Manager, Ag Products Group and Engineering Process Group, Technology Center
• Process and improvement coach for product development and program managers in group

• Staff Engineer, Software System Safety, Product Assurance Group, Helicopters Division
• Systems Engineering member of Engineering Process Group for CMMI Level 3 pursuit/assessment

• Director, Avionics Software Integration Test Team with Joint government-contractor team of 50 engineers
• Lead Engineer for Flight Line Support Avionics Engineers, EMD MV-22 Osprey Flight Test Program
- IPT Lead for Avionics and Software Integration Laboratory Team, MV-22 Osprey Program
- Lead Systems Engineer for System Requirements IPT, MV-22 Osprey Program (EMD)

- Avionics Manager at RAH-66 Comanche Joint Program Office, Mission Equipment & Flight Controls
- Senior Technical Specialist, Avionics Systems Engineer / Requirements and Integration

1986-1991, General Dynamics Ft. Worth Division, Fort Worth, Texas
- Senior Engineer, Advanced Human Factors Technology: YF-22, X-30 NASP, AFTI/CAS F-16, VISTA F-16
- Lead Engineer for YF-22A Head-down Flight Instrument Design, Integration and Test for DEMVAL
- Principal simulator pilot and test director for AFTI/CAS F-16 and X-30 NASP Cockpit Integration Studies
- Assistant Principal Investigator, Helmet Mounted Display and HUD Symbology IRADs (F-16 and YF-22)

1974-1998, United States Armed Forces, Various locations (Active Duty, Guard, Reserve)
- Active Duty USAF Pilot, Instructor Pilot & Flight Examiner, 2500 flight hours and 2000 simulator hrs (T-37B, T-38A, F-111D, F-111F), 300 hours in civil fixed wing aircraft, 9.5 hours in gliders
- Military rated parachutist (free fall)
- FAA rated Air Transport Pilot Multi-Engine Land
- FAA rated Commercial Pilot Single Engine Land
- US Army Reserve, Military Intelligence: Operations Intelligence Analyst and German Linguist;
- Texas Army National Guard, Military Intelligence and Tank crewman
- Honorable Discharge, Captain, USAF; Retired Sergeant, US Army Reserve (29 years total service)

PUBLICATIONS
- Proceedings of INCOSE International Symposia (2), 2000, "Commercial System Development Models", Grady, Jeffrey; Cathcart, Tim; Jain, Ravi; Surber, Dan; and, 2005, "10 Golden Questions for Concept Exploration and Development".
- INCOSE-COA Chapter Conference Proceedings (5): “10 Golden Questions for Concept Exploration and Development”) 2005); “CMMI and Systems Engineering”; “Systems Engineer the

AWARDS

Meritorious Service Medal, Air Force Commendation Medal, Army Commendation Medal, Air Force Achievement Medal, Army Achievement Medal (Oak Leaf Cluster), Combat Readiness Medal (Oak Leaf)

INTERESTS