Proposal for Graduate Certificate in Systems Engineering
College of Engineering, University Of Utah
November 2008

This proposal consists of four sections:

1. Proposal (below)
2. New courses (Enclosure 1)
3. Existing UU courses (Enclosure 2)
4. Relevant adjunct faculty (Enclosure 3)
5. Letters of support from CoE Dean and Department Chairs (Enclosure 4)

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SYSTEMS ENGINEERING (extracted from, and only slightly modified from, the definition provided on the Southern Methodist University (SMU) web site): http://engr.smu.edu/emis/Programs/MS_SE/ms_se.html:

Systems are defined as a collection of elements that work together as a unit. Systems engineering is focused on the development of systems and may be applied to large systems, such as power plants, or to small systems, such as circuit components. It may be applied to hardware or to software systems. It may be applied to tangible products such as automobiles or to intangible products such as services or processes. All branches of engineering use the principles of systems engineering in the development of systems relating to a specific discipline. In addition, the concepts of systems engineering provide a framework and methodology through which different engineering disciplines can most effectively collaborate in systems development.

The goal of systems engineering is development and management of systems (products, services, and operational systems such as traffic networks or utility water delivery) that satisfy customer requirements while also considering engineering, technology, environmental, management, risk, and economic factors by viewing the system as a whole, over its life cycle.

Systems engineering is also the practice of "good engineering." Through systems engineering and related courses, the student gains exposure to a variety of topics such as reliability, quality, logistics/supply webs, operations research, engineering management, software engineering, telecommunications and environmental engineering. "Systems thinking" skills are developed which foster more effective practice for the engineer or engineering manager within the business or government domain.

The proposed graduate certificate program has been requested by and is being supported by ATK Launch Systems

1. NEED *(A statement of the need for the proposed program and the basis for such a need, supported by either externally or internally derived data.)*

We are entering a different era, where a system's complexity requires a far broader range of expertise than was typical previously. Professionals are coming to systems engineering earlier in their careers without the benefit of years of experience as discipline or component specialists. To mitigate the affects of reduced experience it is imperative that appropriate tools be used, and that appropriate training in applying the tools be provided. While "overdependence on tools at the expense of talent or training" may be a common pitfall, tools can, nevertheless, enhance and standardize systems engineering efforts. Without standardization the subjective nature of many systems analyses is typically at the highest level, directly influencing or creating the conclusion. Some of the techniques available to the systems engineer put the subjective assessments at the lowest level of the analysis, where the conclusion is likely to be less affected by subjectivity. This allows sensitivity studies within the analyses themselves to evaluate the conclusions sensitivity to the subjective assessments.

Numerous studies have been performed evaluating the benefits of effective systems engineering and the challenges attributable to its sometimes ineffective implementation:

In an internal NASA memo as part of a review of systems engineering at Marshall Space Flight Center (April, 1997) it is noted that "Ineffective systems engineering is the reason for a majority of the significant failures within the past ten years in the aerospace chemical propulsion area, and for many of the failures within non-propulsion areas."

The Space launch Broad Area Review (BAR) performed a national study on launch vehicle failures (November, 1999) and found ""Inadequate Systems Engineering" as a primary cause for launch vehicle failures." (http://klabs.org/richcontent/Reports/Failure_Reports/Space_Launch_Vehicles_Broad_Area_Review.pdf)

In internal ATK document it is noted that: "The quality of our products and the success of our programs are dependent on good management of internal and external program, design, and performance requirements. Up front investment in requirements management pays for itself in the long term."

Yaneer Bar-Yam of the New England Complex Systems Institute (*When systems engineering fails-toward complex systems engineering,* IEEE International Conference on Systems, Man and Cybernetics, Oct, 2003, Volume 2, Issue , 5-8, vol 2 Pages: 2021-2028) noted the following:

"A general survey of large software engineering projects was performed in 1995 by the Standish Group International (Standish Group International, The Chaos REPORT,

1994). This study classified projects according to whether they met stated goals of the project, the time table, and cost estimates. They found that under 20% of the projects were on-time, on-budget and on-function (projects at large companies had a lower rate of under 10% success), over 50% of the projects were "challenged" which meant they were over budget typically by a factor of two, they were over schedule by a factor of two, and did not meet about two thirds of the original functional specifications. The remaining 30% of the projects were called "impaired" which meant that they were abandoned. When considering the major investments these projects represent of time and money, the numbers are staggering, easily reaching $100 Billion each year in direct costs. The high percentage of failures and the remarkable percentage of challenged projects suggest that there is a systematic reason for the difficulty involved in large engineering projects beyond the specific reasons for failure that one might identify in any one case." (http://necsi.org/projects/yaneer/E3-IEEE_final.pdf)

***2. EDUCATIONAL OBJECTIVES**. (A statement of the educational objectives of the program.)*

The primary objective of the Graduate Certificate in Systems Engineering will be to provide engineers with the skills to design and manage complex mechanical and organizational systems. It is proposed that this objective be met with a program that provides participants with an understanding of the fundamentals of systems engineering and the ability to develop, analyze, and model systems of all kinds. The participant will be able to develop both general system performance requirements and quantitative system metrics for the management and evaluation of system performance.

***3. IMPACT ON EXISTING PROGRAMS**. The program proposal will address the question of the impact of the graduate certificate program on any related degree program.*

The Graduate Certificate in Systems Engineering will, at least initially, be located in, and draw students from, the Mechanical Engineering Department. It is also expected that the program will be attractive to engineers at ATK. Many ATK participants will be those with a mechanical background, however, the certificate can also be pursued by those with undergraduate degrees in other engineering areas. The only envisioned impact on other degree programs will be the opportunity for students in other departments in the UU College of Engineering to complete the Graduate Certificate in Systems Engineering, if possible, within their specific departmental requirements.

***4. COURSES**. A statement of the proposed course sequence associated with the certificate, including titles and course descriptions both for existing courses and any new courses that may be developed. The proposal will address the possibility of program delivery using distance education approaches.*

Three new courses will be developed as a collaborative effort (development by and co-instruction) between UU CoE faculty and doctoral level personnel employed in local industry, primarily ATK, and will be the core of the Graduate Certificate in Systems

Engineering. The three new courses are (1) ME 6960-1"Fundamentals of Systems Engineering", (2) ME 6960-2 "Requirements Engineering and Management" and (3) ME 6960-3 "Systems Engineering Capstone and Project: Systems Engineering and Integration." These three courses are outlined on Enclosure 1 and will be the core of the Systems Engineering Certificate. ME 6960-1"Fundamentals of Systems Engineering" is being taught Fall semester 2008 by Dr. Ben Goldberg as a special topics course. (See Section 6 "Faculty" and Enclosure 3.) The course has an on-campus enrollment of 4 and an ATK enrollment (distance) of 15.

Systems Engineering Certificate options will be based on existing UU courses. Possible option areas include:

Systems Engineering Management
Product Engineering Design
Manufacturing and Process Systems Design
Systems Optimization
Transportation Operations

Six additional credits will provide the basis for the above option areas. Example certificate electives for the five noted option areas are noted below. Other courses may be used to complete the option areas if approved by the student's Graduate Advisory Committee and the Systems Engineering Certificate Program Coordinator. Additional information on possible electives is included in Enclosure 2.

Systems Engineering Management

ME EN 5000 Engineering Law and Contracts (3)
ME EN 6030 Reliability Engineering (3)
ME EN 6040 Quality Assurance Engineering (3)
ME EN 6960 Project Management in a Technical Environment (3)
ME EN 7010 Computer-Aided Engineering (3)
BIOEN 6060 Scientific Presentation (1)
BIOEN 6061 Scientific Presentation II (1)
CVEEN 6260 Applied Probability and Statistics (3)
CVEEN 6820 Project Scheduling (3)
CVEEN 6830 Project Management and Contract Administration (3)
CVEEN 6850 Engineering Law (3)
ECON 6360 Industrial Organization (3)
FINAN 5270 Business Risk Management (3)
FINAN 6020 Financial Management (1.5 to 3)
FINAN 6025 Managerial Economics (1.5)
FINAN 7090 Industrial Organization I (3)
FINAN 7091 Industrial Organization II (3)
MGT 6040 Data Analysis and Decision Making I (1.5)
MGT 6041 Data Analysis and Decision Making II (1.5)
MGT 6060 Production and Operations Management I (1.5)
MGT 6061 Production and Operations Management II (1.5)

MGT 6160 Operations Management (2.8)
MGT 6420 Quality Management I (1.5 to 3)
MGT 6421 Quality Management II (1.5 to 3)
MGT 6630 Operations Planning and Control (1.5 to 3)
MGT 6660 Project Management (1.5 to 3)
MGT 6710 Strategy & Technology (1.5 to 3)
MGT 7590 Multivariate Statistics for Management (1 to 4)
MET E 5690 Process Engineering Statistics (2)
URBPL 5370 System Dynamics and Environmental Policy (3)
URBPL 5871 Complexity and Systems Thinking

Product Engineering Design

ME EN 6030 Reliability Engineering (3)
ME EN 6040 Quality Assurance Engineering (3)
ME EN 6100 Ergonomics (3)
ME EN 6120 Human Factors in Engineering Design (3)
ME EN 6130 Design Implications for Human-Machine Systems (3)
BIOEN 6060 Scientific Presentation (1)
BIOEN 6061 Scientific Presentation II (1)
CVEEN 6850 Engineering Law (3)
MGT 6420 Quality Management I (1.5 to 3)
MGT 6421 Quality Management II (1.5 to 3)

Manufacturing and Process Systems Design

ME EN 6010 Principles of Manufacturing Processes (3)
ME EN 6030 Reliability Engineering (3)
ME EN 6040 Quality Assurance Engineering (3)
ME EN 7010 Computer-Aided Engineering (3)
BIOEN 6060 Scientific Presentation (1)
BIOEN 6061 Scientific Presentation II (1)
CH EN 6303 Environmental Applications of Chemical Engineering (3)
CH EN 6960 Green Engineering (3)
CVEEN 6530 Quantitative Methods in Transportation Operation (3)
CVEEN 6660 System Dynamics and Environmental Policy (3)
CVEEN 6661 Complexity and Systems Thinking
CVEEN 6830 Project Management and Contract Administration (3)
CVEEN 6850 Engineering Law (3)
ECON 6360 Industrial Organization (3)
MGT 6060 Production and Operations Management I (1.5)
MGT 6061 Production and Operations Management II (1.5)
MGT 6160 Operations Management (2.8)
MGT 6420 Quality Management I (1.5 to 3)
MGT 6421 Quality Management II (1.5 to 3)
MGT 6630 Operations Planning and Control (1.5 to 3)
MGT 6660 Project Management (1.5 to 3)

Systems Optimization

ME EN 6030 Reliability Engineering (3)
ME EN 6040 Quality Assurance Engineering (3)
ME EN 6200 Advanced Modeling and Control (3)
ME EN 6210 State Space Methods (3)
ME EN 6810 Thermal System Design (3)
ME EN 7000 Optimal Design (3)
ME EN 7010 Computer-Aided Engineering (3)
ME EN 7200 Nonlinear Controls (3)
ME EN 7210 Optimal Controls (3)
ME EN 7220 Advanced Control Design (3)
BIOEN 6060 Scientific Presentation (1)
BIOEN 6061 Scientific Presentation II (1)
ECE 5510 Random Processes (3)
ECE 5520 Digital Communication Systems (3)
ECE 6530 Digital Signal Processing (3)
ECE 5570 Control of Electric Motors (3)
ECE 6235 Wireless Communications (3)
ECE 6530 Digital Signal Processing (3)
ECE 6551 Survey of Optimization Techniques (3)
ECE 6570 Adaptive Control (3)
MGT 6040 Data Analysis and Decision Making I (1.5)
MGT 6041 Data Analysis and Decision Making II (1.5)
MGT 7590 Multivariate Statistics for Management (1 to 4)
MET E 5690 Process Engineering Statistics (2)

Transportation Operations

ME EN 5000 Engineering Law and Contracts (3)
ME EN 6030 Reliability Engineering (3)
ME EN 6040 Quality Assurance Engineering (3)
ME EN 6960 Project Management in a Technical Environment (3)
CH EN 6960 Green Engineering (3)
CVEEN 6530 Quantitative Methods in Transportation Operation (3)
CVEEN 6260 Applied Probability and Statistics (3)
CVEEN 6660 System Dynamics and Environmental Policy (3)
CVEEN 6661 Complexity and Systems Thinking
CVEEN 6820 Project Scheduling (3)
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ECON 6360 Industrial Organization (3)
FINAN 5270 Business Risk Management (3)
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MGT 6060 Production and Operations Management I (1.5)

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MGT 6420 Quality Management I (1.5 to 3)
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MGT 6630 Operations Planning and Control (1.5 to 3)
MGT 6660 Project Management (1.5 to 3)
MGT 6710 Strategy & Technology (1.5 to 3)
MGT 7590 Multivariate Statistics for Management (1 to 4)
MET E 5690 Process Engineering Statistics (2)

The Graduate Certificate in Systems Engineering will be available to all graduate students, but it is expected that most/all students will be in the College of Engineering. The certificate can be imbedded within existing masters degree programs (M.S.-thesis, M.S.-nonthesis, Master of Engineering), but does not eliminate or replace any existing degree requirements. For example, it is expected that the 15-credit Systems Engineering certificate will serve as the 15-credit focus for the existing M.S.-nonthesis in Mechanical Engineering.

The certificate program will be an integral part of the existing ATK Program that allows students to earn an M.S. degree by taking regular graduate coursework through videotaped lectures and streaming video. (Engineering management personnel of Hill Air Force Base have also expressed interest in participating).

5. ASSESSMENT. *A statement of how the proposed course sequences associated with the certificate will meet the stated educational objectives and be assessed.*

The three core courses noted above will provide engineers with a basic understanding of systems engineering and the ability to develop, analyze, and model systems of all kinds. The five option areas will allow students to apply this understanding of systems engineering to their specific background or area of interest. Assessment mechanisms will include student course evaluations, student exit interviews, and student placement. In addition, graduates of the certificate program will be contacted one year after certificate completion (or graduation, in the case of students who receive the certificate as part of an M.S. or M.E. degree) to provide feedback on the relevance of the certificate curriculum and make suggestions for course modifications, new course material, and new courses. The Systems Engineering Certificate Program Advisory Committee will also be assembled at least once per year to review and assess the program.

6. FACULTY. *The names of regular and adjunct faculty associated with or contributing to the certificate program, either by teaching one or more of the courses associated with the program or participating in the design of the course sequence.*

Course instructors for the three core courses are Benjamin Goldberg, Angelo Trego, and Kim Langdorf. All have Ph.D. degrees, systems engineering experience/expertise, and considerable teaching experience. All are ATK employees and will be appointed as

adjunct faculty in the UU Department of Mechanical Engineering. Their vitas are attached as Enclosure 3. Initially, the three core courses will be co-directed by Dr. Don Bloswick, Professor of Mechanical Engineering (vita attached as Enclosure 4). This co-directorship will be turned over to other UU CoE faculty as appropriate.

The list of electives is too extensive to allow efficient presentation of all faculty vitas.

7. COORDINATOR. *The name and curriculum vita of the faculty member who will be designated as the coordinator of the program, for purposes of communication with the Graduate School.*

Don Bloswick, Professor of Mechanical Engineering, will be the UU faculty member designated as Program Coordinator.

8. ADVISORY COMMITTEE. *The program may have an Advisory Committee which will include representation from the professional, business, or government sectors which the program is designed to serve.*

David Riemer VP, Science and Engineering, ATK Launch Systems has provided a letter of support and will likely be the initial chair of the advisory committee. Other possible members include:

1. Davy Belk, Ph.D., Director of Engineering for the Ogden Air Logistics Center
2. Kim Langdorf, Acting President Northern Utah INCOSE chapter
3. Dr. Randal R. Sylvester, Chief Technologist Communication Systems-West, L-3 Communications

9. BUDGET. *Describe the costs of the certificate program and how the program will be funded.*

No additional costs are foreseen. General program administration for ATK personnel will be accomplished within the structure of the existing ATK Program by Dr. Bloswick and his staff. Academic program administration for all students will be accomplished through the existing Graduate Program Office of the Department of Mechanical Engineering. ATK will provide appropriate compensation for up to three faculty personnel, from ATK, for no less than four semesters. These personnel will be provided to teach core and capstone courses for the Systems Engineering Certificate. It is projected that the program will be self supporting in the third year. In addition, as noted above, ATK will provide one Advisory Committee member.

ENCLOSURE 1
NEW COURSES FOR SYSTEMS ENGINEERING CERTIFICATE

ME 6960-1 Fundamentals of Systems Engineering

This course provides an overview of the art and science of systems engineering, and an introduction to the systems approach and methodological framework for creation and reengineering of large-scale systems and processes at technology readiness levels 1 through 6. Topics covered include the systems approach, understanding and defining customer (stakeholder) problems, eliciting and defining stakeholder requirements, defining stakeholder-driven value systems, developing alternative system concepts, modeling and analysis of alternatives and associated risks. There will be a focus on multi attribute utility theory to provide guidance for integrated engineering approaches, and design uncertainty as part of the architecture tradespace. The student will develop an understanding of the larger context in which requirements for a system are developed, and learn about trade-offs between developing mission needs or market opportunities first (versus assessing available technology first). Techniques for translating needs and priorities into an operational concept and then into specific functional and performance requirements will be presented. The student will develop an understanding of risk management techniques and the circumstances where they are appropriately employed. Students will carry out projects and assignments both individually and as teams. This course is being taught in Fall semester 2008 by Dr. Ben Goldberg as a special topics course. The course has an on-campus enrollment of 4 and an ATK enrollment (distance) of 15.

ME 6960-2 Requirements Engineering and Management

This course provides the principles, practices, knowledge, and skills to organize and distribute requirements, and develop derived requirements, which together form the starting point for engineering of complex hardware / software systems. The student will assess and improve the usefulness of requirements, including such aspects as correctness, completeness, consistency, measurability, testability, and clarity of documentation. There will be a strong focus on developing a master verification plan (MVP), assigning verification types, determining requirements validation, and developing the compliance matrix. This course will provide the student with the theoretical and practical aspects of discovering, analyzing, modeling, validating, testing and writing requirements for systems of all kinds. The student will learn how interface control and how ICs are created and managed through the life of a program. The course will examine the processes and methods to identify, control, audit, and track the evolution of system characteristics throughout the system life cycle, and the student will be able to create and maintain a configuration and requirements management plan and procedures. Case studies involving different types of program / engineering systems and requirements engineering methods and techniques will be used.

Prerequisite: Fundamentals of Systems Engineering

ME 6960-3 Systems Engineering Capstone and Project: Systems Engineering and Integration

This course provides the student with an understanding of the context and framework for carrying out a systems engineering project and the system-level responsibilities of a systems engineer, through hands-on activity. Topics covered include systems design and development, system test and evaluation, system reliability, system maintainability, human factors and system design, system producibility and supportability, balancing life-cycle cost, schedule, suitability and performance, risk management, and systems engineering project management and control. Types of systems considered will range from small-scale to large-scale and from primarily technical to primarily social-political. Students will carry out projects and assignments both individually and as teams, with a final project accounting for up to 40% of the course grade.

Prerequisite: Fundamentals of Systems Engineering

ENCLOSURE 2
EXISTING UNIVERSITY OF UTAH COURSES

U.U. Courses Relevant to Systems Engineering
(Some courses may have departmental or program prerequisites or restrictions.)

Mechanical Engineering:

ME EN 5000 **Engineering Law and Contracts (3)** Cross listed as CVEEN 5850. Prerequisite: Upper division ME EN status. Meets with CVEEN 6850. Designed to provide science and engineering students with a sufficient knowledge of law to enable them to recognize and deal with legal problems which may arise in the fields of science, engineering, or technical management. Topics covered include courts, trial procedures, evidence, contract law, engineering contracts, agency, patents, trademarks, copyrights, trade secrets, product liability, employer/employee law, business law including corporations, partnerships, joint ventures, etc.

ME EN 6010 **Principles of Manufacturing Processes (3)**
Prerequisite: ME EN 2650 and Graduate status.
Application of fundamental theories in solid mechanics, heat transfer, chemistry and surface science in solving complex problems in material processes. Meets with ME EN 5010.

ME EN 6030 **Reliability Engineering (3)**
Prerequisite: ME EN 4050 and Graduate status.
Application of statistical concepts for interpretation of component and system failures, redundancy, maintainability, exponential failure laws, and failure prediction techniques. Meets with ME EN 5030.

ME EN 6040 **Quality Assurance Engineering (3)**
Prerequisite: ME EN 4050 and Graduate status.
Acceptance sampling procedures, control charts for quality controls, military standards in controlling quality. Meets with ME EN 5040.

ME EN 6100 **Ergonomics (3)**
Prerequisite: ME EN Graduate status or instructor consent.
Introduction to study of humans at work; disability and accident prevention, and productivity improvement. Human musculoskeletal system as mechanical structure. Recognition, evaluation, and control of ergonomic stresses in occupational environment. Meets with ME EN 5100.

ME EN 6120 **Human Factors in Engineering Design (3)**
Prerequisite: Graduate or upper division undergraduate status in Engineering.
An introduction to the discipline of Human Factors Engineering. HFE is the science of designing for human use. Course will focus on information processing and the cognitive aspects of ergonomics design. Students will gain insight into effects of various environments (heat, cold, noise, information overload, etc.) on humans and human performance. Physical ergonomics (cumulative trauma disorders and biomechanics will be addressed briefly.

ME EN 6130 **Design Implications for Human-Machine Systems (3)**
Prerequisite: Graduate or upper division undergraduate status in Engineering.
Course addresses Human Factors Engineering aspects of design and implications on system performance. Various aspects of human interaction with systems, both simple (hand tools) and complex (piloting an aircraft) will be addressed. Course will emphasize human factors engineering principles and the often catastrophic results of poor design with respect to humans in the system. Physical ergonomics (cumulative trauma disorders and biomechanics) will be addressed briefly. These topics are covered in more depth in ME EN 6100 Ergonomics and ME EN 7100 Advanced Ergonomics. Meets with ME EN 5130.

ME EN 6200 **Advanced Modeling and Control (3)**
Prerequisite: ME EN 3210 and ME EN Graduate status.
Students learn modeling in the frequency domain, time domain, and sampled data domain. The theory and application of techniques and tools used for the design of feedback control systems, including root locus, Bode and Nyquist techniques are discussed for continuous and sampled systems. Meets with ME EN 5200.

ME EN 6210 **State Space Methods (3)**
Prerequisite: CH EN 4203 or ME EN 3210 or equivalent.
Introduction to modeling of multivariable systems in state space form. System analysis including stability, observability and controllability.Control system design using pole placement, and linear quadratic regulator theory. Observer design. Meets with ME EN 5210 and CH EN 5203.

ME EN 6810 **Thermal System Design (3)**
Prerequisite: ME EN 3600 and 3650 and Graduate status.
Design of steam-power plants, feed-water heater systems, pumping systems, compressor blades, turbine blades, and heat exchangers. Equation fitting and economic analysis as basis of design

decisions. Optimization of thermal systems using Lagrange multipliers, search methods, dynamic programming, geometric programming, and linear programming. Probabilistic approaches to design. Meets with ME EN 5810.

ME EN 6960 **Project Management in a Technical Environment** (taught summer 2006, 2007).
This course involves project management *knowledge area* topics such as: scope, time, cost, risk, quality, procurement, human resources, communication, and integration. In addition, *process area* topics such as: initiation, planning, execution, and closure of projects are fully explored. In general, the course provides an overview of the relevant project management principles and practices as applied in technically-oriented, contemporary organizations. The study of program management topics, as related to the international arena, will also be explored in depth. The focus of the material covered is on topics that will lead into a major written assignment, couples with a professional level presentation by the student.

ME EN 7000 **Optimal Design (3)**
Prerequisite: Graduate standing required.
Explores optimization theory and practice as it applies to engineering design. Topics include monotonicity analysis, numerical methods in continuous design spaces and techniques for discrete optimization. Students will learn these areas through analytical and computer-based assignments and design exercises.

ME EN 7010 **Computer-Aided Engineering (3)**
Prerequisite: Graduate standing required.
Explores technology behind current topics in computer-aided engineering. Topics have included: network-based computer-aided design, expert systems, constraint propagation, pattern recognition, etc. This is NOT a course in learning how to use any commercial CAD program, but rather a course in learning the basis for developing new tools. Students learn these topics through extensive programming projects.

ME EN 7040 **Advanced Computer-Aided Manufacturing (3)**
Prerequisite: ME EN 5020 or 6020 and Graduate status.
Advanced topics in computer-aided manufacturing. Applications of computers to planning and control of manufacturing systems.

ME EN 7100 **Advanced Ergonomics: Occupational Biomechanics (3)**
Prerequisite: Instructor consent or ME EN Graduate status.
Recommended Prerequisite: ME EN 2150 and 2080 and one of

5100 or 6100.
Application of engineering statics and dynamics in determining biomechanical stresses on humans in the work environment; anthropometric measurement methodologies; determination of physiological stresses during work.

ME EN 7105 **Advanced Erogonomics: Occupational Biomechanics Laboratory (1)**
Prerequisite: Instructor consent or ME EN Graduate status.
Recommended Prerequisite: ME EN 2150 and 2080 and one of 5100 or 6100.
Empirical evaluation of biomechanical and physiological stresses on humans in the work environment.

ME EN 7200 **Nonlinear Controls (3)**
Prerequisite: ME EN 6210 or 5210 and ME EN Graduate status.
The modeling, analysis, and control of nonlinear systems is discussed.

ME EN 7210 **Optimal Controls (3)**
Prerequisite: ME EN 6210 or 5210 and ME EN Graduate status.
Optimization of systems using variational calculus and simulation techniques are discussed.

ME EN 7220 **Advanced Control Design (3)**
Prerequisite: ME EN 6210 or 5210 and ME EN Graduate status.
Current topics in the area of control design are discussed. The subject areas depend on the interest of the instructor and students.

Bioengineering:

BIOEN 6060 **Scientific Presentation (1)**
Students will learn how to organize and give effective written and oral technical presentations for scientific meetings.

BIOEN 6061 **Scientific Presentation II (1)**
Continuation of BIOEN 6060. The course is designed to introduce bioengineering graduate students to standard scientific presentation formats and to forum to practice/improve oral and written communication skills. Departmental seminar attendance is required.

Chemical Engineering:

CH EN 6303 **Environmental Applications of Chemical Engineering (3)**
Prerequisite: Instructor's Consent.
The nature of pollutants, their sources, and existing and evolving strategies for their abatement and control. Environmental considerations in the production, transportation, and processing aspects of coal and petroleum. Topics include air pollution, surface water pollution and subsurface pollution analysis. Public-domain software will be used to study realistic environmental problems.

CH EN 6960 **Green Engineering (3)**
Prerequisite: Instructor's Consent.

Civil and Environmental Engineering:

CVEEN 6530 **Quantitative Methods in Transportation Operation (3)**
Prerequisite: CVEEN 3520 or URBPL 3250. Quantitative methods in transportations studies: operations research techniques, linear programming, forecasting, queuing theory, flow optimization algorithms.

CVEEN 6660 **System Dynamics and Environmental Policy (3)**
Environmental policy design requires an understanding of human interactions with environmental systems. It requires an accounting of the complexities of behavior, context and policy. These complexities often produce indirect and unanticipated consequences. They yield unexpected patterns and counter-intuitive results. Students from many academic fields learn user-friendly software (STELLA) to do environmental policy simulation without proficiency in advanced mathematics. Students use computer simulations to sort out environmental complexities; transform group perceptions into simulation models; apply principles of environmental management; test policy effects and define possible pathways for future policy change.

CVEEN 6661 **Complexity and Systems Thinking (3)**
Using a systems thinking approach to conceptualize complex problems,multi-disciplinary student teams resolve real world problems in maintaining system resiliency, stability, diversity, and sustainability. Student teams define/discover system structures, feedback loops, counter-intuitive outcomes and the unintended consequences of policy decisions. Topics of analysis include: urban growth, land use and transportation, renewable and non-renewable resources, environmental justice, and the dynamics of human administrative systems.

CVEEN 6820 **Project Scheduling (3)**
Meets with CVEEN 5820. This course is endowed by Floyd and Jeri Meldrum. Critical path methods, resource balancing, influence of probability on the time and cost (PERT), network techniques, case studies, computer applications.

CVEEN 6830 **Project Management and Contract Administration (3)**
Meets with CVEEN 5830. Partially endowed by Jacobsen Construction. Construction management processes; basic time and cost methodologies; scheduling and controlling the use of labor, equipment, and materials; financial and accounting systems used in the construction industry.

CVEEN 6850 **Engineering Law (3)**
Meets with CVEEN 5850. Introduction to the principles and practices of law relevant to engineers and technical managers. Topics covered include courts, trial procedures, evidence, contract law, engineering contracts, agency, patents, trademarks, copyrights, trade secrets, product liability, employer/employee law, business law including corporations, partnerships, joint ventures, etc.

Economics:

ECON 6360 **Industrial Organization (3)**
Prerequisite: ECON 2010
Meets with ECON 5360. Graduate students should register for ECON 6360 and will be held to higher standards and/or additional work. The basic theory of industrial organization; interrelationships among market structure, conduct, and performance; public policy, and empirical evidence.

Electrical and Computer Engineering:

ECE 5510 **Random Processes (3)**
Prerequisite: ECE 3500 and ECE 3530
review of probability theory; multivariate distributions, Gaussian distributions, weak and strong law of large numbers, random processes, stationarity and ergodicity, mean-value function, auto and cross-correlated functions, power spectral densities, Wiener-Khincchine theorem, Karhunen-Loeve expansion, Gaussian random processes, random filter processes in linear filters, white Gaussian noise.

ECE 5520 **Digital Communication Systems (3)**
Prerequisite: ECE 5510.
Modern communications; probabilistic viewpoint; vector representation of signal; signal spaces; vector channels; additive white Gaussian noise; optimum receivers; maximum-likelihood detection; error probabilities; memoryless modulation methods: PAM, BPSK, M-PSK, FSK, QAM; message sequences; intersymbol interference (ISI); Nyquist signaling; complex baseband models; noncoherent detection.

ECE 5570 **Control of Electric Motors (3)**
Prerequisite: ECE 3510
Principles of operation, mathematical models, and control techniques for electric motors. Types of motors include brush DC motors, stepper motors, brushless DC motors, synchronous motors and induction motors. Topics covered: steady-state and dynamic characteristics, torque limits and field weakening operation, characteristics under voltage and current sources,open-loop and closed-loop control of position and velocity, and field-oriented operation for AC motors.

ECE 6325 **Wireless Communication Systems (3)**
Prerequisite: ECE 3300 and 3500 or equivalent.
Introduction to wireless transmission systems. This course will emphasize how individual parameters affect overall system design and performance. Topics include: basic cellular systems and parameters, multi-path channels and modulation techniques.

ECE 6530 **Digital Signal Processing (3)**
Prerequisite: ECE 3510.
Discrete-time signals and systems; the z-transform. Input-output relationships; discrete-time networks. The discrete-time Fourier transform and sampling; practical sampling issues; signal quantization. The discrete Fourier transform, the fast Fourier transform and high-speed convolution. Filter design from analog models; impulse-invariant, bilinear, and spectral transformations. FIR filter design, windowing, and frequency-sampling methods. Equiripple filter design. Coefficient quantization. Examples of DSP applications and implementations.

ECE 6551 **Survey of Optimization Techniques (3)**
Prerequisite: MATH 2210, 2250 and 3150
Neural networks, gradient and Hessian descent, conjugate gradient, random search, simulated annealing, prejudicial search, least-squares, regression, downhill simplex, genetic algorithms, linear programming, simplex algorithm, Karmarkar algorithm,

quadratic and dynamic programming, Riccati equation, Beard-Galerkin optimal control.

ECE 6552 **Survey of Function Approximation Methods (3)**
Prerequisite: MATH 2210, 2250 and 3150
Meets with ECE 5550. Industrial problems requiring function approximations, Fourier series, universal series approximations, fuzzy logic, radial basis functions, neural networks, linear interpolation, triangulation, window reticulation, response surfaces, polynomials, cubic splines, sinc finctions, Bezier curves. Graduate students only. Extra work required.

ECE 6570 **Adaptive Control (3)**
Prerequisite: ECE 3510 or CH EN 4203 or equivalent.
Recommended prerequisites: CH EN 5203/6203 or ME EN 5210 orequivalent.
Identification using gradient and least-squares algorithms. Indirect adaptive control: pole placement control, model reference control, predictive control, and problems with singularity regions. Direct adaptive control: strictly positive real transfer functions, Kalman-Yacubovitch-Popov lemma, passivity theory, and stability of pseudo-gradient adaptive algorithms. Persistency of excitation and sufficient richness conditions for parameter convergence. Averaging methods and robustness issues. Disturbance rejection.

Finance:

FINAN 5270 **Business Risk Management (3)**
Prerequisite: FINAN 3040 or Departmental Consent.
Topics include the application of modern risk management to identify, measure, and control property, liability, and personnel risks in business. Also included is the use of safety management, self-insurance, captive insurance, and commercial insurance to control business risk.

FINAN 6020 **Financial Management (1.5 to 3)**
Prerequisite: Master's status in the School of Business and either ACCTG 6001 or equivalent.
Topics include financial analysis, planning, working-capital management, financial math, valuation, and capital budgeting.

FINAN 6025 **Managerial Economics (1.5)**
Prerequisite: Master's status in the School of Business and either MATH 1100 or equivalent.
Addresses fundamental principles of economics from the managerial perspective. Topics include supply and demand in

markets, analysis of production and cost, consumer theory, analysis of market structure, the banking system, and macroeconomics.

FINAN 6152 **Ethics and Foundations of Business Thought (1.4)**
Prerequisite: Masters status in the School of Business.
Personal and organizational values and ethics are discussed in an environment of competing and complementary rights and monetary goals. Readings of a classic nature are presented to underscore the timeless nature of business and the relevancy of great works to today's business environment.

FINAN 7090 **Industrial Organization I (3)**
Meets with ECON 7100. Graduate level theory of industrial organization. The course will emphasize game theoretic approaches to microeconomics. The course will cover some or all of the following topics: game theory, monopoly, oligopoly, mergers, vertical restraints, price discrimination, vertical integration, product differentiation, auctions, empirical analysis of market structure, technological change, antitrust law, and regulated industries.

FINAN 7091 **Industrial Organization II (3)**
Prerequisite: FINAN 7090.
Meets with ECON 7101. A continuation of FINAN 7090 covering advanced topics in signaling, agency, econometrics, game theory, financial economics, and other topics.

<u>Management</u> (MBA program status required - will need to coordinate with Business school):

MGT 6040 **Data Analysis and Decision Making I (1.5)**
Prerequisite: Master's status in the School of Business, MATH 1090, MGT 2350.
This course will develop decision making abilities with data-analysis and decision models. Applications will be in the business functional areas. Students will use computers to solve business problems. Course topics will include advanced statistical analysis, regression models, linear programming, decision analysis, and project management.

MGT 6041 **Data Analysis and Decision Making II (1.5)**
Prerequisite: MGT 6040.
This course is a continuation of Data Analysis and Decision Making I. Course topics will include simulation, linear programming, and Bayes theorem.

MGT 6060 **Production and Operations Management I (1.5)**
Prerequisite: Masters status in the School of Business.
Operations Management involves designing, operating, and improving the processes wherby any firm (such as a hospital) transforms raw materials (e.g., sick patients) into finished goods (e.g., cured patients). A key role of Operations is to manage the flow of work through these process steps, with the goal of closely matching supply with demand while enhancing quality and minimizing cost. Thus we develop a framework for analyzing business process flows within a firm and across firms, applying the principles not only to service industries but also to manufacturing.

MGT 6061 **Production and Operations Management II (1.5)**
Prerequisite: Master's status in the School of Business, MGT 6060.
This course builds on MGT 6060 by looking more closely at how the management of supply chains, capacity, inventory, quality, and product design can have a positive impact on the match between supply and demand, and on profitability. The course further examines how firms in both service industries and manufacturing have used the Operations function to help create a competitive advantage, and how firms have achieved a strategic fit between the Operations function and other business disciplines.

MGT 6160 **Operations Management (2.8)**
Prerequisite: Master's Status in the School of Business.
Operations management studies traditional operations management theories and methodologies as well as many new and developing models and associated technologies that are reshaping the way that firms manage procurement, production, and distribution of goods and services in an increasingly competitive international marketplace. This course develops a systems thinking approach that is critical for successful design and strategic management of world-class manufacturing and service operations. Topics covered include integrated product/process analysis and design, materials management, supply chain management, industry structure and virtual organizations, use of information technologies in the extended enterprise, service operations management, total quality management, experience curve concepts, technology management, project management, and current developments in operations strategy. Superior management of operations can result in considerable competitive advantages.

MGT 6420 **Quality Management I (1.5 to 3)**
Prerequisite: MGT 6050.
Introduction to the principles of quality management, with an emphasis on cross-functional problem solving. Topics include

system design to control the quality of products and services, customer driven quality, leadership, employee participation and training, and strategic quality planning.

MGT 6421 **Quality Management II (1.5 to 3)**
Prerequisite: MGT 6050.
An introduction to the tools of process control and improvement. Topics include design quality and error prevention, management by fact, statistical thinking and statistical process control. Emphasis will be given to the design and interpretation of process control charts.

MGT 6630 **Operations Planning and Control (1.5 to 3)**
Prerequisite: MGT 6060 or 6061.
Design of information and decision systems for allocating resources and scheduling activities. Development of conceptual structures for guiding the design of integrated planning and control systems. Topics include forecasting, materials resource planning, just-in-time manufacturing, and capacity management.

MGT 6660 **Project Management (1.5 to 3)**
Prerequisite: Masters status in the School of Business.
Project management has become the way of life in many industries. Whether it is development of a new product, organizational-wide implementation of a new IT tool, or execution of a merger, project management skills are required to manage cross-functional teams subject to strict deadlines and tight budget constraints. In this course we discuss all three phases of project management: project conception, execution, and closure. Issues related to project leadership, budgeting, and scheduling will be addressed in the course, and case discussions will highlight state of the art project management practices. Project management software will be introduced (possibly including group project using MS Project Software).

MGT 6710 **Strategy & Technology (1.5 to 3)**
An introduction to the management of technology as a business activity. The focus is on the processes by which technological enterprises evolve, and on the technological innovation process in established technology-based firms. Special emphasis is placed on intellectual property issues and the management of knowledge. Heavy emphasis is placed on classroom analysis of published case studies of technological enterprises, together with readings which outline basic concepts applicable to the subject.

MGT 7590 **Multivariate Statistics for Management** (1 to 4)
Multivariate statistical methods, excluding multiple regression, beginning with a review of matrix algebra up through eigenvalues and eigenvectors. Principal components, cluster and discriminant analysis, canonical correlation and factor analysis. A theoretical approach is used, but emphasis is on applications to management and administrative problems. Applying prepackaged computer programs to implement statistical tools outlined; interpreting and analyzing computer output.

Metallurgical Engineering:

MET E 5690 **Process Engineering Statistics (2)**
Recommended Prerequisite: MET E 3070.
Laboratory fee assessed. One laboratory period. Advanced statistical methods applied to solve engineering problems and to analyze massive experimental database. One-factor experiments, simple, and multiple linear regression, statistical quality control and response surface method.

ENCLOSURE 3
ATK FACULTY VITAS – Goldberg, Langdorf, Trego

BENJAMIN GOLDBERG, Ph.D.

Fellow, AIAA

112 W 4050 N
Pleasant View, UT 84414

Cell: 435.720.7150
Benjamin.Goldberg@ATK.com

EDUCATION

University of Pennsylvania, Ph.D., Materials Science and Engineering, 1992
Concentration: Polymers, Crystallization processess – rheometry and kinetics
Dissertation: *Crystallization of polyethylene under low gravity conditions: Implications for continued microgravity research on polymers*, University of Pennsylvania, 1992

Northwestern University, MS, Material Science Engineering, 1983
Concentration: Polymers, Polymer chemistry and characterization test methods
Dissertation: *Heterogeneities in Poly (Methyl methacrylate): Monomer Fluctuations*, Northwestern University, June 1983.

Northwestern University, BS, Material Science Engineering, 1981

ACADEMIC / TEACHING EXPERIENCE

Formal academic experience limited to infrequent substitute instruction at University of Alabama, Huntsville Campus, 1986 – 2000. General Engineering courses only.

Related experience within industry and government includes:

"Dean, Systems Engineering ", Pratt & Whitney's "Engineering Technical University"
2003 - 2005

- Supervised (50 course) curricula and (8 member) faculty for internal training
- Developed two short courses (4 day): Design Engineering Process
  Risk Management

Created and instructed short courses for NASA: Systems Engineering
1990 - 2005

Risk Management
Solid Rocket Motor Design
Systems Engineering Toolbox

- Systems Engineering Toolbox courses requested after 3rd reprinting of *Systems Engineer's "Toolbox" Handbook*

Supervised 5 Master's Thesis for National Graduate School (industry program)
2001 – 2005

Technical consultant for research at Jet Propulsion Laboratory, University of Alabama – Huntsville, **1989 - 1999**
Georgia Tech University

Initiated and supervised 6 Summer Faculty Research Fellowships at NASA, Marshall Space Flight **1984 - 1991**
Center

Created, or served as Technical Chairman for National Workshops (Use of Composites in **1987 - 1999**
Aerospace), and Environmental Issues (multiple NASA Operational Environment Team Conferences)

PROFESSIONAL EXPERIENCE

ALLIANT TECHSYSTEMS INC., Promontory, Utah
2007 -
Director, Engineering Processes
Technical leader focusing on Systems Engineering processes, tools, and culture including design, reviews, and technical management.

PRATT & WHITNEY, West Palm Beach, FL; East Hartford, CT **2000 - 2006**
Director, Engineering, Research and Advanced Programs (2004-2006)

- Led P&W Engineering integration of the $600 million Rocketdyne Propulsion acquisition
- Stewarded technical activities for all West Palm Beach propulsion products and research activities.
- Revitalized quality and customer satisfaction as measured by:
  - 100% mission success
  - Increase in customer scorecard average from 4 to 6 (7 scale); similar increase in Employee Survey
  - Engineering rates 10% favorable to stretch targets with demonstrated 5% productivity gains
  - Cost of Poor Quality savings for Engineering rework of more than $2,000,000 annually
- Met Advanced Programs financial plan for sales while doubling profit / earnings targets.
- Significantly enhanced processes resulting in a reduction in proposal overspending by 15 times while improving win ratio and reducing B&P-to-contract value ratio by more than 2 times.
- Executive Champion for Diversity Council, Safety Incident Investigation Committee, Site Level Initiative Team, Employee Activity Board, and the United Way Campaign.

Chief Engineer, Chief Systems Design and Component Integration (2003-2004)
Technical leader for approximately 1000 personnel performing systems engineering and design, review and technical management of approximately $9 billion of products. Fielded product lines include more than 10,000 commercial engines on wing, and more than 10,000 military engines on wing.

- Optimized the technical risk management activities (including milestone review process, process failure modes and effects analysis, and risk matrices); created Chief Engineer's discipline.

- "Dean" of Pratt & Whitney Engineering Technical University's Systems Engineering "school".
- Developed and implemented, along with manufacturing and purchasing, a comprehensive part cost reduction resulting in more than $150,000,000 in projected cost savings, $40,000,000 realized to date.

Director, Engineering and Research (2000-2003)
Led 700 Engineers in the comprehensive revitalization of Engineering, Reliability and Mission Assurance organizations, processes and procedures for the $400 million / year Pratt & Whitney solid, liquid, electric and hypersonic propulsion activities. Senior contact on international technical negotiations.

- 100% mission success for 56 launches.
- Creation of greater than 150 documents, and associated courses delineating standard work for Engineering, capturing lessons learned and expertise of a mature workforce, resulting in 45% reduction in design and quality escapes.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, MSFC, AL **1983 - 2000**
Program Manager, Space Shuttle Re-useable Solid Rocket Motor (1999-2000)
Program Manager for $400 million per year Shuttle Solid Rocket Motor (RSRM).
Initiated innovative enhanced statistical process control program at vendors and developed and implemented industrial safety ratio metrics.

- Developed and implemented the first RSRM Strategic and Tactical Plan.
- Secured funding for system enhancements including propellant upgrades and NDE optimization.
- Led investigation for Shuttle External Tank (ET) Foam Loss. Team results were reviewed by the Columbia independent review team and found flawless and un-related to the Columbia foam anomaly.

Deputy Director, Structures and Dynamics Laboratory (1997-1999)

- Appointed to the Senior Executive Service responsible for leading 400 personnel in structural, thermal, computational fluid dynamics analyses, structural test and design / drafting research and operational activities. This included developing and applying advanced methods of analysis, instrumentation, and testing in the areas of guidance, navigation and controls, structures, thermal, life support, and fluid and gas dynamics; and operation of MSFC fluid, gas dynamic and structural test facilities.
- Successfully chaired Agency and MSFC independent review teams for such varied activities as
  - ET (Foam spallation, Friction Plug Welding , Composite Nosecap)
  - Shuttle Main Engines (subsynchronous and synchronous vibration evaluation, NDE assessment)
  - RSRM / SRB (Sustaining Engineering, TPS reduction, pyrotechnics, Toxic Gas Cloud)
  - Lockheed Martin Launch Vehicle, Pegasus launch system
- Led the development of the Shuttle Systems upgrade prioritization approach and the development of the Shuttle probabilistic risk models, as well as providing export control authority.

Technical Staff, Structures and Dynamics Laboratory (1995-1997)
Led special teams, studies and committees for the Laboratory and the Center as an authority and consultant in the field of systems engineering and integrated design engineering.

- Developed four NASA or Marshall Space Flight Center (MSFC) level Strategic Plans.
- Chairman of a special NASA-wide team evaluating Shuttle anomalies.
- Chairman of the Laboratory's Safety Review Team.
- Created and chaired the NASA Composite Materials Working Group.

Chief Engineer, Reusable Solid Rocket Motor and Solid Rocket Booster (SRB) (1994-1995)

- Senior manager responsible for the research, technical design, development and production assurance.
- Managed a multi-million dollar budget and provided the final technical approval for SRB launch.
- Authored NASA Shuttle risk management approach, innovating out-of-family concepts.
- NASA's senior representative for the NATO / AGARD Propulsion Conference in Norway.
- Created a NASA / Navy / Air Force Chief's Council for solid propulsion.

Branch Chief, Solid Propulsion Branch (1989-1994)

- Responsibilities centered on the systems engineering of all MSFC managed solid and hybrid rocket motors including design, development, and verification. Additionally, served as Deputy Division Chief for the Propulsion Systems Division, managing solid, hybrid and liquid systems.
- Acquired and allocated funds ranging from $1,500,000 to $2,000,000 per year.
- Defined and developed a national Propulsion Testbed facility and Program.
- Regularly provided service to the Air Force for anomaly and incident investigations.

Staff Engineer, Materials and Processes Laboratory (1983-1989)

- Started as non-metallic materials expert and progressed rapidly into technical management, providing leadership in solid rocket motor technology development and failure investigations. Chaired MSFC Shuttle Non-destructive Evaluation (NDE) team.
- Chairman of the Joint Army Navy NASA Air Force nozzle subcommittee.
- Defined, fabricated, analyzed, tested and flew polymer materials using a microgravity environment.

PUBLICATIONS

Goldberg, Benjamin E.; *Heterogeneities in Poly (Methyl methacrylate): Monomer Fluctuations*, A Dissertation for the Degree of Master of Science, Northwestern University, June 1983.

Goldberg, Benjamin E.; and Semmel, Marie Louise; *Dielectric Cure Monitoring Preliminary Studies,* NASA Technical Memorandum TM-86452, May 1984.

Goldberg, B.; Hediger, L.; and Noel, E.; *Computed Tomography for Non-Destructive Evaluation of Composites: Applications and Correlations*, NASA Technical Memorandum TM-86529, August 1985.

Penn, B.G.; Daniels, J.G.; Ledbetter III, F.E.; Semmel, M.L.; Goldberg, B.E.; White, W.T.; Clemons, J.M.; *Effects of Seawater and Deionized Water at 0 to 80°C on the Flexural Properties of a Glass/Epoxy Composite,* NASA Technical Memorandum TM-86544, March 1986.

King, H.M.; Webb, D.D.; and Goldberg, B.E.; *The Non-Metallic Materials Sample Array*, NASA TM-86578, December, 1986.

Goldberg, Benjamin E.; *Microgravity Crystallization of Macromolecules: An Interim Report and Proposal for Continued Research*, NASA Technical Paper 2671, December 1986.

Goldberg, Benjamin E.; *Characterization Studies of 2-D Carbon-Carbon Processing,* JANNAF Nozzle Subcommittee Workshop, MSFC, AL, May, 1987.

Goldberg, Benjamin E.; *MSFC Nozzle Materials Performance Test Beds*, JANNAF Nozzle Subcommittee Workshop, MSFC Al, May, 1987.

Rooney, M.; Koenig, J.R.; and Goldberg, B.E.; *NDE Methods for Use on Thin-Walled Exit Cones*, JANNAF Nozzle Subcommittee Workshop, MSFC, AL, May, 1987.

Crose, J.; Mack, T.; Marx, D.; Goldberg, B.; and Shrader, J.; *NASA/MSFC Nozzle Test Bed,* Presented at AIAA/ASME/SAE/ASEE 25th Joint Propulsion Conference, July, 1989.

Goldberg, Ben E.; Wiley, Dan R.; *Hybrids: Best of both worlds,* Aerospace America, June 1991.

Cook, Jerry R.; Goldberg, Ben E.; Estey, Paul N.; Wiley, Dan R.; *Hybrid Rockets: Combining the best of liquids and solids*, Aerospace America, July 1992, pg. 30.

Goldberg, B.; and Cook, J.; *Preliminary Results of NASA / Industry Hybrid Propulsion Program*, AIAA 92-3299, Presented at AIAA/ASME/SAE/ASEE 28th Joint Propulsion Conference, July, 1992.

Goldberg, Benjamin E.; *Crystallization of Polyethylene Under Low Gravity Conditions: Implications for Continued Microgravity Research on Polymers*, A Dissertation for the Degree of Doctor of Philosophy, University of Pennsylvania, December 1992.

Boardman, T.A.; Carpenter, R.L.; Goldberg, B.E.; Shaeffer, C.W.; *Development and Testing of 11- and 24-Inch Hybrid Motors Under the Joint Government / Industry IR&D Program*, AIAA 93-2552, Presented at AIAA/ASME/SAE/ASEE 29th Joint Propulsion Conference, July, 1993.

Goldberg, B.; and Cook, J.; *Results of Small-scale Solid Rocket Combustion Simulator Testing at Marshall Space Flight Center,* AIAA 93-2554, AIAA/ASME/SAE/ASEE 29th Joint Propulsion Conf., July, 1993.

Boardman, T.A.; Carpenter, R.L.; Claflin, S.E.; Goldberg, B.E.; Shaeffer, C.W.; *JIRAD Subscale Hybrid Rocket Testing Results*, AIAA 93-4280, AIAA Space Programs and Technologies Conference, September, 1993.

Cruit, W.; Schutzenhofer, S.; Goldberg, B.; and Everhart, K.; *Prioritization Methodology for Chemical Replacement*, NASA Technical Paper 3421, October 1993 and AGARD-CP-559, 38-1, February 1995.

Schwinghamer, R.J.; Congo, Richard T.; Goldberg, Benjamin E.; *Environmental Initiatives at NASA: Taking the Lead in Alternative and Replacement Technologies*, Federal Facilities Environmental Journal, Volume 4, Number 4, Winter 1993-94, pg. 437.

Goldberg et al; *Systems Engineer's "Toolbox" Handbook*, NASA Reference Publication 1358, December 1994.

Goldberg, B. and Schutzenhofer, S; *Manufacturing Waste Disposal Practices of the Chemical Propulsion Industry*, NASA Conference Publication 3297, March 1995.

Hayes, J. and Goldberg, B.; *Environmental Benefits of Chemical Propulsion*, NASA Conference Publication 3297, March 1995.

Goldberg, Benjamin.; *More Green for NASA,* Aerospace America, August 1996.

Clemens, P.L. and Goldberg, B.E.; *Avoiding the Pitfalls and Abuses: "System Engineering 'Toolbox' for Design-Oriented Engineers"* , AIAA 98-5277, AIAA Defense and Civil Space Programs Conference, October, 1998.

Goldberg, B. and Verderaime, V.; *Quasi-Static Probabilistic Structural Analysis Process and Criteria* , NASA Technical Paper-1999-209038, January 1999.

Goldberg, B. and Sullivan, R.; *Workshop on the Future of Composite Materials in Space Transportation*, 2001.

PATENTS

EH 10776 Electrostatic Detonation Propulsion	**2003**
EH 10777 Staged Emitter-Attractor Ion Drive.	**2003**

SIGNIFICANT AWARDS

NASA Exceptional Service Medal	**1990**
NASA Exceptional Achievement Medal	**1999**
Inducted as Fellow, AIAA	**2005**

PROFESSIONAL AND COMMUNITY LEADERSHIP

AIAA	Provided leadership in Chairman roles for Technical, and Education Committees
Florida Space Research Institute	Served on Board of Directors

United Way of Palm Beach County	Served on Board of Directors
Florida State University / Florida A&M	Served on Engineering Advisory Council
University of Florida	Served on Engineering Advisory Council
Embry Riddle Aeronautical University	Served on Engineering Advisory Council

Reviewer – Journal of Propulsion and Power
Reviewer for Research Proposals – NASA, U.S. Air Force. U.S. Army, DARPA

Kim A. Langdorf

Qualifications

Thirty years of leadership positions with the United States Army and Aerospace Industry, with assignments as program manager, systems engineer, test and evaluation engineer, operations manager, acquisition, academics and scientific research

Education

- **Doctor of Philosophy, Virginia Polytechnic Institute and State University, Electrical Engineering, 1995**
- Masters of Science, Naval Postgraduate School, Space Systems Technology, 1986
- Bachelor of Arts, University of Utah, Psychology, 1977

Leadership

- Deputy Director and Chief Engineer, Systems Engineering and Integration Advanced Programs, Launch Systems, ATK
- Deputy Discipline Manager, Systems Engineering, Raytheon Information and Intelligence Systems
- Chief Systems Engineer and SEIT Manager for $2B Proposal, Raytheon Information and Intelligence Systems
- Exo-atmospheric Kill Vehicle (EKV) Payload Systems Engineering Team Lead, Raytheon Missile Systems
- Senior Program Manager, NATO C3 Agency
- Principal Investigator (Lead Scientific Researcher), U.S. Army

Accomplishments

- Led team responsible for the specification and verification of 4500 requirements for the Initial Defense Capability Exo-atmospheric Kill Vehicle, National Missile Defense System
- Led effort to plan the technical system design for the next generation NATO communications satellite system
- Led team that installed a major NATO communications system in 59 days at less than 50% of estimated cost
- Led team that designed and installed a $3,000,000 global space test range for NASA's STS-44 space shuttle mission

Professional

2006- Current Deputy Director and Chief Engineer, Systems Engineering and Integration, Advanced Programs, Launch Systems, ATK

2004-2006 Chief Systems Engineer and SEIT Manager for $2B Proposal, Deputy Discipline Manager for 130 Systems Engineers

2003-2004 Team Lead of EKV Payload Systems Engineering Team, Raytheon Missile Systems, Contracts Account Manager (CAM), Section Manager for EKV Systems Engineering Department

2001-2002 Technical lead and principal systems engineer for the communications link and global positioning system subsystems on the EKV Program,
Raytheon
Missile Systems

1998-2001 Program Manager, NATO C3 Agency, The Hague, The Netherlands
- Developed the initial technical system design for the future NATO communications satellite system. Projected budget was $600,000,000
- Led team in the installation of a seven node Ku-band VSAT system to provide backbone communications for all NATO Forces Headquarters in Kosovo, Macedonia, and Albania at the conclusion of the air war over Yugoslavia. The system was operational 59 days from the award of contract. Projected first year cost was $11,000,000. Final cost was less than $4,000,000

1995-1998 Assistant Professor of Electrical Engineering, United States Military Academy, West Point, New York
- Created two new introductory electrical engineering courses and doubled the number of electrical engineering majors
- Taught courses in electrical engineering, computer science, control systems, and telecommunications
- Conducted research in satellite position-location systems and wearable computers

1992-1995 Graduate Student, Virginia Polytechnic Institute and State University, Blacksburg, Virginia
- Doctoral Dissertation: A Position-Location System Utilizing Geosynchronous Communication Satellites
- Designed a position-location system as accurate as the Global Positioning System (GPS) which could be achieved at a significantly less cost by using readily available geosynchronous communications satellites

Affiliations
- Interim President, Wasatch Chapter, International Council of Systems Engineers

Contact
- Office Phone: (801) 251-5465
- Cell Phone: (801) 870-1581

ANGELA TREGO, Ph. D., P. E.
tigr_ldy@yahoo.com

PROFESSIONAL LICENSE

Washington State Professional Engineer Ref: 35623 *99*

PATENTS

Vehicle Condition Monitoring *04*
A. Trego, E. Haugse, R. Ikegami US 06691007
Material Removal Rate Fiber Optic Corrosion Sensor *00*
E. Udd, A. Trego and E. Haugse US 06144026
Structural Health Monitoring Architecture using Sensor Technology *Pending*
A. Trego, E. Haugse, A. Akdeniz, D. Anderson, C. Greenberg US 20060004499

PROFESSIONAL EXPERIENCE

Director of Structures *06 - present*
Launch Systems – SE&I, ATK
Tasks include:
- Supervise and manage professional development of 5 individuals with structural expertise
- Design and develop launch systems

Manager *05 - 06*
Becton Dickinson Medical
Tasks include:
- Supervise and manage professional development of 45 individuals with industrial design, packaging, graphics, BD Identity, molding and physical testing expertise and all associated regulatory compliances.
- Managed cross-functional OneCath PICC Flash Team to successful resolution of strategic direction.
- Managed worldwide CAE effort to align all BD personnel to uniform software packages resulting in increased collaboration, functionality and cost savings.

Lead Engineer *03 - 05*
Phantom Works - Structures, Boeing
Tasks include:
- Structural IVHM Team Leader for Advanced Support Concepts Thrust. In charge of technology development, budgets, and personnel.
- Aging Aircraft Team Leader for Phantom Works. One of six team leaders across the Boeing Company and the only non-manager of the team leaders. This is an enterprise wide team defining the state of the art in structural life assessment and enhancement, maintenance and utilization of aging aerospace platforms. Responsible for the effective and efficient transition and integration of multiple advanced technologies into robust and reliable methods and practices ensuring the safe operation of Boeing products throughout their economic life.
- 787 Technical Lead for the development of an onboard structural health monitoring system for the new airplane development team. Responsibilities include developing and evaluating new technologies and presenting this information to upper management. Technologies include impact detection, damage detection and environmental damage for

composite and metallic aircraft. Congruently, a flight qualified battery operated health monitoring system was developed which was retrofitted onto existing commercial airplanes.
- Program manager for joint research effort with Australian government research agencies, CSIRO and DSTO developing corrosion prognostic algorithms.
- Member of various proposal and non-advocate teams.
- College recruiting including interviewing students for prospective jobs, scholarships and internships and interfacing with both the Society of Women Engineers and American Society of Mechanical Engineering chapters.

Senior Specialist Engineer *97 - 03*
Phantom Works - Structures, Boeing
Tasks include:
- Principal investigator, including liaison, program management and subcontract management, for the X-34 Acoustic Emissions Structural Health Monitoring System Experiment. Provided customer interface, experiment analysis and presentation of final report to NASA Marshall. Integrated a flight qualified experiment onto the X-34 developed by Orbital Science Corporation.
- Principal investigator / technical lead, for the Internal Research and Development program overseeing remote NDI sensor development and autonomous corrosion monitoring for maintenance and modification repairs.
- Program manager / technical lead, including responsibility for statement of work, program budget and scheduling over several fiber optic health monitoring SBIR contracts. Developed new health monitoring technology using fiber optics.
- Assisted in developing a corrosion damage assessment framework for the USAF, including performing crack growth analysis and risk analysis to model fatigue cracking due to corrosion. Interfaced with the customer, maintenance crews and university consultants.
- Performed dynamic modal analysis using PATRAN and NASTRAN for various programs including JSF, B-52, Sea Launch, TRAM II, and the Space Station.

Project Engineer *04 - Present*
PSI Forensics
Provide analysis, consultation, patent litigation and expert testimony regarding fatigue and fracture analysis of materials, statistical analysis involving quality control, process flow and regression analysis, finite element analysis, vibration analysis, design analysis, accident reconstruction and accident reconstruction computer modeling.

Project Engineer *01 - Present*
Injury and Crash Analysis
Teaching short course for under ride analysis to a variety of disciplines including lawyers, accident re-constructionists and policemen. Provide analysis, consultation, patent litigation and expert testimony regarding fatigue and fracture analysis of materials, finite element analysis, vibration analysis, design analysis, accident reconstruction and accident reconstruction computer modeling.

Adjunct Faculty, Dynamics and Thermodynamics *02 - 03*
Mechanical Engineering Dept., Seattle University
Taught junior level thermodynamics and dynamics courses to mechanical and civil engineers. Responsibilities included preparing and giving lectures, homework and tests. Student evaluation rating was 4.23 / 5.00.

Instructor, Integrated Product and Process Engineering *96-97*
Mechanical Engineering Dept., Brigham Young University
Faculty coach for two 5 person senior student design teams learning a structured design process while each team worked with a company liaison engineer to solve industrially sponsored and financed, two semester long "design and build" projects.

Instructor, Material Science & Associated Laboratory *96*
Mechanical Engineering Dept., Brigham Young University
Developed and taught sophomore level materials science course and laboratory for mechanical engineers. Responsibilities included preparing and giving lectures, homework and tests.

Teaching Assistant, Aerodynamics *96*
Aerospace and Mechanical Engineering Dept., Australian Defence Force Academy
Taught sophomore engineering drawing class. Developed and graded homework and design problems for second year aerodynamics design class.

Research Assistant, Composites *94-97*
Mechanical Engineering Dept., Brigham Young University
Developed new modeling tools for analyzing and predicting passive damping in composite structures utilizing a new damping technology. Developed manufacturing methods of novel passively damped composite structures. Tested and designed composite damping structures utilizing this new technology.

Research Assistant, Tolerance Analysis *90-94*
Mechanical Engineering Dept., Brigham Young University
Programmed, developed, tested, debugged and marketed AutoCATS, a Computer-Aided Tolerance Modeling System. Wrote users manual and presented software to sponsoring/buying companies.

EDUCATION

Mechanical Engineering, Ph. D.

SCHOOL	Brigham Young University, Provo, Utah	*94-97*
DISSERTATION	Modeling of Stress Coupled Passively Damped Composite Structures in Axial & Flexural Vibration©	
GPA	4.0 / 4.0	

Mechanical Engineering, M. S. *93-94*

SCHOOL	Brigham Young University, Provo, Utah
THESIS	A Comprehensive System for Modeling Variation in Mechanical Assemblies
GPA	4.0 / 4.0

Mechanical Engineering, B. S. *90-92*

SCHOOL	Brigham Young University, Provo, Utah	
GPA	3.88 / 4.0, Magna Cum Laude	
SCHOOL	Idaho State University, Pocatello, Idaho	*88-90*
GPA	3.94 / 4.0	

PROFESSIONAL DEVELOPMENT

Appointments

External reviewer for ADFA Mechanical Engineering PHD Thesis	*06*
External Advisory Board, ME Department, Brigham Young University	*04*

Organizing Committee

SPIE International Symposium on Nondestructive Evaluation	*05, 06*
SAMPE Material Exposition	*03, 04*
Northwest Fiber Optic Society Workshop	*03*
Australian International Aerospace Congress	*01*

Session Chair

Congress on Corrosion in the Military Cost Reduction Strategies	*05*
AEROMAT Conference	*04*
Workshop on Structural Health Monitoring	*03*
Fifth Joint DOD/FAA/NASA Conference on Aging Aircraft	*02*
SPIE International Symposium on Nondestructive Evaluation	*00*
Techniques for Aging Infrastructure & Manufacturing Conference	*00*

Short Courses Taught

Reconstruction of Trailer Side Underride Analysis	*02*

Short Courses Taken

Managing for Performance Excellence	*05*
Performance Problem Solving	*05*
Mentoring Techniques	*05*
Object Oriented C++ Programming for Non-C Programmers	*03*
Reconstruction of Trailer Side Underride Analysis	*01*
Behavior Description Interview Training	*99, 05*
Hazardous Material on the Job Training	*99*
Structural Integrity of New and Aging Metallic Aircraft	*99*
Computer Based Modeling for Design Analysis with MSC/NASTRAN	*99*
Hands on Fiber Optics Sensor Course	*98*
Computer Based Modeling for Design Analysis with MSC/PATRAN	*97*
Fatigue, Fracture Mechanics & Damage Tolerance	*97*

AWARDS & HONORS

Boeing High Potential Team	*04*
Boeing Pre Management Assessment Program	*04*
Boeing Achievement Award, 7E7 CAS	*03*
Employee Appreciation Award, 7E7 Nacelle	*03*
Boeing Future Leaders Program	*03*
Employee Appreciation Award, Boeing Sonic Cruiser	*02*
Employee Appreciation Award, MRB & Liaison	*01*
Employee Appreciation Award, Phantom Works	*01*
Boeing Cash Award, Phantom Works	*01*
ASM Outstanding Technical Presentation	*00*
Employee Appreciation Award, Boeing Test Facilities	*00*
National Science Foundation Graduate Fellowship	*95-97*

Brigham Young University Mechanical Engineering Outstanding Scholar	*92*
Boeing Undergraduate Scholarship	*90-91*
Big Sky Academic / Athletic Top Ten Team	*89*
Sigma Nu Fraternity Scholarship	*89*
Idaho State University Full Academic Scholarship	*88*
Society of Women Engineers Freshman Scholarship	*88*

PROFESSIONAL SOCIETIES

WATAI	*04-present*
Tau Beta Pi (service committee member for 3 years)	*91-present*
Society of Women Engineers (publicity chairman for 3 years)	*88-present*
American Society of Mechanical Engineers	*92-present*
ASM International	*00-present*
Phi Kappa Phi	*92-present*

SERVICE / ACTIVITIES

Jr. USAV Girl's Volleyball Coach	*04-05*
Interlake High School Varsity Volleyball Assistant Coach	*01-02*
USAV Executive Board Adult Representative	*99-00*
USAV Women's Volleyball Coach	*98-00*
Varsity Volleyball (Idaho State University)	*88-90*
LDSSA Student Organization (service committee member)	***88-90***

TECHNICAL SKILLS

Underride crash analysis
Material failure and fracture analysis
Subject matter expert in Structural Health Monitoring and sensor technologies for Boeing
Basic Finite Element Analysis (static and dynamic) using PATRAN and NASTRAN
Mechanical assembly of fiber optic components
Quality control, design of experiments and statistical processes using MINITAB and QFD
UNIX and DOS environment programming with FORTRAN, AutoLISP and RLAB
Designing with CATIA, CADAM, and AutoCAD systems
SEM and XRAY analysis including dark room experience

PRESENTATIONS & PUBLICATIONS

Peer Reviewed Journals

A. Trego, et al, 2003, "A Scientific Approach to Side Underride Analysis," **Advances in Vehicle Aggressivity and Compatibility, Side and Rear Impact and Rollover Protection**, SP-1775, Society of Automotive Engineers, Warrendale, PA, SAE Technical Paper No. 2003-01-0178, pp. 41-47, 2003.

A. Trego et al, 2001, "Axial Passive Damping Testing of Mass Produced Stress Coupled, Co-cured Damped Composites," **AIAA Journal**, Vol. 41, No. 3.

A. Trego and D. Cope, 2001, "Evaluation of DaDT Lap Joint Analysis Tools," **AIAA Journal**, Vol. 39, No. 12, pp. 2250-2254.

A. Trego and P. Eastman, 1999, "Flexural Damping Predictions of Mechanical Elements Designed Using Stress Coupled, Co-cured Damped Fiber Reinforced Composites," **Journal of Advanced Materials**, Vol. 31, No. 1, pp. 7- 17.

A. Trego and P. Eastman, 1997, "Optimization of Passively Damped Composite Structures," **International Journal of Modelling & Simulation**, Vol. 17, No. 4, pp. 284-288.

A. Trego, D. Olcott, and P. Eastman, 1997, "Improved Axial Damping of Mechanical Elements Through the Use of Multiple Layered, Stress Coupled, Co-cured Damped Fiber Reinforced Composites," **Journal of Advanced Materials**, Vol. 28, No. 2, pp. 28-34.

Journals / Papers

A. Trego et al, 2001, "Structural Technology and Analysis Program (STAP) Delivery Order 0004: Durability Patch," **AFRL-VA-WP-TR-2001-3037**.

A. Trego et al, 2001, "Analysis of Side Underride Crashes Misconceptions and the Problems," **Accident Investigation Quarterly**, Issue 27, summer 2001, pp.17-19.

Peer Reviewed Conferences

A. Trego and G. Clark, 2005, "Structural Health Monitoring System: from Collection to Analysis," **International Workshop on Structural Health Monitoring**, San Francisco, CA. September 2005.

A. Trego, et al, 2005, "Development of a Corrosion Diagnostics and Prognostics System," **First World Congress on Corrosion in the Military Cost Reduction Strategies**, Sorrento, Italy. June 2005.

A. Trego, 2004, "Structural Health Monitoring Technology on Commercial Aircraft II," **European Workshop on Structural Health Monitoring**, Munich, Germany. July 2004.

C. Greenberg et al, 2004, "Structural Health Monitoring Technology on Commercial Aircraft," **Seventh International Aerospace Corrosion Control Symposium**, Amsterdam, Holland. April 2004.

A. Trego, 2003, "Installation of the Autonomous Structural Integrity Monitoring System," **International Workshop on Structural Health Monitoring**, San Francisco, CA. September 2003.

A. Akdeniz et al, 2003, "Structural Health Management (SHM) Technology Implementation on Commercial Airplanes," **Sixth Joint DoD/FAA/NASA Conference on Aging Aircraft Proceedings**, New Orleans, LA. September 2003.

A. Trego, 2003, "An Update on Monitoring Moisture Ingression with Fiber Optic Sensors," Sixth Pacific **Northwest Fiber Optic Workshop**, Troutdale, Oregon. May 2003.

A. Trego, 2003, "Monitoring Moisture Ingression with Fiber Optic Sensors," **Sixth International Conference on Sandwich Structures**, Ft. Lauderdale, Florida. March 2003.

J. Elster, et al, 2003, "Flight Demonstration of Fiber Optic Sensors," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Newport Beach, California. March 2003.

A. Trego, and D. Smith, 2002, "Battery Operated Health Monitoring System," **Fifth Joint DoD/FAA/NASA Conference on Aging Aircraft Proceedings**, San Francisco, Ca. September 2002.

D. Banaszak, et al, 2002, "Damage Dosimeter Third Octave and Time History RMS Values," **Joint Statistical Meeting 2002**, New York, NY. August 2002.

D. Banaszak, et al, 2002, "A Quick Look at Flight Data from a Digital Damage Dosimeter," **ESTECH 2002 Environmental Sciences and Technology**, Mount Prospect, IL. May 2002.

A. Trego, R. Keller, 2002, "Fiber Optics in Bonded Repairs," **SAMPE 2002 International Symposium & Exhibition**, Long Beach, CA. May 2002.

E. Haugse, et al, 2001, "Structural Vibration Monitoring for Damped Repair Design," **Third International Workshop on Structural Health Monitoring**, Stanford, Ca, 2001.

A. Trego, et al, 2001, "Optical Fiber-Based Health Monitoring Systems for Composite Structures," **AIAC Australian International Aerospace Congress**, Canberra, ACT, Australia 2001.

J. Elster, et al, 2001, "Optical Fiber-Based Adhesive Bondline Monitoring Systems for Composite Patch Systems," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Newport Beach California. March 2001.

J. Elster, M. Jones, P. Tuloa, A. Trego, and I. Perez, 2000, "Corrosion Monitoring in Aging Aircraft Using Optical Fiber-Based Chemical Sensors," **Fourth Joint DoD/FAA/NASA Conference on Aging Aircraft Proceedings**, St. Louis, Missouri, pp. 13-20.

W. Schulz, E. Udd, J. Seim, I. Perez, and A. Trego, 2000, "Progress on Health Monitoring of An Adhesive Joint Using a Multi-Axis Fiber Grating Strain Sensor System," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Vol. 3991-9, Newport Beach California.

E. Udd, et al, 2000, "Use of Transversely Loaded Fiber Grating Strain Sensors for Aerospace Applications," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Vol. 3994-17, Newport Beach California.

E. Udd, et al, 2000, "Multidimensional Strain Field Measurements Using Fiber Optic Grating Sensors," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Vol. 3986-35, Newport Beach California.

W. Schulz, E. Udd, M. Morrell, J. Seim, I. Perez, and A. Trego, 1999, "Health Monitoring of an Adhesive Joint Using a Multi-Axis Fiber Grating Strain Sensor System," **SPIE's International Symposium on Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing Conference Proceedings**, Vol. 3586, Newport Beach California, pp. 41-52.

A. Berens, D. West and A. Trego, 1999, "Risk Assessment of Fatigue Cracks in Corroded Lap Joints," **RTO Applied Vehicle Technology Panel Meeting Proceedings 18: Fatigue in the Presence of Corrosion**, Cedex, France, pp. 21-1 – 21-10.

D. Cope, A. Trego, and D. West, 1999, "Analytical Framework for Assessment of Corrosion and Fatigue in Fuselage Lap Joints," **Second Joint NASA/FAA/DoD Conference on Aging Aircraft Proceedings NASA/CP-1999-208982/Part1**, Williamsburg, Virginia, pp. 472 – 481.

A. Trego, E. Haugse and E. Udd, 1998, "Material Removal Rate Fiber Optic Corrosion Sensor," **Fourth Pacific Northwest Fiber Optic Sensor Workshop Proceedings of SPIE**, Vol. 3489, Troutdale, Oregon, pp. 105-109.

A. Trego, et al, 1998, "Analytical Methodology for Assessing Corrosion and Fatigue in Fuselage Lap Joints," **1998 Air Force Corrosion Program Conference Proceedings**, Macon, Georgia.

A. Trego, P. Eastman, W. Pratt, and C. Jensen, 1995, "Reduced Boring Bar Vibrations Using Damped Composite Structures," **Proceedings of the 1995 Design Engineering Technical Conferences**, Vol. 3, Part A, pp. 305-311.

A. Trego, P. Eastman, and C. Jensen, 1995, "Optimization of Passively Damped Composite Structures," **Proceedings of the IASTED International Conference on Applied Modelling, Simulation and Optimization**, pp. 137-141.

Presentations

A. Trego, 2006, "Reach, Reflect & Redefine," **SWE Regional Conference,** Salt Lake City, Utah.

A. Trego, 2004, "Structural Health Management: An Overview of Current Research Efforts at Boeing," **ASM Aeromat Conference,** Seattle, Washington.

K. Cooper, et al, 2004, "Fiber Optic Sensor System for Aircraft Health Monitoring," **ASM Aeromat Conference,** Seattle, Washington.

A. Trego, 2004, "Autonomous Structural Integrity Monitoring System for Environmental Conditions," **CPAC Conference,** Seattle, Washington. Invited Presentation.

A. Trego, 2004, "Autonomous Structural Integrity Monitoring System for Environmental Conditions," **CHTE Conference,** Seattle, Washington.

A. Trego, 2003, "Autonomous Structural Integrity Monitoring System," **DASCON Conference,** Seattle, Washington.

R. Ikegami, A. Trego, 2002, "Battery Operated Health Monitoring System," **DASCON Conference,** St. Louis, Missouri.

R. Ikegami, E. Haugse, and A. Trego, 2001, "Structural Monitoring for Damped Composite Repairs," **ASM Aeromat Conference,** Long Beach, California.

A. Trego and T. Leeks, 2000, "Damage Detection Techniques Through The Use Of Acoustic Emissions," **ASM Aeromat Conference,** Seattle, Washington. **Outstanding Technical Presentation Award.**

R. Ikegami and A. Trego, 2000, "Structural Health Management: An Overview of Current Research Efforts at Boeing," **ASM Aeromat Conference,** Seattle, Washington.

E. Udd, W. Schulz, J. Seim, I. Perez, A. Trego, E. Haugse, 2000, "Nondestructive Evaluation of Adhesive Joints Using Advanced Fiber Grating Strain Sensor Technology," **ASM Aeromat Conference,** Seattle, Washington.

A. Trego, 2000, "The Use of Fiber Optic Sensors for Health Monitoring of Bonded Repair Structures," **Fifth Pacific Northwest Fiber Sensor Workshop,** Troutdale, Oregon.

E. Udd, W. Schulz, M. Morrell, J. Seim, I. Perez, A. Trego, 1999, "Structural Health Monitoring of an Adhesive Joint Using a Multi-Axis Fiber Grating Strain Sensor System," **ASM Aeromat Conference,** Dayton, Ohio.

A. Trego, and K. Chase, 1993, "AutoCATS User's Manual," **Association for the Development of Computer Aided Tolerancing Systems (ADCATS)**, Brigham Young University, Provo, Utah.

A. Trego, 1995, "Improved Structural Damping of Mechanical Elements Through the Use of Multiple Layered, Stress Coupled, Co-cured Damped Fiber Reinforced Composites," **SAMPE '95 International SAMPE Symposium & Exhibition**, Anaheim, California. **First place: SAMPE National Student Competition for Ph. D. Division.**

A. Trego, 1993, "Tolerance Analysis," **SAMPE '95 International SAMPE Symposium & Exhibition**, Anaheim, California. **First place: SAMPE National Student Competition for M. S. Division.**

THE UNIVERSITY OF UTAH

Richard B. Brown
Dean of Engineering
1692 Warnock Engineering Building
72 S. Central Campus Drive
Salt Lake City, Utah 84112
PH: (801) 585-7498 FAX: (801) 581-8692
brown@utah.edu
http://www.coe.utah.edu/~brown

May 20, 2008

Dr. Donald S. Bloswick, Ph.D., P.E., CPE
Professor and Director of Graduate Studies
Department of Mechanical Engineering
Director, Ergonomics and Safety Program
Rocky Mountain Center for Occupational and Environmental Health
Department of Family and Preventive Medicine
University of Utah
Salt Lake City, UT 84112

Dear Dr. Bloswick,

I am pleased to provide a letter of support for the College of Engineering Systems Engineering Masters Certificate that you are proposing. There is a great need in the aerospace industry, the military, and in all areas where complex systems are developed, for graduates who have been educated about reliability, quality, logistics, operations research, and other topics that are part of the systems engineering curriculum. Because of the recognized shortage of engineers with this background, opportunities for students who pursue this certificate will be many.

Systems engineers view systems holistically, considering the interactions of the constituent parts, the user's requirements, economic factors such as risk, environmental impacts, and life cycle issues. As engineered systems have become more complex, the need for such a view of engineering design and development has become ever more important.

I am especially happy that your proposal is inclusive of all of the engineering disciplines, as all of them have needs and opportunities in systems engineering. I support the concept of having a common core of requirements, complemented by relevant courses in the specific area of a student's study. The curriculum is flexible, allowing a student to focus on Systems Engineering Management, Product Engineering Design, Manufacturing and Process Systems Design, or Systems Optimization. Each certificate recipient will fulfill the requirements of their own department's program, and will be able to satisfy the system engineering core and option requirements for one of the four emphasis areas through judicious use of their Masters Degree elective courses and/or by taking other courses.

This certificate is an excellent example of collaboration with local industry to enrich our program. We are very fortunate to have in the area leading industrial systems engineers with Ph.D.s who are willing to teach for us as adjunct faculty members, bringing a perspective that we could not otherwise provide. The establishment of an advisory committee made up of industrial leaders who hire systems engineers will provide the needed feedback to make the program excellent.

I strongly encourage all who review this certificate program to support it as I do.

Best regards,

Richard B. Brown

THE UNIVERSITY OF UTAH

Kent Stewart Udell, Ph.D.
Professor and Chair

Department of Mechanical of Engineering

50 S. Central Campus Dr Rm 2110 MEB Salt Lake City, Utah 84112 Phone (801) 581-6441 Fax (801) 585-9826 www.mech.utah.edu

July 18, 2008

Professor Don Bloswick
Department of Mechanical Engineering
College of Engineering
University of Utah
Salt Lake City, UT 84112

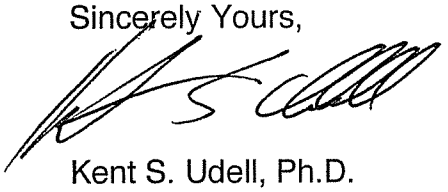
Re: "Systems Engineering Certificate"

Dear Don,

I fully support the establishment of a graduate certificate program in "Systems Engineering". This cross-disciplinary program will meld traditional engineering approaches with higher-level analyses of issues such as reliability, sustainability, and safety. With the increasing complexity of our engineered products, a more focused advanced training in systems engineering will be of benefit to all of our graduate students. However, the existence of a certificate in Systems Engineering will attract new graduate students to our programs who would not have enrolled and will allow us to better serve the engineering community by the production of graduates with valuable, "certified", systems engineering knowledge.

Further, this program will bring graduate students from various engineering disciplines together in classes where they can see overlaps between disciplines and learn how to integrate ideas from other engineering disciplines into their own field of expertise. If approved, this certificate program will be of great value to students, faculty research, and industry. Thus, the department has voted unanimously to support the proposed certificate in systems engineering as I do.

Sincerely Yours,



Kent S. Udell, Ph.D.
Professor and Chair, Mechanical Engineering

THE UNIVERSITY OF UTAH

Department of Civil & Environmental Engineering

MEMORANDUM

Date: July 16, 2008

To: Don Bloswick

From: Paul J. Tikalsky, PhD, PE, FACI
Chair & Professor of Civil and Environmental Engineering

RE: Endorsement of Graduate Certificate Systems Engineering

The Department of Civil and Environmental Engineering has considered the proposal from Professor D. Bloswick for a graduate certificate in Systems Engineering. The plan was discussed by the CvEEN faculty and reviewed in detail by several designated faculty. The faculty has strongly encourages the adoption of the new certificate program in Systems Engineering. The program will meet a growing need to develop leaders with a more comprehensive view of engineered systems. It is anticipated that 5-10 CvEEN graduate students would pursue this certificate in any given year.

122 South Central Campus Drive, Suite 104
Salt Lake City, Utah 84112-0561
(801) 581-6931
Fax (801) 585-5477

THE UNIVERSITY OF UTAH

July 9, 2008

Dr. Don Bloswick
Department of Mechanical Engineering
College of Engineering
University of Utah
Salt Lake City, UT 84112

Re: "Systems Engineering Certificate"

Dear Don,

I am pleased to support your initiative to establish a graduate certificate program in "Systems Engineering". This is a very important interdisciplinary area that is underrepresented nationally and currently non-existent at the University of Utah. Industry has a need for these graduates and I am confident that the certificate will enhance the marketability of our graduates. The proposed structure is suitable for Biengineering students, especially those that have an interest in systems engineering in medical product industries.

Sincerely,

Richard D. Rabbitt, Ph.D.
Prof. and Chair, Bioengineering

Department of Bioengineering
72 South Central Campus Drive, Rm. 2646
Salt Lake City, UT 84112-9202
(801) 581-8528 Fax: (801) 585-5361

Richard D. Rabbitt
Office: (801) 581-6968
Lab: (801) 581-4549
Email: r.rabbitt@utah.edu

THE UNIVERSITY OF UTAH

2008 May 13

Prof. Don Bloswick
Department of Mechanical Engineering
University of Utah

Dear Don:

The Department of Chemical Engineering supports your proposal to establish a Graduate Certificate in Systems Engineering in the College of Engineering at the University of Utah. I understand that the certificate program has been requested by and is being supported by ATK Launch Systems. Chemical Engineering has roughly 20 non-thesis MS candidates from ATK in our graduate program and is glad that the College is working to improve their educational options.

Systems concepts are central to chemical engineering, particularly in plant design, process integration, process control, energy engineering, and environmental engineering. I am pleased to see that two chemical engineering courses are listed in your proposal. Chemical Engineering looks forward to working with the College to ensure the success of the Graduate Certificate.

Sincerely,

Geoffrey D. Silcox

Geoffrey D. Silcox
Professor (Lecturer) and Associate Chair

cc: JoAnn Lighty

Department of Chemical Engineering
50 S. Central Campus Dr., Rm. 3290
Salt Lake City, Utah 84112
(801) 581-6915

THE UNIVERSITY OF UTAH

Department of Electrical and Computer Engineering

50 South Central Campus Drive Room 3280 Salt Lake City, UT 84112-9206 (801) 581-6941 FAX (801) 581-5281

May 16, 2008

To whom it may concern:

I am writing this letter to express the strong support of the Department of Electrical and Computer Engineering for the proposal from Professor D. Bloswick for a graduate certificate in Systems Engineering. The plan was discussed by the ECE faculty, who felt that our students would benefit very much both from the new courses to be created and from the overall certificate program.

Sincerely,

Marc Bodson

Marc Bodson
Professor and Department Chair
Phone: (801) 581 8590
Email: bodson@ece.utah.edu
Web: www.ece.utah.edu/~bodson

Subject: Re: Engineering Systems Certificate Letters of Support
Date: Thursday, September 4, 2008 6:50 PM
From: Martin Berzins <mb@cs.utah.edu>
To: Don Bloswick <bloswick@eng.utah.edu>
Cc: Martin Berzins <mb@sci.utah.edu>
Conversation: Engineering Systems Certificate Letters of Support

Hi Don,

We are not involved in this but are supportive of course.

Martin

Please reply to mb@cs.utah.edu

On Fri, 29 Aug 2008, Don Bloswick wrote:

> Date: Fri, 29 Aug 2008 16:03:52 -0600
> From: Don Bloswick <bloswick@eng.utah.edu>
> To: Paul Tikalsky <p.tikalsky@utah.edu>, Kent Udell <udell@mech.utah.edu>,
>   Martin Berzins <mb@sci.utah.edu>, Bodson <bodson@ece.utah.edu>,
>   JoAnn Lighty <jlighty@utah.edu>, Rick Rabbitt <rabbitt@eng.utah.edu>,
>   rlevey@egi.utah.edu, Peter T. Martin <Peter@trafficlab.utah.edu>
> Subject: Re: Engineering Systems Certificate Letters of Support
>
> 29 August 2008
>
> Just missing two letters...thanks...Don
>
>
> xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
>
> 13 August 2008
>
> Department Chairs:
>
> I have now received the letters of support for the Systems Engineering
> Certificate from ECE, Chem. Eng., CvEEN, BIOEN and the Dean's Office. These
> are attached as examples. I've also attached the proposal and proposal
> appendices.
>
> I am on Sabbatical Leave Autumn semester and will be gone all of September.
> If I receive letters of support from MSE, ME and SOC by 25 August, I will be
> able to compile the package and send it forward.
>
> As noted below, I don't feel comfortable sending a proposal forward until
> all CoE departments are officially on board.
>
> Thanks....Don
>
>
> xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
>
> 16 July 2008
>
> Department Chairs:
>
> I have now received the letters of support from ECE, Chem. Eng., CvEEN,

Subject: ATK Launch Systems is pleased to provide support for the University of Utah College of Engineering System Engineering Certificate program.doc
Date: Tuesday, September 2, 2008 10:56 AM
From: Riemer, David <David.Riemer@atk.com>
To: Don Bloswick <bloswick@eng.utah.edu>
Cc: "Goldberg, Benjamin" <Benjamin.Goldberg@atk.com>
Conversation: ATK Launch Systems is pleased to provide support for the University of Utah College of Engineering System Engineering Certificate program.doc

Don

This is the draft support letter I sent. I didn't address to anyone as I didn't know the audience.

If this needs any improvements please let me know.

David

ATK Launch Systems is pleased to provide support for the University of Utah College of Engineering System Engineering Certificate program. ATK has been a key member of the team driving the creation of this important certificate. The need for systems engineers is one of the most acute in our business. This need limits our ability to grow our business in Utah and the creation of this certificate is an essential element in our ability to fill this need.

ATK's commitment to the success of the Systems Engineering Certificate program is demonstrated in our providing the initial Systems Engineering Course instructor at ATK expense. ATK has supported the development of the certificate course requirements and has provided support to the development of the course syllabus and material. We are committed to support the program with instructors as the university builds its system engineering capability.

ATK currently has a significant number of employees enrolled in the initial systems engineering course and will be providing financial incentives, in addition to tuition reimbursement, to employees who complete the certificate. ATK expects employees who are enrolling in a Masters Engineering degree to pursue the Systems Engineering Certificate and for employees who have recently received their Masters degree to pursue the certificate on a stand-alone basis.

ATK supports and is committed to making systems engineering an integral part of the College of Engineering at the University of Utah.

David H. Riemer
Vice President
Science and Engineering
ATK Launch Systems

ENCLOSURE 4
LETTERS OF SUPPORT FROM CoE DEAN AND DEPARTMENT CHAIRS