BUSKERUD University College

in cooperation with

STEVENS Institute of Technology

Master Systems Engineering

THIS MASTER PROGRAM CAN BE FOLLOWED INTEGRAL TO OBTAIN A MASTER DEGREE IN SYSTEMS ENGINEERING OR PARTS CAN BE FOLLOWED AS PROFESSIONAL DEVELOPMENT PROGRAM.

Systems Engineering

Today's projects often hit delays and cost overruns late during the development project. Worse is that the system doesn't meet customer's expectation when introduced in the market. The combination of increased functionality and performance, large development crews and ever shortening project durations turns the development of systems into a challenging endeavor. The field of Systems Engeering addresses thes causes of these problems throughout the development life cycle. Systems Engineering provides methods and techniques to:

* integrate design work across disciplinary and organizational boundaries
* communicate with stakeholders and capture the results
* understand the customer needs and context
* understand the system life cycle
* explore future needs and technology developments
* anticipate where necessary
* identify and mitigate risks
* write explicit and to the point specifications and designs

Some real life scenarios:

Scenario: *Crisis during system integration*After several years of work the project stumbles from crisis into crisis, causing delays and budget overruns. The interconnected parts of the system don't function properly, performance is poor and the overall system is unstable. This situation typically happens when little to no systems architecting took place earlier in the project. The system architect has to start as troubleshooter and do damage containment. After this stressful period the architect and the team hopefully have learned enough to do more proper architecting for the next system. They may even have been able to identify refactoring opportunities to bolster the system.

Scenario: *Broad product portfolio where synergy should be harvested.*This is a very common situation. The development organization is active with multiple product lines on the market. The history of individual product lines has resulted in divergence, where from the broader perspective synergy is expected. How do you migrate to a situation where synergy between systems can be harvested? How do you juggle variation to harvest synergy? What are the threats and pitfalls of increased synergy?

6 mandatory courses

- **SDOE 625/SEFS**Fundamentals of Systems Engineering
- **SDOE 650/SEDS System Architecture & Design**
- **SDOE 612/SEPM Project Management of Complex Systems**
- **SDOE 605/SESI**System Integration
- **SERP Reflective Practice**
- **SDOE 800/SETH Master Project**

and 4 elective courses

- **SDOE 640/SESL System Supportability and Logistics**
- **SDOE 684/SEST**Systems Thinking
- **SDOE 680, SYS681, SDOE645, SDOE 678, SDOE 660**
- **SEMA** System Modelling & Analysis
- **SESA** Advanced System Architecting
- **SEPD** Product Design
- **SECE** Control/Signal Engineering
- **SERE** Robust Engineering
- **Control Engineering, Product design, Embedded Systems courses**

REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
tel 3286 9500 www.hibu.no

Stevens Institute of Technology
Hoboken, NJ, USA

Systems Engineering
Høgskolen i Buskerud
Postboks 235
3603 Kongsberg, Norway

BUSKERUD University College

in cooperation with

STEVENS Institute of Technology

Master Systems Engineering

Program Objectives

Objective of the program is to provide broad theory and practice of systems engineering.

Program Content

* stakeholders and concerns

* life cycle

* requirements elicitation and management

* system architecture and design

* functional, physical, dynamic, object modeling

* use cases

* systems engineering processes

* program and project phasing

* review

* project management

* systems integration and management

* leaderhip

* and a choice of electives related to systems engineering itself or control engineering, embedded systems or product design

Theory, Practical Experience, and Reflection

Systems Engineering is a field with a broad Body of Knowledge. However, many years of experience are required to become an effective systems engineer. This program provides theory and within the constraints of time practice. The program emphasizes reflection to learn effective and to link theory and practice.

SESA6201

Advanced Systems Architecting

BUSKERUD University College

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

Module Description and Objectives

System architects play an integrating role between many specialized engineers and other stakeholders during the creation of new systems. The role of system architect requires a broad set of skills. How do you cope with conflicting needs, opinions, and interests? How do you lead the design team effectively? How do you balance innovation and risk mitigation, installed base and new systems, short term and long term? How do you share vision and make pragmatic choices at the same time?

Let's look at some real life scenarios:

Scenario: The stovepipe organization. The R&D organization is decomposed in functional disciplines. System architects are perceived as free agents without responsibilities, doing the fun work. They meddle with ongoing engineering work and limit the autonomy of the discipline. The challenge for system architects in such organization is to transform from being a threat into becoming someone who brings value.

Scenario: Crisis during system integration. After several years of work the project stumbles from crisis into crisis, causing delays and budget overruns. The interconnected parts of the system don't function properly, performance is poor and the overall system is unstable. This situation typically happens when little to no systems architecting took place earlier in the project. The system architect has to start as troubleshooter and do damage containment. After this stressful period the architect and the team hopefully have learned enough to do more proper architecting for the next system. They may even have been able to identify refactoring opportunities to bolster the system.

Scenario: Broad product portfolio where synergy should be harvested. This is a very common situation. The development organization is active with multiple product lines on the market. The history of individual product lines has resulted in divergence, where from the broader perspective synergy is expected. How do you migrate to a situation where synergy between systems can be harvested? How do you juggle variation to harvest synergy? What are the threats and pitfalls of increased synergy?

Scenario: The brilliant but invisible architect. Designers and architects tend to be introverted people who dislike socio-political situations. Quite naturally they hide themselves in the safe world of design. Communication with management is quite limited. This poor relationship degrades the decision making process. Architects need to train their communication and presentation skills, especially towards the less technical managers. How does a system architect communicate complex topics to managers who may fail to grasp the nuances?

Lecturer:

prof. Gerrit Muller

Systems Engineering
Høgskolen i Buskerud
Postboks 235, 3603 Kongsberg

Day 1 session 1	**Process and Organization.** How does systems architecting fit in the organization and its processes ?
session 2	**Role and Task.** What are deliverables, responsibilities and activities of the system architect?
Day 2 session 3	**Requirements Engineering.** How to elicit requirements? Coping with tension between formal and management and practical use.
session 4	**System Architect Toolkit.** What methods, tools and techniques are available for the architect? A.o. CAFCR model, story telling
Day 3 session 5	**Roadmapping.** How to anticipate on future needs, trends, and changes?
session 6	**Product Families.** How to harvest synergy? How to create and deploy common platforms?
Day 4 session 7	**Supporting Processes.** How to structure and manage documentation?
session 8	**Role of Software.** What is the role of software in complex systems?
session 9	**Board of Management.** How to present to less technical management teams?
Day 5 session 10	**Human Factors.** What human factors impact systems architecting?
session 11	**Follow-up.** How to apply this material in the own organization, short term and long term.

MODULE ORGANIZATION
This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of Systems Architetcing. A project assignment allows participants to integrate and apply their knowledge.

MODULE REGISTRATION & INFORMATION
For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
tel 3286 9500 www.hibu.no

Course Objectives

Objective of the course is to teach system engineers and architects methods and techniques function effectively in multi-disciplinary design environments with lots of stakeholders.

After this course students will:

* understand how the architecting process fits in the much broader set of company processes

* understand the priorities of company processes and their mutual relationships

* know their deliverables and responsibilities

* have insight in the multitude of activities and the need to balance them by time management

* elicit requirements from different perspectives

* understand the tension between formal requirements management and the actual use of requirements

* have seen a collection of system architecting methods and techniques, such as CAFCR and story telling

* be able to analyze create and asses stories

* be able to structure a roadmap and facilitate a roadmapping process

* understand synergy approaches, such as platforms, product families, common components, or re-use, with their advantages and disadvantages

* be able to manage expectation level of different stakeholders

* understand the role of software in systems

* be able to structure documentation modular, maintainable, and manageable

* be able to present architectural issues to less technical management teams

* have insight in the many psychological, social, political and cultural aspects that have impact on systems architecting

Educational objectives:

* teach system engineers and system architects how to interact with many stakeholders and how to fit their work in the company processes

* teach them to understand the complexity of this task in relation with the broader context of customers, life cycle, and organization

* provide them with an mental framework for the role and task

* provide them with an overview of methods, knowledge, techniques, and methods to be applied in their daily job

Course duration and format

The course takes 5 full days. Participants taking the course for credits have to do a 10 week project afterwards. During the course participants work on real-life cases, preferably from their own domain. About half of the exercises are being done in randomly mixed teams on prescribed cases. Theory and exercises alternate continuously. Theory is ample illustrated with examples from practice.

The exercises provide even more value when multiple participants from the same company participate. We recommend to send a small team to the course, if possible.

BUSKERUD University College

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STEVENS Institute of Technology

SDOE 605
SESI

SYSTEMS INTEGRATION

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

This course is designed to provide the participants with an understanding of the scope of systems integration (SI), different SI approaches to design, architect, implement, and test integrated systems, tools and techniques to measure the successful implementation of SI and best practices. The objective of the course is to provide the students an understanding of the technical and business process issues involved in systems integration.

Our end-to-end approach focuses on how integration issues can be addressed up-front to minimize integration related complexities and challenges later on in the system engineering process. The SI activities have to be directed towards the design and architecture of systems that are easy to integrate or in other words "integration-friendly" or "integrationready" (ready to be integrated) systems. Therefore, the challenge is to understand the impact of system design and architecture on integration complexity. The focus of our approach is on pre-empting integration issues upfront in the process. Identifying the best practices that will ensure this upfront focus is the challenge that projects need to manage.

The students will appreciate the role of system architecture and design in influencing system integration complexity, theory and practice of business process integration, legacy integration, new systems integration, COTS integration, application integration, architecture integration, and integrated program management. Specific focus will be given to issues of interoperability, openness, interface control and management, verification and validation, system testability, and the final acceptance of the system.

MODULE ORGANIZATION

This modular course combines lectures, readings, case studies, and inclass exercises to develop an understanding of the systems integration concepts. Lastly, the team project on a failed or successful system integration project allows participants to apply and integrate their knowledge in a team environment.

MODULE AUDIENCE

This modular course would be of interest to systems integrators, systems engineers, systems designers and architects, program and project managers, and test planners and managers. People who are involved in any aspect of systems integration and testing would find the module useful.

COURSEWARE

Participants receive a binder containing course notes and additional readings specifically organized for this course.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
tel 3286 9500 www.hibu.no

Day 1 session 1	**Overview –** course content, teaching methodology, guidelines for exams, final project and grading. The concept of systems integration will be introduced with the discussion on definitions, scope, and approaches
session 2 & 3	**System Integration (SI) Process, Issues, and Planning –** Understand the concept, approaches, strategies, planning, and drivers for systems integration. Topics covered will include: SI Planning, A Comprehensive View on SI, Drivers for SI, Impact of Complexity, Flexibility, Modularity on SI, Attributes of Operationally Integrated Systems, Integrating Existing vs. New Systems: Legacy Systems Integration, Problems Posed by Legacy Systems, Rationale for Legacy Integration, and Strategies for Legacy Integration. Boeing 777 – Systems Integration Case Study
Day 2 session 4	**Impacting SI through Architecture and Design –** Understand the role of system requirements, architecture, and technology maturity selection in SI in order to increase the odds of an efficient and successful integration, verification and validation. Provide tools to aid the system engineer to assess the goodness of requirements, architecture, technology maturity selection, and risk assessment & mitigation.
session 5	**System Integration Maturity –**Understand the impact of system integration activities and their maturity level on system integration complexity (Technical, Programmatic, Configuration, Operational, and Organizational), system integration readiness, and system operational effectiveness. Provide tools and best practices to aid the system engineer to assess the maturity of SI activities, their impact on SI readiness and operational effectiveness, and risk assessment & mitigation.
Day 3 session 6	**System Verification –**Understand the objectives, process, activities, methods, and approaches of verification. Challenges and Issues.
session 7	**System Validation –**Understand the objectives, process, activities, methods, and approaches of validation. Discussion on Conceptual Validity, Requirements Validity, Design Validity, Operational Validity, Acceptability.
Day 4 session 8	**Interface Control and Management –**Understand the role of interface control and management in SI. Definition, assessment, and documentation of interfaces, Interface Control Documents (ICDs), Key Components of Interface Control, Interface Management, Interface Architecture, System Interface Agreement, and Interface Definition Language (IDL) and Technologies.
session 9	**Commercial-off-the-shelf Products Integration –** Understand the issues related to integrating COTS products, the uniqueness of such issues, factors affecting COTS integration, benefits of COTS, pitfalls of COTS, Critical Success Factors, and challenges.
Day 5 session 10	**System Integration Final Project Presentations;** Takehome Final Exam; Session Evaluation and Conclusion.

Systems Engineering
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SYSTEMS INTEGRATION

Overview

Systems Integration introduces students to the principles and processes of integration, test, verification and validation within the systems engineering discipline. The course enables them to more effectively integrate and prove-in solutions that meet system requirements and customer needs. The course centers on a group project that students pursue in small teams. Systems Integration provides students with disciplined approaches for 1) performing early validation of a solution to meet a customer or stakeholder need, 2) factoring integration and test issues into the system requirements and architecture, 3) identifying and selecting among alternative means to integrate and test, 4) identifying comprehensive test cases, 5) performing fault diagnosis, 6) verifying systems, 7) validating systems, and 8) managing integration and test. The focus is on extending the model-based approaches for integration, verification and validation that are introduced in the courses on Fundamentals of Systems Engineering and Systems Architecture and Design. The course also emphasizes the importance of systems engineering the integration and test environment used to build and prove-in the system being developed. The intent is not just to describe the systems integration, testing, verification and validation process. Rather, the course helps students understand how to think through the choices at each step of the process. What decisions have to be made? What factors should be considered in making them? It is the answers to these questions that make for good systems integration, not just adherence to a standard process. The primary objective of this course is for the student to leave with a strong foundation in systems integration principles and processes.

Course Objectives

After taking this course, the student will be able to:

• Understand the up-front need to factor in the integration, test, verification and validation of a system in determining the system requirements and architecture.

• Review and evaluate the various system integration, test, verification, and validation models in use today.

• Understand the criticality of defining, documenting and managing interfaces during system development.

• System engineer and architect the integration and test environment.

• Select suitable test methods, techniques, and metrics.

• Apply fault diagnosis techniques.

• Adopt a systems perspective when making integration and test decisions that affect the determination of performance, development time, or total ownership cost of the system.

BUSKERUD University College

in cooperation with

STEVENS Institute of Technology

SDOE 612 SEPM

PROJECT MANAGAMENT OF COMPLEX SYSTEMS

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

A project is a temporary endeavor undertaken to create a unique product or service. Project Management is the application of knowledge, skills, tools, and techniques accomplished through five linked processes for initiating, planning, executing, controlling, and closing work to meet a set of defined requirements. This project based module exposes students to tools and methodologies useful for the effective management of systems engineering and engineering management projects. This course presents the tools and techniques for project definition, work breakdown, estimating, resource planning, critical path development, scheduling, project monitoring and control, and scope management. Reinforcing these fundamentals in project management, the course will introduce advanced concepts in project management, and establish the building blocks for the management of complex systems.

MODULE ORGANIZATION

This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of project management concepts and principles for complex systems. A project assignment allows participants to integrate and apply their knowledge.

MODULE AUDIENCE

This modular course would be of interest to systems engineers, project managers, integrated product team members, business managers, and contract administrators. People who are involved with any aspect of system and business analysis, design and development, mission capability and business process definition and architecting, and test and verification will find this module to be useful.

COURSEWARE

Participants receive a binder containing notes specifically developed for this course and additional readings. A textbook will also be used to convey the concepts discussed.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
tel 3286 9500 www.hibu.no

Day 1

session 1	**Executive Overview -**Defining Project and Program Management; Benefits and Obstacles of Project Management; Basic Concepts of Project Management; Defining Roles of Leadership in a Project; Exploring the Definition of Complex Systems
session 2	**Bounding Project Scope**- Creating the Project Charter; Project Classification Frameworks
session 3	**Leading and Managing the Project Team**- Difference Between Management and Leadership; Power and the Influencing of Behavior; Situational Aspect of Leadership Styles and Follower Readiness; Team-Building and Conflict Resolution Techniques; Successful Motivation Practices; Effective Leader Communications
Day 2	
session 4	**Work Breakdown and Organizational Structures**- Work Breakdown Structure; Organizational Structures; Selecting the Organizational Form; Selecting the Project Manager; Building the Project Team; Complex Systems: Organizational Issues
session 5	**Task Planning** - Introduction to Estimation; Time Estimates; Equipment Driven Activities; Labor-Driven Activities; Software Estimates
session 6	**Project Network Modeling**- Introduction to Networks; Creating the Network; Determining the Critical Path; Gantt Charts; Fast-Tracking The Project Schedule
Day 3	
session 7	**Project Management Software**- MS Project and Other Software Packages; Gantt Charts; MS Project Tutorial
session 8	**Resource Leveling and Project Budget**- Resource Leveling; Generating a Project Budget; Management Reserve/Contingency Funds; Budget Estimation Tips
Day 4	
session 9	**Project Control** - Elements of Project Control; Earned Value Analysis; Change Control and Configuration Management
session 10	**Project Quality Management**- Project Metrics; Calculate Performance Metrics; Quality Control; Quality Assurance
session 11	**Contracting and Sub-contracting**- The PM's role for supplier and subcontractor management
session 12	**Risk Management** - Risk Management Process; Identifying Risks; Qualitative and Quantitative Techniques; Risk Mitigation
Day 5	
session 13	**Evaluating, Directing, and Closing Out a Project**- Independent Assessments; Project Closeout; Lessons Learned
session 14	**Business Ethics** - The importance of ethics in the PM profession

Systems Engineering
Høgskolen i Buskerud
Postboks 235, 3603 Kongsberg

Course Objectives

After completion of the course the students will:

* Gain an understanding of program complexity, attributes of complexity, how complexity may change the way we manage programs

* Gain understanding in project leadership, learn situational leadership techniques, leading teams vs leading individuals, understand critical roles within a team

* Understand the importance of sound project planning for program success

* Understand sound sub-contract management practices, what are common mistakes, risks associated with sub-contracting

* Gain understanding in risk management techniques, quantification of risk, offsetting program risks with program opportunities

* Understand the importance of the Quality System, explore lean techniques and use across the program life cycle

* Be able to understand business ethics within context of PM

* Understand the importance of the WBS as the most important planning artifact

* Be able to build a WBS and perform activity/task estimations

* Understand critical path, critical path analysis and be able to create a network schedule

* Understand when and how to crash a program, understand when and how to fast-track a program

* Understand Earned Value Management, become familiar with project control techniques

BUSKERUD University College

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STEVENS Institute of Technology

SDOE 625 SEFS

FUNDAMENTALS OF SYSTEMS ENGINEERING

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

This module presents the fundamental principles and processes for designing effective systems, including how to determine customer needs, how to distinguish between needs and solutions, and how to translate customer requirements into design specifications. The focus is on designing systems that not only provide the required capabilities, but that are reliable, supportable and maintainable throughout their lifecycle. The course concludes with a Systems Requirements Review (SRR) in which students present their class projects.

MODULE ORGANIZATION

The course combines lectures and readings to develop an understanding of key systems engineering concepts and principles. Participants are exposed to numerous case studies and illustrative examples. A team project allows students to integrate their knowledge and apply it in a team environment. The course is designed to facilitate the sharing of experiences among the professionals who participate in the program.

MODULE AUDIENCE

This module addresses systems engineering fundamentals from the perspective of integrators, acquirers and users of complex systems. It not only serves as an essential introduction for systems engineers, architects and analysts, but is also of interest to design engineers, project managers and program managers who must work closely with them to ensure that effective systems are realized.

COURSEWARE

Participants will receive a binder containing notes and additional readings specifically organized for this course, along with systems engineering related textbooks.

Day 1

session 1 — **Course Overview; Business Drivers for Systems Engineering -** Technology, business, and organizational trends that are increasing system complexity and the importance of system integrators; benefits of a disciplined systems engineering process.

session 2 — **Overview of the Systems Engineering Process** – Definition of systems engineering as a process that transforms a functional need into a complete set of system specifications; introduction of the inclass project.

Day 2

session 3 — **Stakeholder Requirements and System Concepts** – Active and passive stakeholders, voice of the customer, acceptance criteria and techniques for systematically evaluating and selecting from alternative concepts.

session 4 — **System Capabilities and Characteristics** – System scope, context diagrams, use case scenarios, checklists, input/ output matrices and Quality Function Deployment.

Day 3

session 5 — **Completing the System Requirements** – Integrating the desired characteristics and capabilities into well-written requirements that are suitable for detailed design; using a requirements management tool (CORE).

session 6 — **Developing a Functional Architecture** – The nature of functions in systems engineering, the distinction between a function and the physical component it is allocated to, functional decomposition and use of a functional modeling tool.

Day 4

session 7 — **Fundamentals of Life Cycle Analysis** – The concept of operational effectiveness, introduction to supportability engineering processes, and integrating life-cycle considerations into the system design process.

session 8 — **Risk Management and Other Program Issues** – Risk as an integral component of technical, cost and schedule performance, risk management and mitigation, and the relationship between systems engineering and program and project management.

Day 5

session 9 — **Systems Requirements Review (SRR)** – Presentations by each project team of a modified SRR for their class project.

session 10 — **Course Evaluation and Wrap-up**

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
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Systems Engineering
Høgskolen i Buskerud
Postboks 235, 3603 Kongsberg

in cooperation with

SDOE 625
SEFS

FUNDAMENTALS OF SYSTEMS ENGINEERING

Overview

Fundamentals of Systems Engineering course introduces students to the principles and processes of systems engineering. The course enables them to more effectively design solutions that meet customer needs. The course centers on a group project that students pursue in small teams. Fundamentals of Systems Engineering provides students with a disciplined approach for identifying a customer or stakeholder need and translating that need into a complete set of requirements or specifications for a system that meets the need. The focus is on developing an outside-in view that treats the system as a black box, without regard to the components from which it will be built. The course emphasizes the distinction between an operational need and a system solution, and stresses the importance of understanding the customer need before jumping to a solution. The intent is not just to describe the systems engineering and architecting process. Rather, the course helps students understand how to think through the choices at each step of the process. What decisions have to be made? What factors should be considered in making them? It is the answers to these questions that make for good systems engineering, not just adherence to a standard process. The primary objective of this course is for the student to leave with a strong foundation in systems engineering principles and processes.

Course Objectives

After taking this course, the student will be able to:

- Understand the need for good systems engineering up front and throughout the life cycle of the system.
- Review and evaluate the various systems engineering models in use today.
- Differentiate between the operational need and the system solution to be implemented.
- Select from a wide range of system concepts as the first step in system design.
- Derive quantitative system requirements that best meet the functions and performance requirements of the system.
- Adopt a systems perspective when making decisions that affect performance or total ownership cost of the system.

BUSKERUD University College

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SDOE640
SESL 6201

SYSTEM SUPPORTABILITY & LOGISTICS

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

This module addresses the development and optimized allocation and location of the numerous elements of system logistics support to ensure that a system satisfies its business and operational readiness requirements and effectiveness. Particular focus is placed on the concept of integrated supply chain and demand management, and the optimization and allocation of a system's logistics resources to ensure maximum availability at the lowest investment in logistics resources. Participants will also be introduced to the latest thinking and technologies with regard to system training, documentation, inventory management, and transportation.

MODULE ORGANIZATION

This module combines lectures and readings to develop an understanding of system supportability and logistics, and its impact on system operational effectiveness. Guest speakers and practitioners from industry will provide participants with illustrative examples and case studies.

MODULE AUDIENCE

This modular course would be of interest to systems engineers, logistics engineers and analysts, and program and project managers, particularly if they are focused on the sustainment of complex systems and value chain enterprises.

COURSEWARE

Participants are provided with a binder containing course notes and additional readings specifically developed and organized for this course.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
tel 3286 9500 www.hibu.no

Day 1	session 1	**INTRODUCTION TO SYSTEM SUPPORTABILITY & LOGISTICS -** Introduction to Basic Concepts; Design the Support & Support the Design; Systems Engineering & Supportability: Current Trends in System Development; Measures of Logistic Support; Summary of 640
	session 2	**INTRODUCTION TO SUPPLY CHAINS -**Introduction; Supply Chain Management; Supply Chain Process; Supply Chain Costs; Supply Chain Challenges; Supply Chain Cost Drivers; Total Logistics Costs; Examples of Supply Chains; Logistics Management
Day 2	session 3	**DETERMINISTIC AND PROBABILISTIC MODELS -**The role of Probability and Statistics; Populations & Samples; Types of Data; Representation of Data; Probability & Probability Distributions; Probability Rules; Probability Distributions; The Normal Distribution; The Lognormal Distribution; The Exponential Distribution;The Weibull Distribution; The Poisson Distribution; Correlation and Regression; Time Series
	session 4	**INVENTORY MANAGEMENT -**Inventory; Introduction to Inventory Management; Basic Inventory Models
Day 3	session 5	**TRANSPORTATION -**Introduction; Cost factors that affect Transportation Decisions; Transportation Modes; Design Options for a Transportation Network; Transportation Routing and Scheduling Models
	session 6	**WAREHOUSING -**Introduction; Warehousing; An introduction to Linear Programming; Optimization
Day 4	session 7	**DOCUMENTATION -**Introduction to Documentation; Design documentation; Technical manuals; Checklists; Database Management
	session 8	**MANPOWER, PERSONNEL & TRAINING-**Introduction to MPT Analysis; Fundamentals of Training; The Training Process; Planning; Course development; Course Conduct; Training Maintenance Personnel
Day 5	session 9	**SUPPLY SUPPORT-**Introduction to Supply Support; Technical Systems and the Support System; Supply Support Costs; Supply Support Metrics; The Cost / Effectiveness Curve
	session 10	**SPARES MODELING -**Description of the Support System; Categorization of Spares; The Basic Sparing Mode; Repairables Spare Parts Optimization; Modeling Cost Investment Repairables (CIR); Alternative problem formulation; Problem Solution: Convexity and Marginal Allocation
	session 11	**SPARES OPTIMIZATION -**Spares Optimization; The Single-echelon Case; Opus 10 Methodology; Spares Optimization; Logistic Support Analysis

Systems Engineering
Høgskolen i Buskerud
Postboks 235, 3603 Kongsberg

SYSTEM SUPPORTABILITY & LOGISTICS

Overview

System Supportability and Logistics introduces students to a disciplined approach to providing efficient and effective system logistics support, so that a system is ensured of satisfying its business and operational readiness requirements. Particular focus will be placed on the concept of integrated supply chain and demand management, and the optimization and allocation of a system's logistic resources to ensure maximum availability at the lowest investment in logistics resources. The course introduces the latest thinking and technologies with regard to system training, documentation, inventory management and transportation.

Course Objectives

After taking this course, the student will be able to:

• Integrate the knowledge acquired in this course.

• Integrate how the concepts and ideas in this course apply to actual business and/or government organizations.

• Apply the System Supportability and Logistics tools and techniques acquired in this course

• Apply and improve the students' ability to effectively work on teams.

in cooperation with

SDOE 650
SESD

SYSTEM ARCHITECTURE AND DESIGN

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

This module presents the fundamentals of system architecting, including practical heuristics for developing good architectures. It extends the systems engineering process introduced in SYS/SDOE 625 Fundamentals of Systems Engineering, through functional analysis, decomposition and requirements flow-down. The implications of open systems architectures and the use of commercial technologies and standards (COTS) are explicitly addressed, as are the linkages between the early architectural decisions, driven by customer requirements and the concept of operations, and system operational and support costs. Prerequisite: SYS/SDOE 625.

MODULE ORGANIZATION

The course combines lectures and readings to develop an understanding of the concepts and principles. A team project allows students to integrate their knowledge and apply it in a team environment. The course is designed to facilitate the sharing of experiences among the professionals who participate in the program.

MODULE AUDIENCE

This module completes the explication of the systems engineering process begun in SYS/SDOE 625. It is intended for systems engineers and architects and, together with its prerequisite, provides a sound basis for effective system design and an essential context for more detailed advanced courses in systems engineering tools and techniques.

COURSEWARE

Participants receive a binder containing course notes and additional readings specifically organized for this course, along with a textbook on systems engineering and architecting, and utilize the academic version of a systems engineering tool.

Day 1

session 1 — **Course Overview; Introduction to System Architecture; Strategic Role of Architectures** – The architecture metaphor; technology, business, and organizational trends that are increasing system complexity and the importance of architecture to system integrators.

session 2 — **Review of SE Fundamentals** – Review of the systems engineering process from customer needs to system requirements; benefits of a disciplined systems engineering process; introduction of the hands-on case study that students will model during the class.

Day 2

session 3 — **Developing the Functional Architecture** – Overview of the architecture process and developing a logical architecture; scenario tracing.

session 4 — **Functional Architecture Tradeoffs** – Extending the decomposition process; architectural considerations and tradeoffs.

Day 3

session 5 — **Developing the Physical Architecture; Interface Architectures** – The distinction between functional and physical architectures; developing a physical architecture that implements a logical design; the role and importance of interfaces; specifying an interface architecture.

session 6 — **Completing the System Model; Functional Modeling** – Integrating functional and physical views into a comprehensive system model, linking requirements to models and the flow-down of requirements to every level of the system design; building and using executable functional models.

Day 4

session 7 — **Architecture Assessment; Object Oriented Methods; Architecture Frameworks** – Characteristics of a good architecture, architectural metrics, examples of system architectures and trade-offs; Object Oriented design and its relation to functional decomposition; the Zachman, DoDAF and other frameworks for describing system architectures.

session 8 — **System Integration and Testing; Completion of the Hands-On Case Study** – The qualification process and its relationship to requirements development; preparation of PDR presentations for the in-class projects.

Day 5

session 9 — **Preliminary Design Review (PDR)** – Presentations by each project team of a modified PDR for their in-class case study.

session 10 — **Course Evaluation and Wrap-up**

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
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Systems Engineering
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BUSKERUD University College

in cooperation with

STEVENS Institute of Technology

SDOE 650
SESD

SYSTEM ARCHITECTURE AND DESIGN

Overview

System Architecture and Design describes the fundamentals of system architectures and the architecting process, including practical heuristics for developing good architectures. The course picks up where Fundamentals of Systems Engineering (SYS 625) left off. In contrast to SYS 625, the focus of this course shifts inside the system boundary to develop a specification for a complete set of logical and physical elements that comprise the logical and physical architectures, to meet the system requirements reviewed during SRR. The course culminates with a Preliminary Design Review (PDR) in which the system design is reviewed before detailed design can begin. The course has a strong "how-to" orientation – both a team project and a final individual project is used to give students an opportunity to apply the architectural concepts and lessons learned. The course highlights linkages between early architectural decisions driven by customer requirements and concept of operations, and system operational and support costs.

Course Objectives

After taking this course, the student will be able to:

• Understand the link between the functional and physical system architectures and the iterative nature of architecture development.

• Apply a process for flowing down or allocating system level requirements to components level requirements through equivalence, apportionment, synthesis and other methods.

• Apply the experience gained through the use of a systems engineering based tool that supports systems engineering requirements, architecture and modeling processes.

• Develop an architecture applying the methods learned in the course.

in cooperation with

SDOE 684
SEST

SYSTEMS THINKING

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DESCRIPTION AND OBJECTIVES

It takes something special for the term "system" to have such ubiquity. The downside is that it is overused, improperly so, detracting from its power. This class builds upon a solid conceptual foundation to ensure that the system/enterprise is properly defined, conceived, and realized. Uniquely, the class shows how it is possible to use systems in order to think more deeply and to act more decisively. This approach is made possible by emphasizing the simultaneity of perspectives, the role of paradox, and the centrality of soft issues in resolving complexity. The SystemiToolTM is used to structure and conduct analysis of decisions. This class is aimed at policy and decision-makers at all levels in an organization. Prerequisites: SYS/SDOE 625 or ES/SDOE 621

MODULE ORGANIZATION

In order to obtain deeper insight, case studies will be defined and executed in small groups. The case studies are designed to stimulate the usage of systems thinking and to gain insight into its relationship to change management and the life cycle of systems.

MODULE AUDIENCE

The module is aimed at policy and decision-makers at all levels in an organization. This includes all business, engineering, scientific, and management related disciplines.

COURSEWARE

All course participants will receive a copy of the textbook "Systems Thinking: coping with 21st century challenges" and module specific courseware that includes a free copy of a software product SystemiToolTM which is downloadable over the web.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
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Day 1	
session 1	**Perspectives -** Introductions. Case study illustrating interaction of perspectives such as technology innovation, business models and media landscape (e.g. Google, Inc.). Systems thinking precepts and mental exercises.
session 2	**Systemigrams**– The role of system description languages in systems thinking. The structure, design and dynamics of systemigrams in capturing perspectives, issues and capabilities.
session 3	**Small Group Studies**- Using the Systemigram description technique to capture strategic intent, e.g. USAF C2 Constellation.
Day 2	
session 4	**Systems Engineering**- The essence of Systems Engineering (SE) as seen through lifecycle models, phase reviews, requirements, stakeholders and trade-offs and inluding processes such as functional decomposition, functional and physical architecting, and extensibility scalability to complex systems engineering.
session 5	**Soft Systems Methodology: SSM**- Simultaneous perspectives, root definitions, conceptual models, feasible and desirable change. A new perspective on human activity systems through Boardman SSM (BSSM), using systemigrams to conduct appreciative inquiry into perplexing issues.
session 6	**Case study**- Using BSSM and Systemigrams, explore case study of Integrated Deepwater Logistics.
Day 3	
session 7	**System Concepts**- Introducing the Conceptagon™ and the fundamental ideas of boundary, emergence, hierarchy, parsimony and feedback.
session 8	**System Dynamics**- Describing and applying causal loop diagrams; system archetypes, e.g. tragedy of the commons. Case study using causal loops, e.g. limits to growth of Google, Inc. or accidental adversaries in Joint Force Development.
Day 4	
session 9	**Frameworks**– Origins and survey of SE frameworks within organizations such as DoDAF, Treasury, Gartner Group. Fundamental principles of framework design. Comparative evaluations of SE and SSM frameworks.
session 10	**System of Systems (SoS)**– Literature survey of definitions and abstracting their essence. Characteristics distinguishing SoS from conventional systems. SoS case study, e.g. Google, Inc. or Intelligence Community applying these characteristics to future systems development.
Day 5	
session 11	**System Paradoxes**– Living with paradox in enterprise systems, e.g. cooperating with competitors. War as paradox, e.g. command and control versus creative disobedience.
session 12	**Complex Adaptive Systems**– An in depth look at emergence, examining notions of self organization and selfsynchronicity. Course evaluation.

Systems Engineering
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What Is Systems Thinking?

While traditional analysis is centered in decomposition and study of the components of a system, ***Systems Thinking*** is centered in context, interfaces and emergent behaviors—the interstitial elements around and within the system; the ‘whole’ rather than the decomposed elements

Systems Thinking recognizes that systems often exhibit behaviors not related to their individual elements in any linear, reductionist combination

Modeling relationships and behaviors is a key to understanding a complex-adaptive system

Coping With Complexity

Today’s complex-adaptive systems require new methodologies to accurately model interactions and behaviors, including convergent and divergent behaviors

Almost all of current societal challenges—sustainable energy strategies, climate change, the economy, healthcare delivery—are clearly challenges that require systems thinking

A large spectrum of disciplines, from all engineering specialties, management and social sciences, are needed to develop feasible, durable solutions

BUSKERUD University College

SECE6201

System Identification and Signal Processing

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DECRIPTION

The aim of this subject is to give students with different backgrounds a common foundation in signal processing and control engineering in preparation for further studies. The student should be familiar with discrete systems in the time- and frequency-domain and be able to design digital filters. He should understand the DFT and spectral analysis. The student should be able to apply system identification and state estimation tools to produce a mathematical model and/or a state estimate of a physical system using experimental input and output data from the system, and to apply the model and state estimate for analysis, design and implementation of control systems.

CONTENTS

Sampling and quantization, discrete systems, the z-transform, frequency response and convolution. The DFT and its application to cyclic convolution and spectral analysis. Nonparametric spectral analysis and minimisation of spectral leakage in practical applications. The principles for divide-and-conquer FFT-algorithms. Design of FIR and IIR filters and filter structures. Basic properties of filter banks and some typical applications. Correlation.

Introduction to stochastic signals and systems, state estimation using the Kalman filter, parameter estimation using the Kalman filter, the least squares method, prediction error methods and subspace methods, application of estimated models and states for analysis, design and implementation of control systems.

MatLab/Simulink and will be extensively used for the course work.

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Day 1	State space controllers, estimation methods, stochastic signals and systems. Examples
Day 2	Discrete and continuous Kalman filters, extended Kalman filters and extended and augmented Kalman filters. Examples.
Day 3	AR, ARX, ARMA, ARMAX and OE models. LSE, PEM, Yule-Walker, Covariance, modified Covariance and numerical search methods. Model order selection. Examples
Day 4	Recursive identification. Introduction to Subspace methods.Examples
Day 5	Review of sampling and quantization, discrete signals and systems, linear convolution.
Day 6	Filter transfer functions and frequency response, DFT, cyclic convolution, linear convolution carried out via cyclic convolution. Spectral leakage and windowing. DFTs over finite rings.
Day 7	Filter design methods and filter structures.
Day 8	Filter banks, with applications

MODULE ORGANIZATION

This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of Robust Engineering. A project assignment allows participants to integrate and apply their knowledge.

MODULE REGISTRATION & INFORMATION

For additional information:
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DETAILED DESCRIPTION

System Identification

1. Repetition:

State space controllers, estimation methods, stochastic signals and systems.

2. Identification/estimation:

Discrete and continuous Kalman filters, extended Kalman filters, extended and augmented Kalman filters.

3. Batch identification:

AR, ARX, ARMA, ARMAX and OE models. LSE, PEM, Yule-Walker, Covariance, modified Covariance and numerical search methods. Model order selection.

4. Recursive identification.

5. Introduction to Subspace methods.

Examples and home works will cover all subjects. MatLab/Simulink will be extensively used for the course work.

Signal Processing

Analogue versus discrete signal processing. Sampling and quantization. Discrete signals and systems. Differential equations, impulse response and linear convolution. Transfer functions, poles and zeros, stability. Amplitude and phase response.

The Discrete Fourier Transform (DFT) and the relationship between the time and the frequency domains. Localisation in the time and frequency domains. Spectral leakage and windowing. DFT defined. The Cyclic Convolution Property (CCP). Linear convolution carried out via cyclic convolution. DFTs defined over finite rings.

Filter specifications, FIR versus IIR filters. Linear phase response filters. FIR-synthesis by the Fourier-windowing method, introduction to min-max optimization, block filters. IIR filters: design methods and structures. Arithmetic complexity. Simulation and synthesis in MatLab.

Filter banks: design and examples of practical applications.

SEPD6201

Mechanical Vibrations & Advanced Materials

BUSKERUD University College

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

LEARNING OBJECTIVES

This course consist of two different topics, namely; a) Mechanical Vibration b) Advanced Materials. The purpose of Mechanical Vibration part of the course is to give the student the fundamental concepts of mechanical vibrations, which are important for design and analysis of mechanical and structural systems subjected to time-varying loads. The objective of the course is to expose the students to mathematical modelling and analysis of such systems

The Materials Science part of the course would give the student an overview over the advanced materials, both, structural and functional in relation to microstructure and physical and mechanical properties, selection, applications and processing.

CONTENTS

Mechanical Vibrations: Practical application of the theory of mechanical vibrations for engineers and scientists working with systems and structures subjected to harsh dynamics environments.

Advanced materials: Light metals: Alloys of Aluminium, Magnesium, Titanium and copper. Polymers, Ceramics, Composites. Rules of mixture. Dislocations and surface defects. Surface science, Dispersion strengthening by phase transformation and heat treatment, Aging. Martensite and shape-memory alloys. Material Selection: General concept, Material Properties for Design. Software practice.

Day 1	Vibration patterns, Vibrations in the time domain and the frequency domain, The relation between dispalcement, velocity and acceleration, Dynamic systems, Calculation of natural frequencies, Examples
Day 2	Damping and damping models, Phase relations, Random vibrations, Effects of dynamic loads, Rotor dynamics, Examples
Day 3	Design with respect to dynamic loads, Vibration fatigue, Packaging of electronics exposed to vibrations, Numerical analysis, Test and test specifications, Examples
Day 4	Vibration Fatigue, Random Vibrations in engineering, Diffference between Sinusoidal and Random Vibrations, Satistical Properties of Random Process, Power Spectral Density, Response calculations in Random Vibrations, Design to avoid structural failures, Examples
Day 5	Light metals: Alloys of Aluminium, Magnesium, Titanium and copper. Properties, and application
Day 6	Polymers, Ceramics, Composites, structure, properties, types and synergies. Rules of mixture, Processing methods
Day 7	Dislocations and surface defects. Surface sciece, Dispersion strengthening by phase transformation and heat treatment, Aging, Applications and processes, Martensite and shape-memory alloys.
Day 8	Material Selection: Material Properties for Design, case studies and software practice.

MODULE ORGANIZATION

This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of Mechanical Vibrations and Advanced Materials. A project assignment allows participants to integrate and apply their knowledge.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
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Systems Engineering
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Detailed description

Mechanical Vibrations:

Topics covered include: formulation of the equations of motion using Newton's Laws, prediction of natural frequency for single-degree-of-freedom systems; modelling stiffness characteristics, damping and other vibration properties of mechanical systems; basic solution techniques by frequency response analysis; introduction to Random Vibration and Vibration Fatigue. Examples may include analysis and design for transient passage through resonance; introductory rotordynamics; frequency response amplitude; Random Vibration Response; fatigue life of vibration exposed systems. The course is mainly focused on analysis of single-degree-of-freedom systems, however a basic introduction into multi degree-of-freedom systems is also presented.

Advanced Materials:

Light metals: Alloys of Aluminium, Magnesium, Titanium and copper. Properties, and application. Polymers, Ceramics, Composites, structure, properties, types and synergies. Rules of mixture, Processing methods. Dislocations and surface defects. Surface sciece, Dispersion strengthening by phase transformation and heat treatment, Aging, Applications and processes, Martensite and shape-memory alloys. Material Selection: General concept, Material Properties for Design, case studies and software practice.

BUSKERUD
University College

SERE6201

Robust Engineering

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

MODULE DECRIPTION

Newly created or updated systems often show reliability and robustness problems. These problems may pop up when scaling to volume production. But also during actual use unexpected use and circumstances cause failures, despite the extensive testing at the end of development. This course provides a collection of design and engineering methods and techniques focused on robustness.

LEARNING OBJECTIVES

The goal with this course is to:

* convey the basic principles of Robust Design and Engineering

* understand the basics of reliability and its role in systems engineering

* form a deeper understanding of the customer value of a robust product

* get a deeper understanding of quality and its relation to robustness

* understand the Taguchi approach to quality and its role in systems engineering

* understand the concept of the Signal-to-Noise ratio and of the Loss Function

* be able to plan, execute and evaluate design experiments using orthogonal arrays

* acquire the knowled to perform Analysis of Variance

* be able to apply FMEA, FTA, QFD and Six Sigma techniques and principles

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Day 1

Introduction to Robust Engineering concept and activities in the need analysis, design, and production phases of the systems' life-cycle.
Reliability: definition, metrics, prediction methods.
Specification and allocation of reliability requirements.
Demonstrations and validations.
Reliability growth programs.

Day 2

Failure mode, effects, and criticality analysis: concept, methodology, role in systems engineering process.
Fault tree analysis: concept, methodology, role in systems engineering process.
Reliability-centered maintenance: concept and role in systems engineering process.

Day 3

Statistical process control.
Understanding variation; random and special cause variation.
Variables and attributes.
Process control charts.
Median, R and Moving Range charts.
Process capability for variables.

Day 4

The Taguchi approach to quality.
Variation: concept and cost.
The Loss Function.
The concept of Signal/Noise ratio.
Orthogonal arrays and the design of experiments.
Experiments with multiple variables and interactions.

Day 5

Analysis of variance (ANOVA).
One-way ANOVA.
Two-way ANOVA.

MODULE ORGANIZATION

This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of Robust Engineering. A project assignment allows participants to integrate and apply their knowledge.

MODULE REGISTRATION & INFORMATION

For additional information:
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Detailed course description

A robust product is capable of carrying out desired functions at the proper performance level for long periods of time irrespective of external conditions and normal variations in the way the product is used. A robust product is reliable and doesn't give nasty surprises. The difficulty of creating robust products and processes is linked to the array of disturbances they are subjected to during their life span. The Taguchi method is a structured way to determine how design parameters settings influence the product's ability to be robust against all type of interference (noise) from the surrounding environment, variations in the production or distribution processes or variations in customer usage.

A structured method of generating creative solutions on difficult technical problems is TRIZ (the Russian acronym for Theory of Inventive Problem Solving) which is based on analysis of millions of patents. TRIZ can be used to describe the evolution of technical solutions. By analyzing a product, one can form an opinion on the logical development steps that should be taken.

TRIZ questions the myths:

- Creativity is a hereditary ability
- Creativity is restrained by systematic approaches
- Ideas comes with inspiration

TRIZ only deals with creativity from the perspective of solving technical problems.

Failure Mode and Effect analysis (FMEA) is a systematic method to identify and analyse the potential failure modes / causes of a proposed system and assess the associated risk levels.

Mitigating actions shall be recommended on the failure modes having too high risk levels.

The course covers historical Background of Failure Mode and Effect Analysis,

types of FMEA: Concept/system-, Design-, Production- FMEA's

BUSKERUD University College

SEMA6201

System Modeling and Analysis

THIS MODULAR COURSE CAN BE TAKEN FOR GRADUATE CREDIT TOWARDS A MASTER'S IN SYSTEMS ENGINEERING OR AS PART OF A PROFESSIONAL DEVELOPMENT PROGRAM.

Module Description and Objectives

Modeling is one of the core techniques in Systems Engineering to facilitate amongst others communication, discussion, exploration, and validation of system specification and design. Modeling can be applied at all levels, from detailed design simulations to high level context models. In practice we struggle with finding the appropriate models and the appropriate level of abstractions. Quite often designers keep on extending and detailing their models. But is the additional effort worthwhile? Is the extended, more complex model better than the previous simpler model? Can we trust the outcome of our models? Should we integrate all aspects in one integrated model?

Let's look at some real life scenarios:

Scenario: The complex not trusted model. The pre-development team has made an extensive model of the system with tens of parameters and possible design options. Unfortunately, designers don't really trust the model, because of its complexity. Since they don't understand what the model does, they don't trust the results. What to do to escape from this cul-de-sac?

Scenario: Assessing system performance from subsystem models. For three different subsystems models have been made to explore performance for a few different design choices. The system designers face the challenge to combine the results into an integral system performance assessment. By making a fourth system level model they trigger the communication between the subsystems and facilitate system-wide design discussions.

Scenario: Overoptimistic performance prediction. During system integration the design team observes behavior and performance that is completely different than expected from previous system and subsystem models. They discover that several housekeeping tasks of the system have not been modeled and have been underestimated significantly.

Scenario: Introduction of Model Based or Model Driven engineering. The development organization has scheduled a transition to model based engineering. The expectations from management are high. Engineering teams are sent to education. Unfortunately, after 2 years of development the team discovers that there are plenty of detailed models, but that system characteristics "eme

Target audience

(sub)System engineers, designers, and architects who create, maintain or use models. This course looks especially at multi-disciplinary models.

Prerequisites: at least bachelor in engineering or science and some practical experience in design and engineeringrge", because system level models have not been made.

Lecturer:

prof. Gerrit Muller

Systems Engineering
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Day 1

session 1 — **Method overview.** CAFCR+ model, customer context, life cycle context, qualities

session 2 — **Customer Context.** Stakeholders, concerns, value chain, customer key drivers, context diagram, productivity, cost of ownership, system specification

Day 2

session 3 — **System.** Functional model, construction decomposition, qualities, multiple decompositions, concurrency, integration

session 4 — **Reasoning.** Scenarios, story telling, use cases, threads of reasoning

Day 3

session 5 — **Modeling.** What is modeling, types of models, purpose

session 6 — **Input facts, data, uncertainties.** Quantification, measurements, modeling, validation, technology background, lifecycle and business input sources

Day 4

session 7 — **System modeling.** Purpose, approaches, patterns, modularity, parametrization, means, exploration, visualization, micro-benchmarking, characterization, performance as example

session 8 — **Application, life-cycle modeling.** Reiteration of modeling approach, applied on customer application and business, and life cycle

Day 5

session 9 — **Integration and reasoning.** Relating key driver models to design models, model based threads of reasoning, FMEA-like approach, modeling in project life-cycle

session 10 — **Analysis, using models.** Sensitivity, robustness, worst case, working range, scalability, exceptions, changes

MODULE ORGANIZATION

This modular course combines lectures, classroom activities, case studies, and readings to develop an understanding of System Modeling and Analysis. A project assignment allows participants to integrate and apply their knowledge.

MODULE REGISTRATION & INFORMATION

For additional information:
Contact Silja Gulbrandsen, Silja.sg@hibu.no,
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SEMA6201

System Modeling and Analysis

Course Objectives

The objective of the course is to teach system engineers and architects methods and techniques for achieving an effective transformation from requirements and business drivers to technology and product design.

After this course students will be able to:

* understand what is a model, types of models, purpose of models

* understand the need for quantification and understand the limits of quantification

* be able to transform loose facts into an insightful model, to be used as input for requirements discussions and system design and verification

* be able to use scenario analysis as a means to cope with multiple alternative specifications and or designs

* apply problem-driven light-weight simulations and understand their value and purpose in early design decisions

* understand and be able to apply the threads-of-reasoning method as a means to communicate about, and discuss the linkage between, business needs and technological decisions

* be able to analyze dependability qualities, such as reliability, safety and security

* be able to analyze the impact of changes; change and variation cases

* understand the value of rapid prototyping for: requirements, potential design issues, modeling inputs

* be able to manage expectation level of different stakeholders

Educational objectives

* teach system engineers and system architects how to model and analyze their system under design, and evaluate alternative design options

* teach them to understand the complexity of this task

* provide them with adequate methods, knowledge, techniques, and methods to be applied in their daily job

Course duration and format

The course takes 5 full days. Participants taking the course for credits have to do a 10 week project afterwards. During the course participants work on real-life cases, preferably from their own domain. Theory and exercises alternate continuously. The models created during the course are limited models, since creating real simulations would take too much time.

The exercises provide even more value when multiple participants from the same company participate. We recommend to send a small team to the course, if possible.