

New Course in Engineering Systems at Purdue University:

Introduction to Civil Engineering Systems Design

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Achievements and Challenges
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Presentation Outline



Introduction/Motivation for the Course



Basic Course Information



Course Content



Lecture Schedule



Uniqueness of this Course



ABET/ASCE Requirements



Lessons Learned



Summary



Introduction

- “Introduction to Civil Engineering Systems Design”
 - Introduced in Purdue in 2003
- Overall purpose:
 - To impart techniques of operations research, systems dynamics, cost analysis, economic analysis, and other systems concepts in CE
 - To raise awareness of the consequences of CE systems construction/operation/maintenance in terms of:
 - Ecology, economy, social and cultural environments, and other performance measures associated with sustainability



Motivation for the Course (1)

- Upon completing the course, students will:
 - Acquire greater appreciation of global developments that require them to infuse systems concepts in the way they will plan, design, construct, and operate future CE systems
 - Be aware of their competitive advantage when seeking future employment, of their “systems thinking” perspectives
- Overall, motivations for applying system concepts include:
 - Large inventory and high value of CE systems
 - Substantial investments in CE preservation and operations
 - Multiplicity of interested parties and stakeholders

Motivation for the Course (2)

- Systems Thinking particularly important now due to following global trends:
 - Aging CE infrastructure, limited preservation funding, increasing user expectations, increased stakeholder participation, greater desire for sustainable solutions, etc.
- With \$billions spent annually, even a marginal percentage of savings will result in hefty returns
- Costs and benefits of civil engineering investments permeate aspects of our lives including our safety, mobility, security, and economy

Basic Course Information (1)

- Course Objectives:
 1. Provide students with an overall picture of the phases of development of systems
 2. Expose students to the tasks and challenges at each phase such as description, analysis, optimization, and evaluation
 3. Equip students with analytical tools to carry out tasks
 4. Expose the students to basic and current systems concepts such as engineering economy, probability and statistics, optimization, simulation, environmental impact analysis, risk/reliability analysis, and sustainability

Basic Course Information (2)

- Main textbook:
 - Introduction to Civil Engineering Systems, by S. Labi, Wiley & Sons (currently available online for Purdue students, due for release 2010)
- Additional texts:
 1. Systems Analysis for Engineers and Managers, by DeNeufville and Stafford, 1974
 2. Fundamentals of Systems Engineering, by Khisty and Mohammadi, 2001
 3. Design and Planning of Engineering Systems, by Meredith, Wong, Woodhead, and Wortman, 1985
 4. Civil and Environmental Systems Engineering, by Revelle, Whitlatch, and Wright, 2003



Basic Course Information (3)

- **Grading Policy:**
 - Mid-term Exam 30%
 - Final Exam 30%
 - Term Project 20%
 - Homework 10%
 - Quizzes 5%
 - Class Participation 5%
 - 100%



Course Content

- Introduction (Systems Concepts)
- Phases of Systems Development
- Tasks at Each Phase of Systems Development
- Necessary Tools for the Systems Tasks
- Application of the Tools
- Peripheral topics

**Terminal System Phases
(Demolition, Failure, etc.)**

- Assessment of System Vulnerability to disaster,
- Failure Analysis
- Analysis, Description, Optimization and Evaluation of Alternative Demolition Processes



**Needs Assessment, Goals
Identification, etc.**

- Does a problem exist?
- Assessing the Need for the System
- Establishment of System Performance Goals



System Preservation

- Analysis, Description, Optimization and Evaluation of Alternative Preservation Practices and Maintenance Systems



System Planning

- Analysis, Description, Optimization and Evaluation of Alternative System Plans, Locations, and Policies



System Operations

- Analysis, Description, Optimization and Evaluation of Alternative Policy and Operational Systems



System Design

- Analysis, Description, Optimization and Evaluation of Alternative Designs and Materials

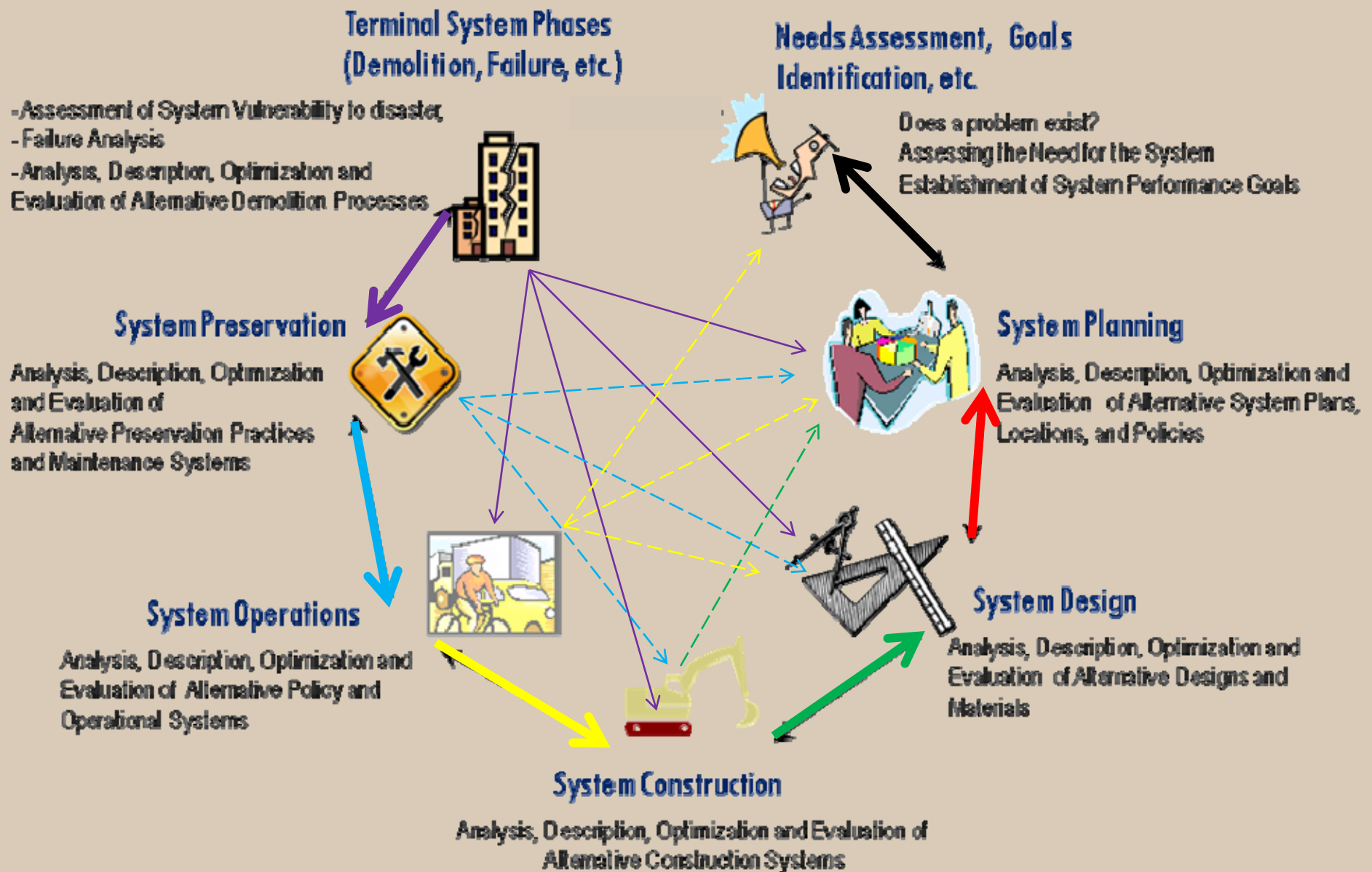


System Construction

- Analysis, Description, Optimization and Evaluation of Alternative Construction Systems



FEEDBACK BETWEEN PHASES





Schedule of Lectures

- **Section 1 – Introduction (Systems Concepts)**
 - Lecture 1: CE Disciplines, Evolution, Future Prospects
 - Lecture 2: What is a System? What are System Phases, Tasks and Tools?
 - Lecture 3: Civil Engineering Systems Goals and Objectives
- **Section 2 – The Tasks at each Phase**
 - Lecture 4: Description/Prediction of Facilities and Processes, and their Outcomes
 - Lecture 5: Evaluation of Alternatives and Decision-making for Best Action/Policies
 - Lecture 6: Feedback mechanisms between Phases



Schedule of Lectures

- Section 3 – The Tools Needed to Carry Out the Tasks
 - Lecture 7: Probability
 - Lecture 8: Statistics
 - Lecture 9: Modeling and Simulation
 - Lecture 10: Engineering Economics
 - Lecture 11: Multiple Criteria Analysis
 - Lecture 12: Optimization
 - Lecture 13: Reliability and Risk Analyses
 - Lecture 14: Communication Tools



Schedule of Lectures

- Section 4 – Application of the Tools at Each Phase of CE
 - Lecture 15: Needs Assessment
 - Lecture 16: Systems Planning
 - Lecture 17: Systems Design and Cost Estimation
 - Lecture 18: Systems Construction/Implementation
 - Lecture 19: System Operations
 - Lecture 20: Systems Monitoring and Preservation
 - Lecture 21: Systems Termination



Schedule of Lectures

- **Section 5 – Other Topics in Systems Development**
 - Lecture 22: Incorporating Sustainability in Systems Development
 - Lecture 23: Vulnerability Analysis for Civil Facilities
 - Lecture 24: Legal Issues in Systems Management
 - Lecture 25: Ethics in Civil Engineering
 - Lecture 26: Management and Administration

ABET and ASCE Requirements

- Course satisfies specific ABET requirements and ASCE rubric for undergraduate civil engineering education including:
 - Problem solving, experiments and simulations, data analysis, optimization and financial analysis, and systems approach in design of facility components and processes
 - Also, the course addresses socially and environmentally sustainable design, engineering practice and licensure issues, ethics, communication and managerial skills, and working in multidisciplinary teams

How this Course is Unique

- In other, traditional civil systems courses, it is the tools that are mostly presented, without explicit and adequate identification of the phases and tasks of civil systems development
- This course includes non-traditional tools such as legal issues, feedback between phases, management and communication skills, and environmental sustainability

Lessons Learned

- Course can be enhanced through informal start-of-semester and mid-semester evaluations by gauging students' background strengths and interests
- From formal end-of-semester student course evaluations, it was found that:
 - Undergraduates appreciated the opportunity to work on term projects that required perspectives other than technical performance measures
 - Students found the consideration of multiple performance measures to be useful in assessing systems
 - Course helped translate real world problems into solvable constructs

Summary

- Course identifies the phases of systems development, tasks faced at each phase, and tools needed to address these tasks
- “Introduction to Civil Engineering Systems Design” course is now a core requirement in the undergraduate curriculum of Purdue’s School of Civil Engineering
- After completing the course, students will have developed non-traditional skills and will have a better understanding of how their future designs/plans will affect each aspect of civil engineering system development



Thank You!

Questions/Comments?