

## The Challenges and Opportunities of Teaching Systems Engineering for Large Scale Engineering Systemse

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The Challenges and Opportunities of Teaching Systems Engineering  
for Large-Scale Engineering Systems

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Systems engineering for large-scale systems, such as energy facilities, development projects, space missions, national laboratories projects, governmental policy portfolio design and analysis, and others face unique challenges as they leave the realm of pure engineering and become complex political and administrative systems. Specifically, the array of stakeholders such as contractors, governments (local through national) bring cultural issues, political power and budget relationships that dwell and thrive in the world of the big, unmanageable, messy problems; i.e., BUMPs.

In this paper, we discuss a course that was developed as part of a Graduate Certificate in Systems Engineering for part-time and returning students. It addresses methodologies that develop solutions to the BUMPs in both economic and technological fashions. Teaching systems engineering for large-scale engineering systems is challenging for many reasons. One of the main challenges is the breadth of material to be addressed within one or two courses. Other challenges result from how students learn about the transitions from the development of a conceptual framework to systems architecture through engineering design, mathematical analysis and eventual construction and delivery.

About 15 years ago the Department of Industrial Engineering at New Mexico State University responded to requests from our graduate students and our customers who hire those

students. There was an interest in large-scale systems engineering coursework without the need to commit to a graduate degree program. In response, we developed a twelve-credit certificate program that employed less restrictive admissions requirements than our degree program. Our thought was that access to current trends in systems engineering should not be limited by previous undergraduate performance—our target was working professionals rather than traditional graduate students. As part of developing this certificate, we recognized the need for a systems engineering course that would survey an array of tools students could use in their regular workday. Such an array, when integrated to develop policy analysis and recommendations, can be thought of as a federation of tools.

Specifically, what was needed was a course that fit within the context of existing course plans, and that addressed the applications of systems engineering to BUMPs. The course was designed to extend beyond hardware and software design and embrace the challenges that large-scale, complex problems present to engineers, who are in general not prepared or educated to deal with. BUMPs issues can appear to be deceptively easy to solve but often require multiple analyses and design strategies for resolution. An organized approach of federated modeling tools can, not only be beneficial, but may be necessary to discover a satisfactory solution.

In this paper we discuss our experiences teaching this course multiple times and employing two fundamentally different approaches to the issue teaching the resolution of BUMPs. One approach relied heavily on the introduction of abstract concepts, the use of rigorous mathematical analyses and computer-based tools, and a class project wherein the students were asked to demonstrate their understanding of these concept and tools. The other approach focused more on managerial and project engineering uses of systems engineering strategies, concepts and tactics. It was refocused to address a large group of engineering

management students who need familiarity with systems engineering concepts and the applications of systems engineering to BUMPs along with the managerial demands.

Regardless of career and education focus, engineers can benefit from a survey of the strategies and technique to pose and resolve such problems. And, when students learn of the benefits of a federation of systems engineering and operations research tools, we reinforce lifelong learning as they pursue additional training and education.