Creating a differentiated relevant accessible Systems Engineering / Enterprise Architecture Degree Programs

Shekar Viswanathan

Department of Applied Engineering

National University, California

sviswana@nu.edu

858-309-3416

National University

- Private, accredited Institution (1971)
- 22000 Students & Comprise of Six Schools
- Over 20 learning centers in California
- ~60% NU students are Graduate Students
- Students have 8-10 years functional specific experience with average age of 30-33
- One month course format
- On-ground and Online Formats

Engineering Management Profession

Engineering Management is rapidly becoming recognized as a professional discipline. Engineering managers are distinguished from other managers by the fact that they posses both an ability to apply engineering principles and a skill in organizing and directing technical projects and people in technical jobs.

National University's Master's Degree in Engineering Management

- **Project Management -- Aspiring to be future project/program managers**
- **Systems engineering -- Interested in becoming a systems engineering expert**
- **Technology Management-- Interested in developing their industrial engineering skills in operation environment**
- **Enterprise Architecture – Interested in becoming experts in Enterprise Architecture**

Context

- **Program Context - 54 Quarter Units per course**
- **Contact Time – 40.5 hours**
- **Format–On Site Format**
  - **One day a week face to face**
- **Format–On-Line Format**
  - **Five days a week**
  - **Multiple Teaching Approaches (Lecture, problem sessions, laboratory, field visits, guest lectures)**
- **Library Resources – Over 100,000 Journals Online**
- **Media Use - Variety of media use to bring reality and freshness to presentations**

What is Good Systems Engineering?

"*Classical" view*

Effective transformation of customer requirements to design

Requirements clearly specified and frozen early in lifecycle

Emphasis on minimizing changes and verifying requirements

System designed to meet well specified set of requirements and performance objectives specified at project start

Focus on reliability, maintainability, and availability of the system

What is Good Systems Engineering?

"Expanded" view

Effective transformation of stakeholder needs to fielded (and sustainable) system

Focuses on capabilities of system/systems-of-systems, with recognition of complex interdependencies of system and enterprise

Emphasizes an expanded set of "ilities" and continuous validation of stakeholder needs

Systems architecting grows in importance, supported by a model-based approach to development -- formal methods and executable requirements

Spiral development approach for designing system to accommodate changes in mission, requirements, threats, new technologies

What is Systems Engineering?

SYSTEMS ENGINEERING (Classical)

Systems engineering is the **process** of selecting and synthesizing the application of the appropriate scientific and technical knowledge in order to **translate system requirements into system design.**

SYSTEMS ENGINEERING (Expanded)

Systems engineering is **a branch of engineering** that concentrates on **design and application of the whole** as distinct from the parts… looking at the problem in its entirety, taking into account all the facets and variables and **relating the social to the technical** aspects.

What is Innovation?

Dictionary Definitions

- act of starting something for the first time
- a creation (a new device or process) resulting from study and experimentation

…*but what is innovation when our focus is large scale complex systems*

Innovation in the Systems Context

- Innovation may occur at multiple levels of the system – component level innovation may impact system behavior at broad system level
- Innovation in enterprise system and product system are intimately linked
- Innovation at the interfaces is just as important as component level innovations

Selected Perspectives on…
FUTURE SYSTEMS

- Systems will evolve over their lifecycle and will be designed to accommodate new technologies and emergent behaviors
- Focus on systems architecture to effectively integrate off-the-shelf products, legacy systems, and new technologies
- Complex interaction of multiple advanced technologies and embedded intelligence, with human/system interface becoming highly sophisticated and complex.
- Simulation, adaptive systems, sensors for condition monitoring, robotics, virtual devices, and other advanced technologies will enable new capabilities
- Systems opportunities include anti-terrorism/conflict resolution, environmental, resource management, healthcare, energy generation/distribution, general upgrading to new military paradigms, space (including search for natural resources), and infrastructure modernization

Selected Perspectives on…..
SYSTEMS ENGINEERING EVOLUTION

- There is a critical need to ensure systems engineering focus is broad, increasingly embracing "non-technical" parameters with focus on complete life cycles, value streams, risk management, and opportunity management.

- Systems, more than ever, will need to effectively accommodate technology, politics, economics, people, culture, environment, geography, and other factors.

- Many serious problems we now confront are generic systems problems, and not uniquely and only component and materials problems. We face system-of-systems challenges that are increasingly global and overarching, involving interdisciplinary team efforts.

- As knowledge expands, engineering specialists will need to take a deeper and narrower focus, while the systems engineer will need to cover an even broader perspective.

Evolving Systems Engineering
Systems Architecting

- Systems architecting as science
- Interrelationship of architecting system and enterprise
- Architecture views and frameworks
- Systems architect as a certified professional role

Critical Questions

Can systems be predicatively architected?

How should we evaluate alternative architectures?

How can models/visualization environments be used?

Can systems be rigorously architected with a specific goal of flexibility, extensibility, sustainability, or agility?

Evolving Systems Engineering
Uncertainty Management

- Uncertainty drives risk… but also opportunity
- Retaining some level of uncertainty during development may be desirable
- Uncertainty can be managed in quantitative manner

Critical Questions

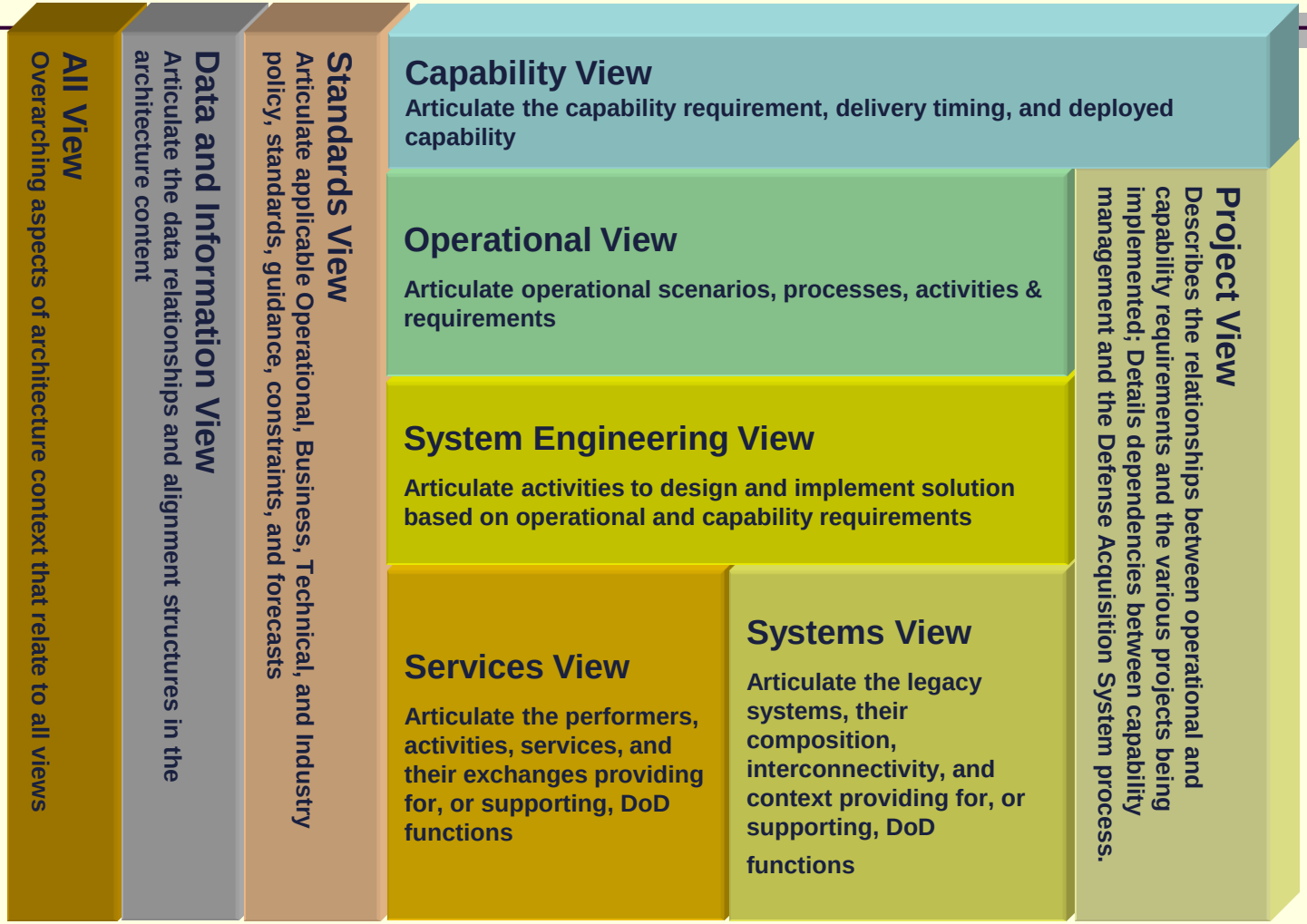
What are methods for multi-attribute trade analysis?

How can engineers use real-options approach effectively?

How can we mature, validate, and automate methods for uncertainty management?

How do we apply uncertainty management to system-of-systems, family-of-systems, and product families

DoDAF 2.0 extensive set of Views



From presentation by **John V. Tieso**

Curriculum Design

- **Modular Curriculum - Three sets of modules - core module, concentration module and elective module**
- **Pedagogical approach - Engages students as active participants in their own learning, in interaction with others, in response to real world problems, and in ways that parallel the process of fieldwork**
- **Curriculum -- Follows a team-based, problem-focused approach**
- **Structured Exercises - Skill training, role-plays and simulations in translating theory into practice in a non-threatening manner**
- **Media Use - Variety of media use to bring reality and freshness to presentations**

Core Module (Must Take)

- **ENM 600 - Engineering Management Concepts**
- **ENM 601 - Project Management Principles**
- **ENM 602- Risk, Contracts, and Legal Issues**
- **PME 602 - Skills Management**
- **ENM 604 – Quality Management**
- **TMG 610 – Global Trends in Technology Transfer / Application**

Specialization Courses: Systems Engineering:

- SYE 600 – Introduction to Systems and the Design Process
- SYE 601 – Systems Analysis and Design Evaluation
- SYE 602 – Advanced Systems Design
- SYE 603 – System Dynamics

Concentration Courses: Enterprise Architecture

- ***DAF 601: Architecture Framework Basics***
- ***DAF 602: Core and Supporting Products***
- ***DAF 603: Enterprise Architecture Planning***
- ***DAF 604: Advanced Architecture Modeling and Analysis***

- ***EEA601: Enterprise Architecture Concepts and Theory***
- ***EEA602: Enterprise Architecture Planning***
- ***EEA603: Enterprise Architecture Implementation***
- ***EEA604: Enterprise Architecture Integration***

Common Criticisms of Systems Engineering
Inhibitors to Innovation

- Too focused on process execution and not enough on system/system properties
- Focuses too quickly specifying requirements without adequately exploring desired system behavior
- Often applied at the subsystem and sometimes at the systems level – but rarely at the system-of-systems/enterprise level
- Assumes the system context as a constraint rather than variable

Summary

- **Advancements in systems education and research are key to effectively address the complex innovation scenarios we face**
- **National University's EM program is innovative**
- **Integrates fundamentals with applications**
- **Program can be readily updated due to modular structure Addresses marketplace needs**
- **On site, Online and hybrid delivery methods – Accessible to geographically diverse learners including working adults**