SYST 659 / SYST 850 Complex Adaptive Systems: Architecting and Integration. (3:3:0). Fall 2010.
Prerequisites: SYST 520 and 619 or permission of instructor.

Complexity theory is an emerging field of study that is evolving from several major knowledge areas: mathematics, physics, biology, economics, organizational science, computational intelligence and systems engineering. It is a needed set of endeavors brought about by two realities. The first is that modern science often does not reflect all of reality, but only the part of reality that is ordered, linear, ergodic, isolatable, predictable, observable, and controllable. The second reality is that modern trends toward disciplinary specialization run counter to the major need for knowledge integration and knowledge management for resolution of contemporary issues. Fundamentally, a system is complex when we cannot understand it through simple cause-and-effect relationships or other standard methods of systems analysis. In a complex system, we cannot reduce the interplay of individual elements to the study of those individual elements considered in isolation. Often, several different models of the complete system, each at a different level of abstraction, are needed. There are several sciences of complexity, and they generally deal with approaches to understanding the dynamic behavior of units that range from individual organisms to the largest economic, technical, social, and political organizations. Many of these studies are agent or element based and involve complex adaptive systems and hierarchical systems. The structure and behavior of these complex systems is not dictated uniquely by the edicts of a leader, but emerges in a natural manner through the interactions of the agents. One measure of system complexity may be the complexity of the simulation model necessary to effectively predict system behavior. The more the simulation model must look like the actual system to yield the same behavior, the more complex the system. As a general rule, we cannot create models that will accurately predict the outcomes of complex systems. We can, however, create a model that will accurately simulate the processes the system will use to create a given output. This awareness has profound impacts for systems engineering and systems management, and many other efforts that are concerned with systems of large scale and scope. Most studies of complex systems often run completely counter to the trend toward increasing fragmentation, compartmentalization, and specialization in most academic disciplines. The current trend in complexity studies is to reintegrate the fragmented interests of disciplines into a common pathway.

The notion of Complex Engineered Systems (CES) has emerged from initial efforts in the area of Complex Adaptive Systems and such emerging technologies as the Internet, GPS, wireless networking, and many others. These complex engineered systems are comprised of many heterogeneous subsystems and are characterized by observable complex behaviors that emerge as a result of interactions among the subsystems at several levels of organization and abstraction. Understanding, designing, building and controlling such complex systems is a major challenge for systems engineers today. Service-oriented architecture (SOA) is one of the major resulting realties. This provides a comprehensive plan to interrelate the enterprise with technology. SOA integrates talents and skills of an entire enterprise, with requisite and associated needs and computing know-how. We present a service-oriented modeling framework that employs agile, universal, and integrated business and technology language to facilitate design, architecture and integration initiatives.

This course is part of the degree track, concentration, and certificate in architecture based systems integration. There is much interest today in the engineering of systems that are comprised of other component systems, and where each of the component systems serves organizational and human purposes. These systems families are often categorized as system families, systems-of-systems, or federations of systems. The design of architectures is a major ingredient in the design of systems families and provides the conceptual basis for achieving system integration. Towards this end, the Department of Defense has issued new regulations for acquisition of systems. These require an architecture-based approach and focus on how a proposed system will be integrated with other existing or planned systems. Studies in this area cover: formulation of the system integration problem, definition of architecture frameworks, use of structured analysis and object oriented methodologies for the design of architectures, modeling and simulation for evaluation of architectures and approaches to integration, and interoperability. Both defense and industrial applications are considered.

References:

Braha, D., Minai, A. A., and Bar-Yam, Y. (Eds), ***Complex Engineering Systems***, Springer, Cambridge MA, 2009.

Bell, M., ***Service-Oriented Modeling: Service Analysis, Design, and Architecture***, Wiley, Hoboken, 2008.

Marks, E. A., and Bell, M., ***Service Oriented Architecture: A Planning and Implementation Guide for Business and Technology***, Wiley, Hoboken, 2006.

Sage, A. P. and Rouse, W. B. (Eds.), ***Handbook of Systems Engineering and Management***, Second Edition, John Wiley and Sons, Hoboken NJ, 2009.

These four books would be well worth purchasing for the course if you have the funds. A plethora of contemporary literature available on the Internet concerning the subjects to be covered will be of much use, and experience will be gained in the Internet as a research tool during the course. A course web site on GMU Blackboard will be operational and put to much use.

Instructor: Andrew P. Sage, Office: Engineering Building, Room 2240, Phone: 703-993-1506, Fax: 703-993-1521
Email: asage@gmu.edu, Office Hours by Appointment.

Course Call Numbers SYST 659 002 (74837), SYST 850 001 (75013) Fall 2010 Thursday from 4:30 PM to 7:10 PM in Room Robinson Hall B111.

Grades: 50% - examinations; 15% - term paper; 35% - home assignments. Two take home exams will be given. There will be a term paper assignment in the general area of the course, and periodic homework assignments.

SYST 659, SYST 850 – Fall 2010 Syllabus and Outline, (subject to change)

1. From Complex Adaptive Systems to Complex Engineered Systems (2 Sep, 9 Sep, 16 Sep 23 Sep)
2. Engineering Complex Systems: Agent Orientation and Evolutionary Engineering (30 Sep)
3. Structure and Dynamics of Complex Product Design Issues (7 Oct)
4. Understanding Complexity in Systems Engineering Design, Architecting, and Integration (14 Oct, 21 Oct)
5. Models for Services (28 Oct) Take Home Mid Term Exams Due
6. SOA Business Modeling (4 Nov, 11 Nov)
7. SOA Technology, and Services Identification, Analysis, and Design (18 Nov)
8. SOA Architecture Organization Model, Business Cases, Technology Cases and ROI (2 Dec, 9 Dec)
9. Term Paper due 9 Dec
10. Take Home Final Exams Due 16 Dec 2010

APS. 1 April 2010