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DEPARTMENT OF SYSTEMS AND INFORMATION ENGINEERING

Systems and Information Engineering:

Departmental Overview

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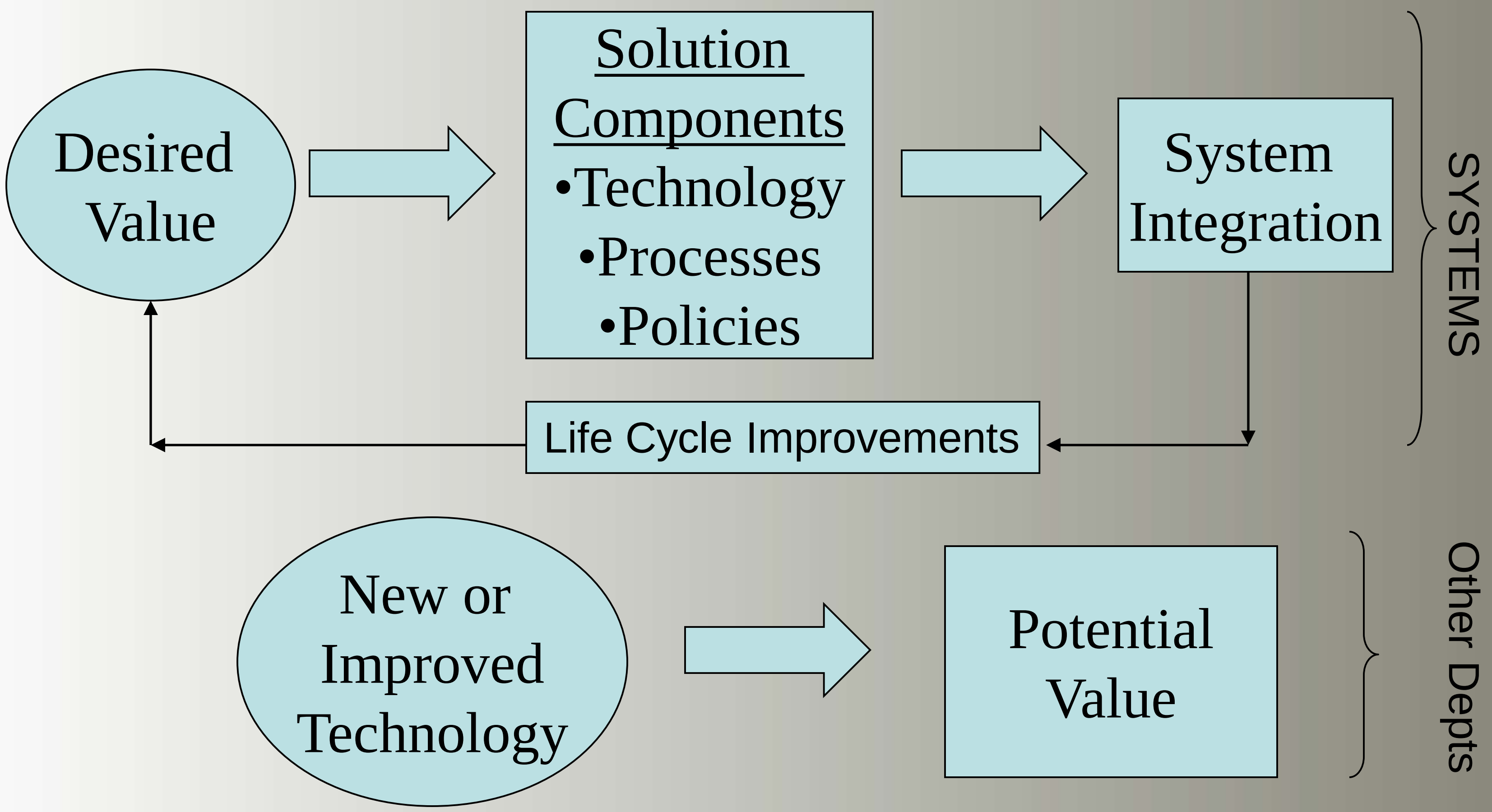
Systems Engineering vs Other UVA Engineering Departments



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- 19 Faculty Members
- 51 PhD Students
- 46 Masters Thesis Students
- 52 Masters Non-Thesis Students
- ~100 BS Degree graduates per year (largest UVA Engineering School Undergraduate Department

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Systems and Information Engineering Research Groups

- Three Research Centers
  - NSF Sponsored Industry/University Cooperative Research Center called WICAT (Wireless Internet Center for Advanced Technology
    Barry Horowitz - Director
  - Center for Risk Management of Engineering Systems
    Yacov Haimes - Director
  - Human Factors Center
    Stephanie Guerlain - Director
- Two Specialty Groups
  - Computational Statistics and Simulation
  - Optimization and Control

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Wireless Internet Center for Advanced Technology

- Adaptive Multi-Scale Optimization
  - Image and Streaming Video Processing and Distribution
  - Ladar Processing and Distribution
- Application of Advanced Technologies to Support Rapid and Assured Reconfiguration
  - Wireless Sensor Networks
  - P2P Networks
  - Service Oriented Architectures
  - Cloud Computing
- System Agility
  - System Design Concepts for Agility
  - Economic Analysis
- Application Layer Information Assurance

Adaptive Multi-Scale Optimization

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Multi-Scale Adaptive Optimization for Rapidly Reconfiguring Wireless Systems

- **Dynamically optimize system performance through rapid reconfiguration at multiple system and component technology levels (individual electronic component level, sub-system level, overall system level)**
  - **Optimally Exploit Available Communications Band Width Across Full Set of Users**
  - **Maximize Individual User Utility**
  - **Minimize Power Consumption**
- **More and more enabling technology is emerging**
  - **Higher performing components, low power electronics**
  - **Embedded sensing**
  - **Greater component-level embedded computing capacity**
  - **Better processing algorithms and algorithms for System Management and Control**
  - **Service Oriented Architectures**
  - **Ad hoc Peer-to-Peer networking**
- **Our areas of application**
  - **Persistent surveillance**
  - **On-body electronics for health care telemedicine**
  - **Video distribution and automated interpretation for the Military Intelligence domains**
  - **Mobile Network Management**
  - **Application Layer Information Security**
  - **Autonomous unmanned platform coordination**
  - **Automatic Target Classification**
  - **Robot-based nuclear power plant inspection**
  - **Space-Based Dynamic Service-Oriented Architectures**

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Agile Large Scale Systems

What is Agility?

- Agile System – Agility is relative. A more agile system is one that can be modified to **respond to new opportunities and risks** by **incorporating significant new design** features: 1) in a **shorter period of time**, and 2) in a **more assured manner**, than a less agile system

- **Different** from **adaptivity** which is designed into a system to make its operation situational

Agile Large-Scale Systems Vision

- Establish System Agility as a feature of large-scale systems that is:
  - Necessary
  - Rigorously defined
  - Measurable

- Develop necessary analysis methods, tools and technologies for system engineers to employ as they create agile systems

- Carry out the necessary validations of research results to enable adoption of system agility by the systems engineering industry

Some Capabilities and Features of Agile Systems (1)

- **Managing Time for Developing System Modifications**

  Predict future system-related opportunities and risks in order to provide more lead time for accomplishing design changes that are decided upon over time

  Technically structured to **reduce the required integration efforts** for adding new system capabilities related to predicted opportunities and risks

  Human organization design is conceived to **more readily permit reorganizations** that are related to predicted future opportunities and risks

Some Capabilities and Features of Agile Systems (2)

- **Managing Confidence in Rapid System Modification**
  - **Automation** support for system **reconfiguration**
  - Include **fault tolerant designs that allow higher confidence in making early operational transitions** of new designs
  - Provide **system operators with information that increases their confidence during transition periods** for new system designs

Four Research Thrust Areas

- Forecasting and Economics of Agility –Built-in Subsystems for Agile Systems
  - Hierarchical Holographic Modeling
  - Systems-based Multivariate Time Series Analysis
  - Real Options/Game Theory
- Multi-Scale Modeling and Analysis
  - Phantom Systems and Tools
- Architectures and Technologies
  - SW-Based Agility
  - Hardware-based Agility
  - Agile Fault Tolerant Systems
- Agile Organizations
  - Agent-based modeling
  - Operational human factors

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System Level Information Assurance

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Large-Scale Enterprise Collaborative Cyber Risk Assessment and Management Tools

- Cyber security risk assessments must be accomplished on a fast track
  - Too many computer-based systems doing too many jobs
  - Too many changes in computer systems for an assessment to stay current for very long
  - Too many threat changes in too short a time period

- Collaborative risk assessment tools that engage the various units of a military organization to create an integrated assessment
  - Multi-objective risk assessment methodology led by operational units
  - Solution development methodology led by technical people
  - Portfolio investment approach for solution led by integrated team

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The System Level Information Assurance Opportunity

- Areas of solution determined based on results from a system-level risk analysis, requiring collaborative computing-based support tools for large-scale systems assessments
    - What can go wrong?
    - What are the consequences?
    - What is the likelihood?
- Solutions include:
    - Defense, including at the application layer
    - Deception at the application layer
    - Rapid detection and recovery from successful attacks
    - Resilience to attacks through fault tolerance approaches

Example: Adding Deception and Defense to SOA-Based and Private Cloud-based Enterprise Systems

Threat: Data disruption

Response: Create uncertainty for adversaries based on dynamic system control and real time digital forensics

- Exploit control of the information service structure to time vary which machines execute which sub-services
- Monitor service providing machines to correlate observed work with anticipated workloads
- Trace data paths for data that relate to most important decisions or control actions

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CENTER for RISK MANAGEMENT of ENGINEERING SYSTEMS EST. 1987

National Ground Intelligence Center

US Army

Joint Program Office

A cross-disciplinary range within and beyond engineering.

One of the few in the nation to apply risk assessment and management to engineering systems.

Experienced since 1987, the Center has a strategic position to evaluate and manage risk in a broad scope of technology-based systems.

Five full-time faculty and other affiliated faculty, one office manager.

Visit our web page at www.virginia.edu/crmes, email risk@virginia.edu

VA Governor's Preparedness Team

National Science Foundation

I3P

PCCIP

FBI

Dept. of Homeland Security

US Army Corps. of Engineers

Defense Threat Reduction Agency

Virginia Dept. of Transport

NASA

H-EMP Commission (SAIC)

Involving Undergraduates - Capstone Program, Technology Leaders Program

Capstone Examples from a set of 20-25 two semester projects conducted each year

- **Developing a Test bed for Distributed Search by Mobile Sensors**

  The goal of the project is to design and construct a prototype system for search and surveillance that endows a single operator with the ability to remotely supervise multiple autonomous robots.

- **Force-feedback Simulation for Operators in Virtual Surgery and Dissection Tasks**

  The goal of this project is to design, implement, and test a series of surgical simulations usimg a Sensable force-feedback, robotic device.

TLP Program

- Joint Systems Engineering/Electrical and Computer Engineering Program
- Focused on technology integration into systems, including 2 laboratory courses
- Includes research opportunities with WICAT Center and internships with industry and government
- Initially supported by NSF grant and a equipment donation by the Center for Advanced Education and Research

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Thank You