

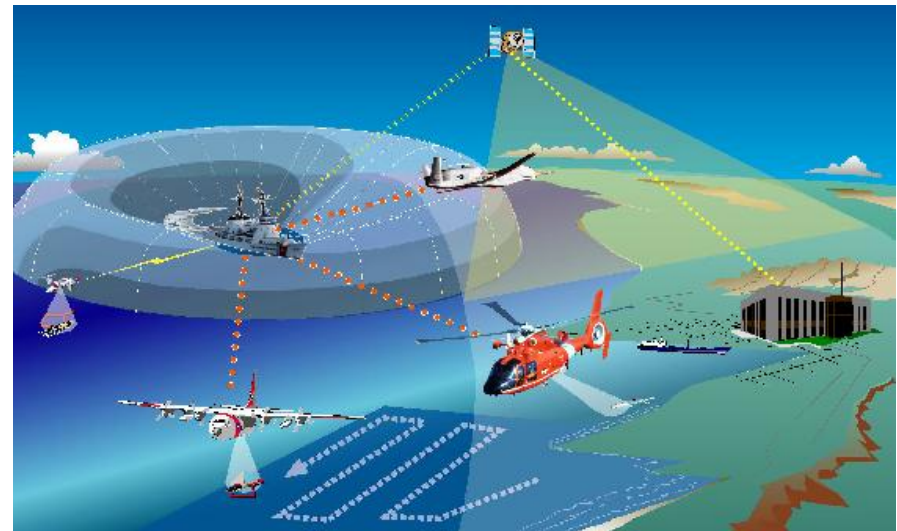


SYSTEMS ENGINEERING
Research Center

A US DoD University Affiliated Research Center

Systems Engineering Capabilities

Purdue University
November 9, 2010



Integrated Deepwater System Concept – US Coast Guard / ICGS

Recent History of SE at Purdue

- 2003 Purdue College of Engineering initiates “Signature Areas”
 - “Systems of Systems” one of eight original areas
 - Hired five faculty members
 - Research and individual course development
- 2004 participated in first CESUN meeting as part of MIT ESD symposium
- 2006 School of Aeronautics and Astronautics added “Aerospace Systems” area along with disciplinary areas (e.g. aerodynamics, structures)
- 2007 Purdue NEXTRANS award Regional University Transportation Center from US DOT
 - Research has emphasis on systems and system of systems
- 2007 Purdue Engineering Professional Education offers “Introduction to Systems Engineering” course
- 2009 Purdue College of Engineering Strategic Plan (2009-2014) contains “System of Systems Institute

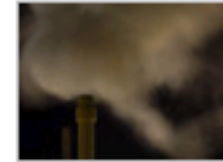
National Academy of Engineering 21st CENTURY CHALLENGES



Make solar energy
economical



Provide energy
from fusion



Develop carbon
sequestration
methods



Manage the
nitrogen cycle



Provide access to
clean water



Restore and
improve urban
infrastructure



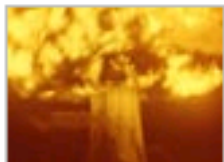
Advance health
informatics



Engineer better
medicines



Reverse-engineer
the brain



Prevent nuclear
terror



Secure
cyberspace



Enhance virtual
reality



Advance
personalized
learning



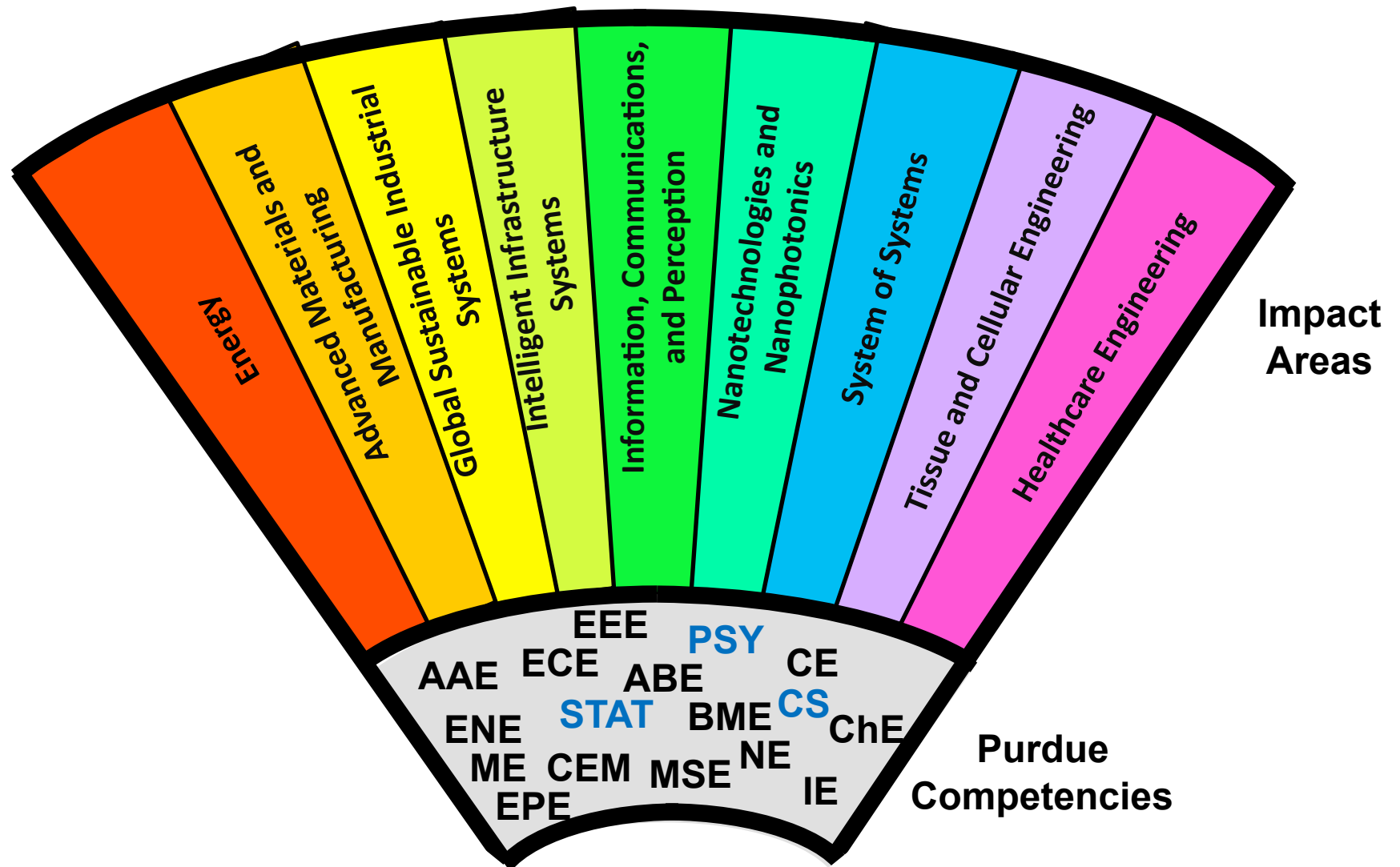
Engineer the tools
of scientific
discovery

2

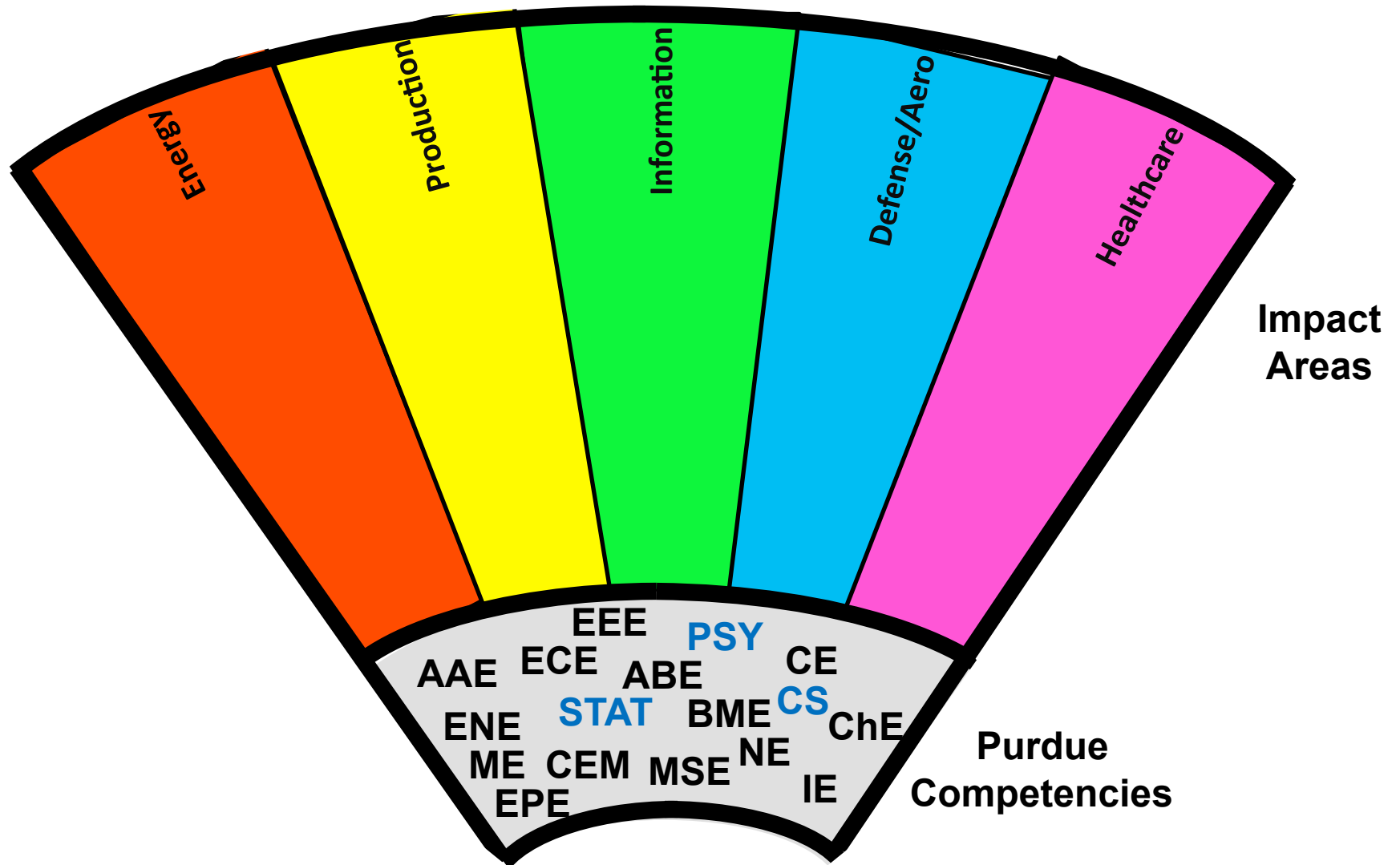
College of Engineering Schools

- **Aeronautics and Astronautics (AAE)**
- **Agricultural and Biological Engineering (ABE)**
- **Biomedical Engineering (BME)**
- **Chemical Engineering (ChE)**
- **Civil engineering (CE)**
- **Construction Engineering and Management (CEM)**
- **Electrical and Computer Engineering (ECE)**
- **Engineering Education (ENE)**
- **Engineering Professional Education (EPE)**
- **Environmental and Ecological Engineering (EEE)**
- **Industrial Engineering (IE)**
- **Materials Engineering (MSE)**
- **Mechanical Engineering (ME)**
- **Nuclear Engineering (NE)**

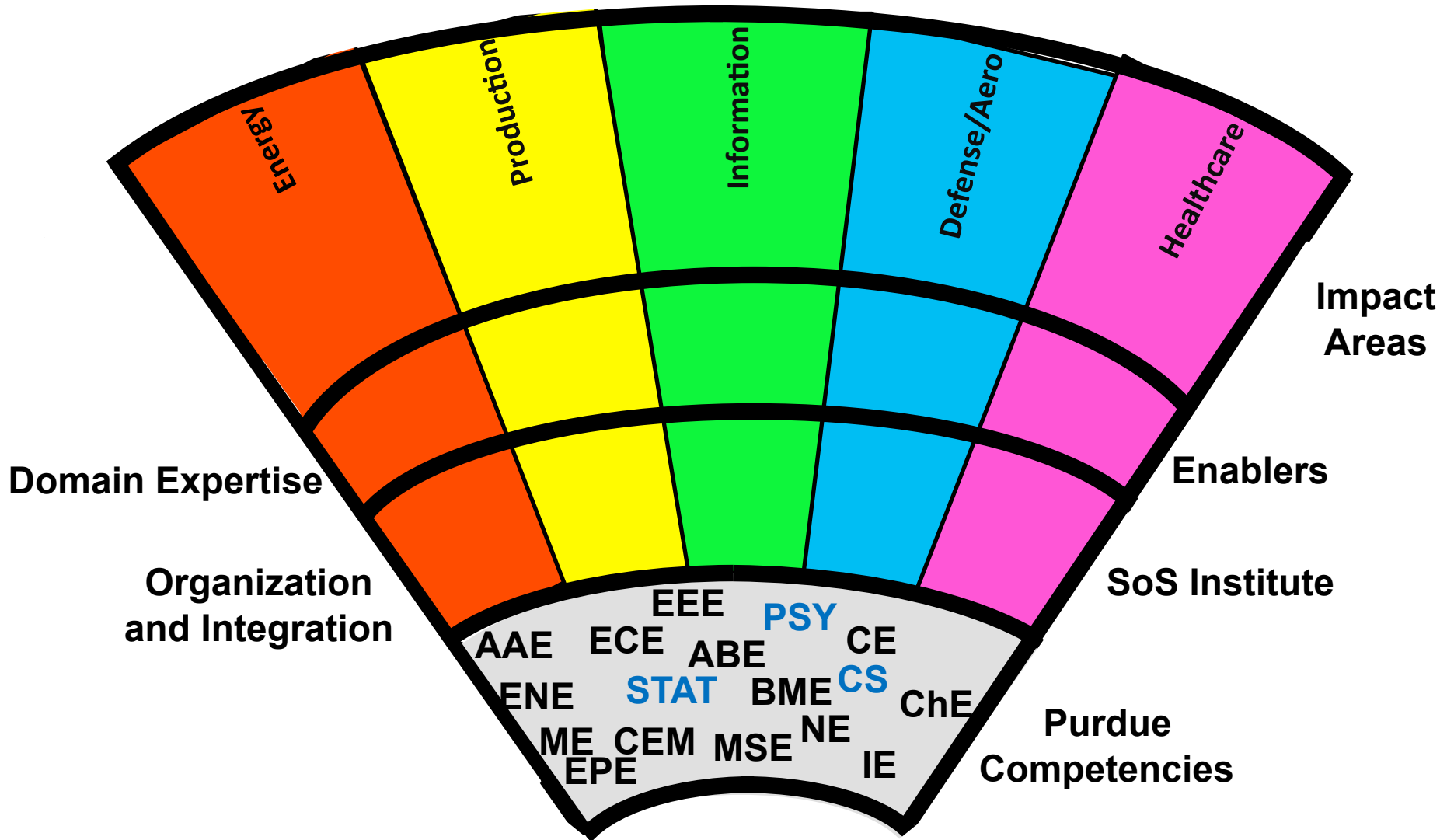
Purdue Engineering Signature Areas



Purdue SE Signature Areas



System of Systems Institute

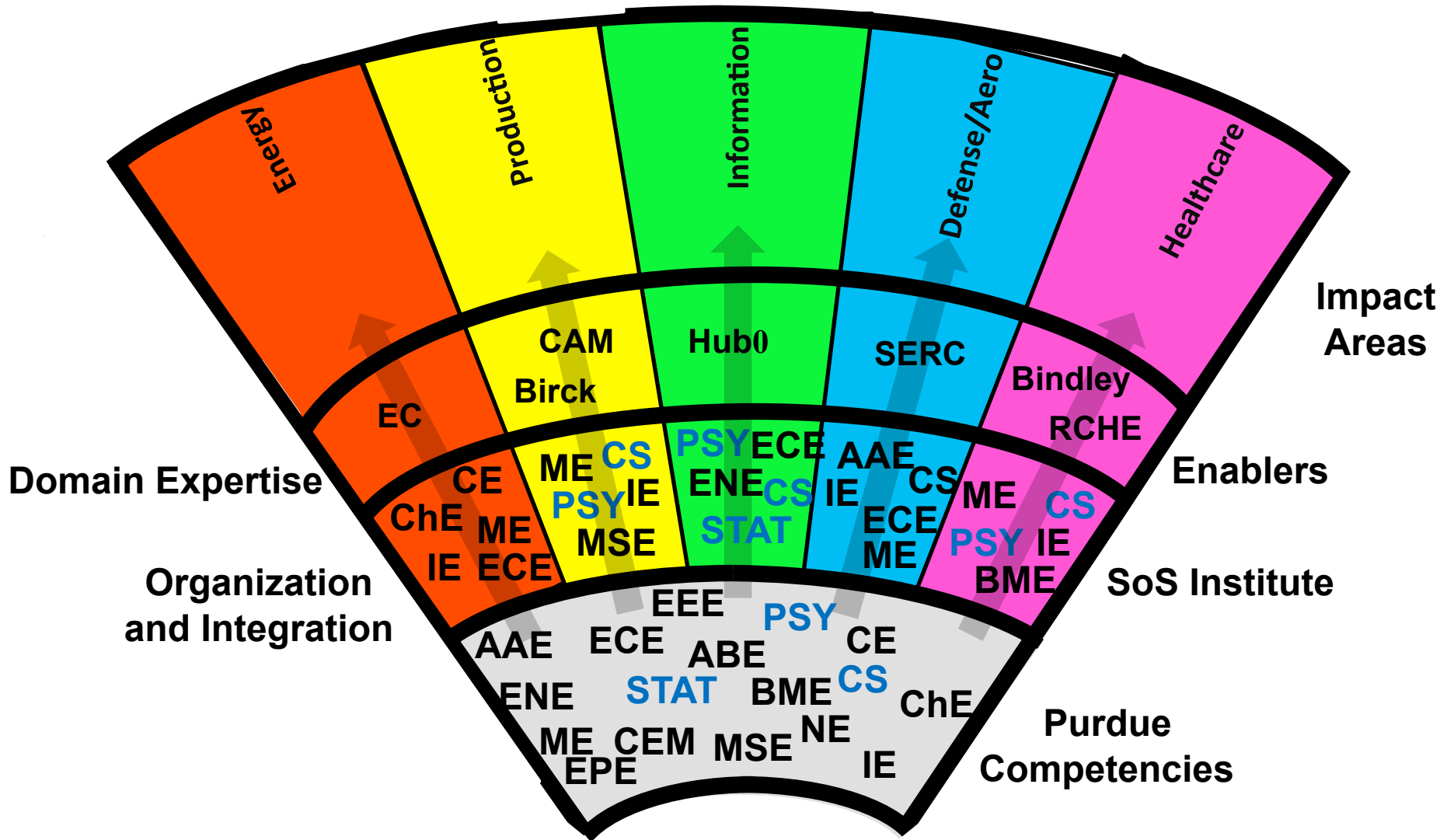


Purdue Discovery Park Centers

- ***Bindley Bioscience Center (Bindley)***
- ***Birck Nanotechnology Center (Birck)***
- ***Burton Morgan Entrepreneurship Center***
- ***Center for Advanced Manufacturing (CAM)***
- ***Center for the Environment***
- ***Cyber Center (Hub0)***
- ***Discovery Learning Center***
- ***E-Enterprise Center***
- ***Energy Center (EC)***
- ***Oncological Sciences Center***
- ***Regenstrief Center for Healthcare Engineering (RCHE)***



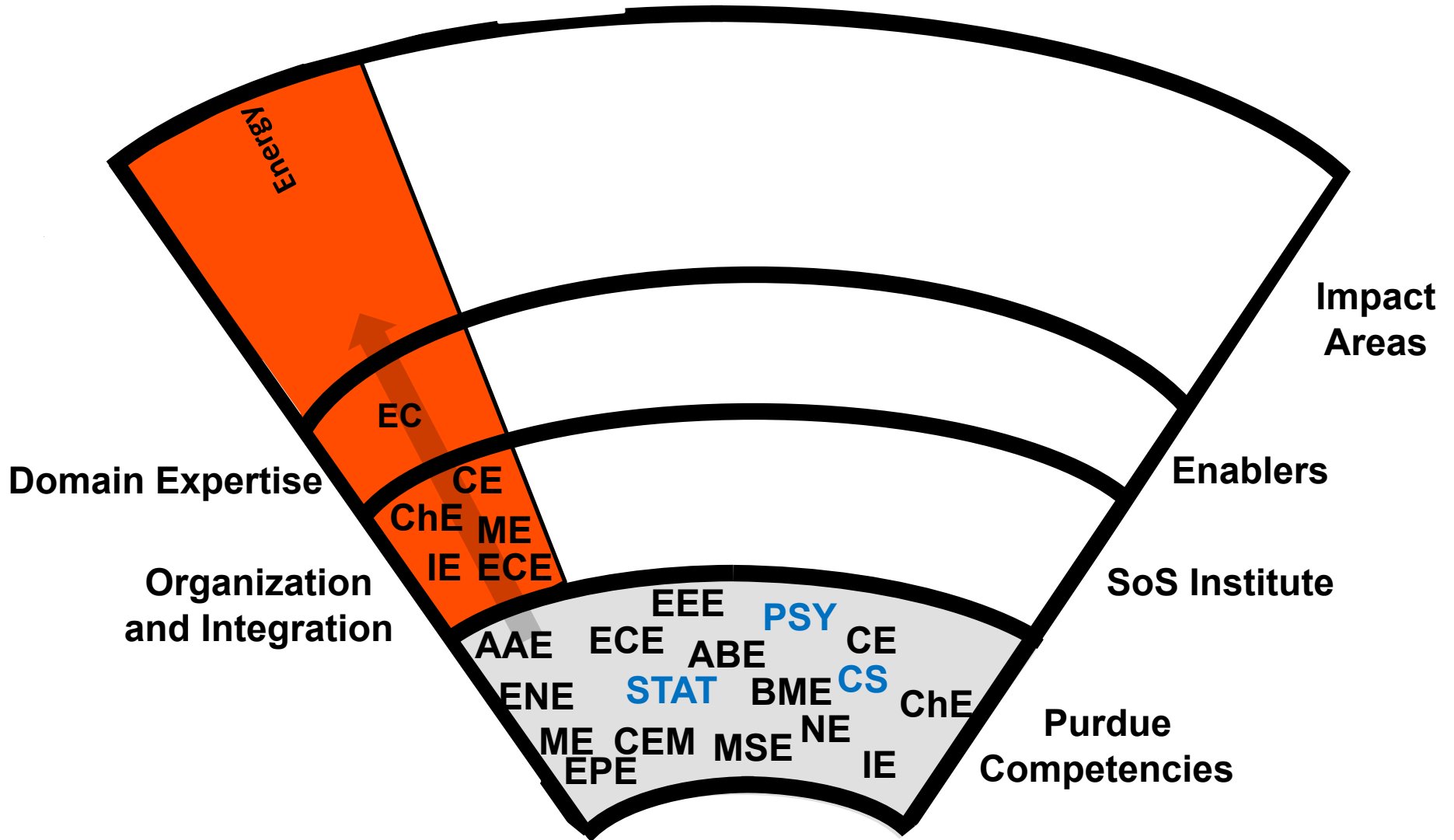
Purdue Engineering SoSI



Benefits of SoSI

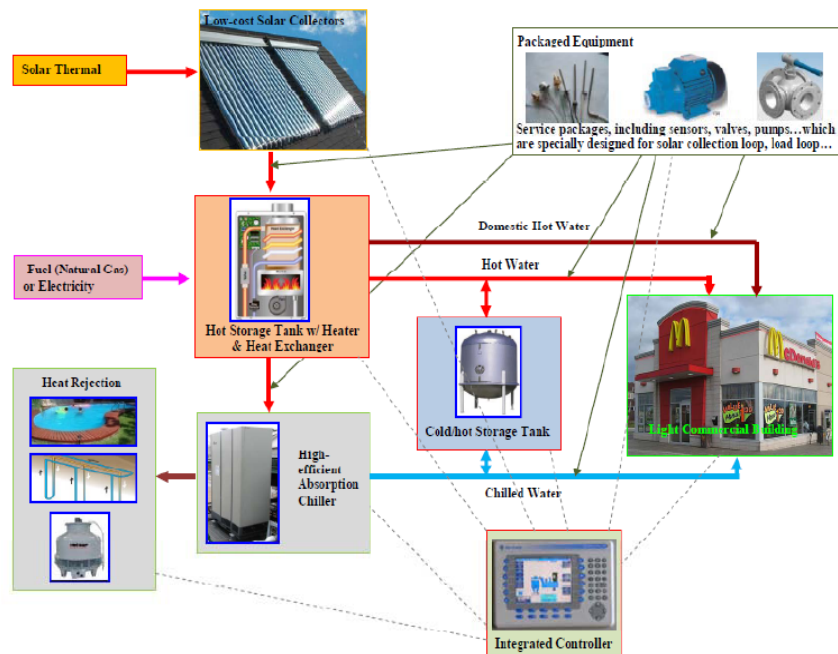
- Facilitates multi-disciplinary approach to systems problems
- Encourages generalized thinking of systems issues
- Results in a larger pool of systems thinkers
- Speeds the introduction of proven systems concepts to diverse application areas

Purdue Engineering SoSI



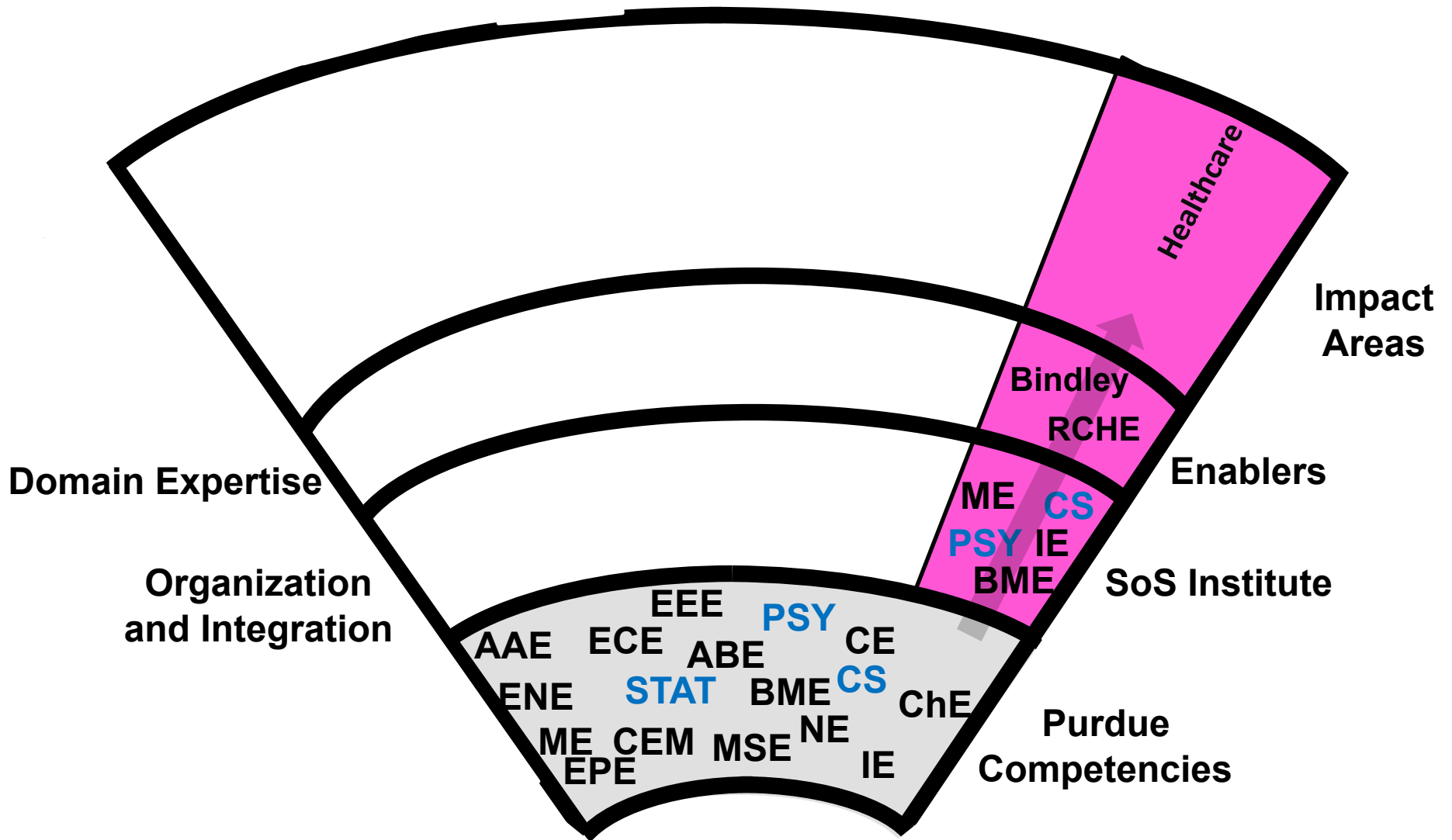
Solar Energy Systems for Buildings

Development of a design platform for solar cooling and heating systems and solar power systems. Provide designers, engineers, vendors, and building investors the appropriate optimization method to assist them in decision making, system design, and system evaluation.



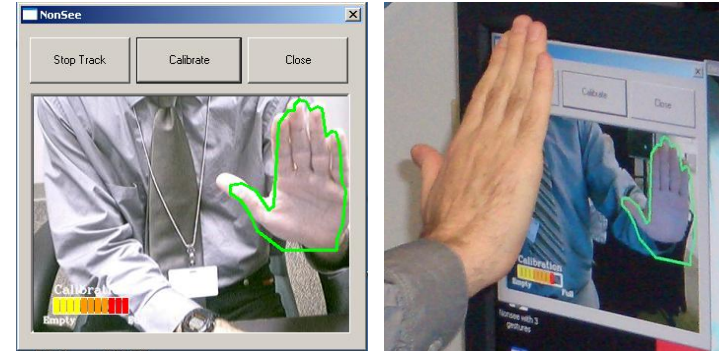
- Create architecture, design principles and tools to rapidly test designs and estimate costs
- Create flexibility in functionality & interfaces to support intersections in other SoS foci

Purdue Engineering SoSI

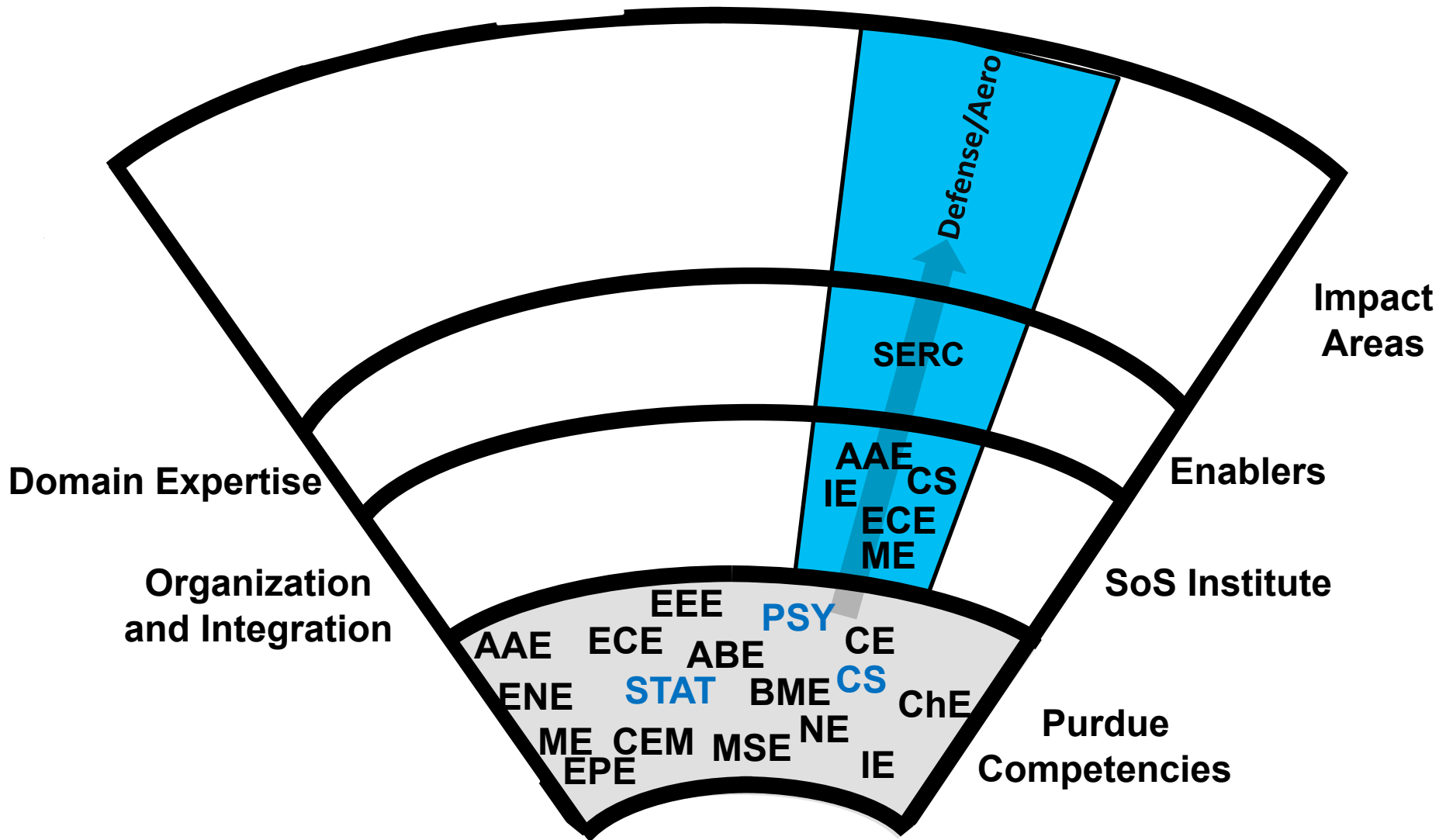


Hand-Gesture Recognition for the Operating Room

- Standard terminal interfaces are non-sterile, not intuitive, and require attention and position shifts.
- Hand-gesture interaction is an alternative, for interaction that allows the environment to remain sterile.



Purdue Engineering SoSI



Selected Defense/Aerospace Research

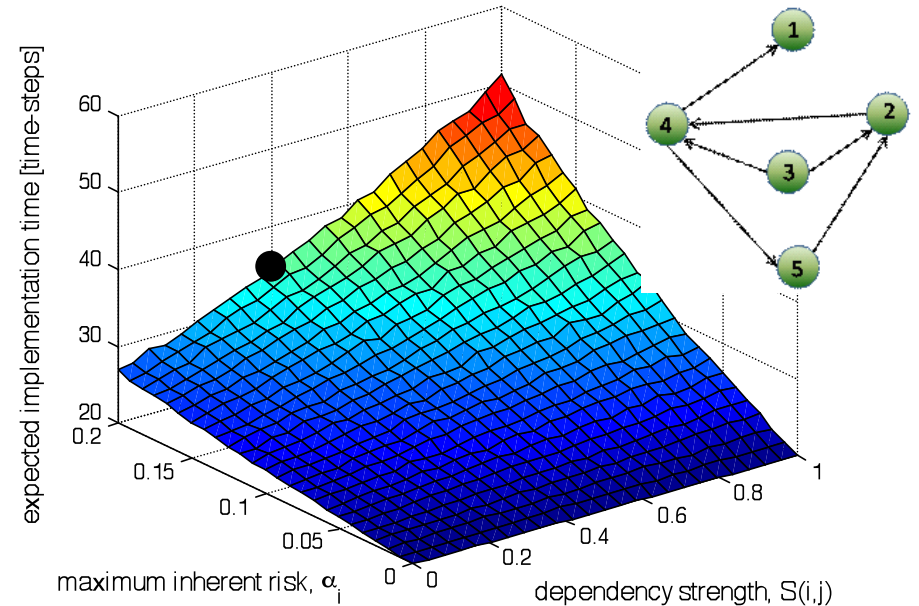
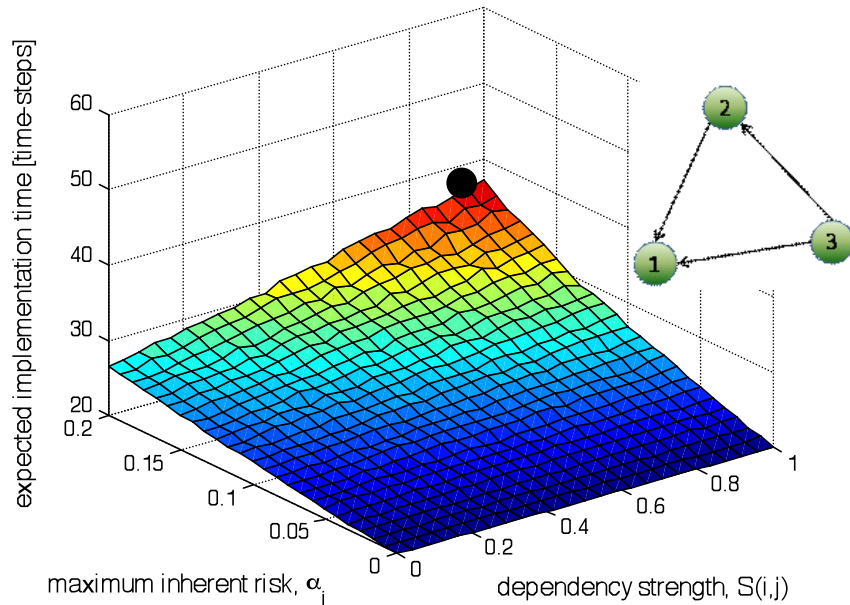
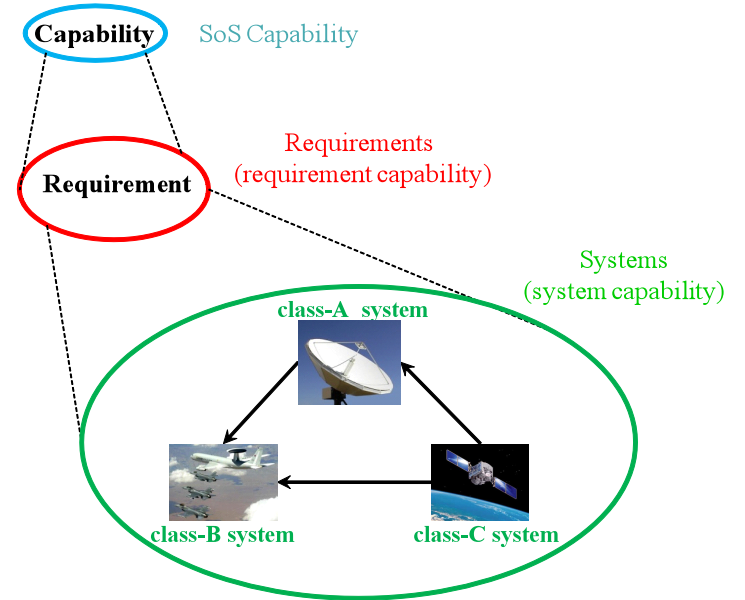
- An Agent-based Concept for an Enhanced C2BMC Architecture (Missile Defense Agency)
- System-of-Systems Approach for Assessing New Technologies in NextGen (NASA NRA)
- Complexity and Adaptability Metrics for DARPA META program (Boeing, for DARPA)
- Aerospace Systems Research in Support of Integration of Advanced Concepts into NextGen (NASA NRA via Raytheon)
- *Acquisition Management for Systems-of-Systems: Exploratory Model Development and Experimentation (Naval Postgraduate School)*
- Near-Term Operational Changes for Reducing Aviation's Environmental Impact (FAA PARTNER Center of Excellence)
- Fractional Shares, Air Charter and Air Taxi Operations as a System of Systems Problem (Cessna and CitationShares)

Project Focus: Impact of Disruptions and Interdependence Structure in Capabilities Development

- Sponsor: Naval Postgraduate School Acquisition Research Program
- Research Questions: How do system-specific characteristics impact the successful development of systems of systems for capability-based acquisition?
- How do system interdependencies impact the development process?
 - How do disruptions propagate in complex networks of interdependent systems?
 - How can we quantify the cascading effects of development risk?
 - How can we compare network of systems in their ability to reduce the impact of risk?
- Objective: Answers to these questions can increase the probability of success in systems of systems development

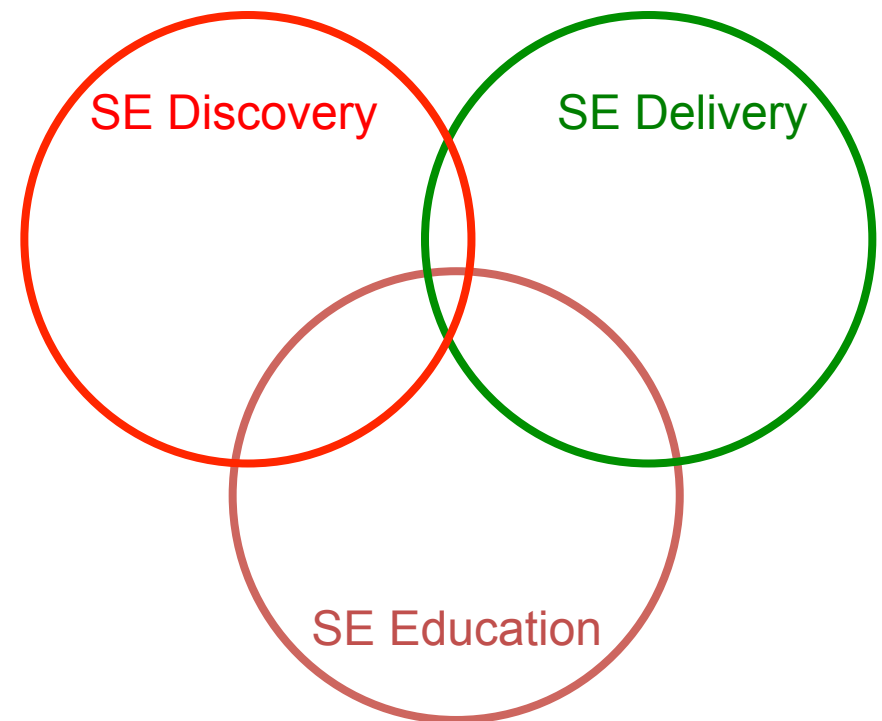
Disruption Propagation in Capability-Based Acquisition

- Two-pronged approach:
 - Discrete event simulation of SE processes
 - Analytical model for risk propagation
- Investigate impact of system interdependencies and development risk on development time
 - Cascading effects of risk and disruptions



SoSI Also Focused on Education

- SE interdisciplinary concentration
 - Expected appeal to thesis seeking MS and PhD students as well as non-thesis MS students
 - 3-4 Courses + SE Project
 - Readily matches a “certificate” program, which is often desirable to distance-learning / professional students
- Example SE Course
 - Instructor: practicing SE
 - Principles of SE and their application across the system life cycle
 - On-campus and distance students



SoS Course

- Graduate (MS-level) offering, seeking students from all engineering departments (and beyond?)
- Application project emphasis across domains
- Methodological emphasis is on understanding dynamic system interactions and problem definition, and then mathematical modeling

Sp06 Semester = 27 Students
 Sp07 Semester = 27 Students
 Sp08 = 32 Students (10 Distance)
 Sp09 = 30 Students (11 Distance)
 Sp10 = 47 Students (17 Distance)

NEW COURSE

SPRING 2006

System-of-Systems Modeling & Analysis

A.&AE 590K
(T/Th 12:00 - 1:15)

Course Instructor: Dr. Daniel DeLaurentis
 Contact information: ddelaure@purdue.edu, *40694, GRIS-312

Course Description:

The primary focus of this course is on understanding, modeling, and analyzing an emerging class of problems called System-of-Systems: large-scale, interdisciplinary problems with heterogeneous collections of independently operating systems. Team projects will be undertaken in which students will explore new methods for analyzing problems such as the National Transportation System, Space Exploration, Integrated Defense and/or other national priorities.

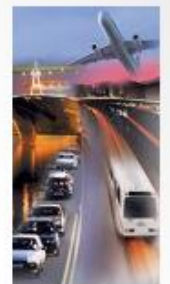
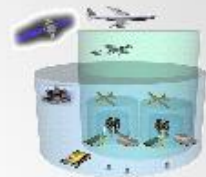
Topics:

- Distinguishing traits and behaviors of Sys-of-Sys problems
- Lexicon and abstraction methods
- Modeling approaches, such as:
 - State equations & control
 - Modern network theory
 - Probabilistic robust design
 - Artificial Intelligence (especially multi-agent simulation)
- Methods for analysis of alternatives through simulation

Prerequisites:

- Graduate or Senior-level standing (latter with consent of instructor)
- Knowledge of probability & statistics is preferred
- Students from Engineering, Management, Computer Science, Physics, Economics, Mathematics and other majors are welcome!

For more information, please visit: <http://web.ics.purdue.edu/~ddelaure/Courses>



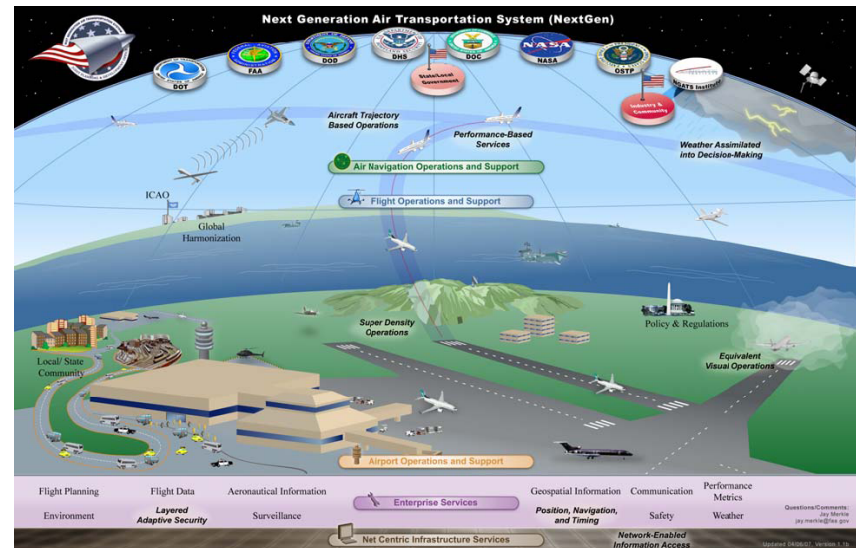


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NextGen Air Transportation System - FAA