

New Challenges in Safety Design, Analysis, Training, and Operation

Novel Applications of the IST

IST Perspectives

- Use IST for getting sophisticated validation data by focusing on V&V needs of advanced codes
- Use IST to "validate" the validation (UQ) methods
- Use IST to validate EOPs
- Use IST as platform for development, demonstration, and testing of CPS (smart NPP)

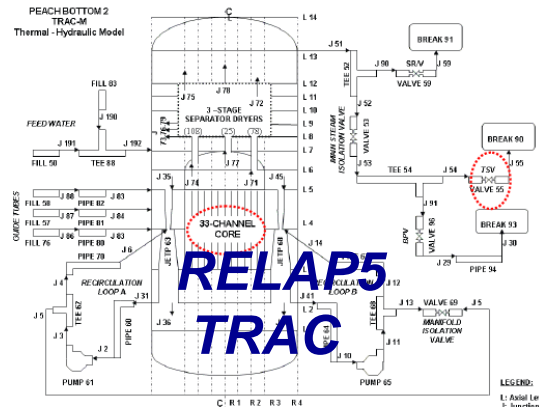
NSF

- Cyber-Physical Systems (CPS) are smart networked systems with embedded sensors, processors, and actuators that are designed to sense and interact with the physical world (including the human users), and support real-time, guaranteed performance in safety-critical applications
- In CPS systems, the joint behavior of the “cyber” and “physical” elements of the system is critical - computing, control, sensing, and networking can be deeply integrated into every component, and the actions of components and systems must be safe and interoperable



2050

2015



1979

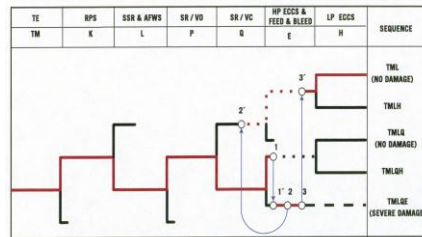
TMI-2



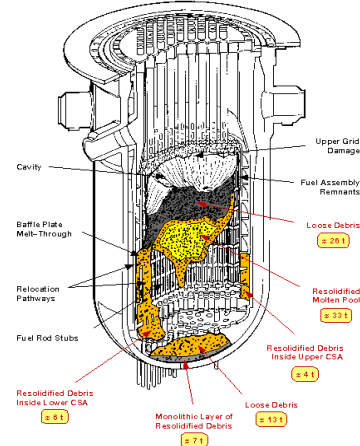
The Loss-of-Fluid Test Facility, Idaho National Labs

WASH-1400

Reactor Safety Study



Original Core Materials Inventory: ≈ 130 t



1953



Space Speech at the United Nations, 1953

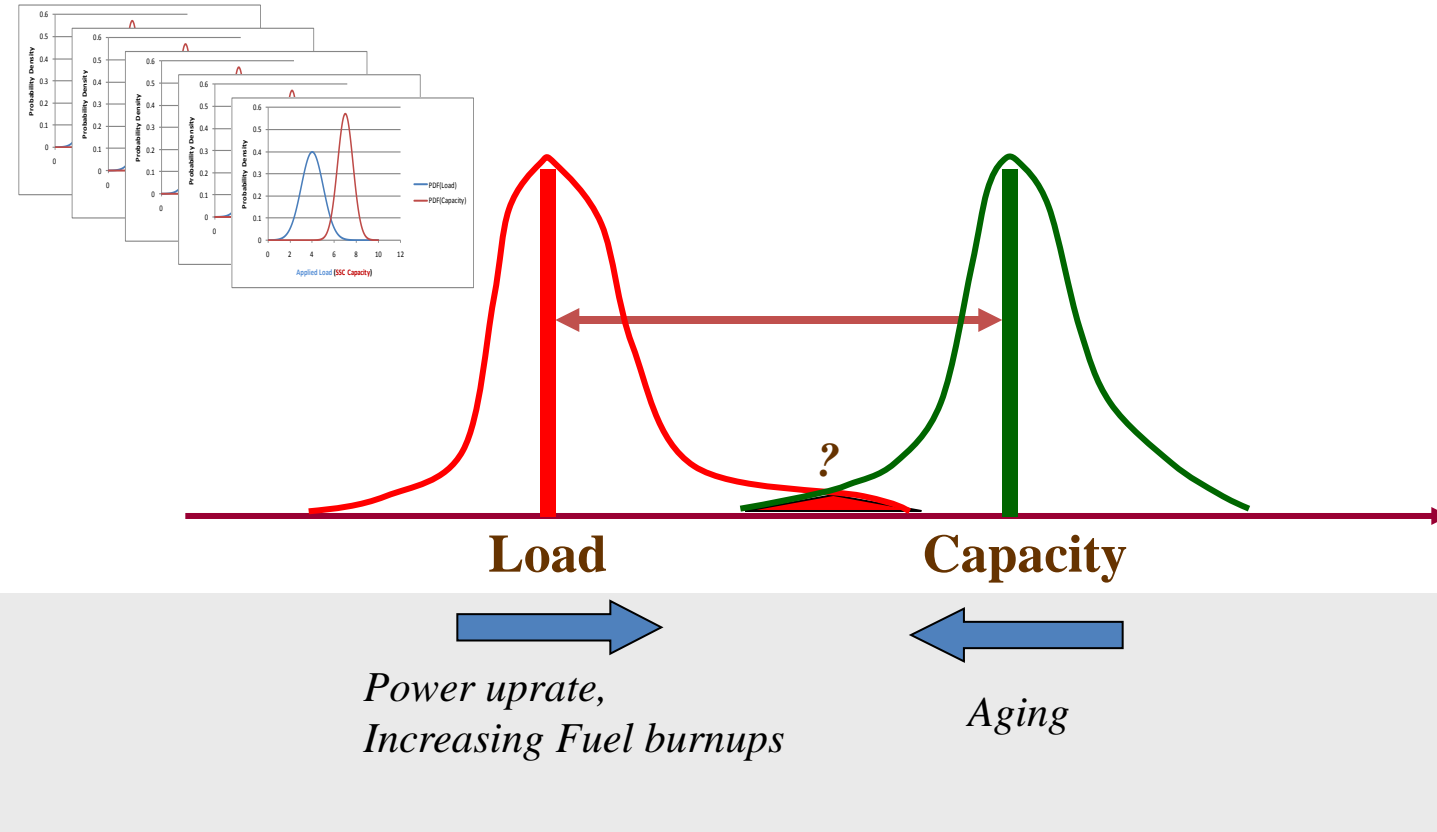
Safety Design

- Passive Safety
- Digital I&C
- Inherently Secure
- Resilient Design
- ??

Safety Analysis

- Predictive Capability
- Risk-Informed Safety Margin Characterization (RISMC)
- Beyond Design Basis Accidents
- Vulnerability Search Engine
- Next-Generation Safety Analysis Codes
- ??

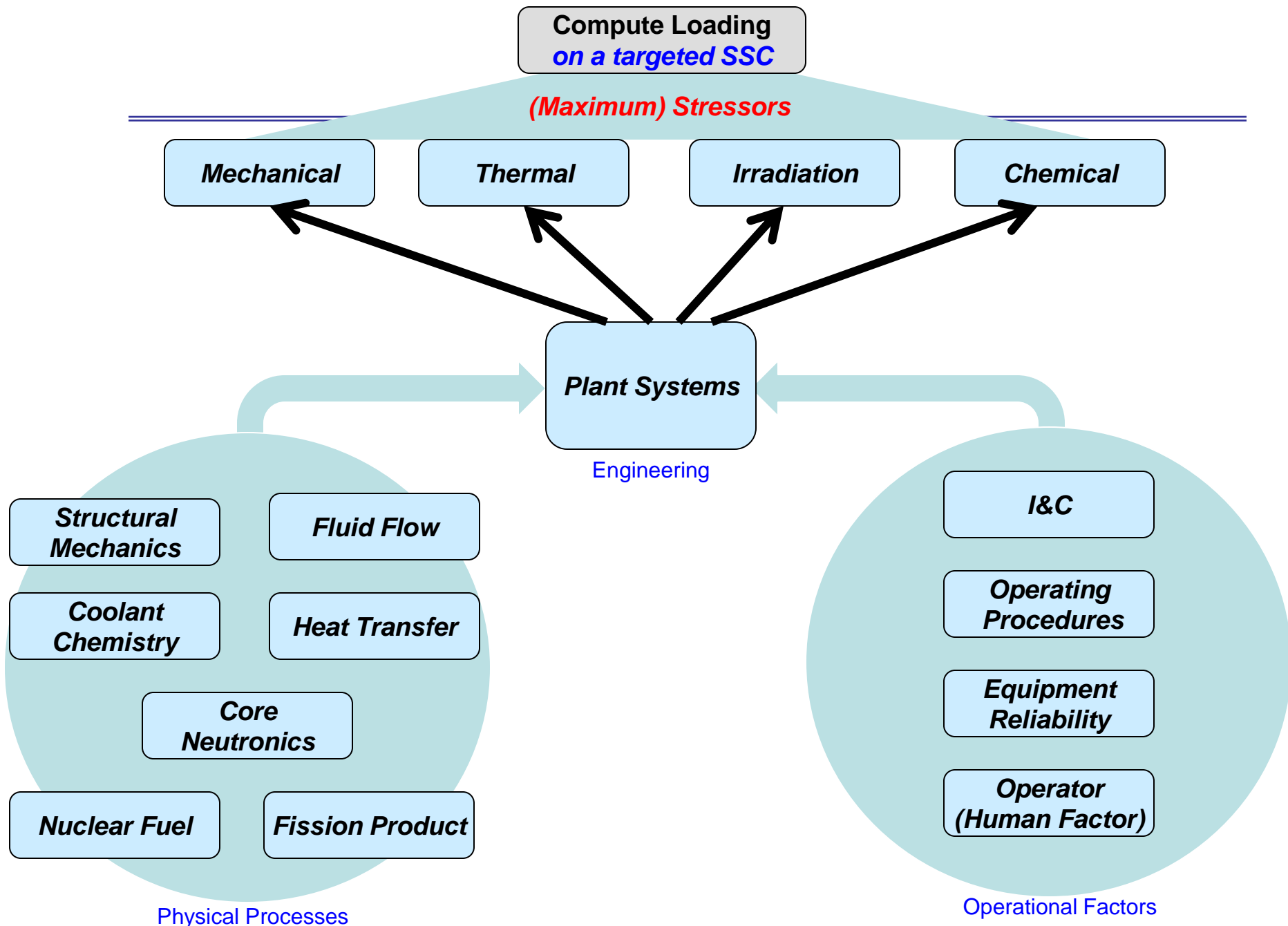
Risk-Informed Safety Margin Characterization

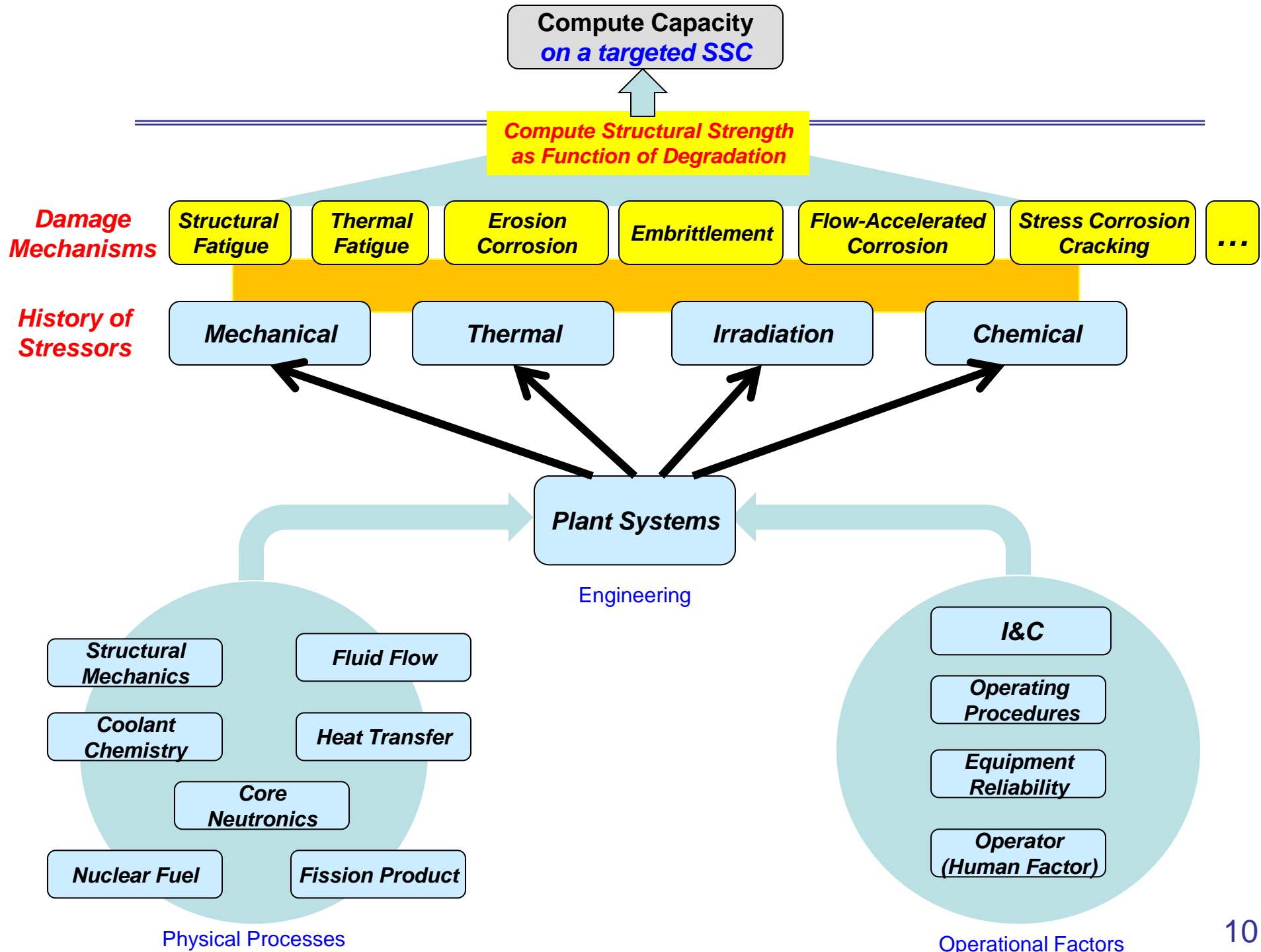


- Scenario uncertainty (e.g. reliability, operator actions)
- Model form uncertainty
- Model parameter uncertainty
- Numerical uncertainty

NGSAC

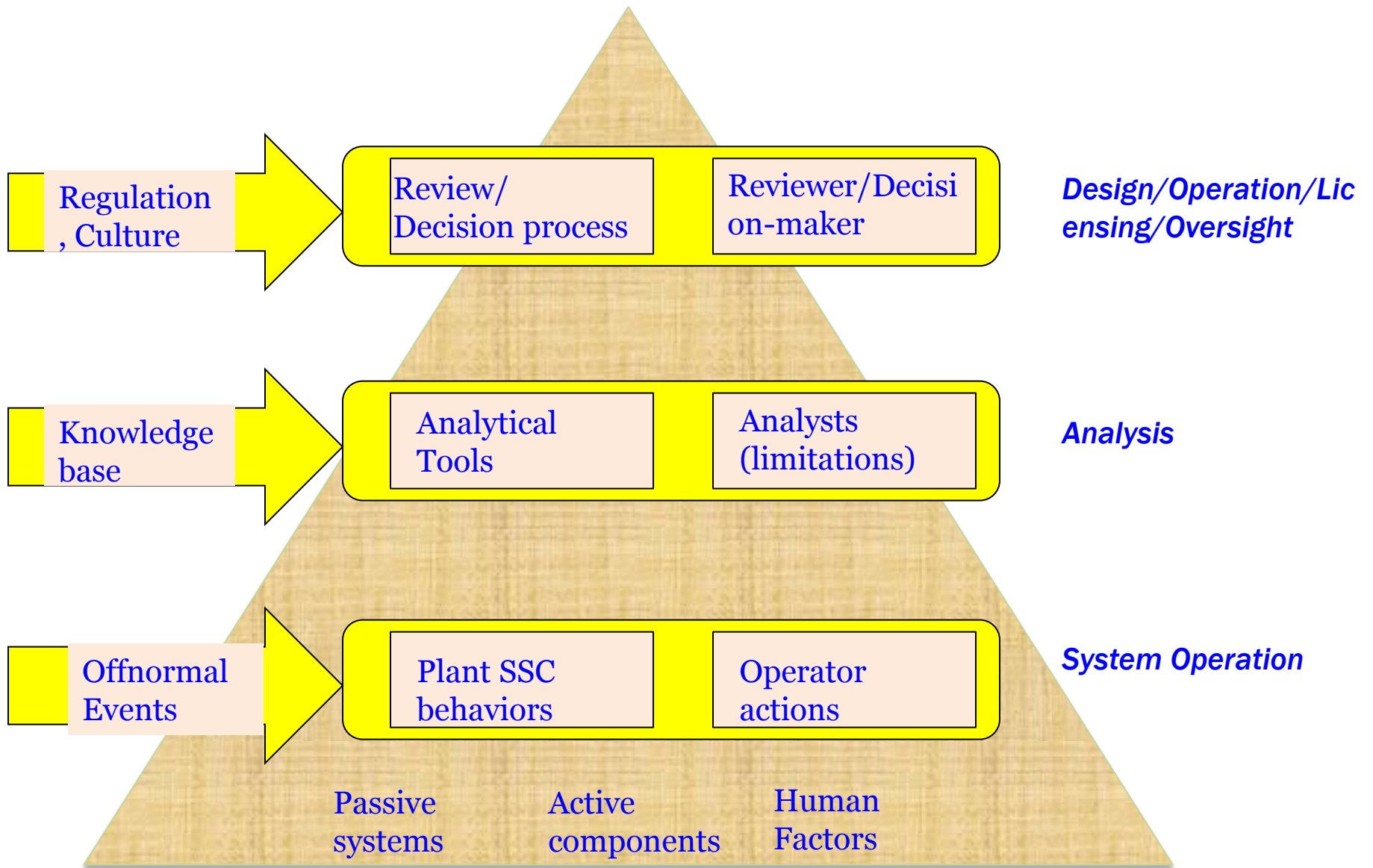
- Multi-physics integration
- Multi-scale integration, 0D-1D-3D
 - → IST
- Predictive Capability Maturity
 - V&V – UQ





Operation (including ER)

- Emergency Operating Procedures (EOP)
- Severe Accident Management Guideline (SAMG)
- Validation of EOP & SAMG
 - Seamless integration
- Computerized Accident Management Operator Support & Training (CAMOST)
 - Diagnostic
 - Prognostic
 - Decision
- ??



“Humans in the Loop” at All Levels

Training

- Prevention, Protection, and Mitigation
- CAMOST
 - Diagnostic
 - Prognostic
 - Decision
- ?

IST as Testing Platform for CPS

- Physical system is advantageous over virtual system
- IST can be used to assess the V&V-UQ process, i.e., how good are prediction methods and how good are V&V-UQ methods

IST facility as
Cyber Physical System (CPS)
*Platform for Evaluation of
Safety Design, Analysis, Training,
and Operation Concepts*

Cyber-physical systems (CPS)

- CPS are engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components
- Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will far exceed the simple embedded systems of today
- CPS technology will transform the way people interact with engineered systems -- just as the Internet has transformed the way people interact with information
- New smart CPS will drive innovation and competition in sectors, such as agriculture, energy, transportation, building design and automation, healthcare, and manufacturing

Novel Applications of the CAER IST as a CPS Platform

- What technologies exist at universities, national laboratories that, if adapted to the CAER-IST, would make a significant and favorable impact?
- Alternatively, what technologies could the CAER-IST be adapted to in order to make a significant and favorable impact?
- What are the biggest obstacles or unique challenges in adopting the CAER-IST to envisioned technology R&D (e.g., thermal-hydraulics, digital I&C, advanced M&S, etc.)?