Technical Challenges and Use Cases that Drive R&D of Next-Generation System Analysis Code

Nam Dinh

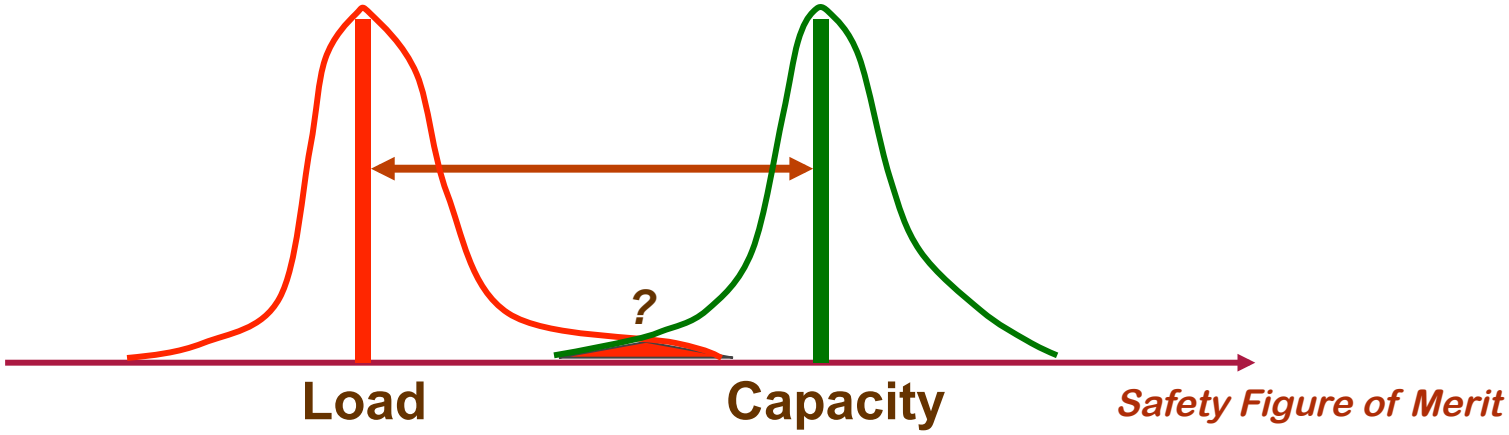
Idaho National Laboratory

Second Workshop on "U.S. Nuclear Power Plant Life Extension and Development,"

Washington DC
February 22-24, 2011

Light Water Reactor Sustainability R&D Program

Risk-Informed Safety Margin Characterization (RISMC)

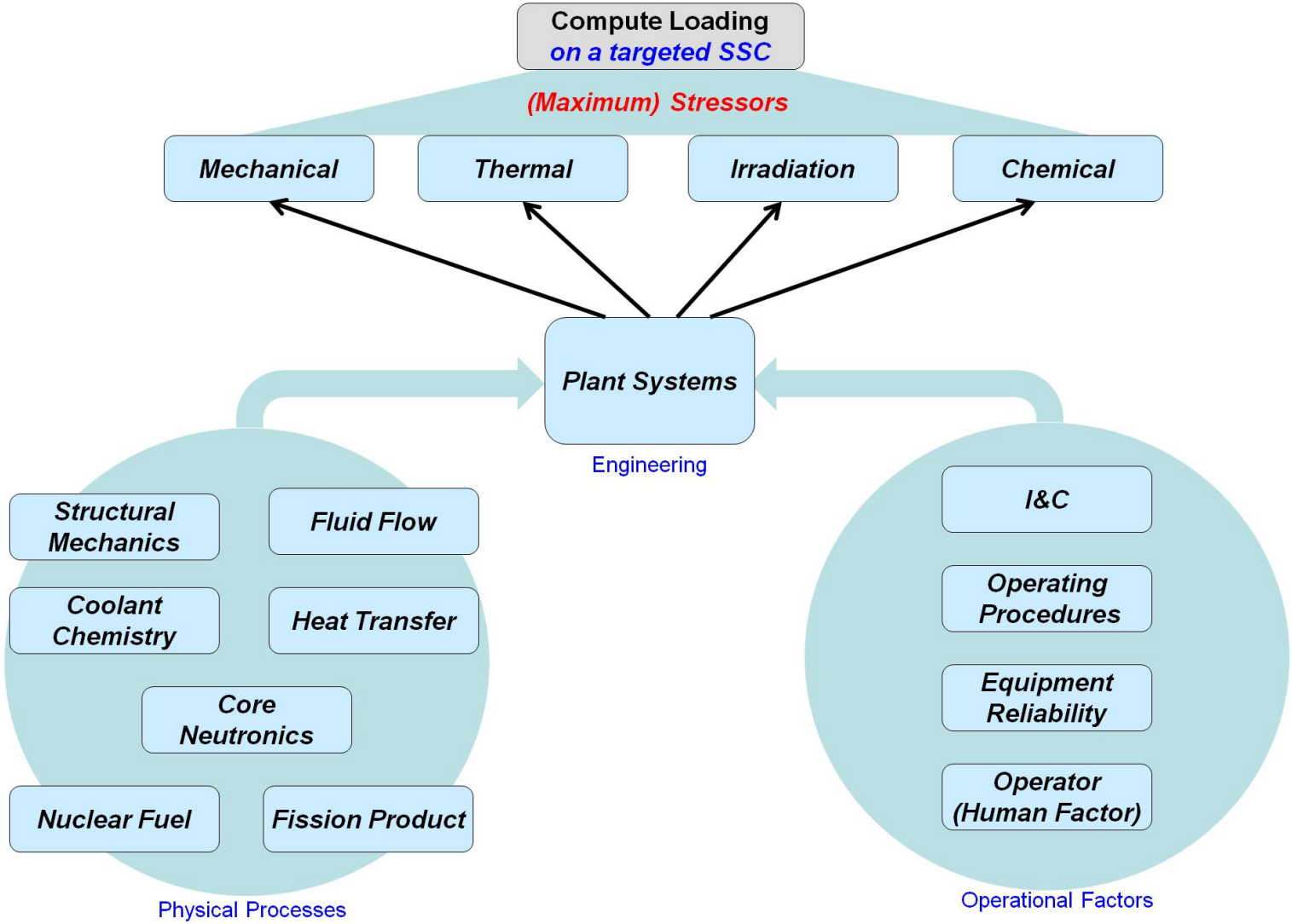


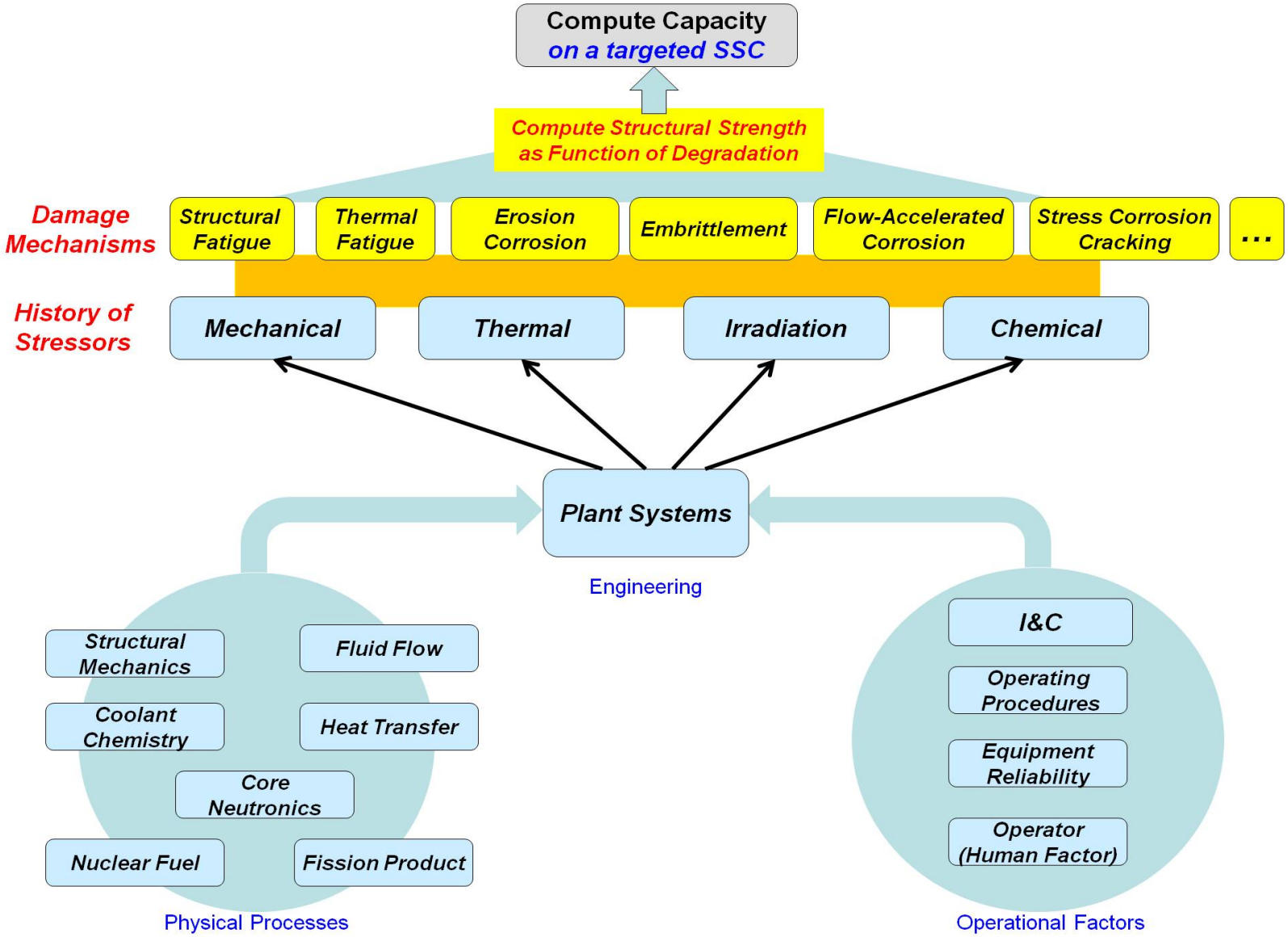
Power uprate,

Fuel burnups

Aging

- Frequencies of IEs
- New IEs/ sequences
- Cascading failures


Compute Loading
on a targeted SSC
(Maximum) Stressors
Mechanical
Thermal
Irradiation
Chemical
Plant Systems
Engineering
Structural Mechanics
Fluid Flow
Coolant Chemistry
Heat Transfer
Core Neutronics
Nuclear Fuel
Fission Product
Physical Processes
I&C
Operating Procedures
Equipment Reliability
Operator (Human Factor)
Operational Factors


Compute Capacity
on a targeted SSC
Compute Structural Strength
as Function of Degradation
Damage Mechanisms
Structural Fatigue
Thermal Fatigue
Erosion Corrosion
Embrittlement
Flow-Accelerated Corrosion
Stress Corrosion Cracking
...
History of Stressors
Mechanical
Thermal
Irradiation
Chemical
Plant Systems
Engineering
Structural Mechanics
Fluid Flow
Coolant Chemistry
Heat Transfer
Core Neutronics
Nuclear Fuel
Fission Product
Physical Processes
I&C
Operating Procedures
Equipment Reliability
Operator (Human Factor)
Operational Factors

Technical Areas in R7 R&D

Numerical Methods for Multi-Physics and Multi-Scale Integration

Coarse-Grained Computational Fluid Dynamics

Advanced Modeling of Physical Processes & Plant SSCs

R7 as Computational (UQ) Engine for RISMC

Advanced Two-Phase Thermal-Hydraulics

Data Support for Model Calibration & Code Validation/UQ

Software Engineering

LWRS Light Water Reactor Sustainability

Technical Areas in R7 R&D

Numerical Methods for Multi-Physics and Multi-Scale Integration

Time scales: minutes to years
(e.g., dynamic time step control)
Length scale: local to system
(e.g., transition between 0D-1D-3D)

Coarse-Grained Computational Fluid Dynamics

Advanced Modeling of Physical Processes & Plant SSCs

Multiphysics-compatible models

R7 as Computational (UQ) Engine for RISMC

Advanced SA/UQ methods

Advanced Two-Phase Thermal-Hydraulics

Data Support for Model Calibration & Code Validation/UQ

Software Engineering

Large and heterogeneous data sets
(I/P/O); multiphysics meshing; GUI

LWRS Light Water Reactor Sustainability

R7 Use Cases

Numerical Methods for Multi-Physics and Multi-Scale Integration

Use Case: Overcooling Transients (OCT)

Coarse-Grained Computational Fluid Dynamics

Use Case: OCT

Advanced Modeling of Physical Processes & Plant SSCs

Use Case: OCT

R7 as Computational (UQ) Engine for RISMC

Use Case: Feed-and-Bleed (FAB)

Advanced Two-Phase Thermal-Hydraulics

Use Case: FAB

Data Support for Model Calibration & Code Validation/UQ

Use Case: FAB

Software Engineering

Use Case: FAB and OCT

LWRS Light Water Reactor Sustainability

Multi-Pronged Approach to R&D Implementation

Risk-Informed Safety Margin Characterization (RISMC) Methodology

Next Generation System Safety (R7) Code

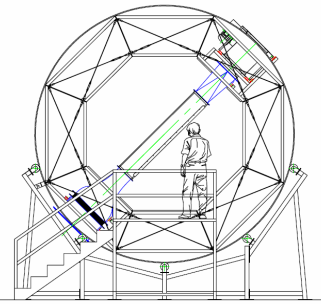
Reactor Safety Research & Testing (V&V) Infrastructure

R7 R&D

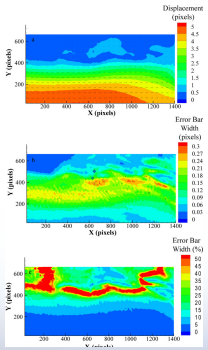
"Modeling, Experimentation, and Validation" (MeV) School

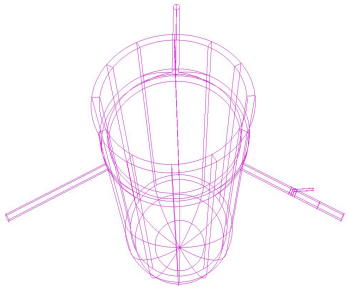
OSU, MIT, TAMU, UC-D, U-Mich, PU, ISU, UoI, USU, NCSU, OrSU

Light Water Reactor Sustainability

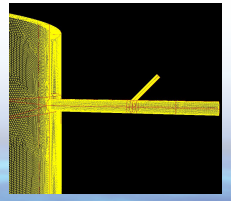


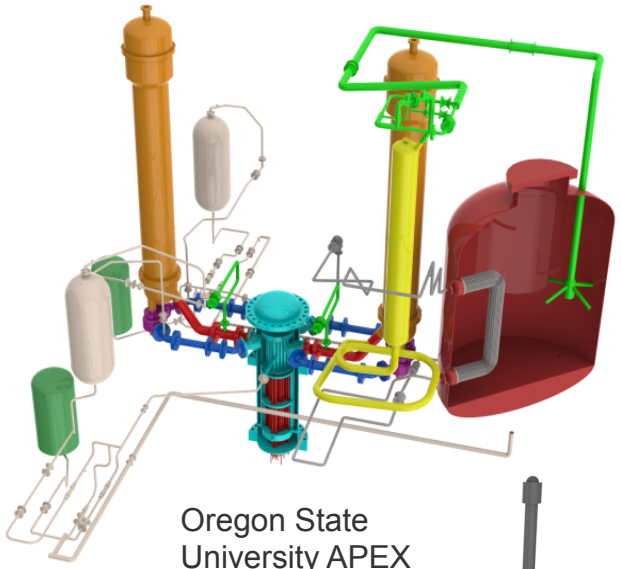
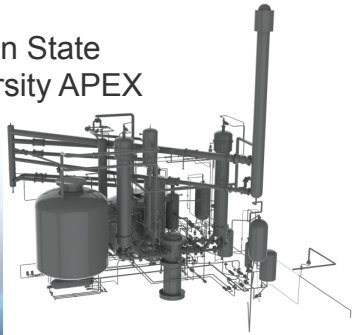
Utah State University





North Carolina State University





Oregon State University APEX