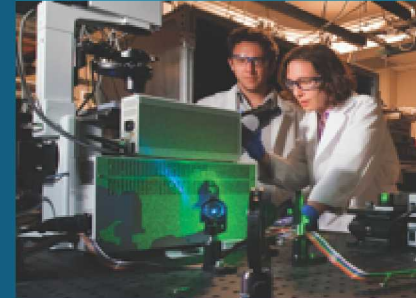


Systems Approaches to Problem Solving at Sandia National Laboratories *An overview with example studies*



PRESENTED BY

Robert Finch

For *Introduction to Systems Thinking* (Prof. D. Costello) 2 September 2020

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Introduction and Overview

Sandia National Laboratories is one of three nuclear weapons laboratories in the US

- Responsible in part for maintaining the reliability of the nation's nuclear stockpile
- Originally established as “Z Division” within Los Alamos Laboratory, Sandia became an independent laboratory in **1949**

Sandia has long been the “systems engineering” lab within the nuclear weapons-lab complex

- Sandia uses systems approaches for solving problems
- No one systems approach, but many approaches to systems applications

Nuclear Deterrence

Nonproliferation

National Security

Satellite Systems

Energy Systems

Transportation Systems

Robotics

Nuclear Weapons Security

Cyber Security

International Cooperation

And more ...

Systems Applications at Sandia

Engineering Systems

Security Systems

- Physical security systems
 - equipment & site design
- Human factors
 - facility personnel & public behaviors

Complex Systems/ Adaptive Systems

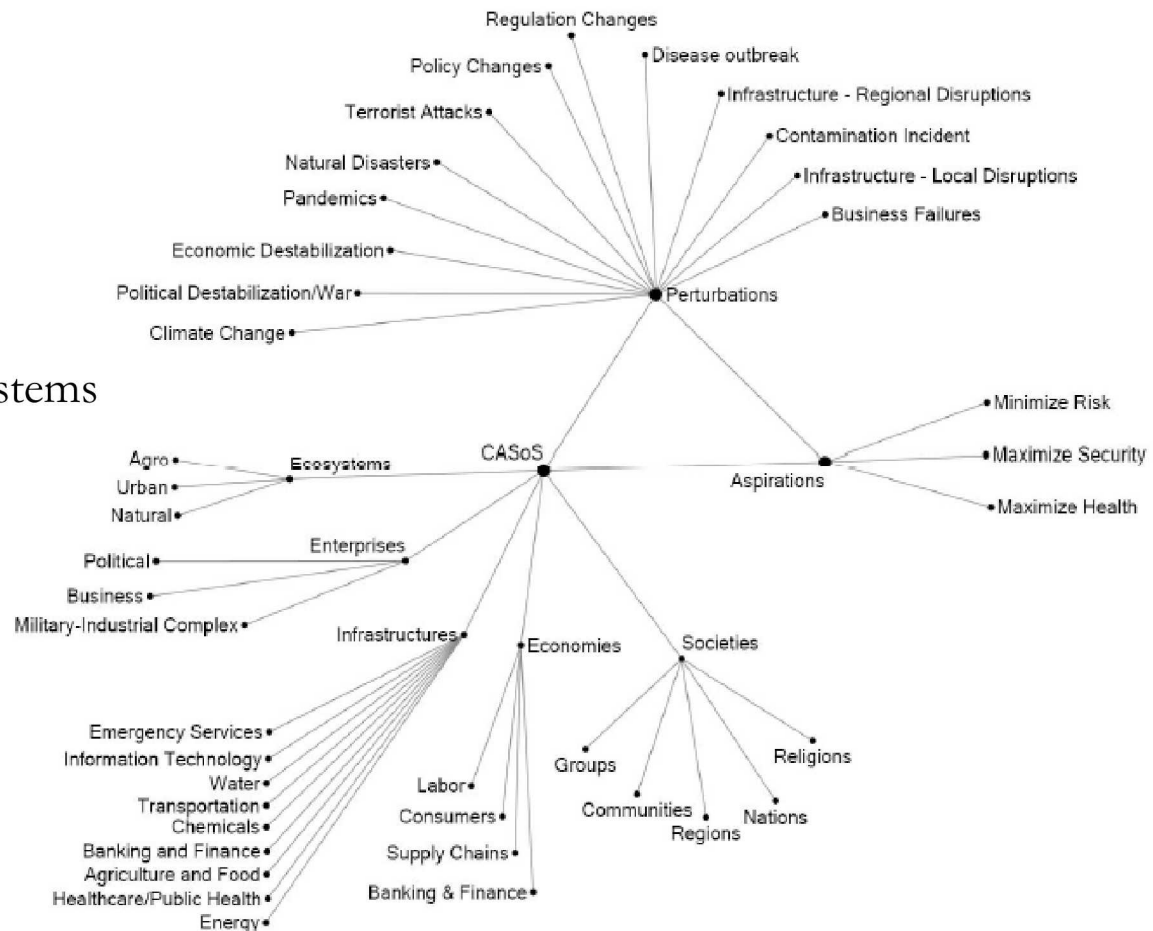
- Infrastructure
 - Healthcare systems
- Networks
 - Energy & Electricity distribution
 - Food distribution

Resiliency

- Natural disasters & Climate
- Epidemics & Pandemics
- Terrorism
- Engineered systems

Strategic Planning

- Scenario Development



Problem solving through modeling and simulation: Model Development & Testing

Identify/define Objective(s) or Aspiration(s)

Define/identify the problem

Identify the system

- Determine System boundary

Develop a system model

- Refine system & boundary
- Identify:
 - Components
 - Interactions
 - Interdependencies
 - Influences
 - Restrictions

Simulate system

- Vary inputs
- Test constraints

Evaluate potential solutions (outputs)

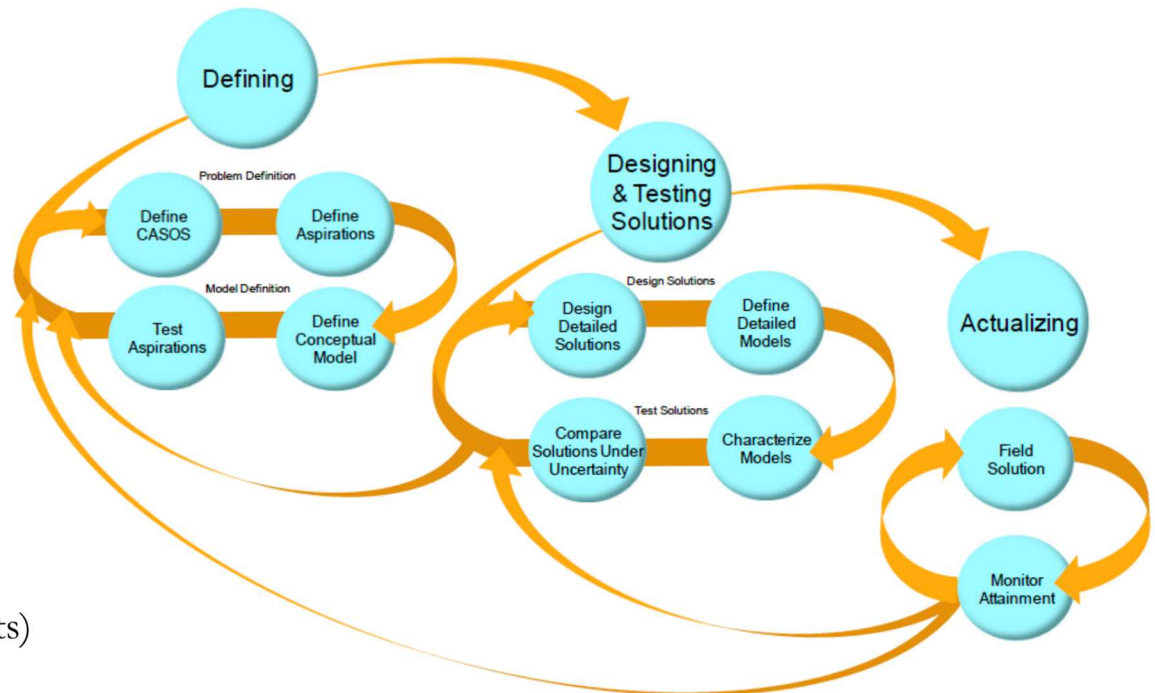
- w/in constraints
- Potential for optimization

Implement solution(s)

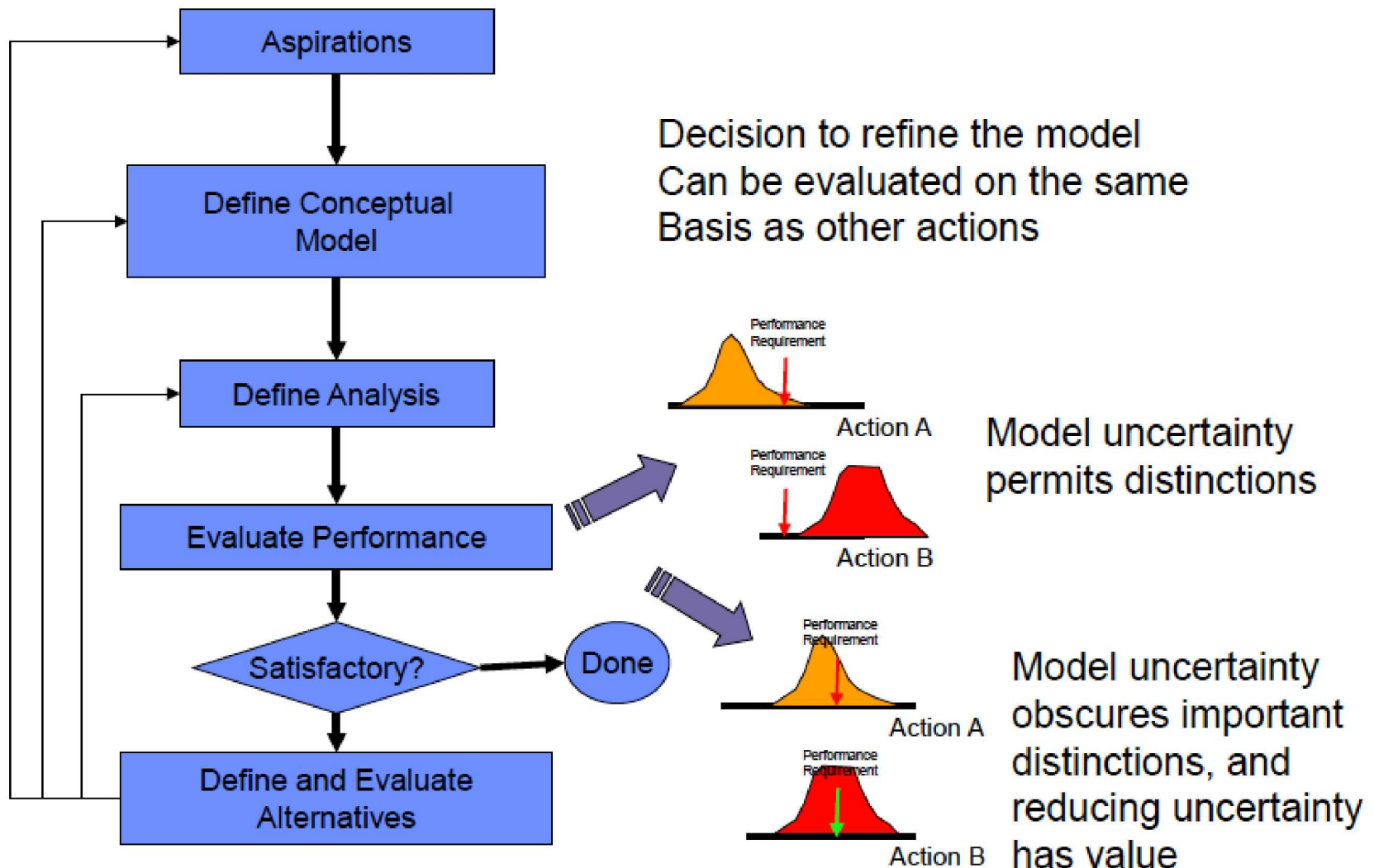
- monitor

Re-evaluate ... objectives/aspirations/problem/system/model/solutions

- Repeat process as necessary

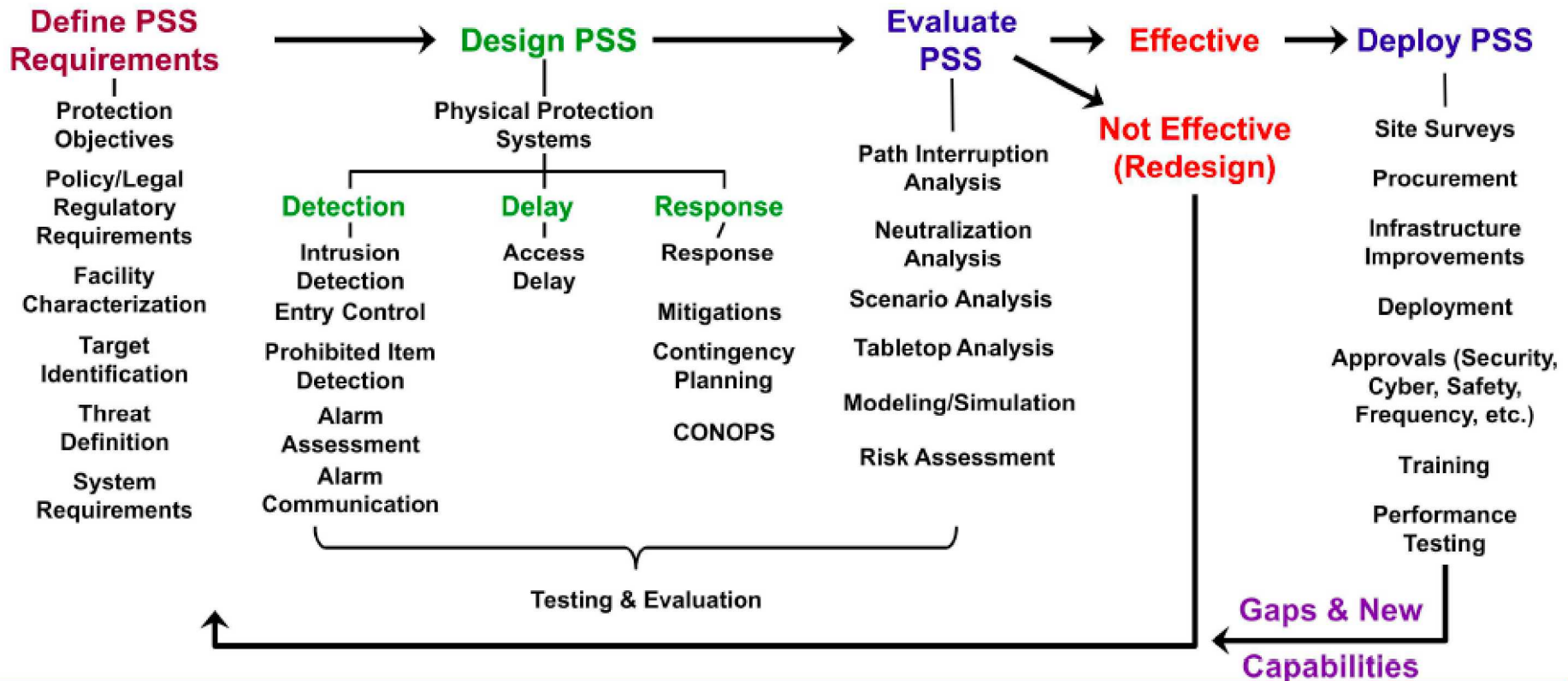


Model development: iterative + uncertainty



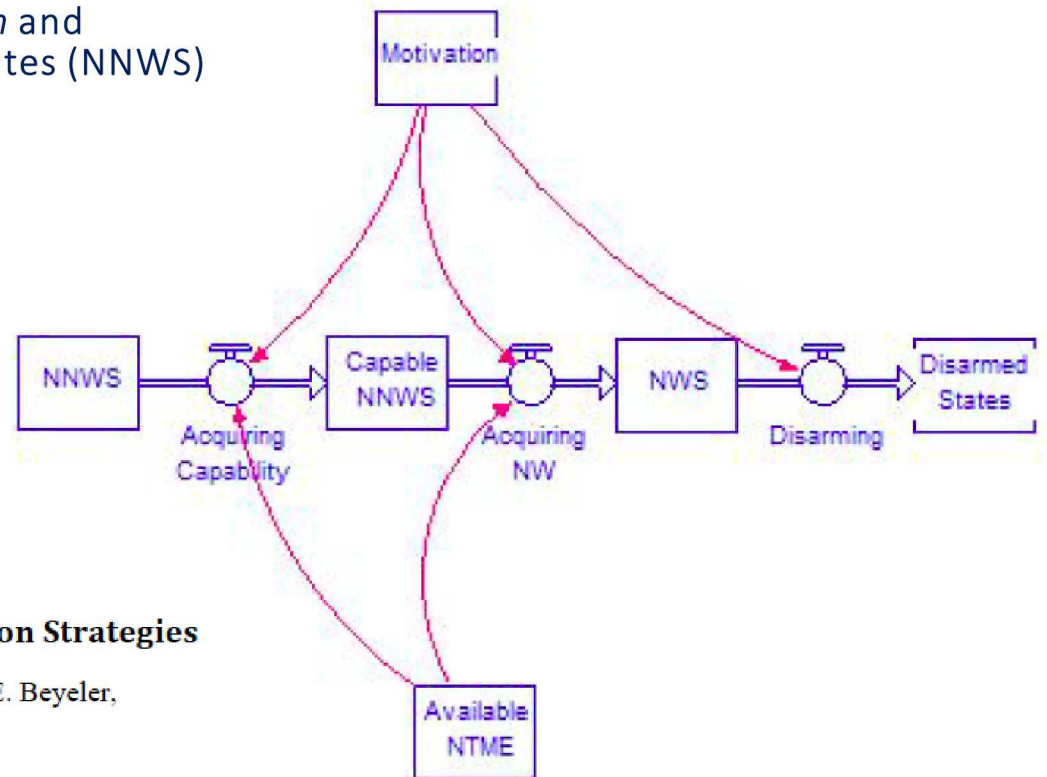
Systems Engineering: Physical Security System Design

Design Evaluation Process Outline (DEPO)



Basic model

Examine roles (influences) of *Motivation* and *Capabilities* on Non-nuclear Weapon States (NNWS)

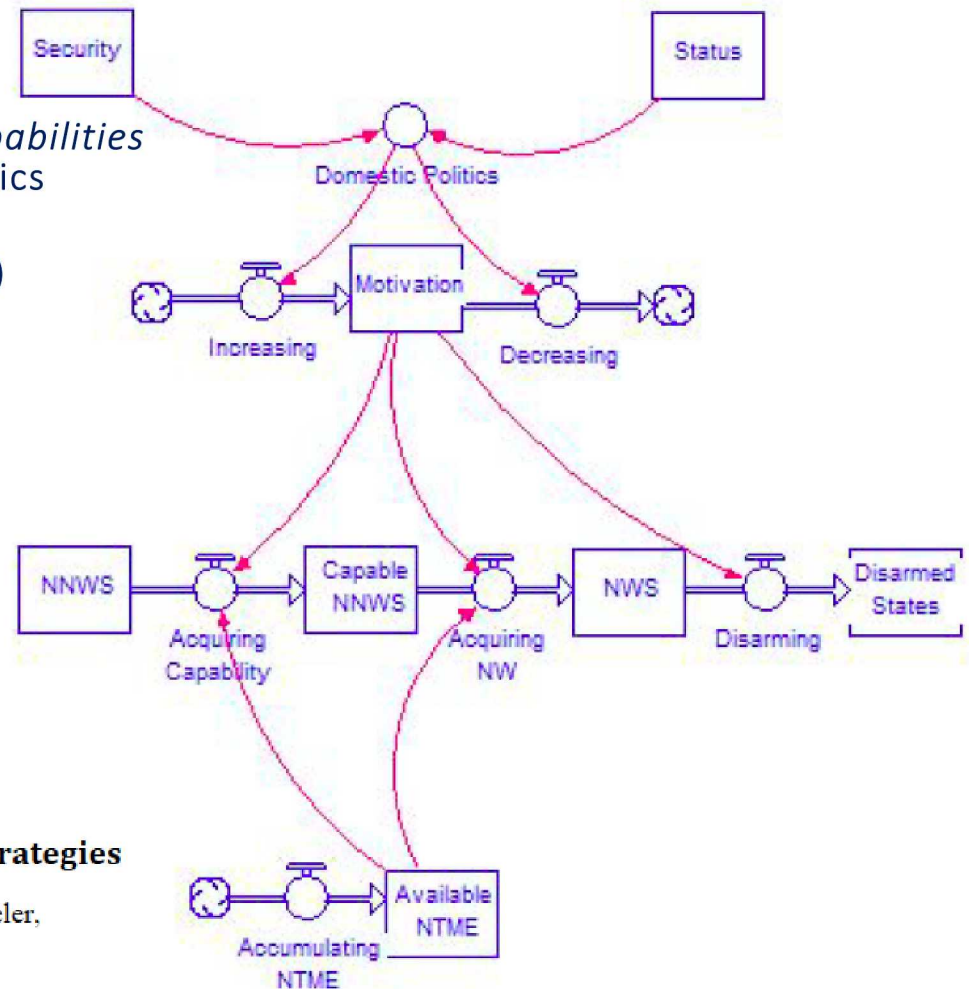


A Systems Approach to Assessing Nonproliferation Strategies

Arian L. Pregonzer, Robert J. Glass, Arlo Ames, Walter E. Beyeler,
Sharon DeLand, and Adam David Williams
Sandia National Laboratories*

Adding Complexity

1. Examine influences on *Motivation* and *Capabilities* (Security & Status) through Domestic Politics
2. Account for time to accumulate nuclear technology, material and expertise (NTME)

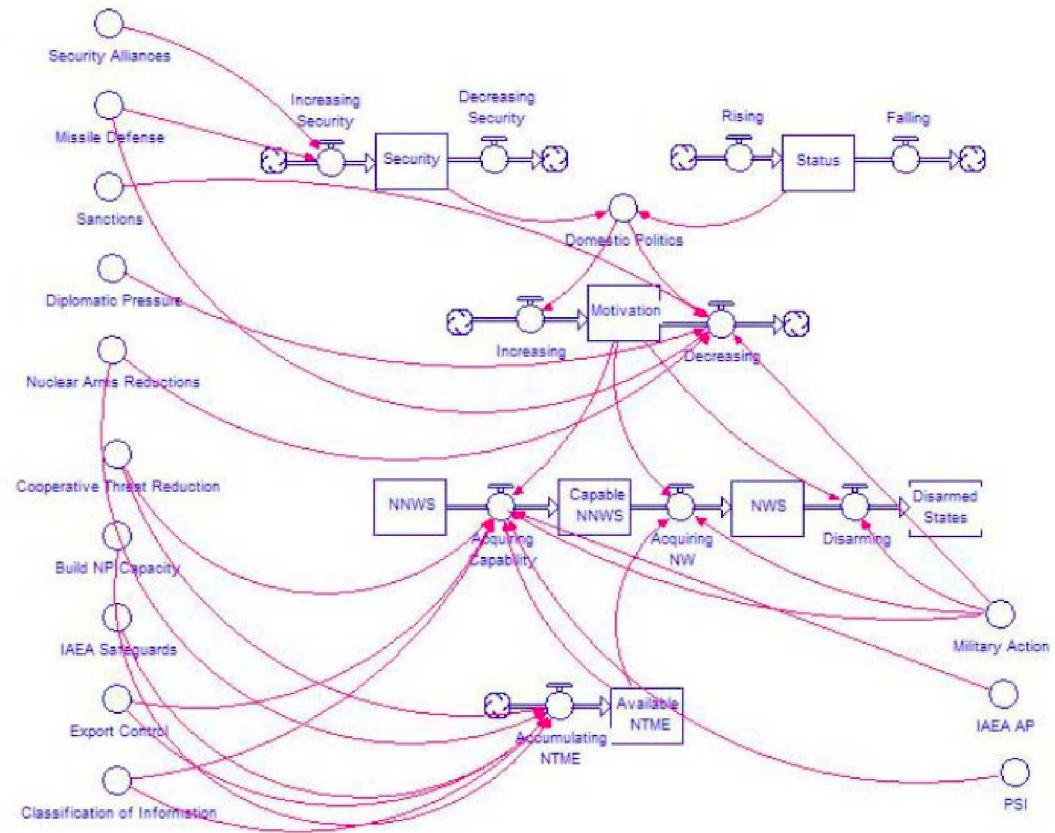


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Examine intended impacts of nonproliferation strategies

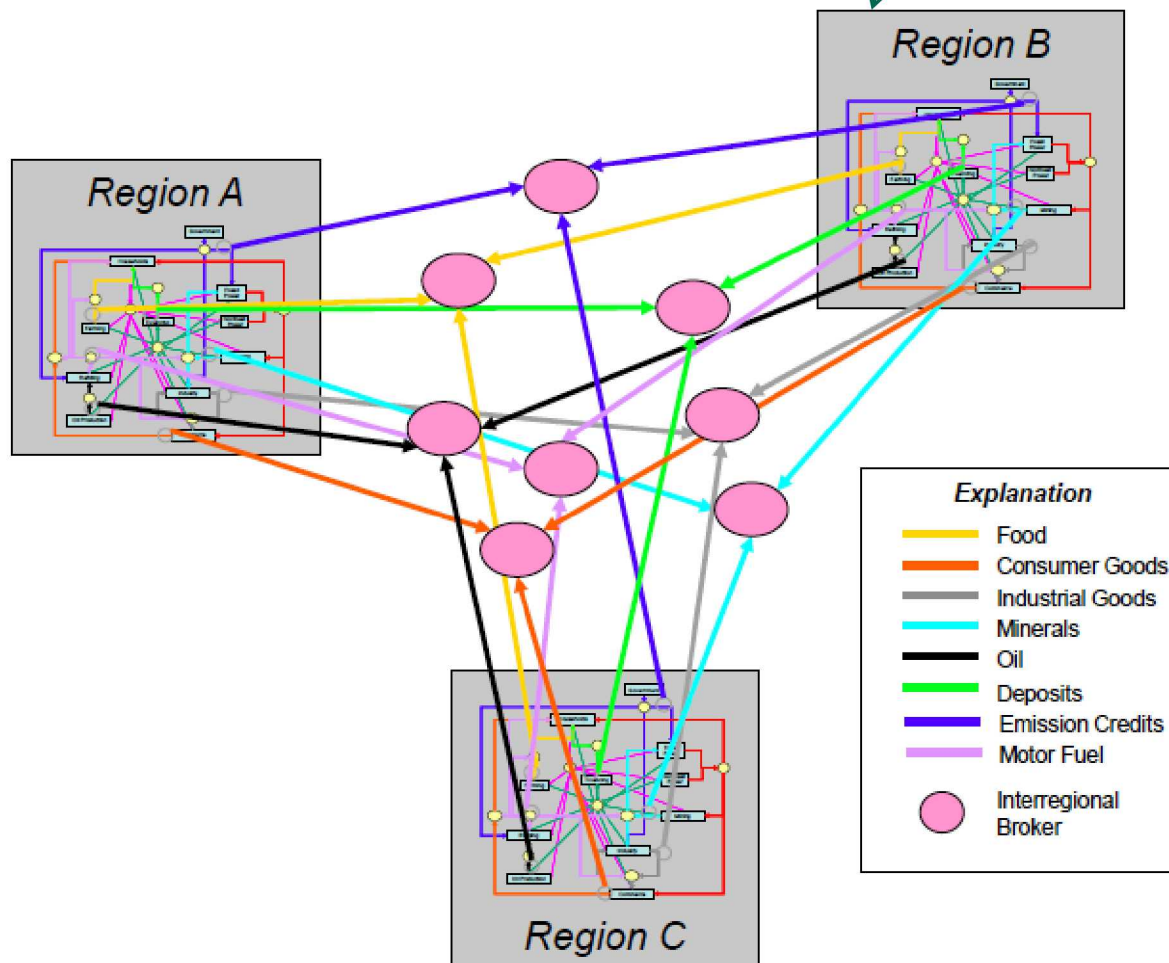
- Can also examine potential unintended consequences



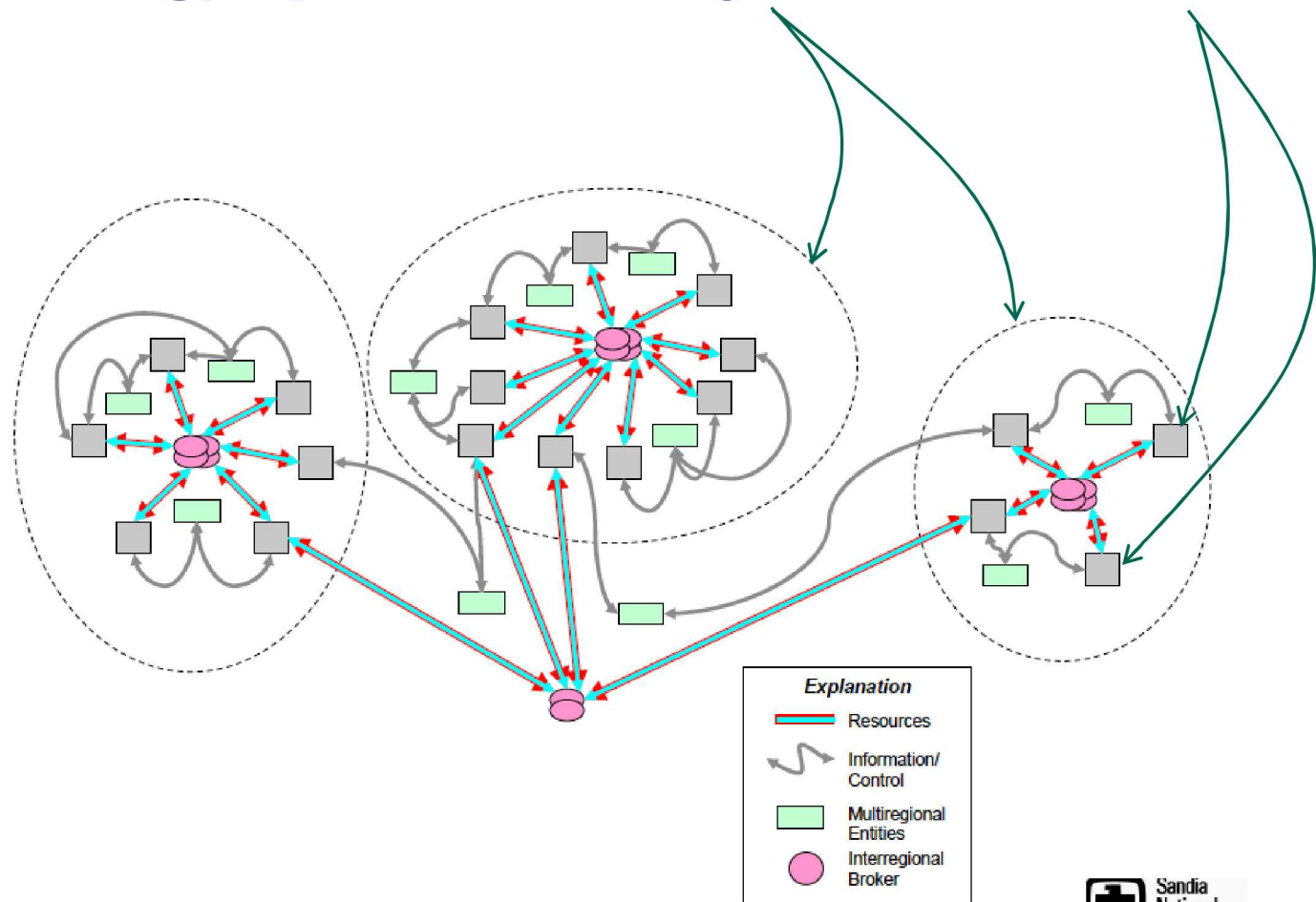
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System of Systems: Trading Blocks composed of *Core Economies*



System of Systems: Global Energy System of Trading Blocks of Core Economies



Modified after Glass et al. (2009) accessed on-line at www.sandia.gov/CasosEngineering/

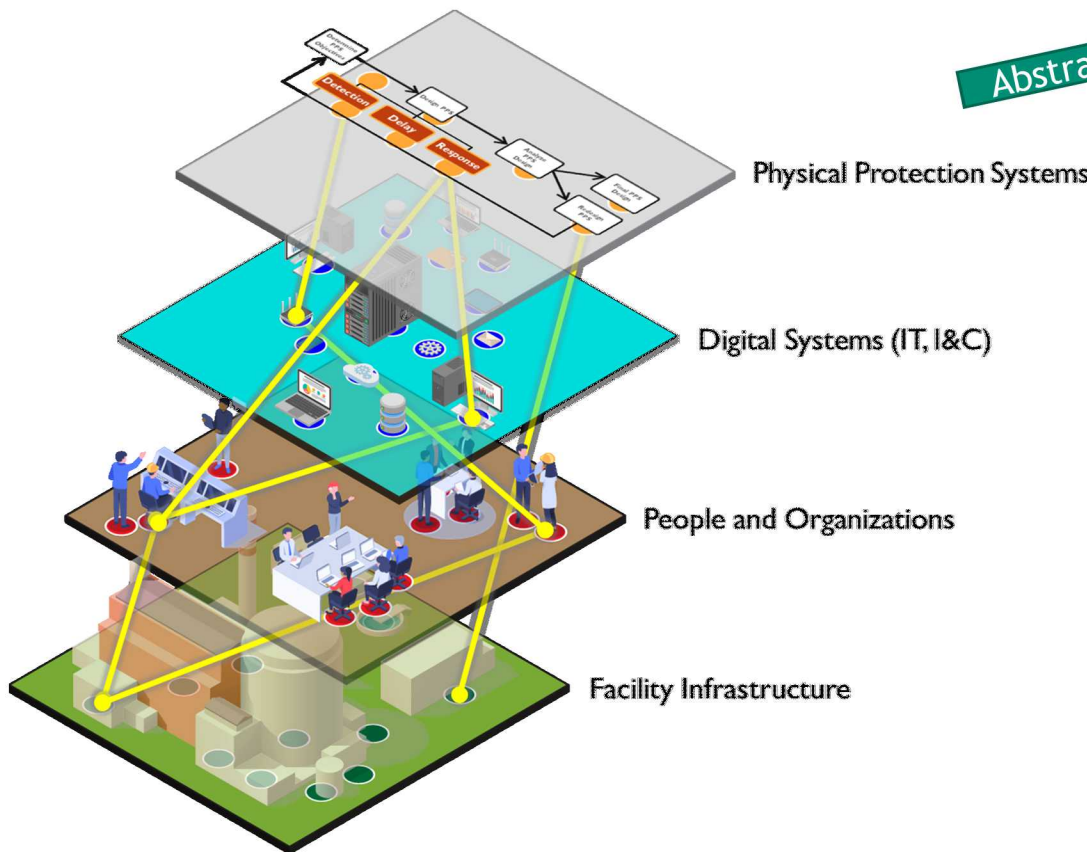
A Multiplex Complex Systems Model for Engineering Security Systems

Adam D. Williams & Gabriel C. Birch

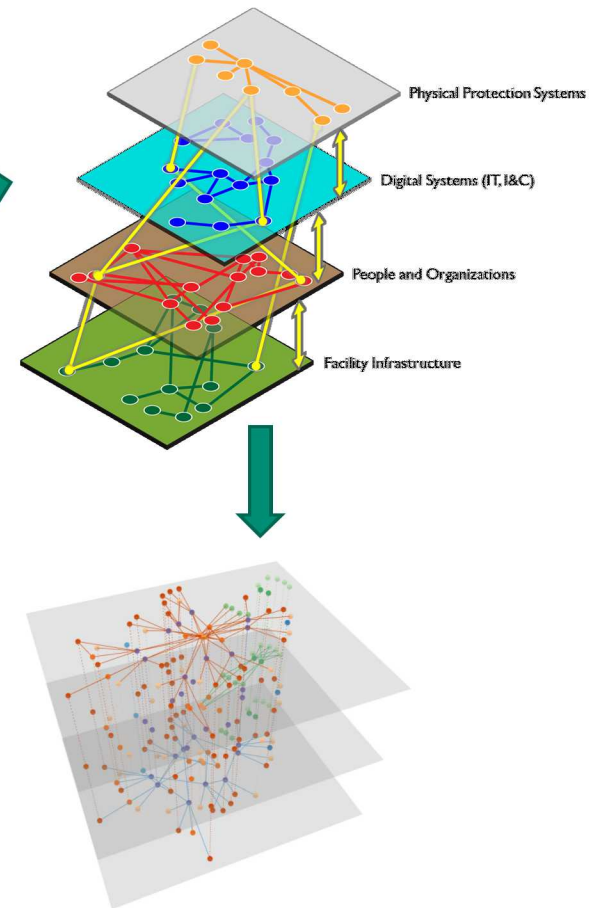
Study Combines

- Resilience theory
- Systems theory
- Network theory

Facility Domains → Multiplex layers



Abstraction



* IT = Information Technologies; I&C = Instrumentation & Control