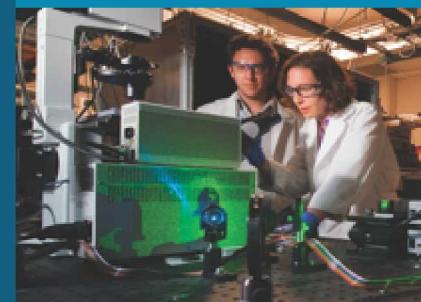


Systems Approaches to Problem Solving at Sandia National Laboratories

An overview with example studies



PRESENTED BY

Robert Finch

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

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

International Cooperation

Cyber Security

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

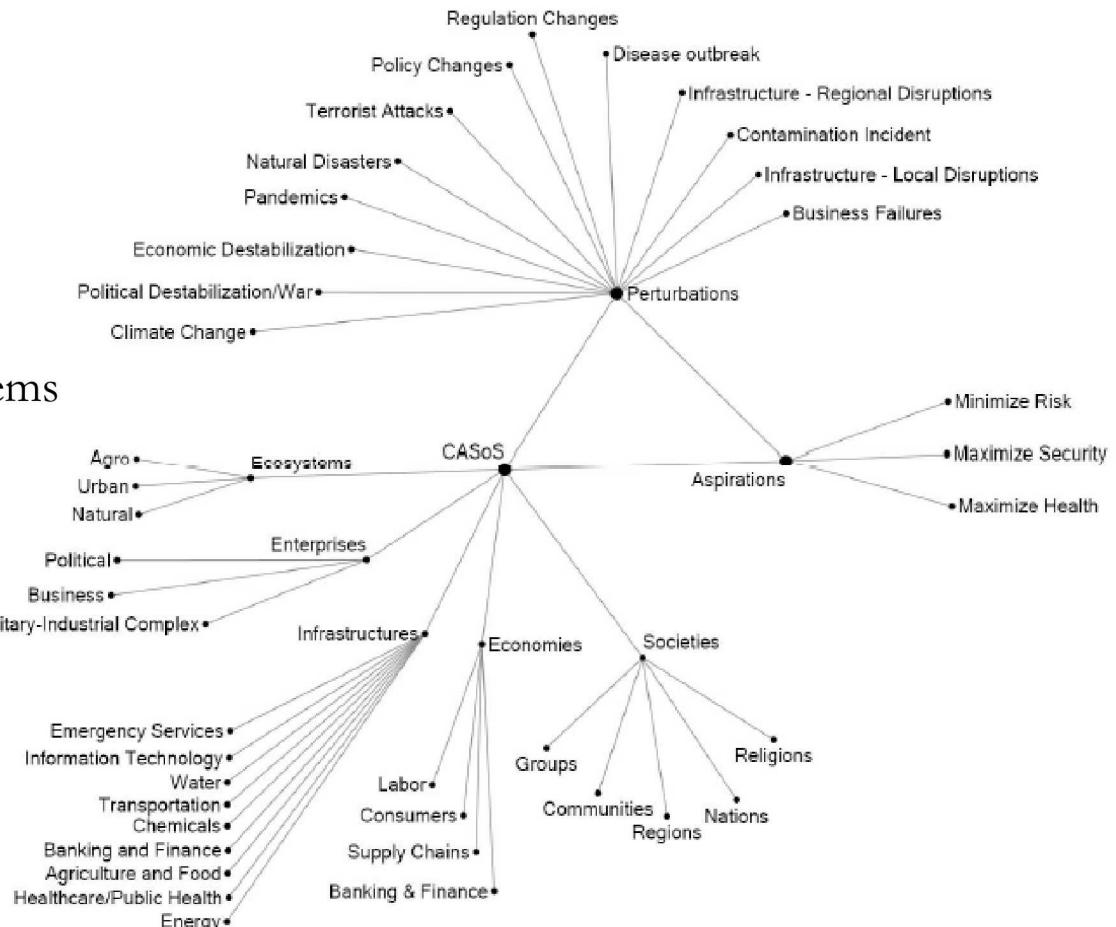
- Infrastructure
 - Healthcare systems
- Networks
 - Energy & Electricity distribution
 - Food distribution

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)

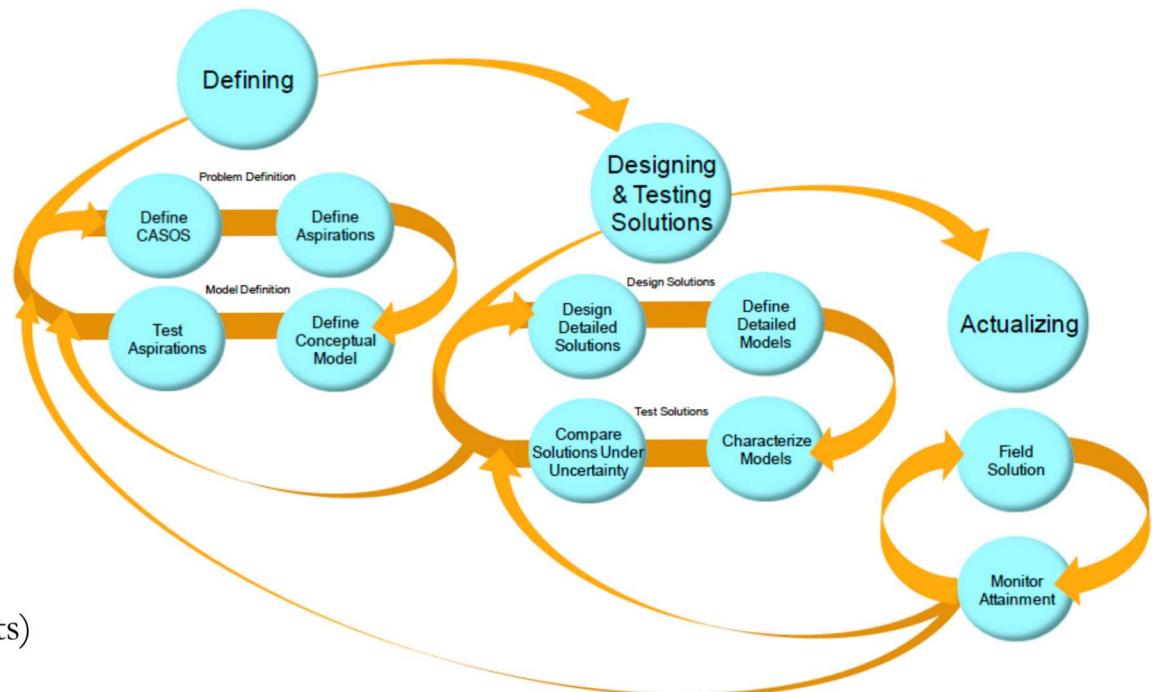
- w/in constraints
- Potential for optimization

Implement solution(s)

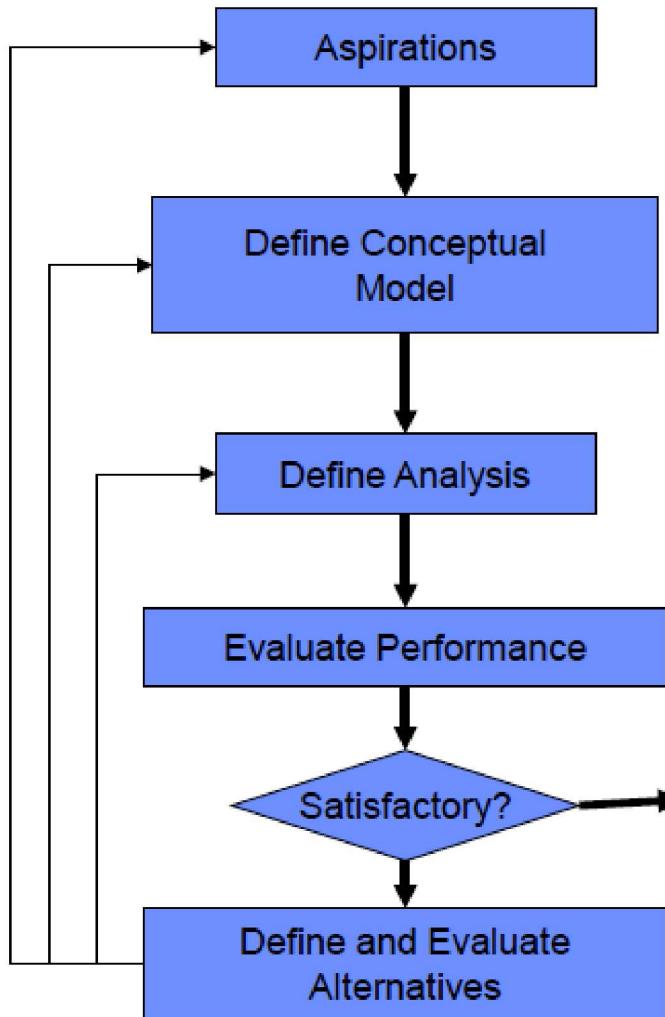
- monitor

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

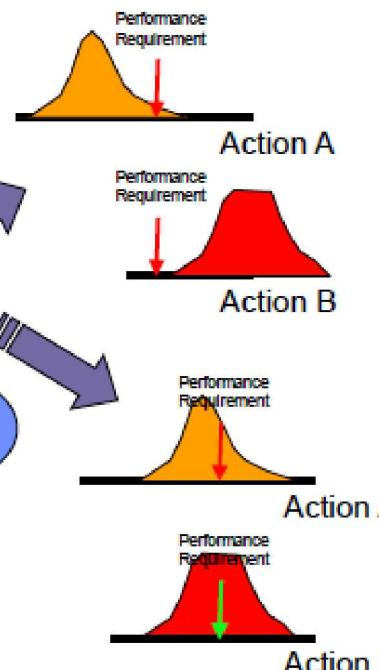
- Repeat process as necessary



Model development: iterative + uncertainty



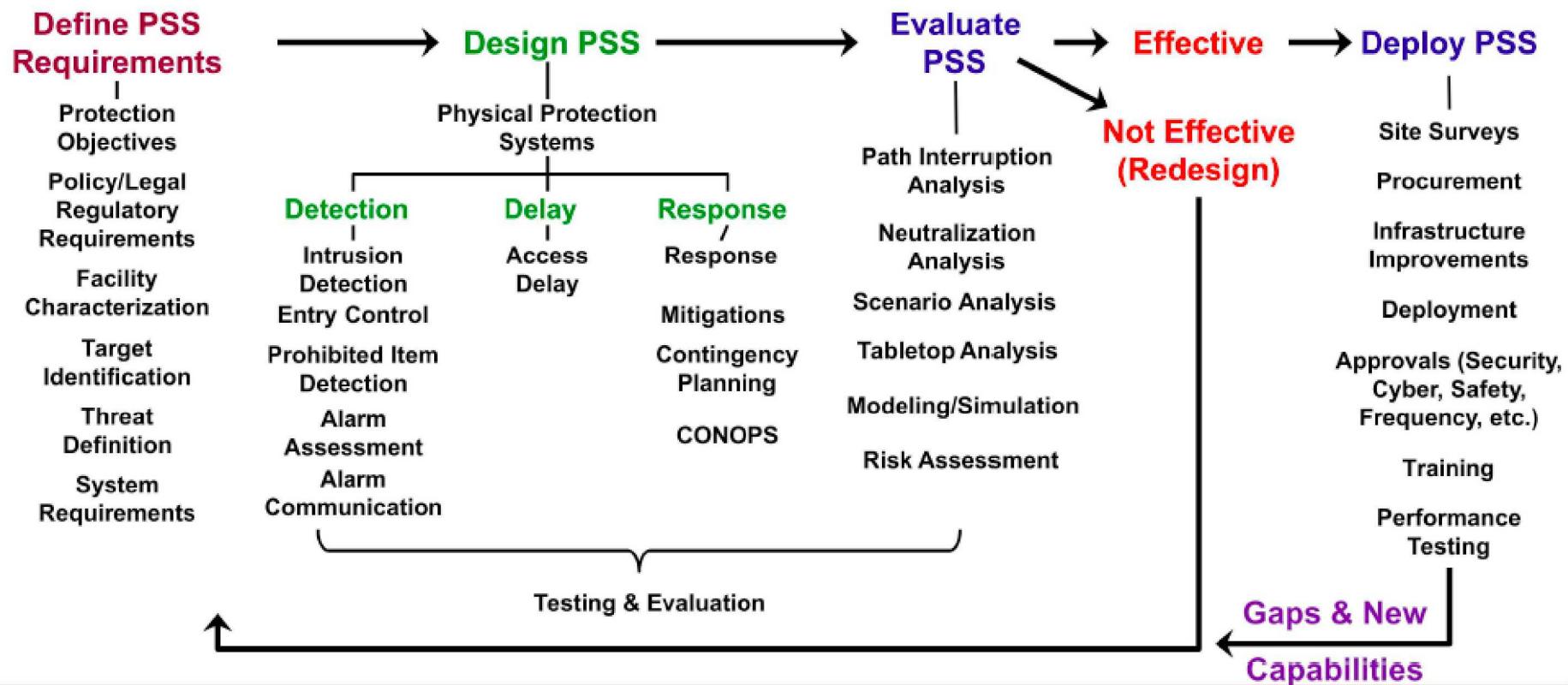
Decision to refine the model
Can be evaluated on the same
Basis as other actions



Model uncertainty
permits distinctions

Model uncertainty
obscures important
distinctions, and
reducing uncertainty
has value

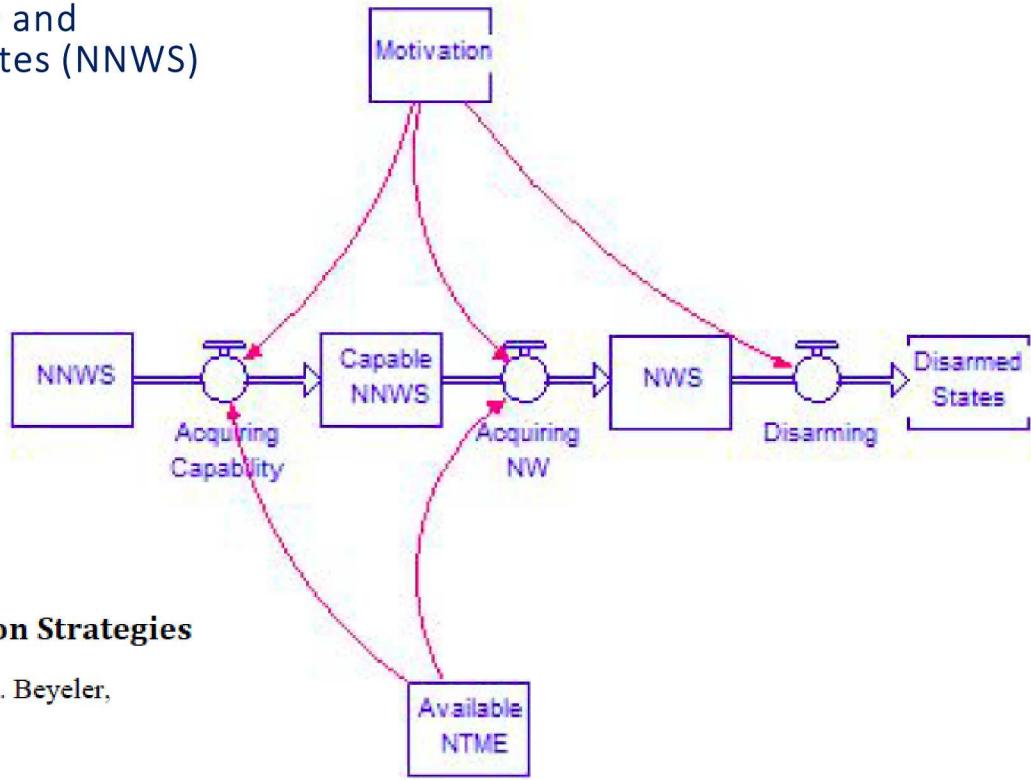
Systems Engineering: Physical Security System Design Design Evaluation Process Outline (DEPO)





Basic model

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



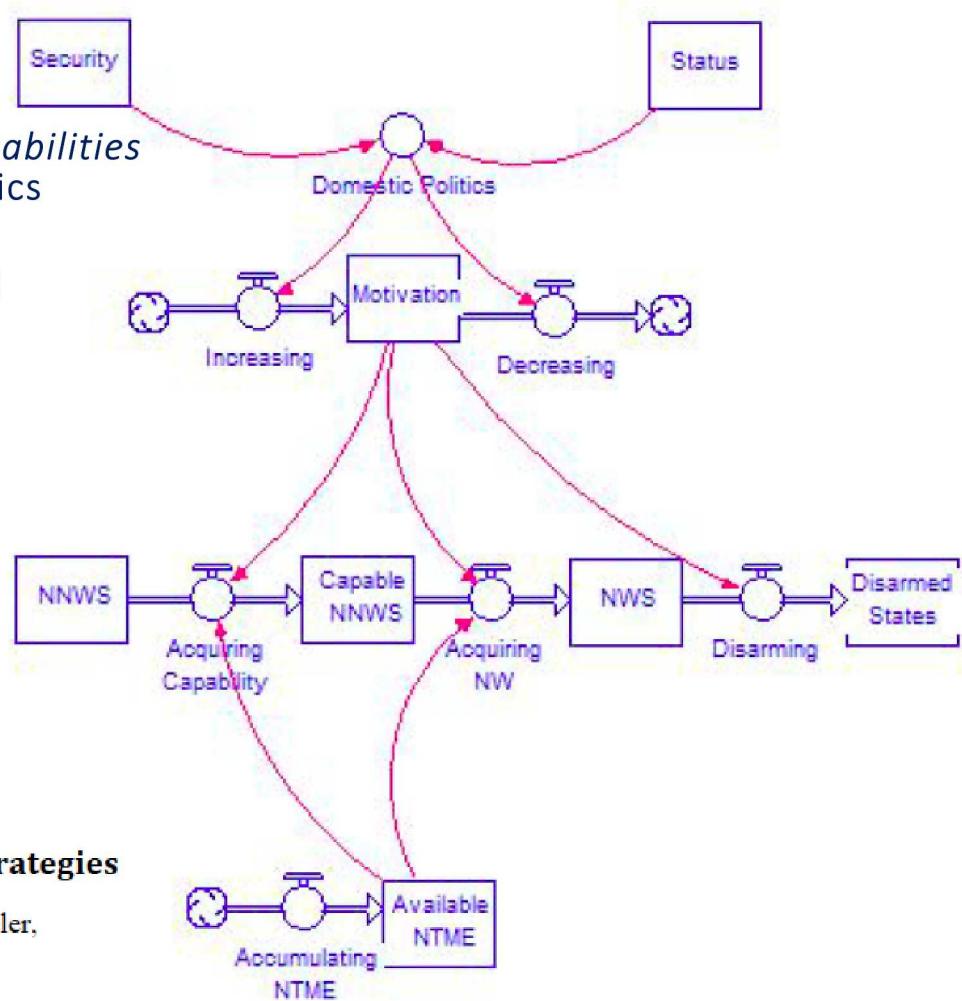
A Systems Approach to Assessing Nonproliferation Strategies

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

Systems Dynamics Modeling

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)



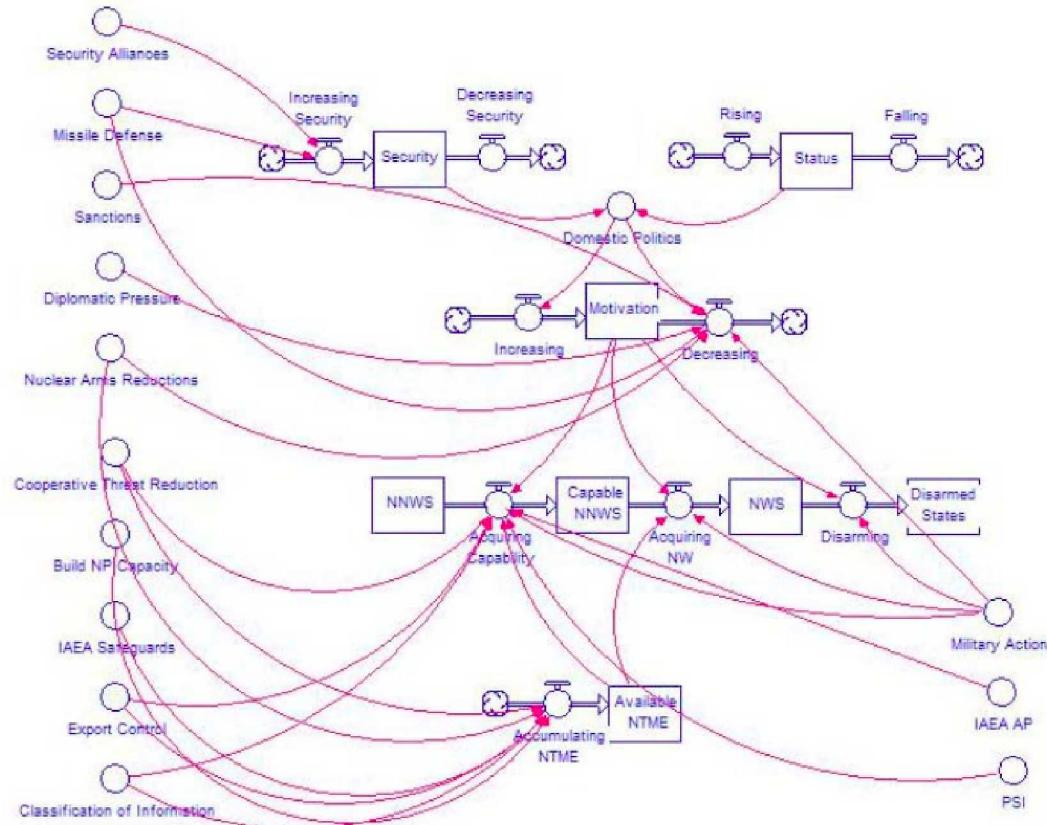
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Systems Dynamics Modeling

Examine intended impacts of nonproliferation strategies

- Can also examine potential unintended consequences

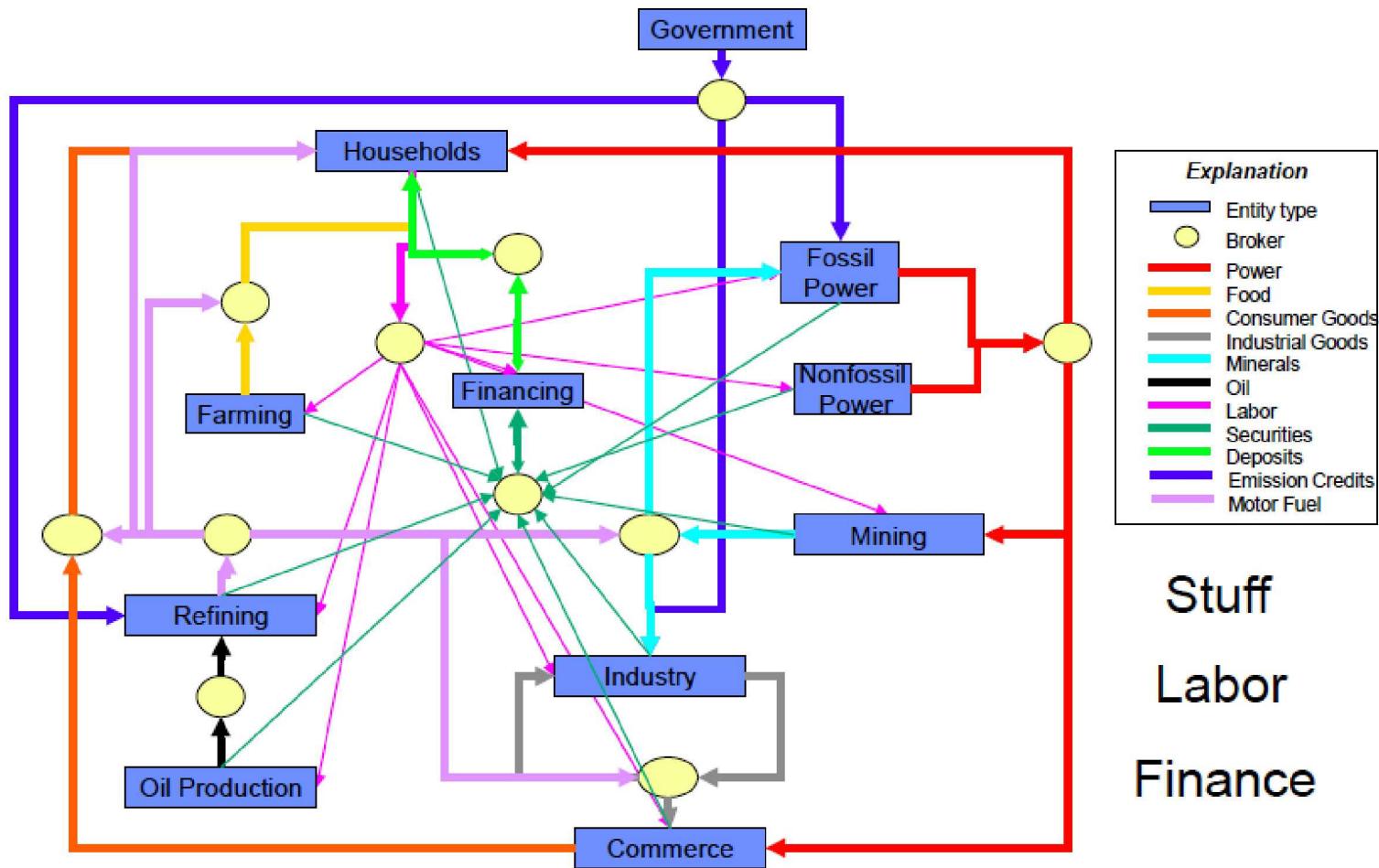


A Systems Approach to Assessing Nonproliferation Strategies

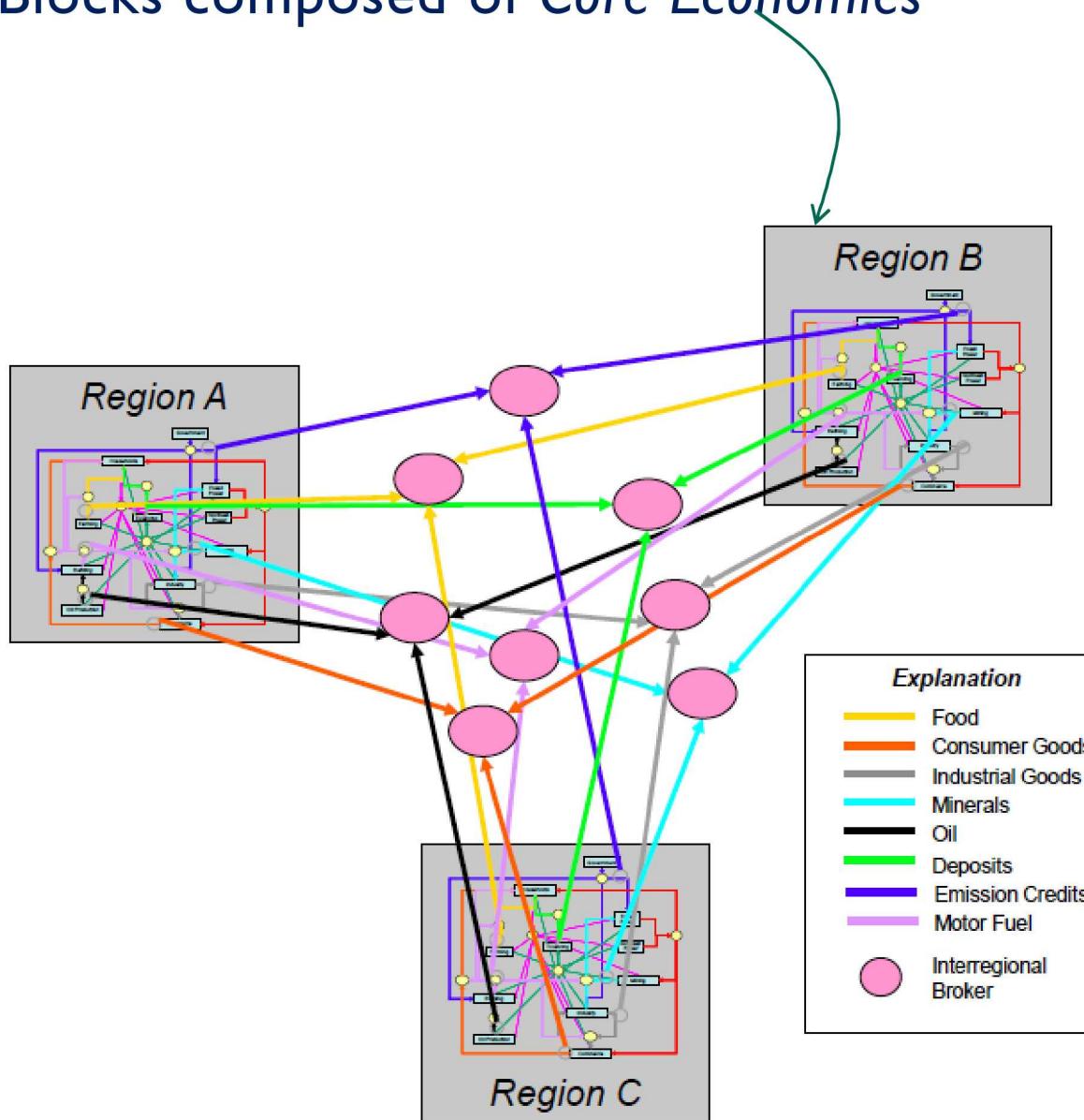
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System of Systems: Core Economy

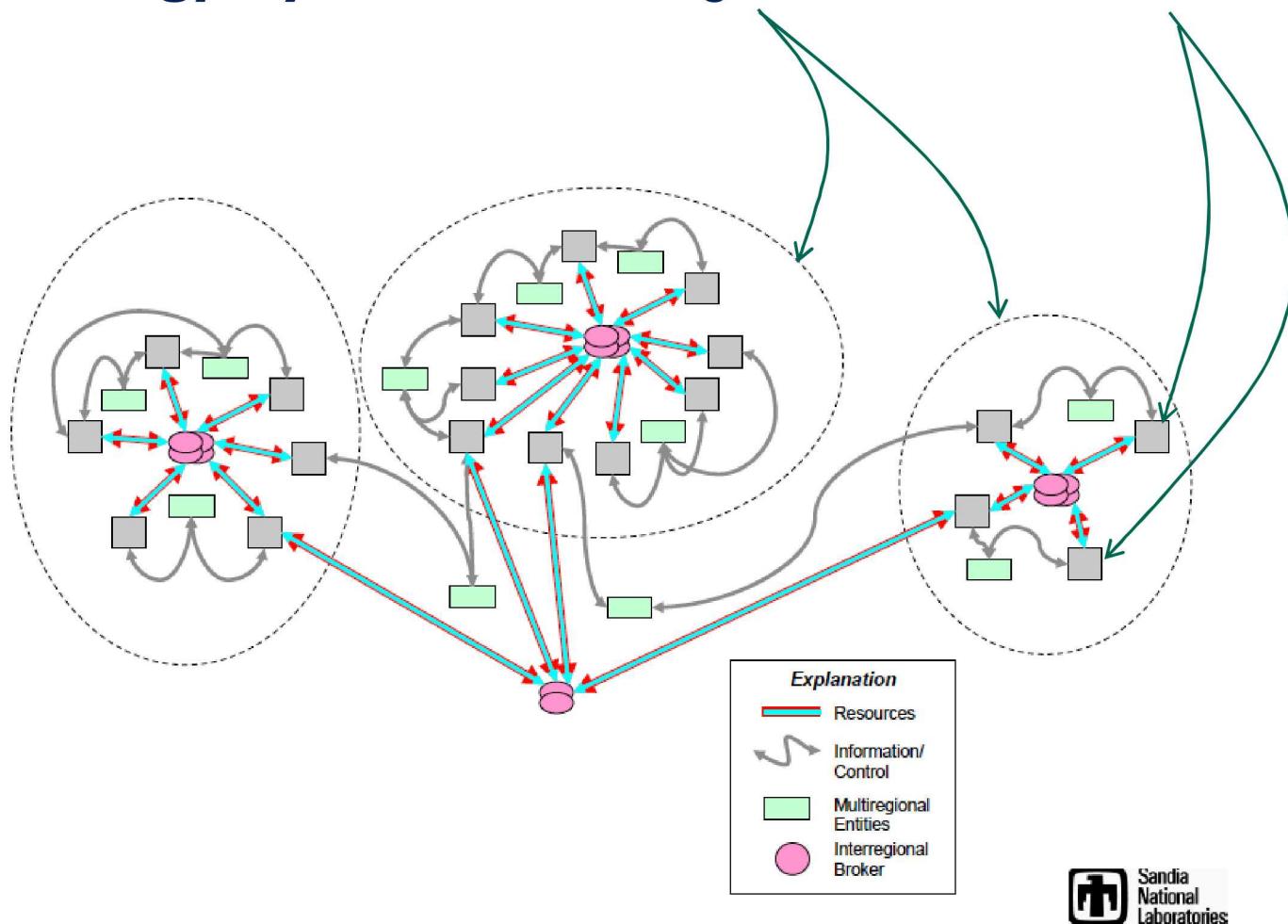
Goal: to evaluate a Global Energy System



System of Systems: Trading Blocks composed of Core Economies



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

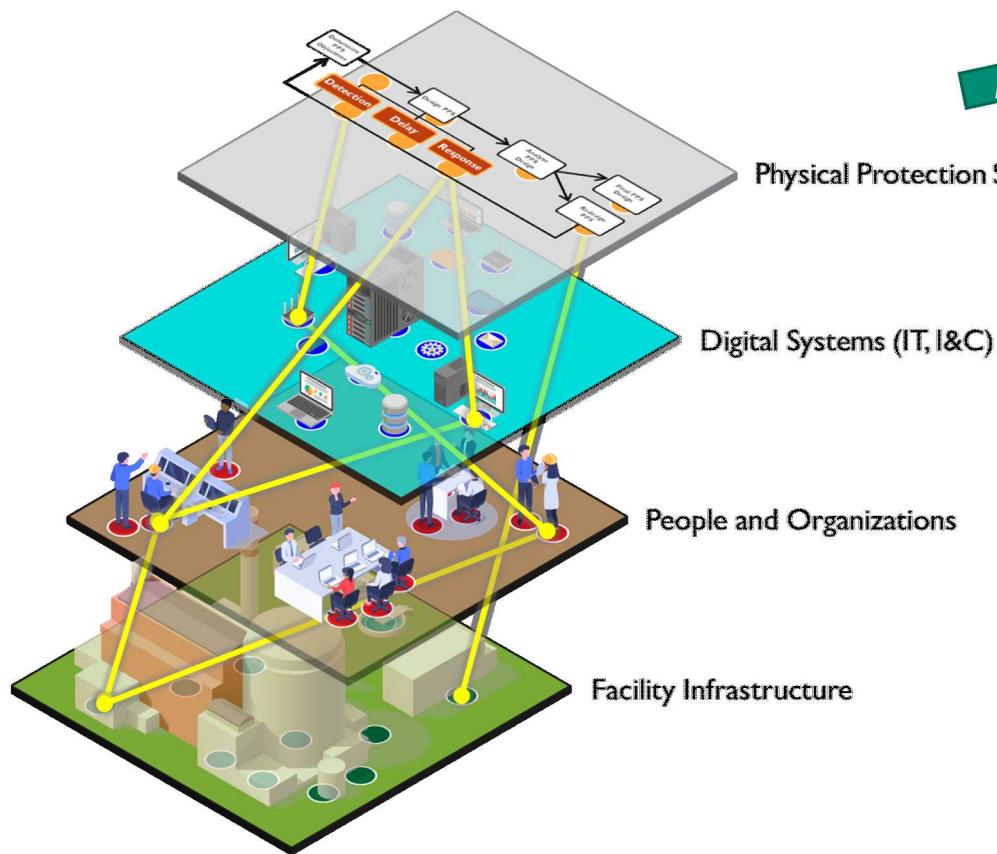


Modified after Glass et al. (2009) accessed on-line at www.sandia.gov/CasosEngineering/

A Multiplex Complex Systems Model for Engineering Security Systems

Adam D. Williams & Gabriel C. Birch

Facility Domains → Multiplex layers



Study Combines

- Resilience theory
- Systems theory
- Network theory

