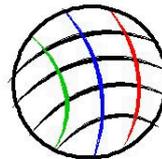


System of Systems Engineering: A Multidisciplinary Perspective

Dr. Chuck Keating
Director, National Centers for System of
Systems Engineering
April 26, 2012



NCSOSE
National Centers for System of Systems Engineering

NCSOSE Snapshot

- An enterprise center for Old Dominion University housed in the Batten College of Engineering and Technology
- Staffed by Research Scientists, Faculty, and Graduate Students
- Located in approx 7,000 sq. ft. in Innovation Research Park I since Summer 2007

*Old Dominion University
Innovation Research Park*



NCSOSE Mission

To develop, disseminate, and put into practice methodologies and technologies grounded in systems theory and focused on decision making for multidisciplinary problems



NCSOSE
National Centers for System of Systems Engineering

Topics

1 Multidisciplinary SoSE Problem Domain

2 Non-Traditional Engineering Challenges

3 Systems Theory Foundations

4 An Example of SoSE in Action

Multidisciplinary SoSE Problem Domain

Conflicting Perspectives

Divergent Stakeholders

Lack Sufficient Information

Shifting Demands

Unstable Resources

Misinformation/defensiveness

Unintended Consequences

Ambiguous Boundaries

Politically Charged

High Uncertainty

Emergent Situation

Unclear Entry Point

Solution Urgency

*Multidisciplinary
Problems*

Multidisciplinary SoSE Problem Domain

Healthcare

Energy

Multidisciplinary
Problems

Transportation

Education

Sussex Express
3 Jan 2003

It's too close
for comfort

Threat of flood
returns with
New Year deluge

Sussex Express
11 Jul 2003

Fury grows over
flood work delay

Lewes Life
22 Aug 2003

Anger as Government
scraps flood schemes

Six-month setback for flood defenses

Evening Argus 8 Jan 2003

Military
& Security
Systems

State dips into mental health
trust fund to hire new staff

\$30 million

HEALTH RISKS RISE
AID FAILS TO ARRIVE

victims sleep

WHAT'S IN IT FOR YOU?
HEALTH REFORM
LANDMARK
HOUSE PASSES HEALTH REFORM
BILL

Forty-five killed in 'Tornado Alley'

Deregulation Jolts Texas Electric Bills
FERC examines causes of,
responses to rising electricity costs
California to hike electricity rates by 40 percent

Fuel
SHORTAGE
Gas bubble
Speculation fuels in

Real-time education makes headlines

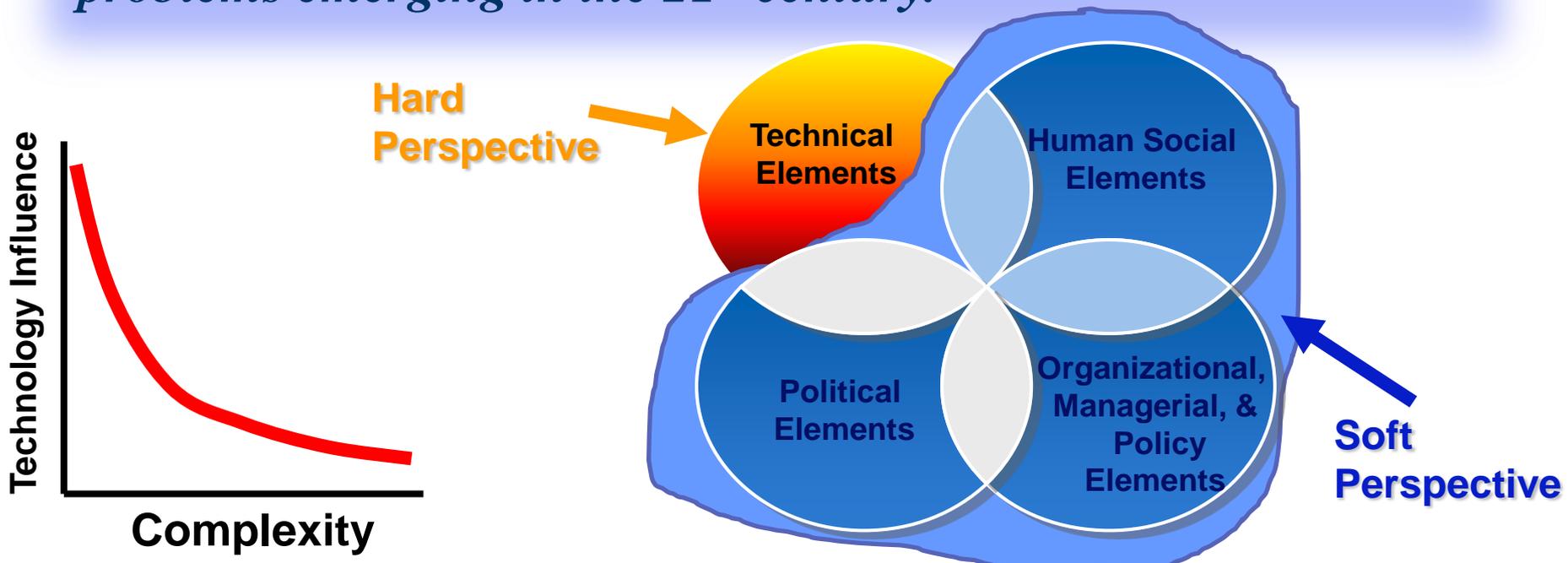
STUDIES
READING
UNIVERSITY



Non-Traditional Engineering Challenge

As complexity has increased, the ability of technology to dominate the solution space is diminishing.

We lack capabilities to effectively address multidisciplinary problems emerging in the 21st century.



Non-Traditional Engineering Challenge

System of Systems Engineering

The design, deployment, operation, and transformation of higher level metasystems that must function as an integrated complex system to produce desirable results.

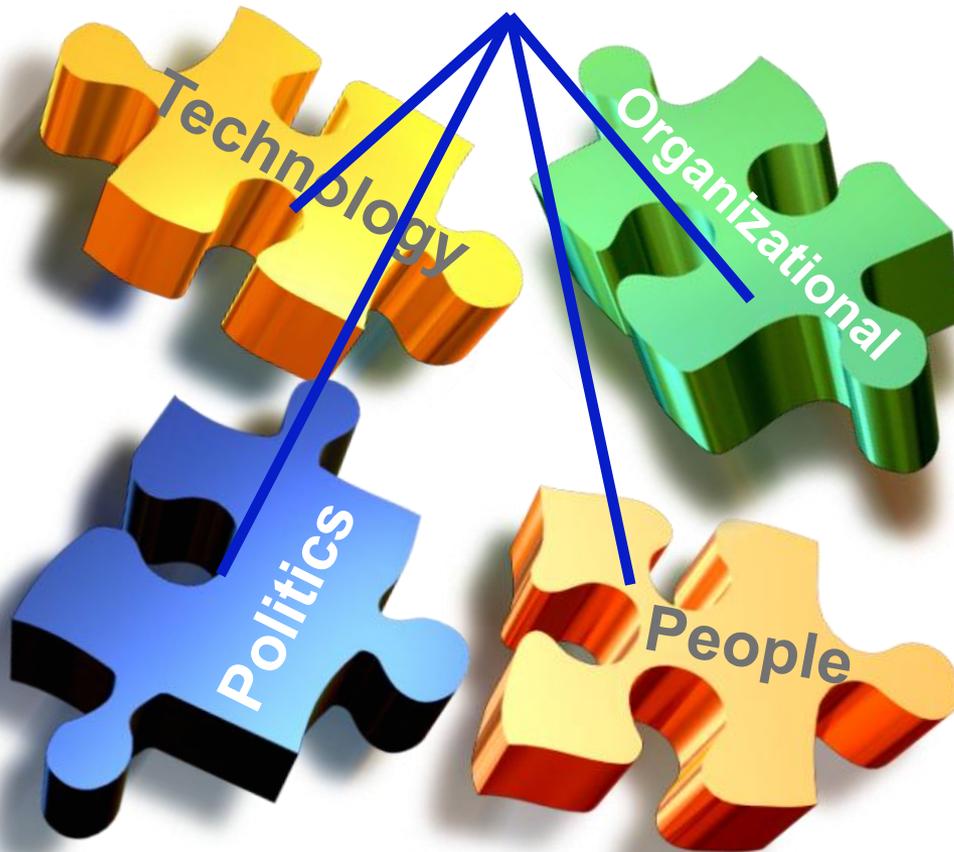
Keating, et. al, 2003, p. 41

Keating, C. B., Rogers, R., Unal, R., Dryer, D., Sousa-Poza, A., Safford, R., et al. (2003). System of Systems Engineering. Engineering Management Journal, 15(3), 36-45.

Non-Traditional Engineering Challenge

What does SoSE do with Multidisciplinary Problems?

Metasystem View



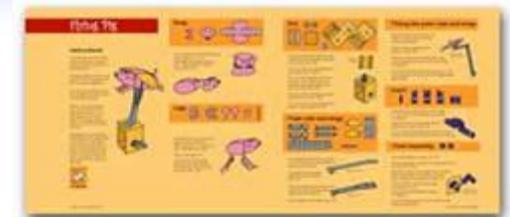
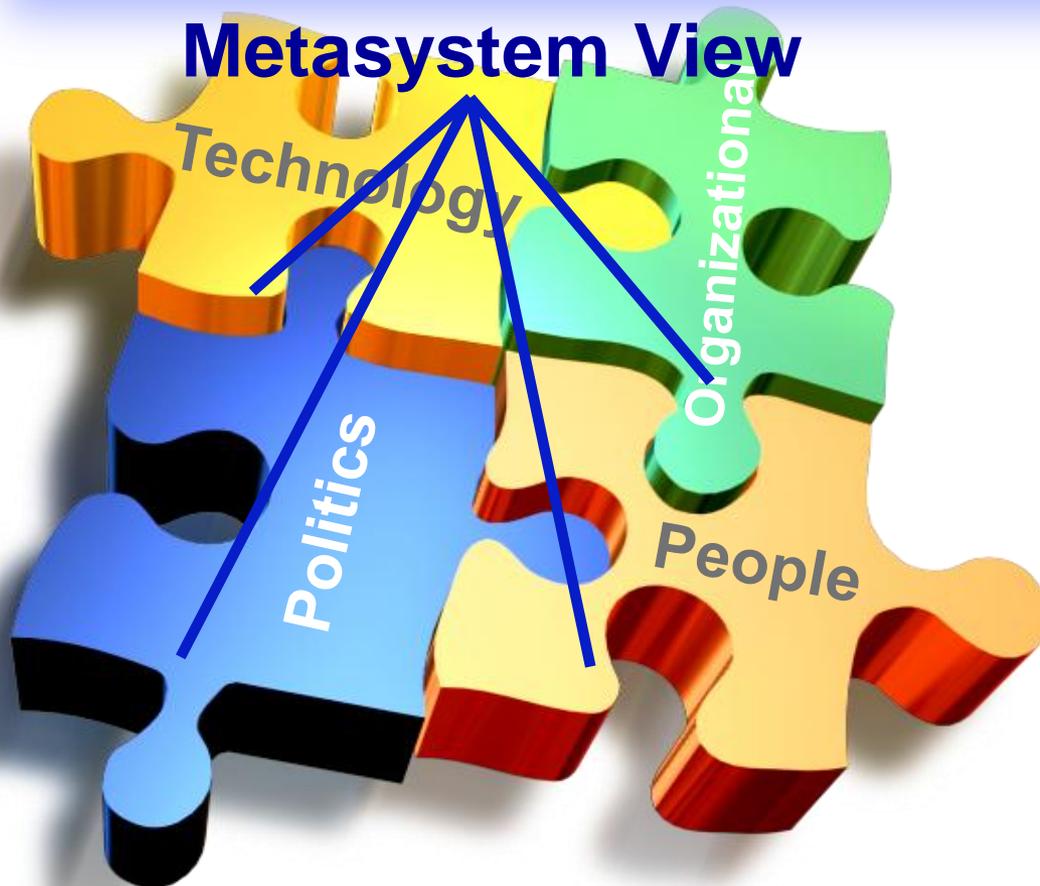
SoSE Brings

- ➡ Systems Theory Foundation
- ➡ Methodologies & Technologies
- ➡ Applied Multidisciplinary Problem Perspective

Non-Traditional Engineering Challenge

*Systems Theory + Approaches + Multidisciplinary
Problem Focus*

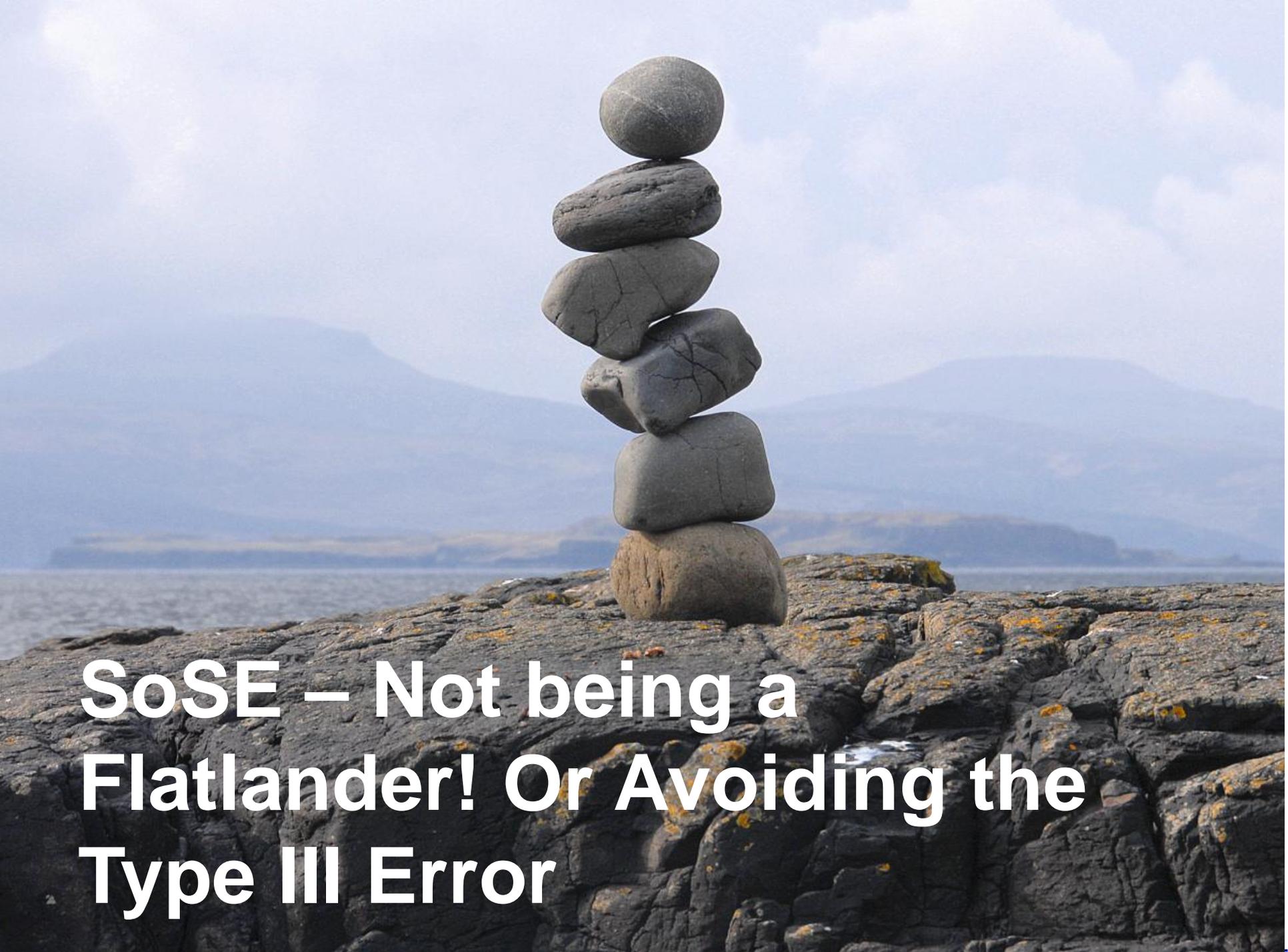
Metasystem View



=



SoSE Research



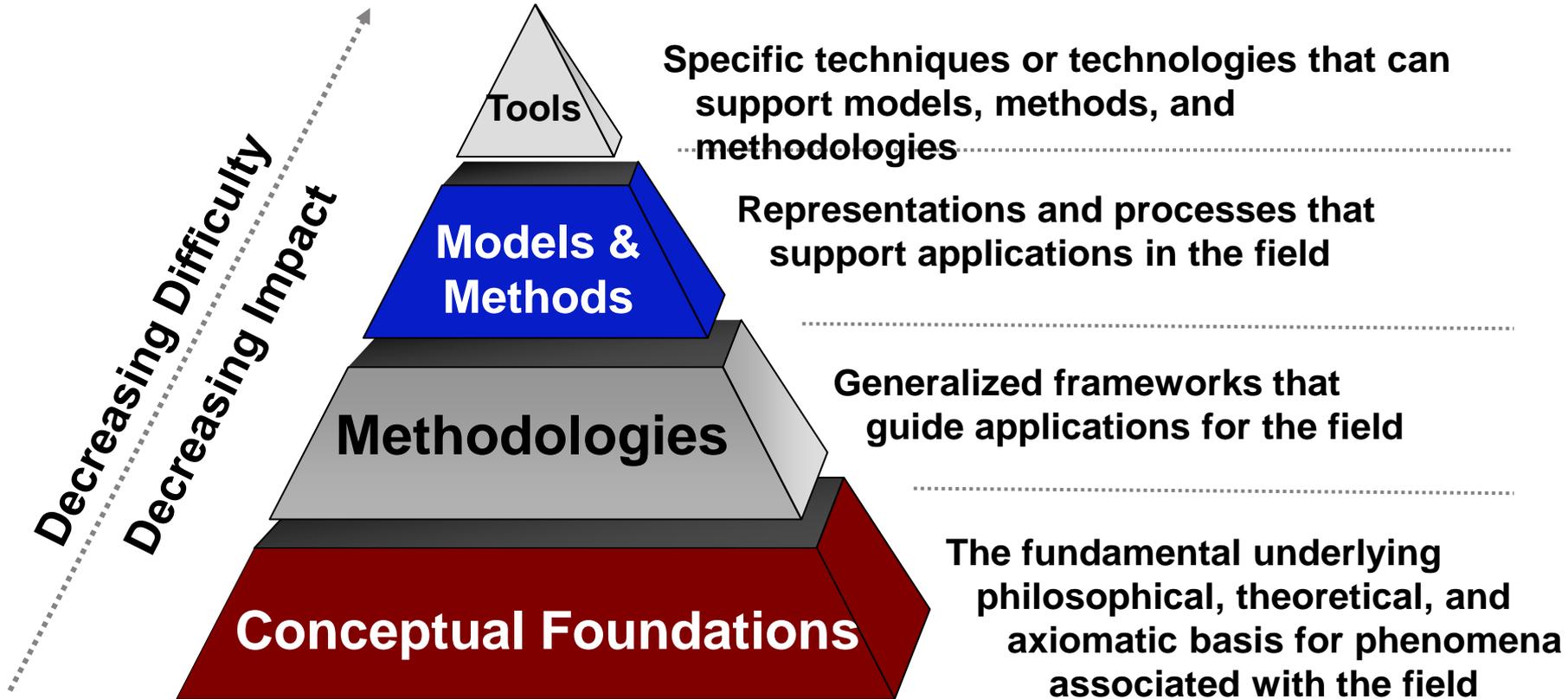
**SoSE – Not being a
Flatlander! Or Avoiding the
Type III Error**

Distinctions between SE and SoSE

Area	Systems Engineering	System of Systems Engineering
<i>Focus</i>	Single complex system	Multiple integrated complex systems
<i>Objective</i>	Optimization	Satisficing
<i>Approach</i>	Process	Methodology
<i>Expectation</i>	Solution	Initial response
<i>Problem</i>	Defined	Emergent
<i>Analysis</i>	Technical dominance	Contextual influence dominance
<i>Goals</i>	Unitary	Pluralistic
<i>Boundaries</i>	Fixed	Fluid

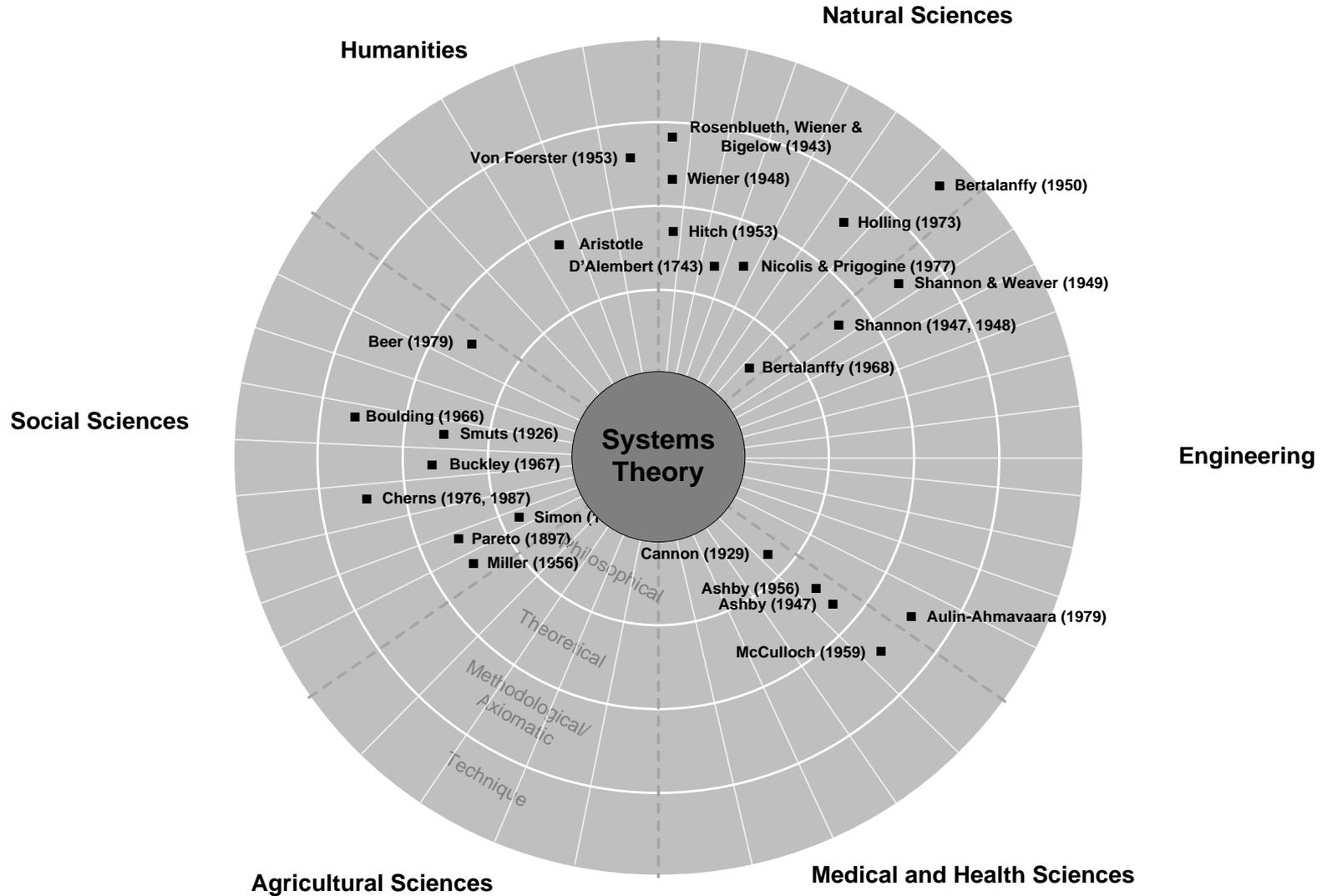
Table taken from Exhibit 4 on p. 40 in Keating, C. B., Rogers, R., Unal, R., Dryer, D., Sousa-Poza, A., Safford, R., et al. (2003). System of Systems Engineering. Engineering Management Journal, 15(3), 36-45.

SoSE Systems Theory Foundations Role



Conceptual grounding – increases the half-life of any tool, model, method or methodology

Systems Theory & Multidisciplinary SoSE



Systems Theory Foundations

Centrality Axiom

- *Emergence*
- *Hierarchy*
- *Communications*
- *Control*

Contextual Axiom

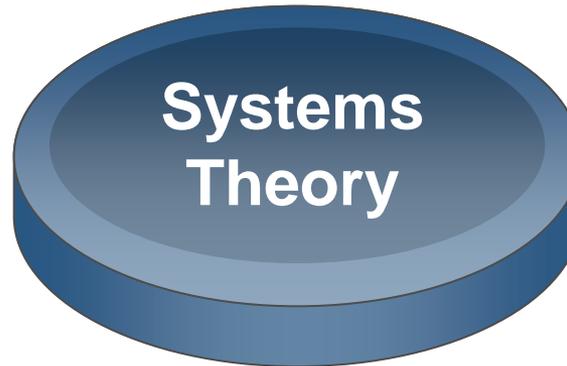
- *Holism*
- *Darkness*
- *Complementarity*

Goal Axiom

- *Equifinality*
- *Satisficing*
- *Viability*

Information Axiom

- *Gödel's Incompleteness*
- *Information Redundancy*
- *Redundancy of Command*



Operational Axiom

- *Dynamic Equilibrium*
- *Relaxation Time*
- *Suboptimization*
- *Self organization*
- *Redundancy of resources*
- *Basins of stability*
- *Homeostasis*

Design Axiom

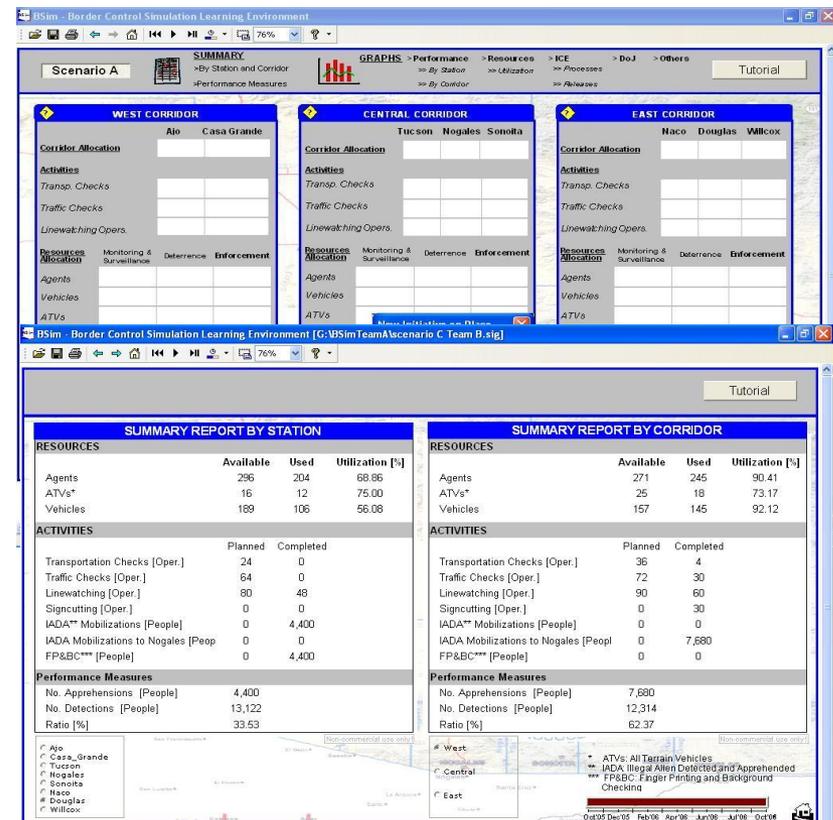
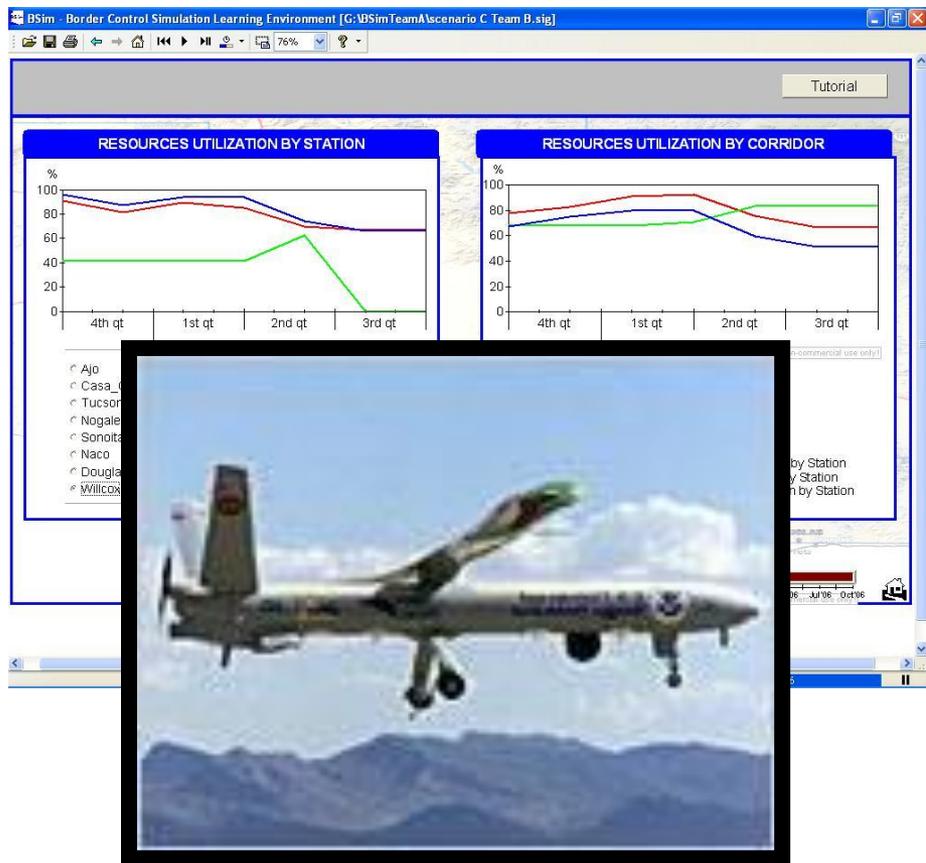
- *Pareto*
- *Requisite Parsimony*
- *Requisite Saliency*
- *Minimum Critical Specification*

Viability Axiom

- *Requisite Variety*
- *Requisite Hierarchy*
- *Feedback*
- *Circular Causality*
- *Recursion*

SoSE in Action: Border Security

What are SoS considerations for deployment of unmanned aircraft on the Southern Border?



Questions and Contact

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