Decision Making for Resilience within the Context of Network Centric Operations

ERDC
Engineer Research and Development Center

Igor Linkov, Zachary Collier,

Matt Wood, Emanuele Massaro,

Andrew Steen

US Army Engineer Research and Development Center

Igor.Linkov@usace.army.mil
617-233-9868

US Army Corps of Engineers

Agility, Responsiveness, Resilience

Agility

=

Responsiveness **+** Resilience **+** Versatility, Flexibility, Innovativeness, Adaptability

- detect change
- decide on action
- execute action
- achieve desired result

Ability to…
- *plan & prepare*
- *absorb*
- *recover*
- *adapt*

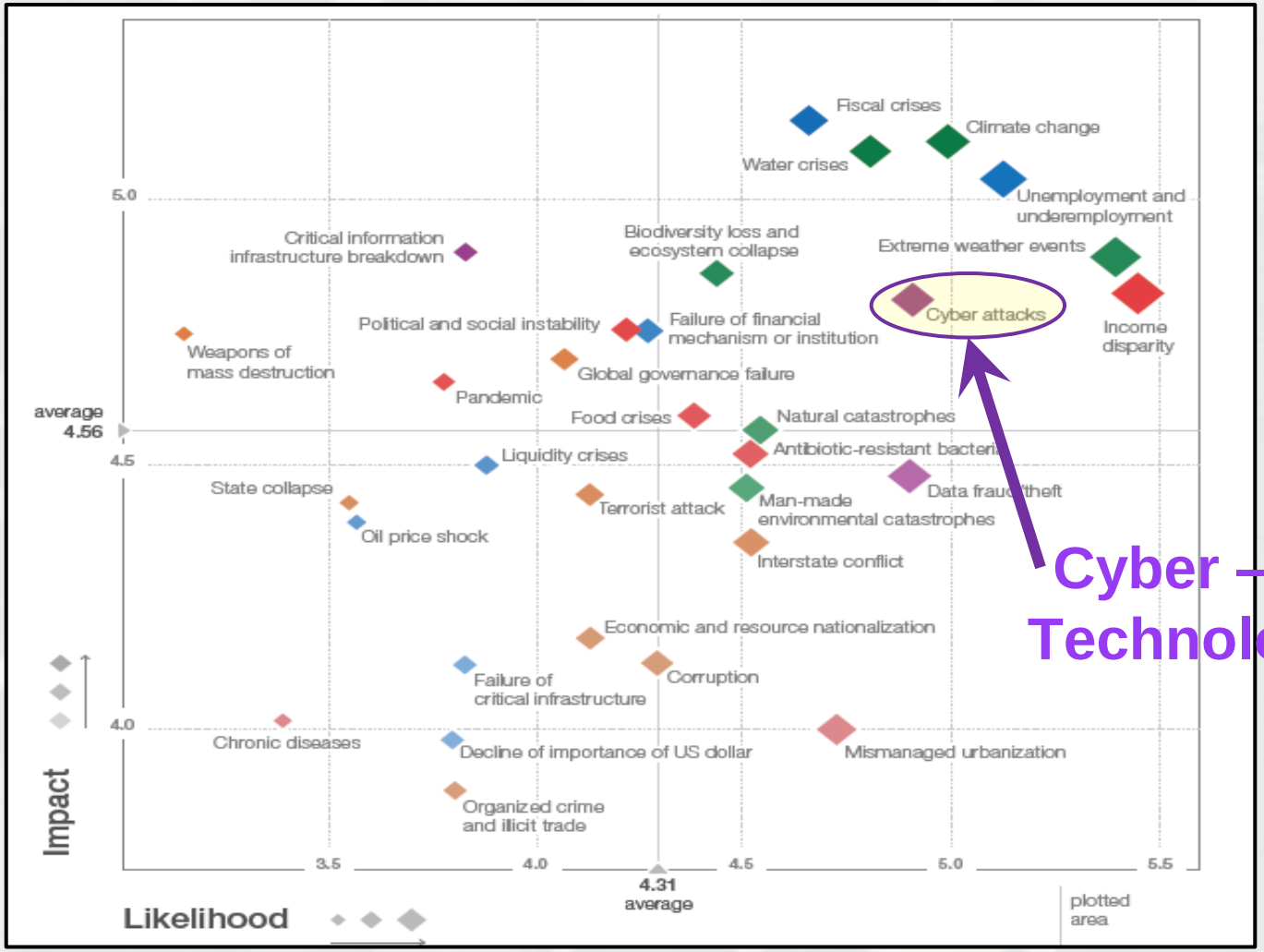
… to actual or potential adverse events

Resilience v. Agility

- RESILIENCE – focus on reaction to adverse event

- AGILITY – focus on reaction to adverse or beneficial event

Global Risks: World Econ. Forum 2014



Cyber – Largest Technology Risk

Risk and Resilience: Political Importance and Challenge

The White House

Office of the Press Secretary

For Immediate Release Octo

Presidential Proclamation -- Critical Infrastructure Security and Resilience Month, 2013

CRITICAL INFRASTRUCTURE SECURITY AND RESILIENCE MONTH, 2013

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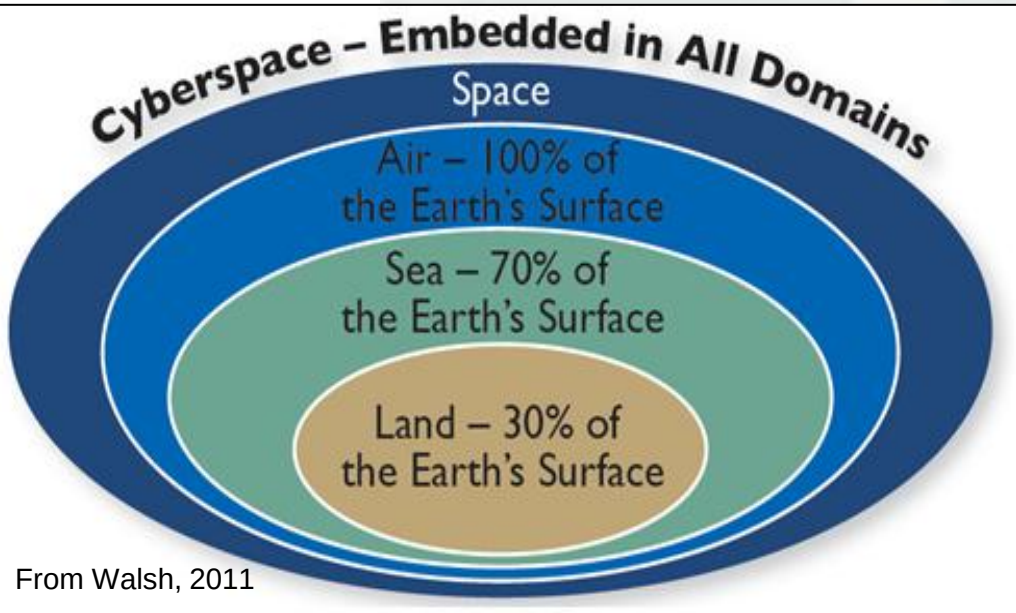
BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

Over the last few decades, our Nation has grown increasingly dependent on critical
our national and economic security. America's critical infrastructure is complex and
both cyberspace and the physical world -- from power plants, bridges, and interstate
massive electrical grids that power our Nation. During Critical Infrastructure Security
resolve to remain vigilant against foreign and domestic threats, and work together to
systems, and networks.

Executive Order:

"resilience" means the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.



From Walsh, 2011

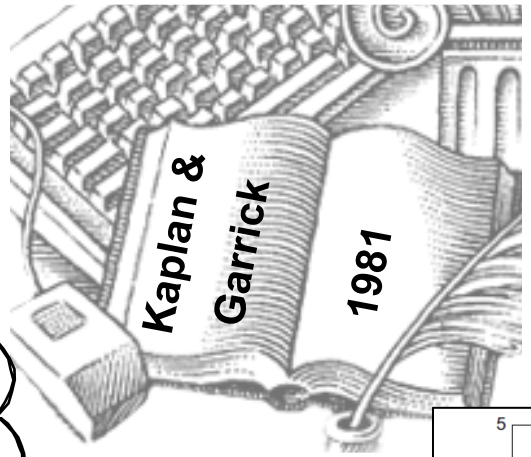
Summary

- Problem: Complex Threat Space, traditional risk-based approaches do not work
  - Cyber
  - Natural disaster
  - Political crises
- Solution: Moving from Risk to Resilience using Network Science
- NCO
  - Major influence on military
  - used by government and industry (e.g., Boeing)
- Needs
  - Define resilience
  - Integrate NCO and Resilience Assessment and Management

Risk Assessment Formulation

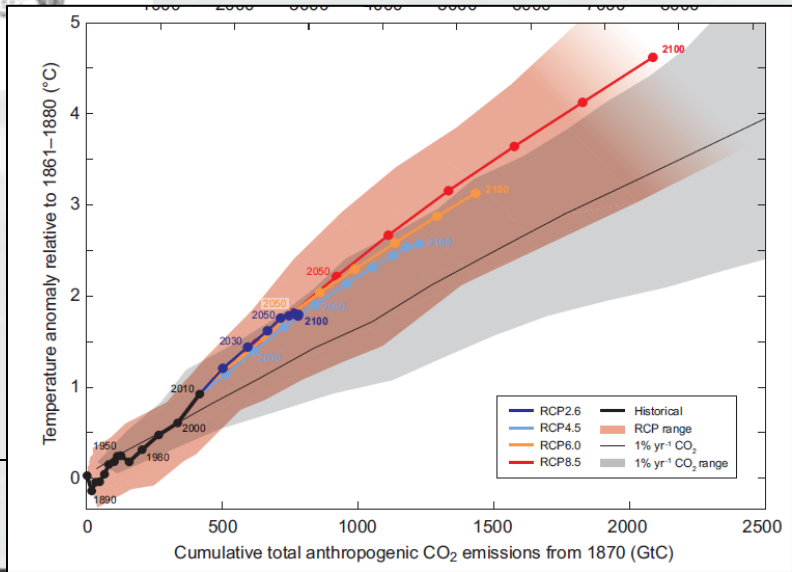
What can happen (go wrong)?

How likely is it?

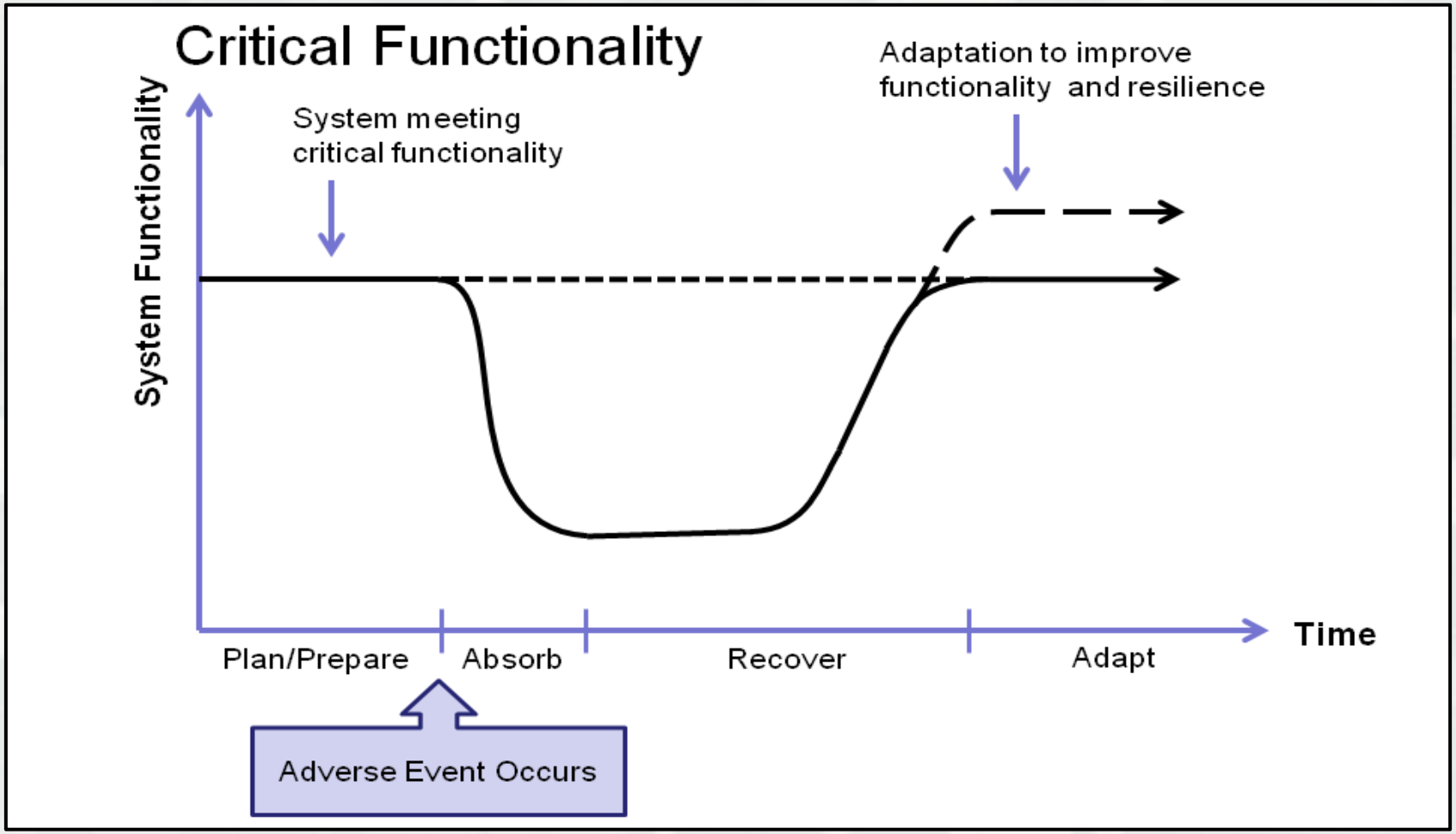


What are the consequences ?

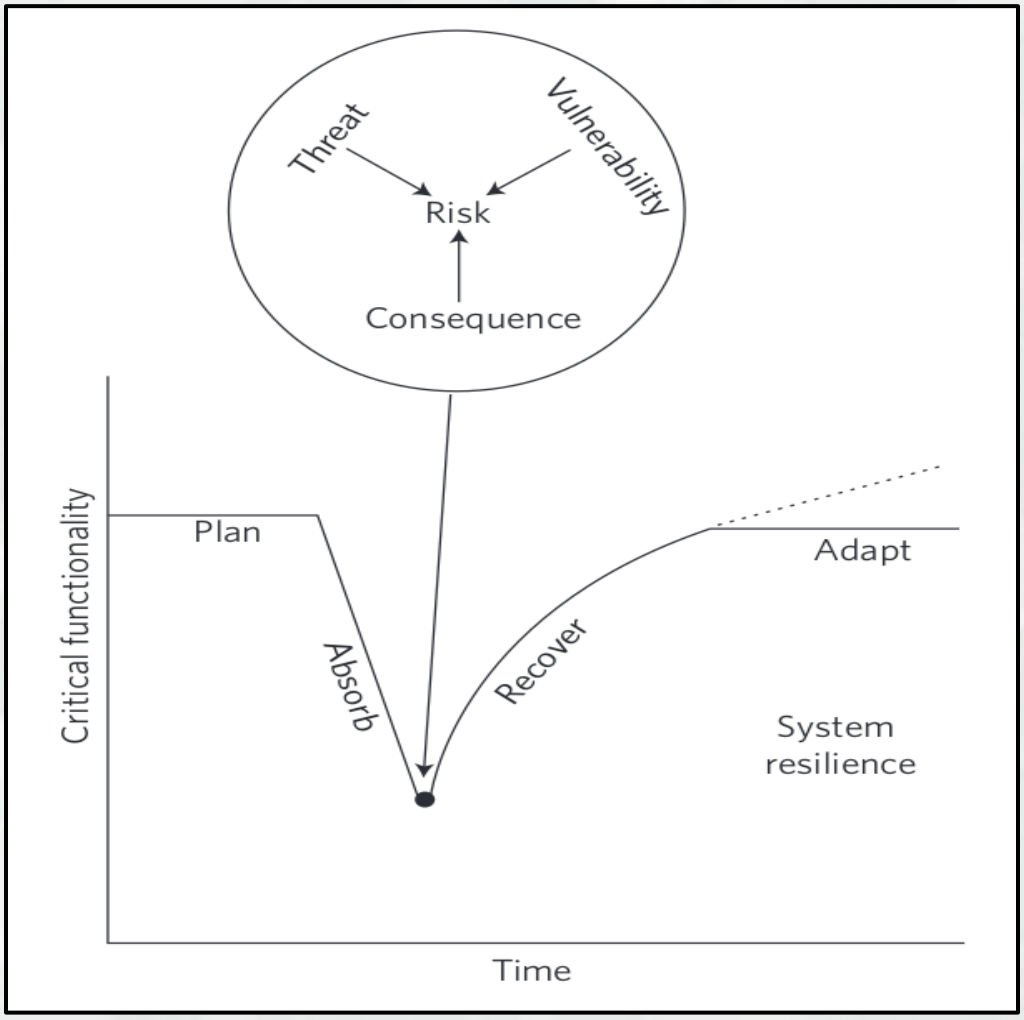
Example: IPCC



Resilience Formulation



Resilience vs. Risk



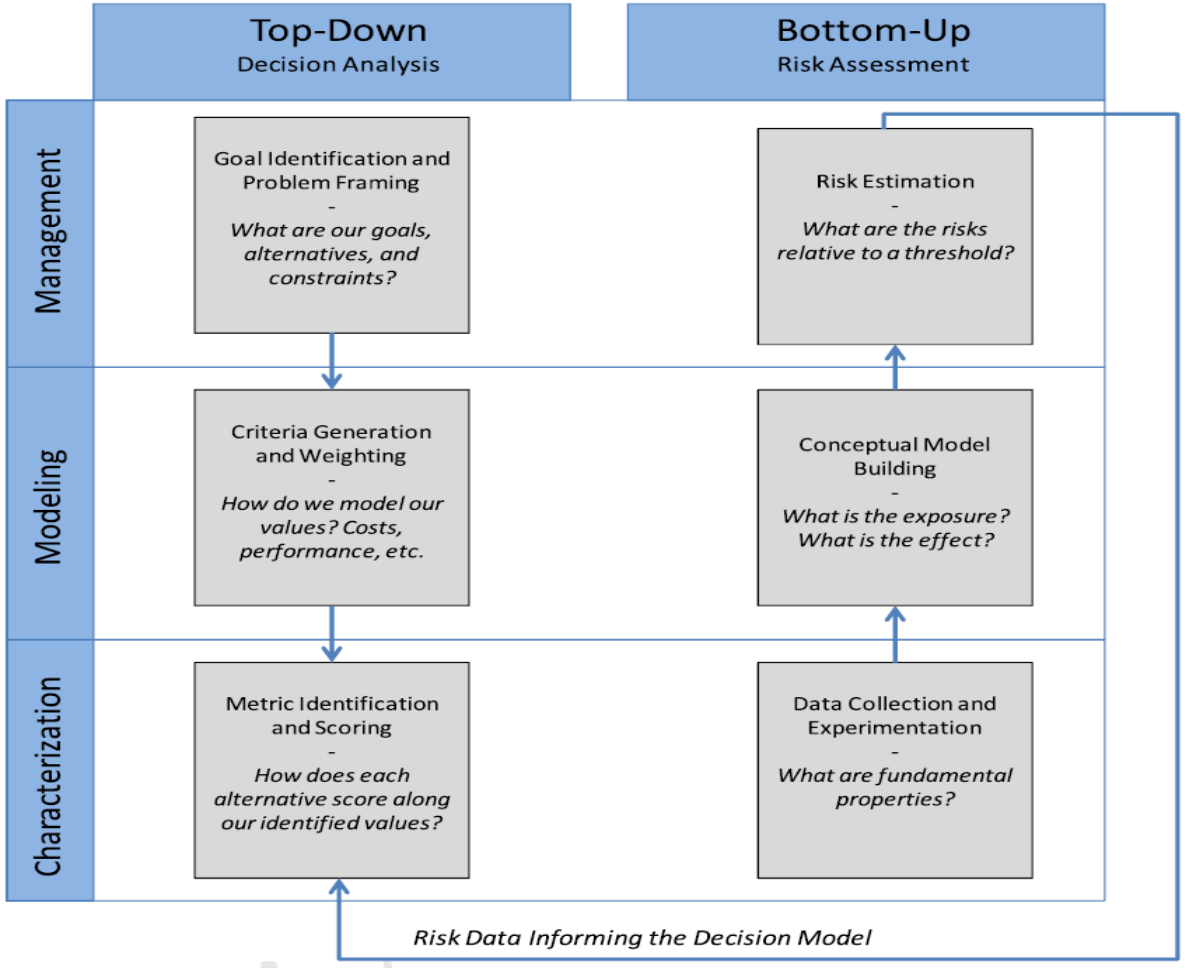
Resilience- Dynamic property of the system

Risk- Probability of a component failure

* I. Linkov et al. (2014), Changing the resilience paradigm, Nature Climate Change 4, 407–409

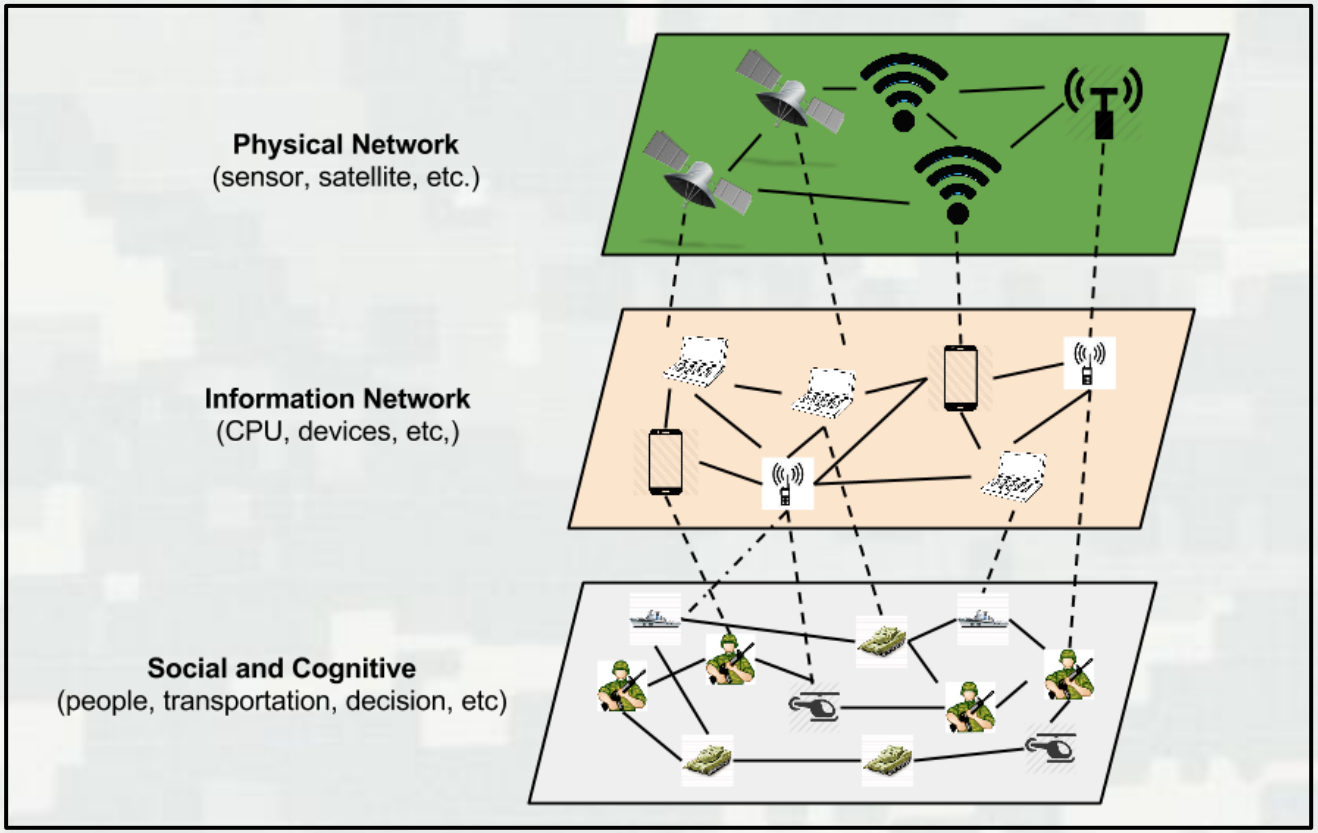
Assessing Resilience vs. Risk: Top-Down and Bottom-Up

Fig. 1 Comparison of top–down and bottom–up approaches. Estimates of risk can be used to inform decision models and thus facilitate risk-based decisions



Linkov et al., 2014

Linking with NCO



NCO is a complex interdependent system.

Each layer of the system can be seen as a single network.

Each network is dependent upon the other networks.

The systems that provide critical functions exist within and across these four connected domains!

To Plan/Prepare, one must decide and act

Comparison

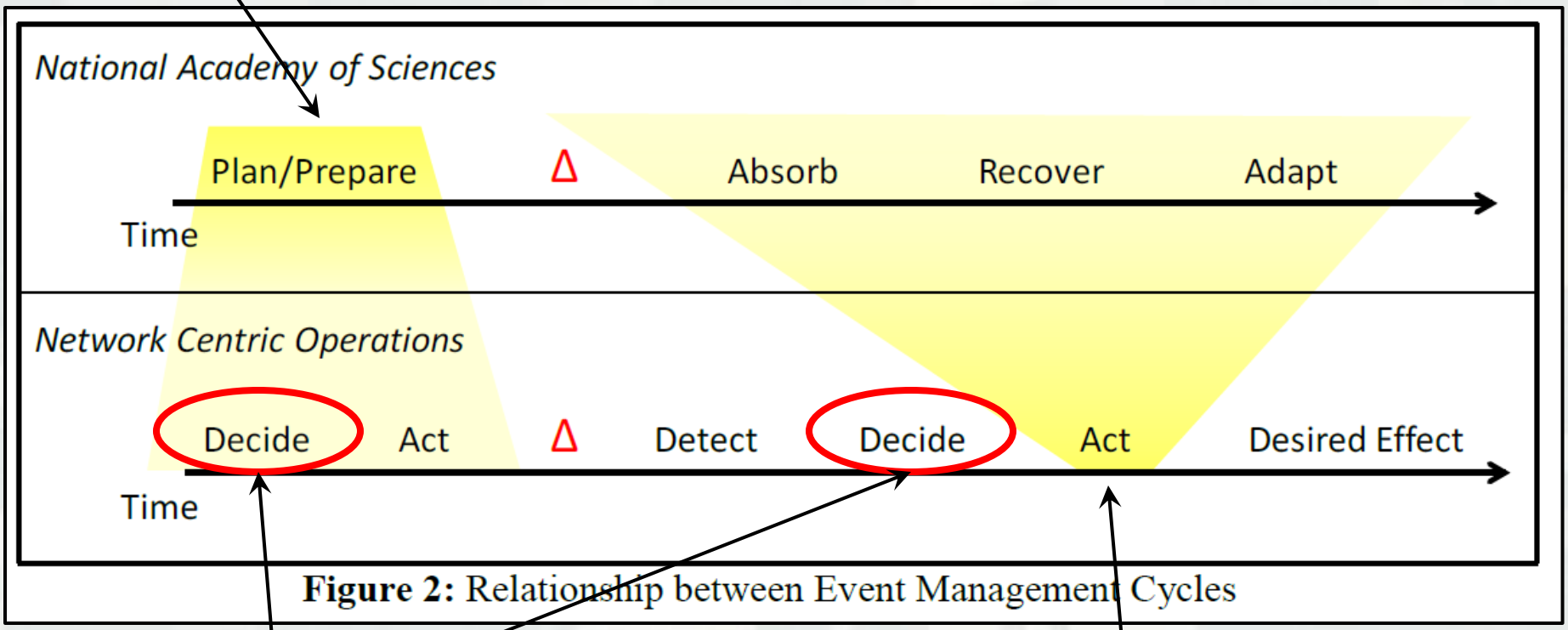
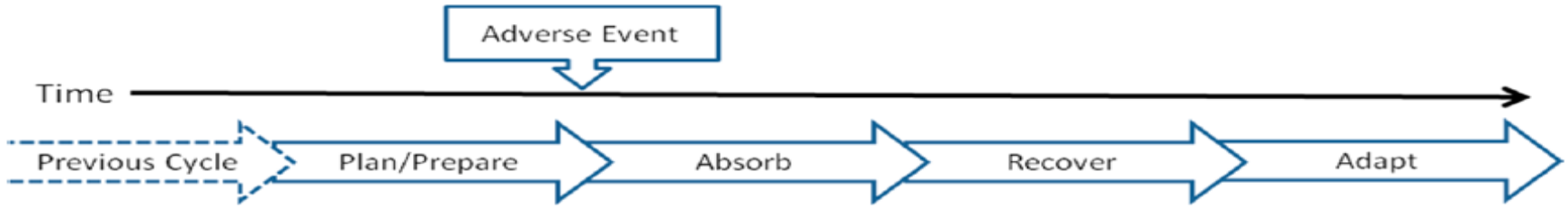


Figure 2: Relationship between Event Management Cycles

This requires effective decision making!

Post-event actions include multiple alternatives that allow the system to absorb, recover, and/or adapt

Resilience Matrix Approach



	Plan/Prepare	Absorb	Recover	Adapt
Physical	• State and capability of equipment and personnel, network structure	• Event recognition and system performance to maintain function	• System changes to recover previous functionality	• Changes to improve system resilience
Information	• Data preparation, presentation, analysis, and storage	• Real-time assessment of functionality, anticipation of cascading losses and event closure	• Data use to track recovery progress and anticipate recovery scenarios	• Creation and improvement of data storage and use protocols
Cognitive	• System design and operation decisions, with anticipation of adverse events	• Contingency protocols and proactive event management	• Recovery decision-making and communication	• Design of new system configurations, objectives, and decision criteria
Social	• Social network, social capital, institutional and cultural norms, and training	• Resourceful and accessible personnel and social institutions for event response	• Teamwork and knowledge sharing to enhance system recovery	• Addition of or changes to institutions, policies, training programs, and culture

Assessment using Decision Analysis

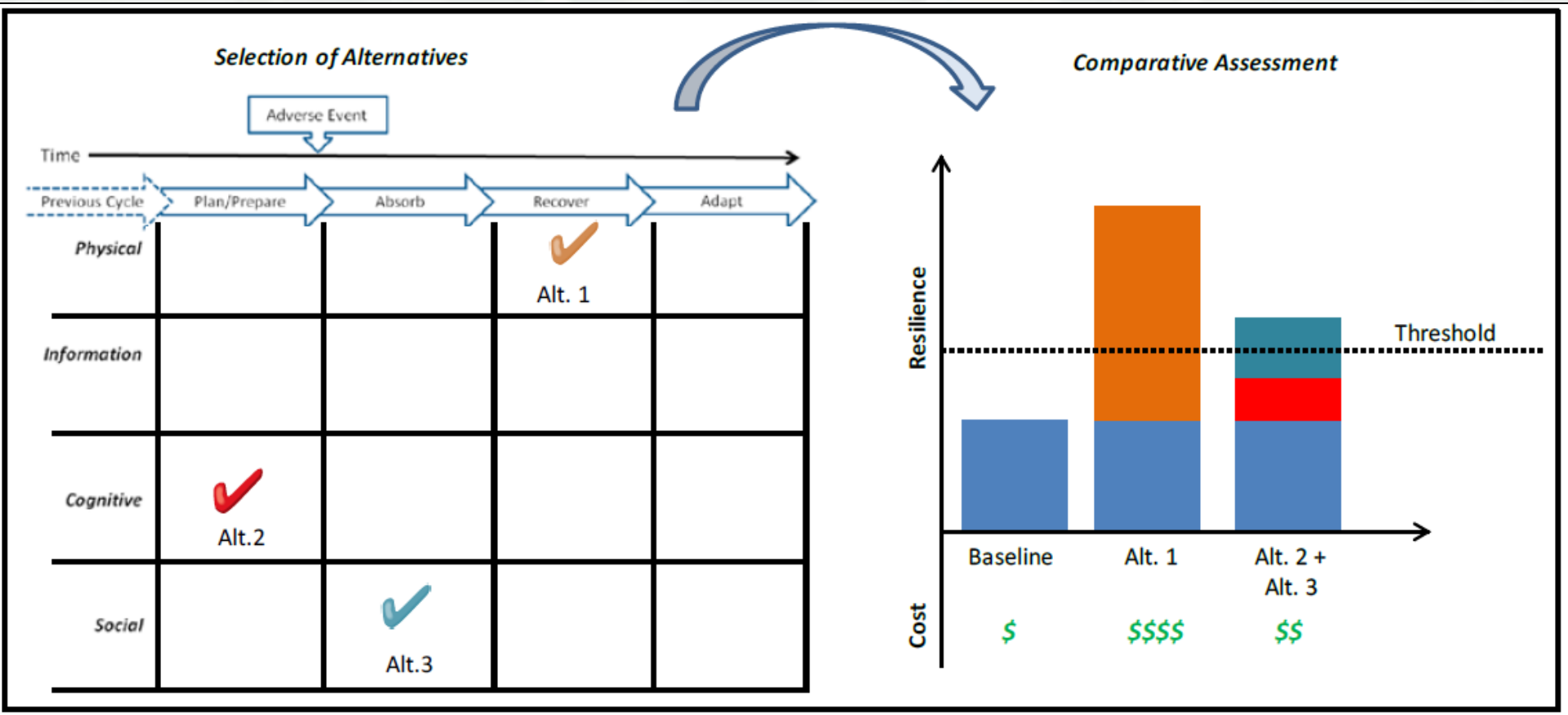


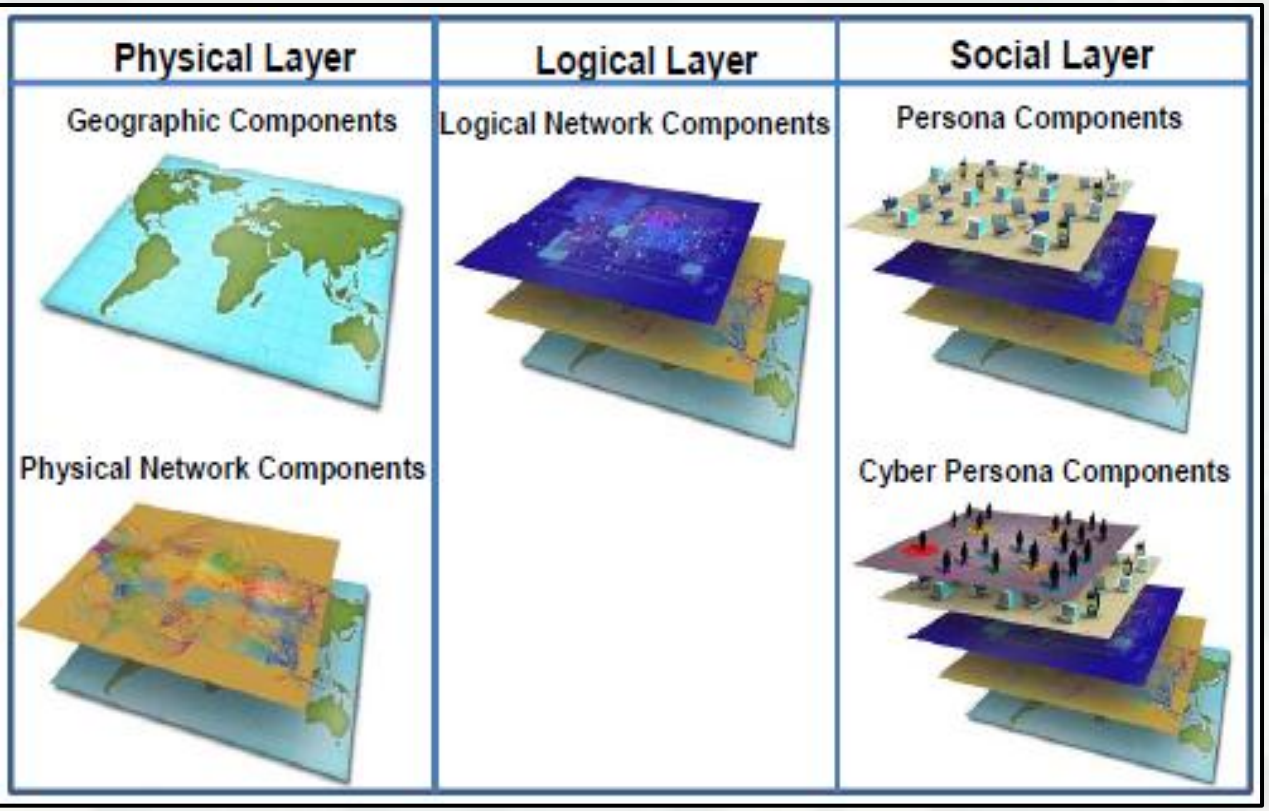
Figure 5: Comparative Assessment of Resilience-Enhancing Alternatives

Use developed resilience metrics to comparatively assess the costs and benefits of different courses of action

ERDC

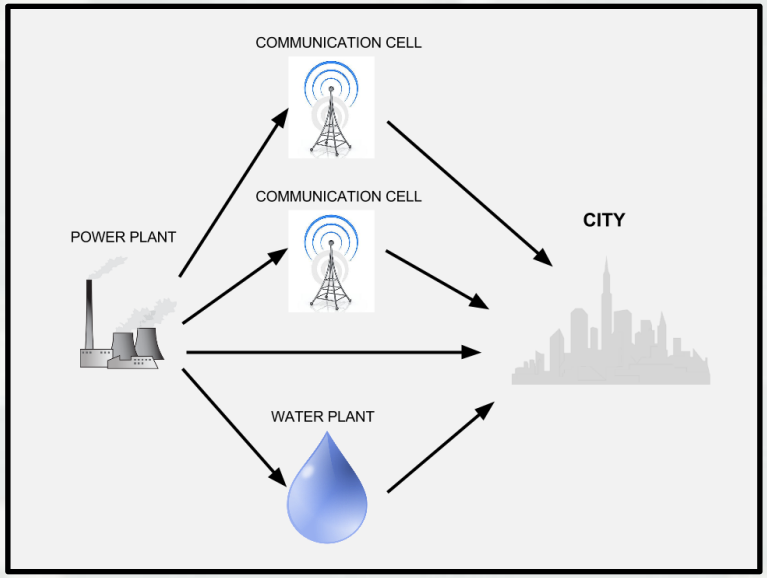
solutions for a safer, better world

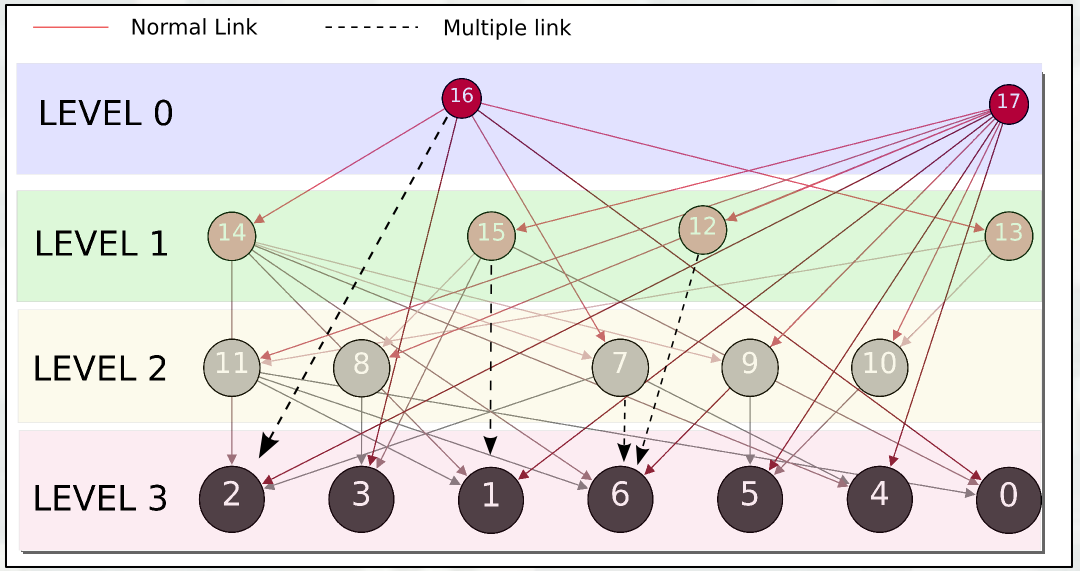
Defining Resilience through Network Science: Multi-Domain Networks



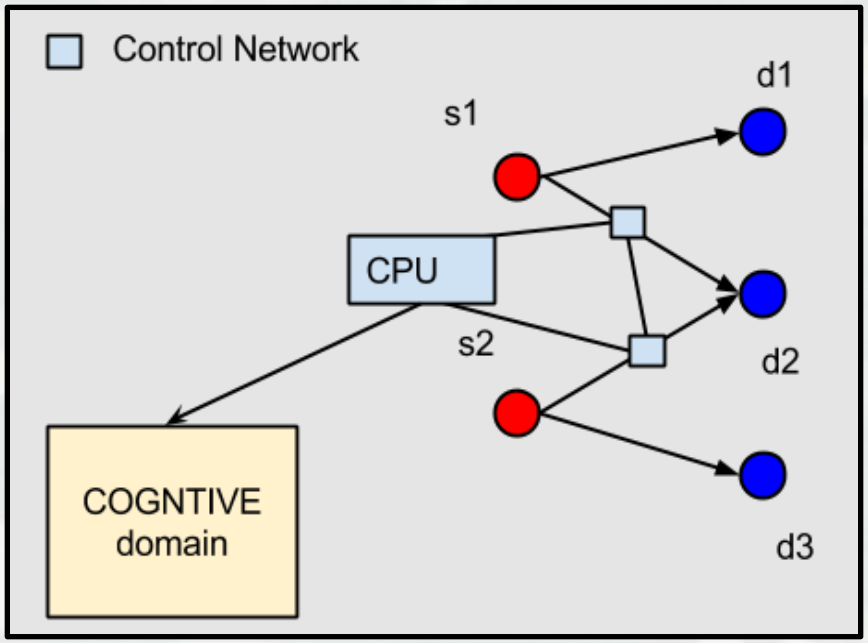
Domains are networks and interdependency among individual layers and components needs to be accounted for.

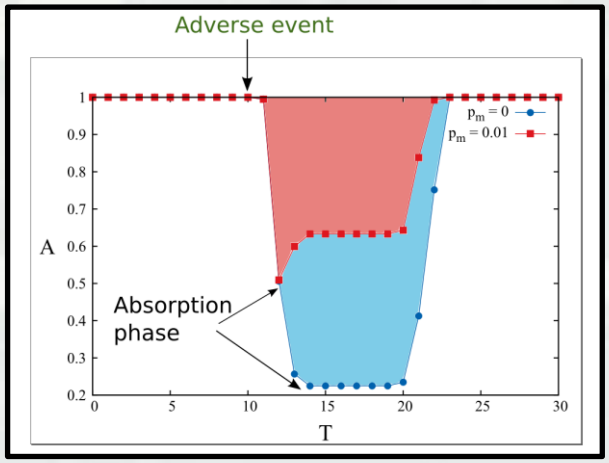
Proposed Approach: Domain Mapping

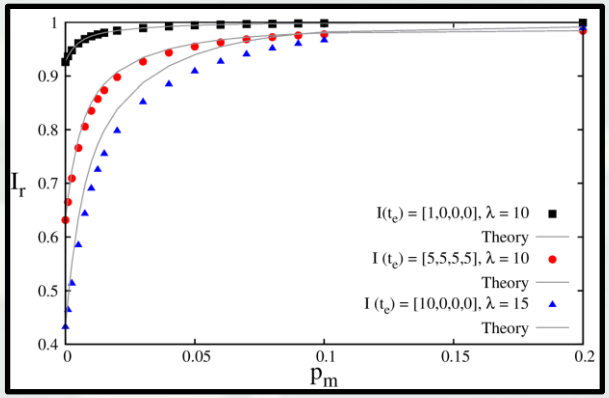




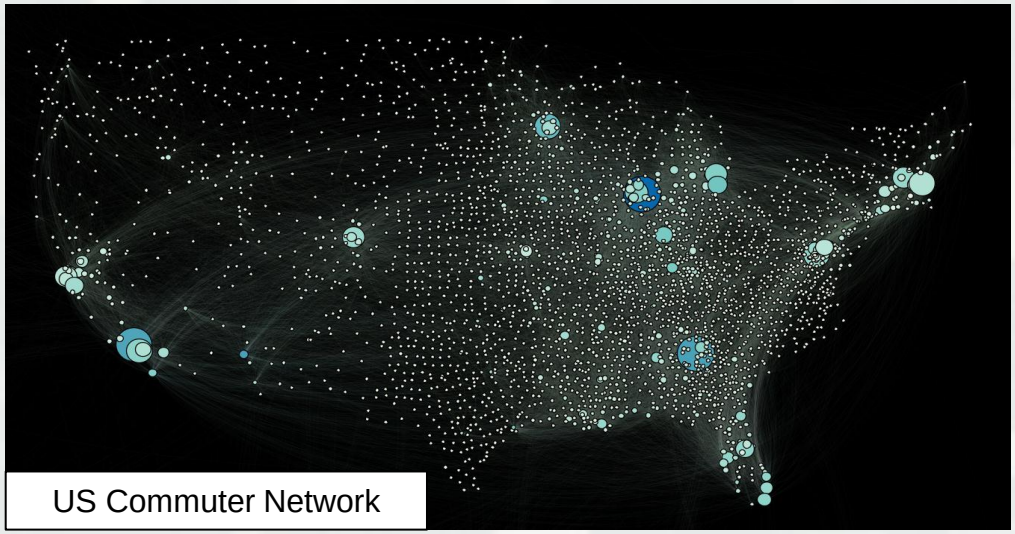
Approach to Quantifying Resilience







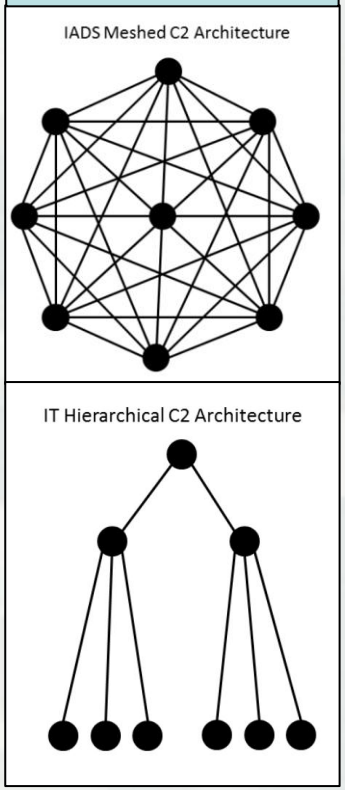
Goal: To Apply Resilience Model Across Multiple Case Studies



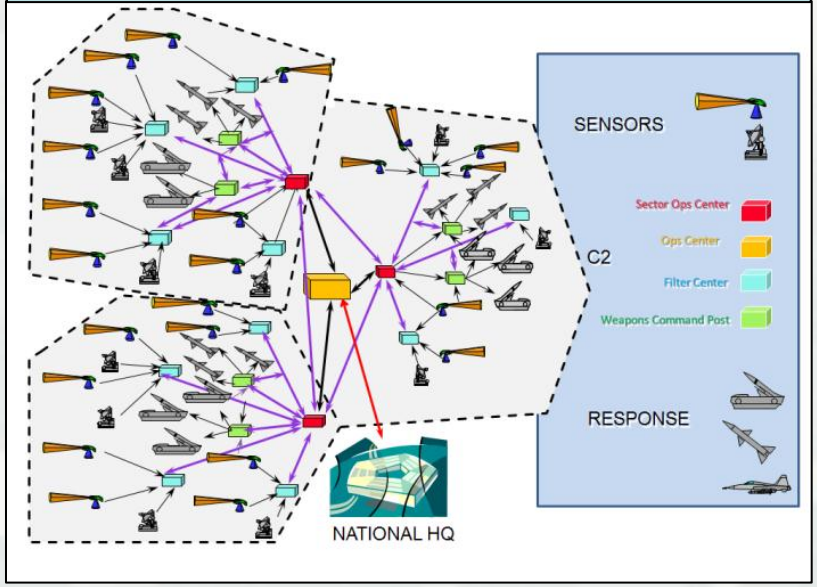
US Commuter Network

Previous NCO Studies - Dynamic Network Structure

Decision Strategy Model



Architectural Model



Clark, Ronald. “Implementing An Integrated Network Defense Construct.” *The 18th ICCRTS, Alexandria Virginia, June 19-21, 2013.* Ed. CCRP. Presentation.

The goal was to apply lessons learned from US air defense structure to create a more dynamic and agile network defense system.

It was found that a safer, more dynamic network can be realized through a collaborative environment and a meshed operational network structure.

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Extensions – Adaptive Management

Adaptively update courses of action as new information becomes available – feed back into decision model

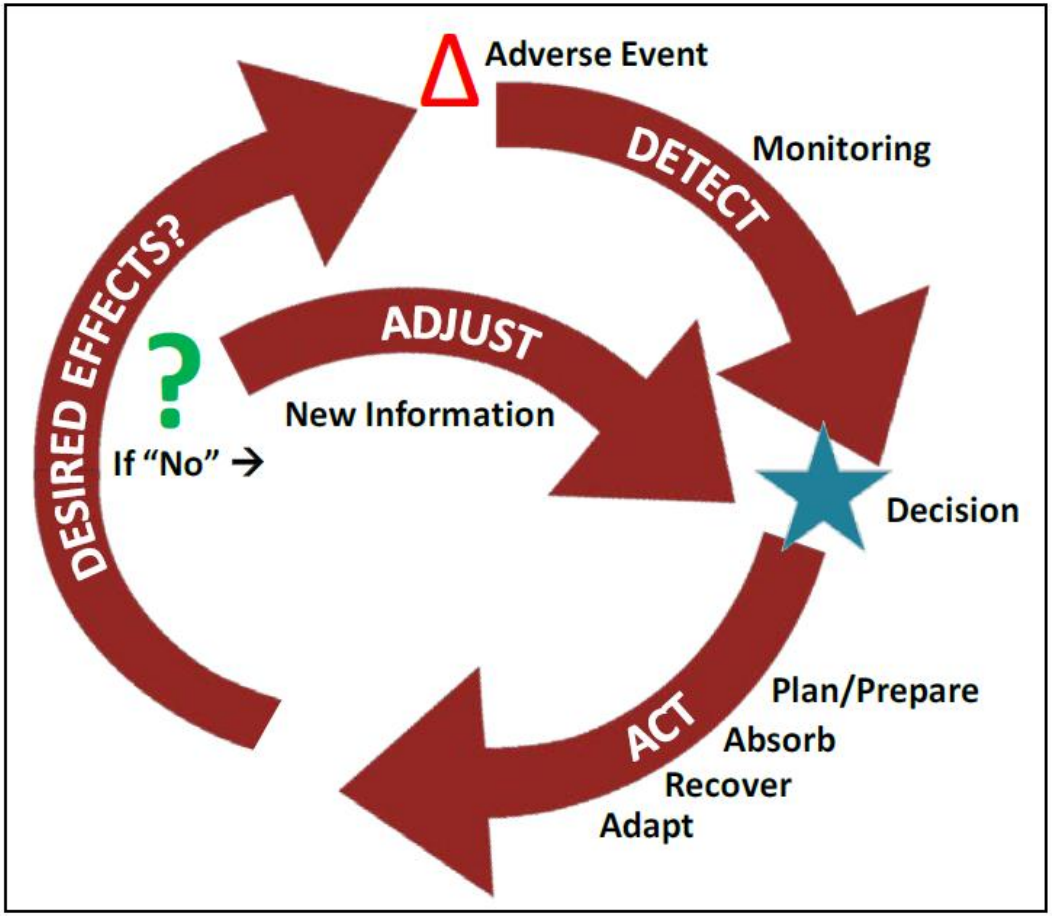


Figure 6: Enhanced Adaptive Management for Resilience (adapted from Jones, 2009)

Conclusions

- Resilience requires formalized decision making
- Resilience metrics must be developed for each problem context
- Resilience is a critical component of agility
- Structured tools are necessary for facilitating agile & resilient decision making
- … there is more research to be done

Contact Information

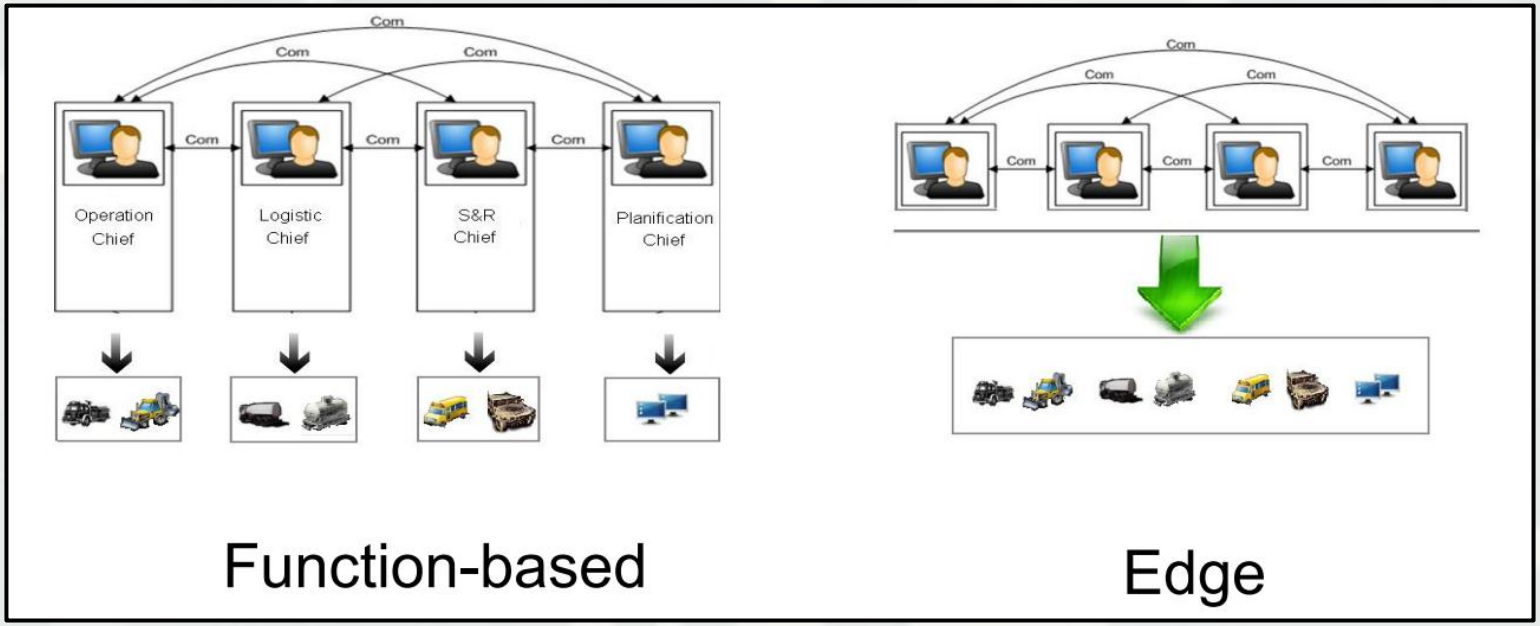
Dr. Igor Linkov

US Army Engineer Research and Development Center

Igor.Linkov@usace.army.mil
617-233-9868

Previous NCO Studies - Edge vs Functional Teams

Jobidon, Marie-Eve. “Adaptability in Crisis Management: The Role of Organizational Structure.” *The 18th ICCRTS, Alexandria Virginia, June 19-21, 2013.* Ed. CCRP. Presentation.



Findings:

Functional teams adapt better to sudden and surprising events.

Edge teams are more efficient in optimal environments.