TOWARDS A NEW HORIZON IN CRITICAL INFRASTRUCTURES RISK GOVERNANCE

RISK, VULNERABILITY AND SUSTAINABILITY FOR CRITICAL TRANSPORT INFRASTRUCTURES

Crown Plaza Hotel

Bucharest, Romania

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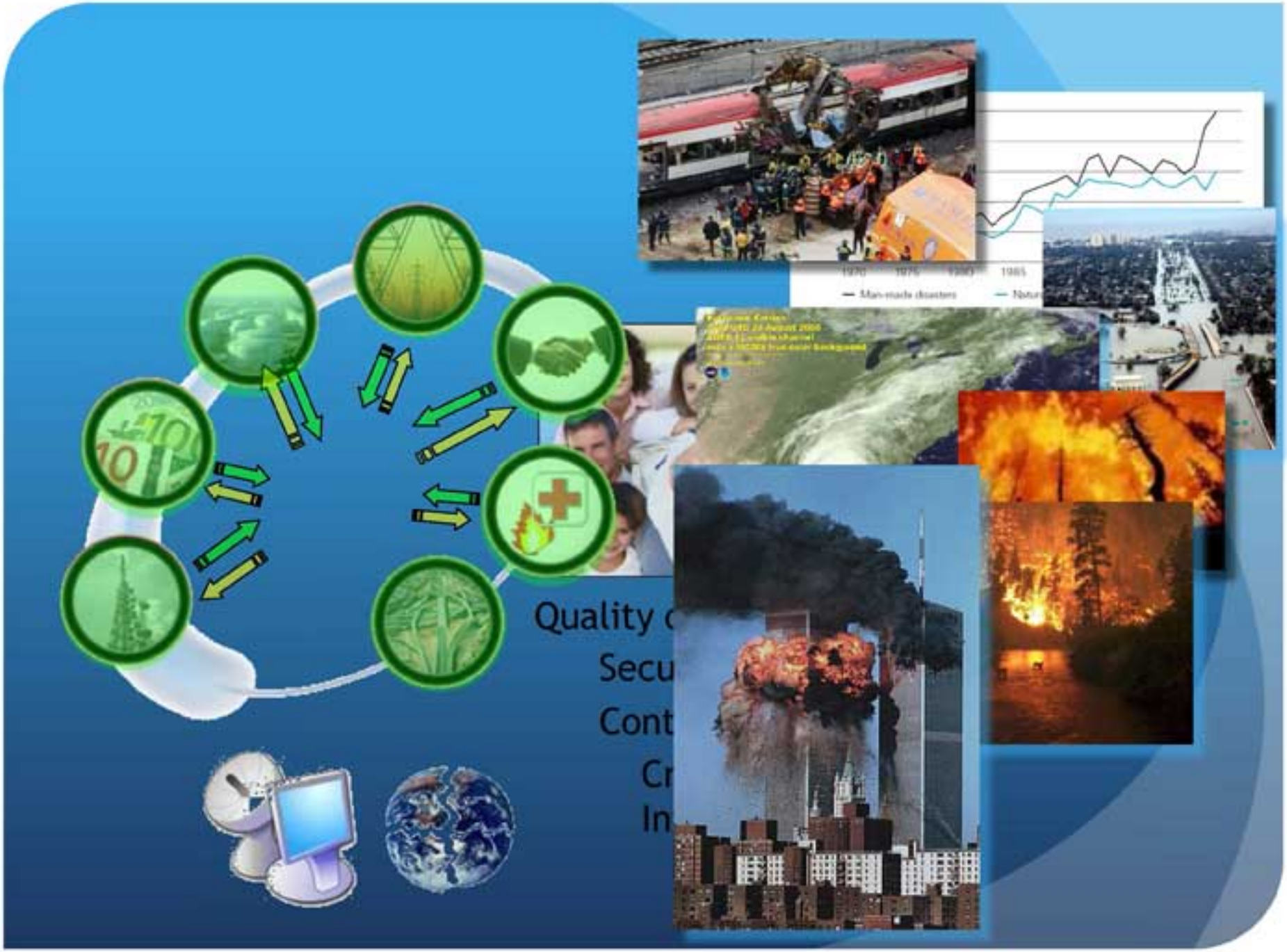
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Systems Engineering

Introduction to the foundations and fundamentals for systems engineering.

Systems Theory

Exploration of the principles, laws, and concepts foundational to systems based problem solving.

Complex Systems

Understanding the nature and implications for dealing with complexity of modern day systems.

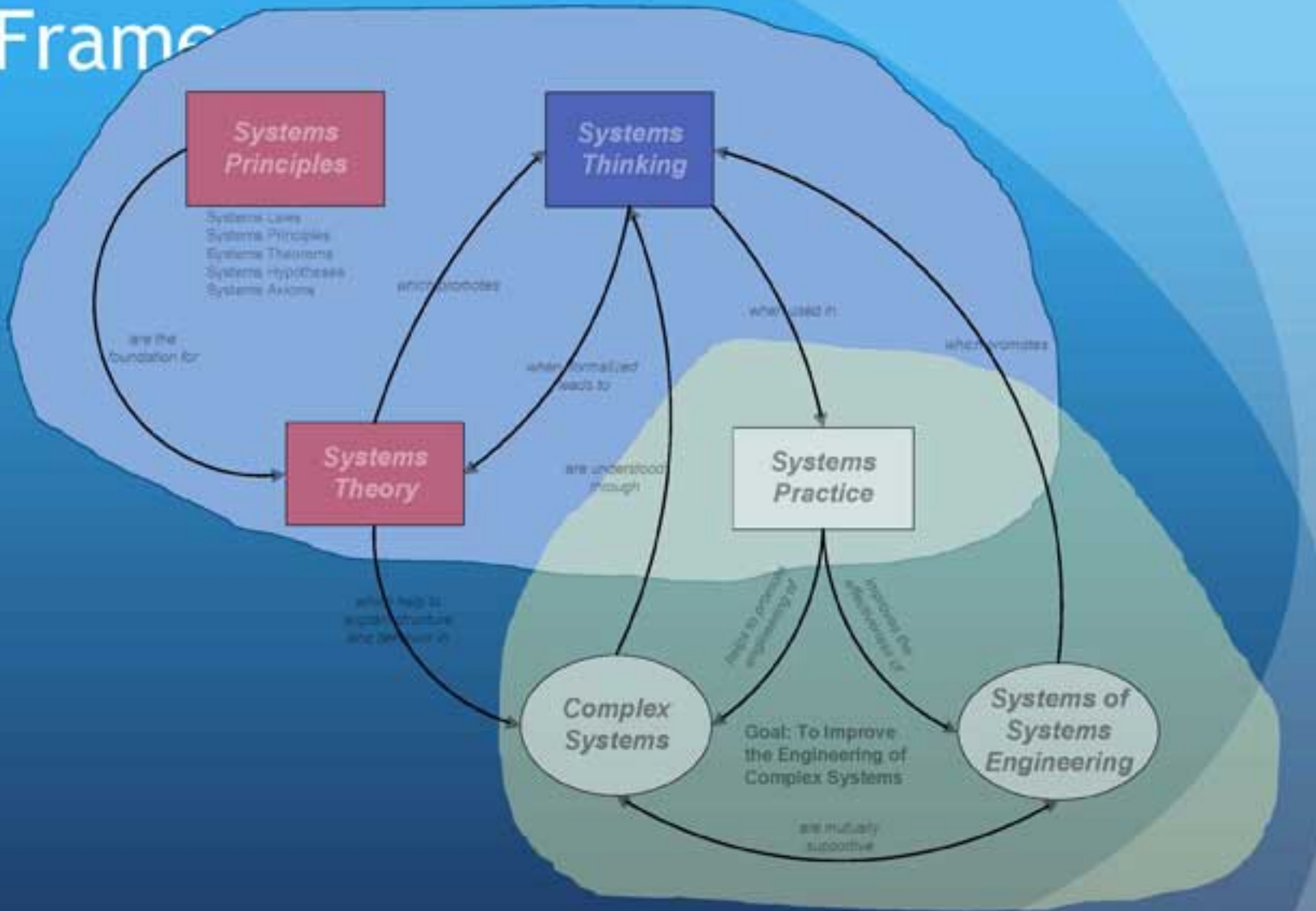
System of Systems Engineering

Examination of the methodologies, tools, and issues for engineering systems of systems.

Capstone Case Study

A real world application that integrates the entirity of the curriculum -- targeted to a specific problem..

Applies a New Thinking Frame



CRITICAL INFRASTRUCTURE & CONTINUITY OF OPERATIONS IN A POST 9/11 WORLD

Critical Infrastructure & Continuity of Operations in a Post 9/11 World

- Outline of Presentation
  - Overview of Critical Infrastructures
  - U.S. Critical Infrastructures
  - Global Critical Infrastructures
  - Critical Infrastructures Interdependences
  - Continuity of Operations

Overview of Critical Infrastructures

- Defining Critical Infrastructures
  - Pre 9/11:
    Those systems whose prolonged disruptions could cause significant military and economic dislocation.

Defining Critical Infrastructures

- Post 9/11:

Systems and assets,
Whether physical or virtual, so vital
that the incapacity or destruction
of such systems and assets would
have a debilitating impact insecurity,
national economic security,
national public health and safety,
or any combination of those matters.

Critical Infrastructure Sectors

- 1. Agriculture and food
- 2. Energy
- 3. Public Health
- 4. Emergency Services
- 5. Government
- 6. Defense Industrial Base
- 7. Information & Telecommunications (Cyber)
- 8. Water Supply Systems
- 9. Transportation
- 10. Banking and Finance
- 11. Chemicals and Hazardous Materials
- 12. Postal
- 13. Ports and Shipping

Agricultural and Food

- Supply chains for feed, animals, and animal products
- Crop production and supply chains of seed, fertilizer,
- Post-harvesting-production, packaging, storage, etc.

Water Supply System

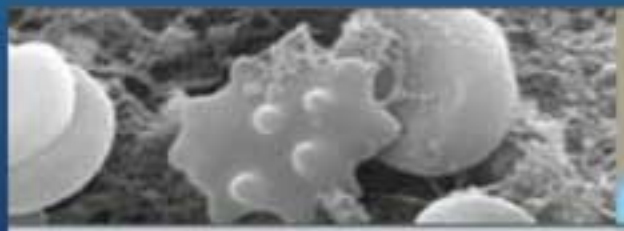
- Fours areas of Concentration:
  - 1. Physical damage or destruction
  - 2. Actual or threatened contamination
  - 3. Cyber Attack
  - 4. Interruption of services

U.S. Water Infrastructure

- 75,000 dams and reservoirs, thousands of miles of pipes and aqueducts
- 168,000 public drinking water facilities
- 16,000 publicly owned waist water treatment facilities.

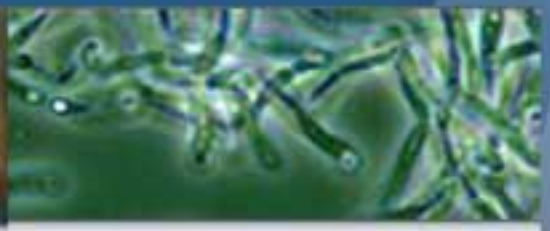
Public Health

- Public Health Sector Challenges:
  - Open and free access to most public health facilities
  - Variation in structural and system designs from one hospital to the next
  - Lack of protocols governing isolation of infections individuals during a crisis
  - Stockpiles and critical emergency resources
  - Legal and regulatory issues
  - Delivering of critical services during a crisis
  - Specialized medical and pharmaceutical laboratories



EM Imagery

Influenza



Bioterrorism

Emergency Services

- Inadequate information sharing between different organizations
- Telecommunications problems
- Enhancing force protections

Government

- Physical Protection of critical infrastructures
- Key Assets
- Continuity of Operations Plan
- Continuity of Government

Defense and Industrial Base

- DOD's dependency on the private sector
  - Outsourcing
  - Utilities
  - Single or limited # of suppliers
  - Military Product Specifications
  - Procurement Process
  - Enhanced Infrastructure Protection Measures

UNITED STATES DEPARTMENT OF DEFENSE

Information and Telecommunications

- Public Switched Telecommunications Network (PSTN)
- Next Generation Network (NGN)
- Sector Challenges
- Sector Priorities

Energy

- Electricity
  - Generation
  - Transmission and Distribution
  - Control and Communications
  - NERC, FERC, NRC
  - Sector Challenges

Electrical Infrastructure

- Electrical Power System
  - 92,000 electric generating units (including fossil fueled, nuclear, and hydroelectric units)
  - 300,000 miles of transmission lines
  - 150 control centers that regulate the flow of electricity.

Energy

- Oil and Natural Gas
  - Five general Components
    - Oil Production
    - Crude Oil Transport
    - Refining
    - Product transport and distribution
    - Control and other external support systems.



Key Oil Production Capacity

- *FOUR KEY OIL FIELDS THAT PRODUCE OVER ONE MILLION BARRELS PER DAY*
  - Saudi Arabia (Ghawar)- 4.5 million barrels
  - Mexico (Cantarell) - 2 million barrels
  - Kuwait (Burgan) - 1 million barrels
  - China (Da Qing) - 1 million barrels

Asian Critical Infrastructure

Oil Pipeline: *Kazakhstan To China* (Sino-Kazakh)

- *980 KM of pipeline*
- *246 KM crude oil pipeline to Dushani Refinery*
- *10 Billion Tons of Capacity*

Middle Eastern Pipeline

- Saudi Arabia-

Roughly 25% of the earth's total crude oil resources

Russian Oil

Largest Non OPEC Energy Producer



Transportation

- Aviation
- Maritime Traffic
- Rail
- Pipelines
- Highways
- Trucking and Busing

Maritime Traffic

- There are 361 seaports in the United States, and their operations range widely in size and characteristics.
- Most of Ports in the US are owned either by state and local governments or by private corporations.
- Most ships are privately owned and operated
- Major portions of the maritime industry's operations are international in nature and are governed by international agreements and multinational authorities

Transportation Infrastructure

- Transportation Civil System-
  - Aviation system
    - 500 Commercial-service airports
    - 14,000 smaller general aviation airports
  - Commuter and urban rail system
    - 10,000 miles

Pipeline

- The current system of pipelines consists of hundreds of thousands of miles of pipelines, many of which are buried underground. These lines move a variety of substances such as crude oil, refined petroleum products, and natural gas. These system are relatively stable and because of the design and layout most elements of pipeline infrastructures can be quickly repaired or bypassed to mitigate local disruptions.
- Challenges to the Pipeline infrastructure include
- Pipelines are part of a network that supports both industrial and public service. Loss of a pipeline could impact a wide array of facilities and industrial factories.
- Because of the extent of pipelines in the US protection efforts are only focused on those particular systems that have the potential if impaired of having significant effects on the energy markets and the economy as a whole.
- AS is the case with most of the systems I have spoken about today, the pipeline industry is increasing interdependencies with the energy and telecommunications sectors

National Highway System Infrastructure

U.S. Highway system

- 600,000 bridges

- 4 million interconnected Miles of paved roadways

- 45,000 miles of interstate freeway

Mass Transist

- Making security changes to the National Highway system are impractical given its size and complexity…..however in most states as part of their security planning they have identified and in many cases provided security systems to key highways and bridges.
- Generally **The US trucking and busing infrastructure is considered highly resilient, flexible, and responsive to market demand however if they go down there could be a cascading effect on other systems.**

- 9.5 Billion public transit trips are taken annually by passengers
- Mass transit carries more passengers in a single day than air or rail transportation
- The US transit system, like much of Europe and other countries, are designed to be publicly accessible. Most in the US are owned and operated by state and local agencies. Contributing to the difficulty of making these systems secure
- As is the case with other CI in the US each city and region have their own unique transit system making it difficult to apply requirements and standards across the sector. No one program will fit all of these different systems.
- This is one area that the US continues to struggle with and is still in the development phase with many ongoing R&D projects to provide solutions.

Banking and Finance

- Highly regulated and competitive
- Interdependencies
- FBIIC
- National Infrastructure Protection Center
- Challenges

Banking and Finance

- After 9/11 the equity securities markets remained closed for 4 business days , not because any markets or market systems where inoperable, but because the telecommunications lines in lower Manhattan that connect key market participants were heavily damaged.
- To better organize how threat information is communicated and handled in the BF sector the DOT organized the Financial and Banking Information Infrastructure Committee FBIIC. This committee has 13 federal and state financial regulatory agencies and this group works closely with the National Infrastructure Protection Center to improve information dissemination and sharing processes.
- The two key areas that remain a challenge to the BF sector is the risks associated with sector dependencies on electronic networks and telecommunications services and the exchange of security-related information.

Chemicals and Hazardous Materials

- Key provider for public health
- Nations Top Exporter
- Highly Diverse
- Assurance of Supply
- Chemical Stockpiles
- Interdependence with Energy

- The Chemical industry provides $98 billion dollars worth of products to the health care industry alone and is top US exporter, accounting for 10 cents on very dollar. This is a highly diverse sector in terms of company sizes and geographic dispersion. This sector relies heavily on delivery of raw materials, manufacturing plants and processes, as well as the distribution system.
- Assurance of supply is critical as many large municipal water works maintain only a few days supply of chlorine for disinfecting water supplies. Agricultural chemicals, particularly fertilizers, are often required in large volumes during very short time periods.
- Contamination of key chemical stocks could impact a wide range of industries which in turn affect public health and the US economy. The Chemical sector is the nations 3rd largest consumer of electricity.

Postal and Shipping

- Volume of mail
- Size of the USPS
- Interdependencies
- Areas of Concern

- Every day the USPS handles more than 2/3's of a billion pieces of mail into the US postal system. Each day more than 300,000 city and rural postal carriers deliver mail to more than 137 million addresses nationwide and employ nearly 750,000 full time personnel.
- The postal system is highly dependent on the transportation sector and depends upon their own fleet of both service-owned and contractor operated vehicles. Mail also travels by air, truck, railroad and ship.
- The size and pervasiveness of the system as a whole have important implications in terms of the potential secondary effects of a malicious attack….which is best illustrated by ex anthrax attacks in 2001.

Postal and Shipping

- Currently the Commercial postal and shipping companies are in the process of organizing themselves as a sector to begin to identify and address specific protection issues. Based upon some of this work and other ongoing assessments the USPS has identified five areas of concern for the postal system:
  1. Points of entry and locations of key facilities
  2. The mails chain of custody
  3. Unique constitutional and legal issues
  4. Interagency coordination and
  5. The ability to respond in emergency situations.

Postal and Shipping

- Other challenges are inherent simply because of the way mail is handled in the US for example USPS dos not always maintain control of the mail during it entire chain of custody…often mail is transported using other systems and the mail moves into and out of USPS control.

- Something that is now being required of this sector is to have all those handling the mail at any point in the chain of control must have a criminal and drug background check

Key Assets

- National Monuments and Icons
- Nuclear Power Plants
- Dams
- Government Facilities
- Commercial Key Assets

Private Sector Responsibility for Protecting Critical Infrastructure

- Planning Assurance
- Increased threshold investments
- Undertaken enhancements in security
- Risk versus consequence tradeoffs

Government Responsibility for Critical Infrastructures

- Responsibility of the U.S. Federal Government:
  - *Law Enforcement and internal security*
  - *Foreign Intelligence*
  - *Foreign affairs; and,*
  - *National Defense*

Critical Infrastructure: An International Perspective

- Australia
- Canada
- The United Kingdom
- Sweden
- Switzerland
- European Union
- Japan

- Global nature of Critical Infrastructure

- Critical infrastructures are highly interconnected and mutually dependent in complex ways, both physically and through a host of information communications technologies …or cyber based systems.
- There exists both national and international interdependencies that can be either physical, cyber, geographical, and logical. These interdependencies are not mutually exclusive. What happens to one infrastructure can directly and indirectly affect other infrastructures, impact geographic regions, and send ripples throughout the national and global economy.

- Many of today's infrastructures are inherently international. For example, the telecommunications, banking and finance, and oil and gas Infrastructures are truly global in scope, and the US and Canadian electric power infrastructures are inseparable.

- Political issues as diverse as OPEC decisions, hydroelectric power in the Pacific Northwest, instability in a number of the OPEC and Non OPEC regions, and foreign ownership of parts of the US telecommunications infrastructure substantially affect the critical infrastructure environment. Political and social issues, at both national and international levels, are important variables that fundamentally shape the infrastructure environment and the global community we all live in.

- Identifying, understanding, and analyzing national and international interdependencies has taken on increasing importance, key technological , economic, and regulatory changes have dramatically altered the relationships among infrastructures, and the information technology revolution has led to substantially more interconnected and complex infrastructures.

- The operational, R&D, and policy communities are beginning to accept the importance of infrastructure interdependencies and the need to more fully understand their influence on infrastructure operations and behaviors. Critical Infrastructure Interdependencies have now more than ever become a security concern that has the potential to impact the global economy and calls for innovative security ideas and solutions.

Too Advanced to be Governed?

Next Generation Infrastructures

- Vast and Large Scale: Transcontinental and Global
- Business and Infrastructures
- Complex and Connected
- Advanced
- Intelligent / Smart
- Fragile or Resilient
- Governed?
- …

Some Questions to be Addressed

- Too Big to Fail
- Too Complex to run Safe or Fail Safe
- Too Connected to Fail
- Too Complex to Regulate
- Too Intelligent to Address
- Too Advanced to be Governed
- Too Agile not to … Escape Feral Events ???

Use of Top-Ease to Guide Transition

NAS and UAS Descriptions
-processes
-external influences
-activities
-organizations

Top-Ease®

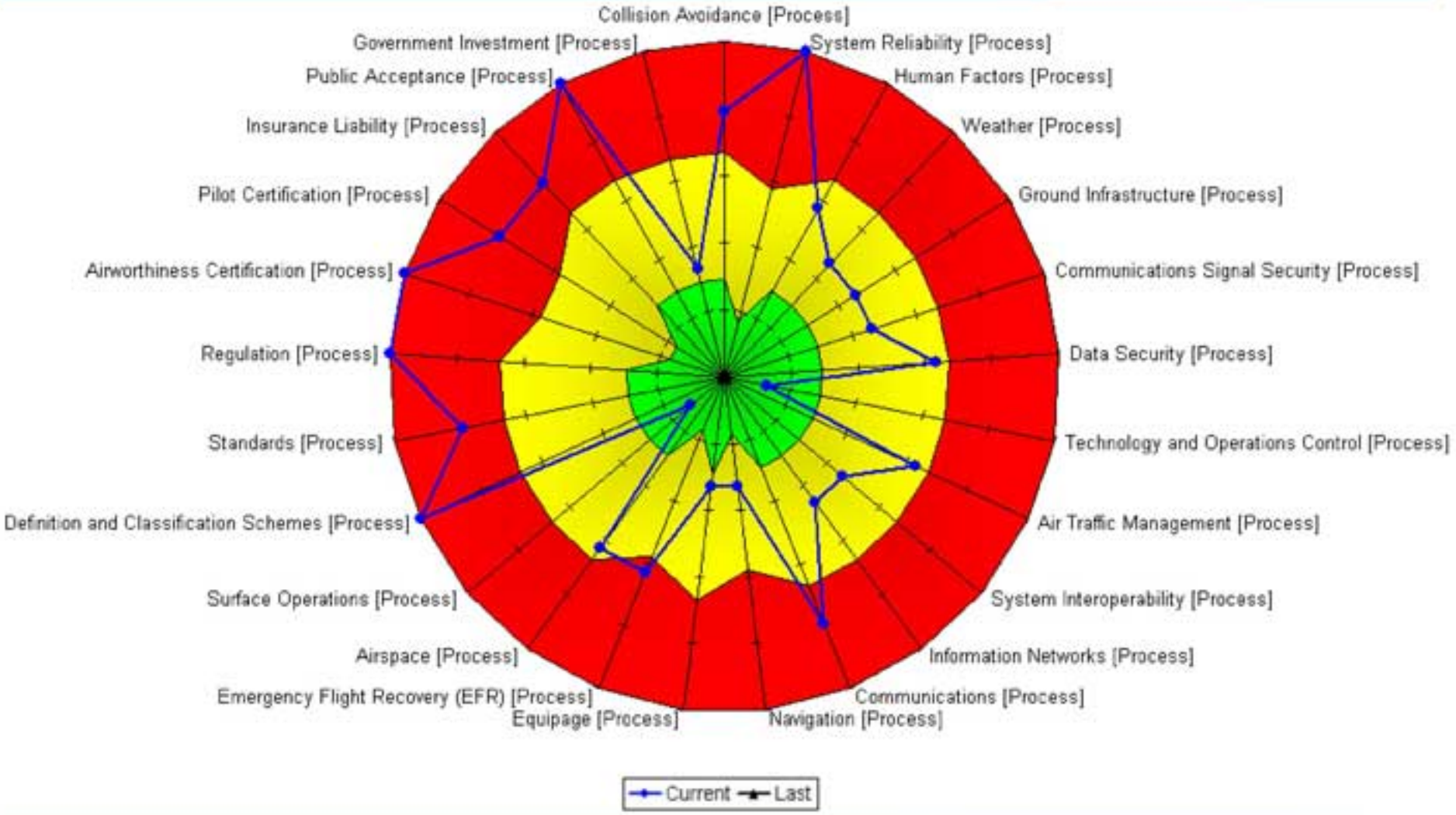
Flight Research Results

Risk Calculation Engine

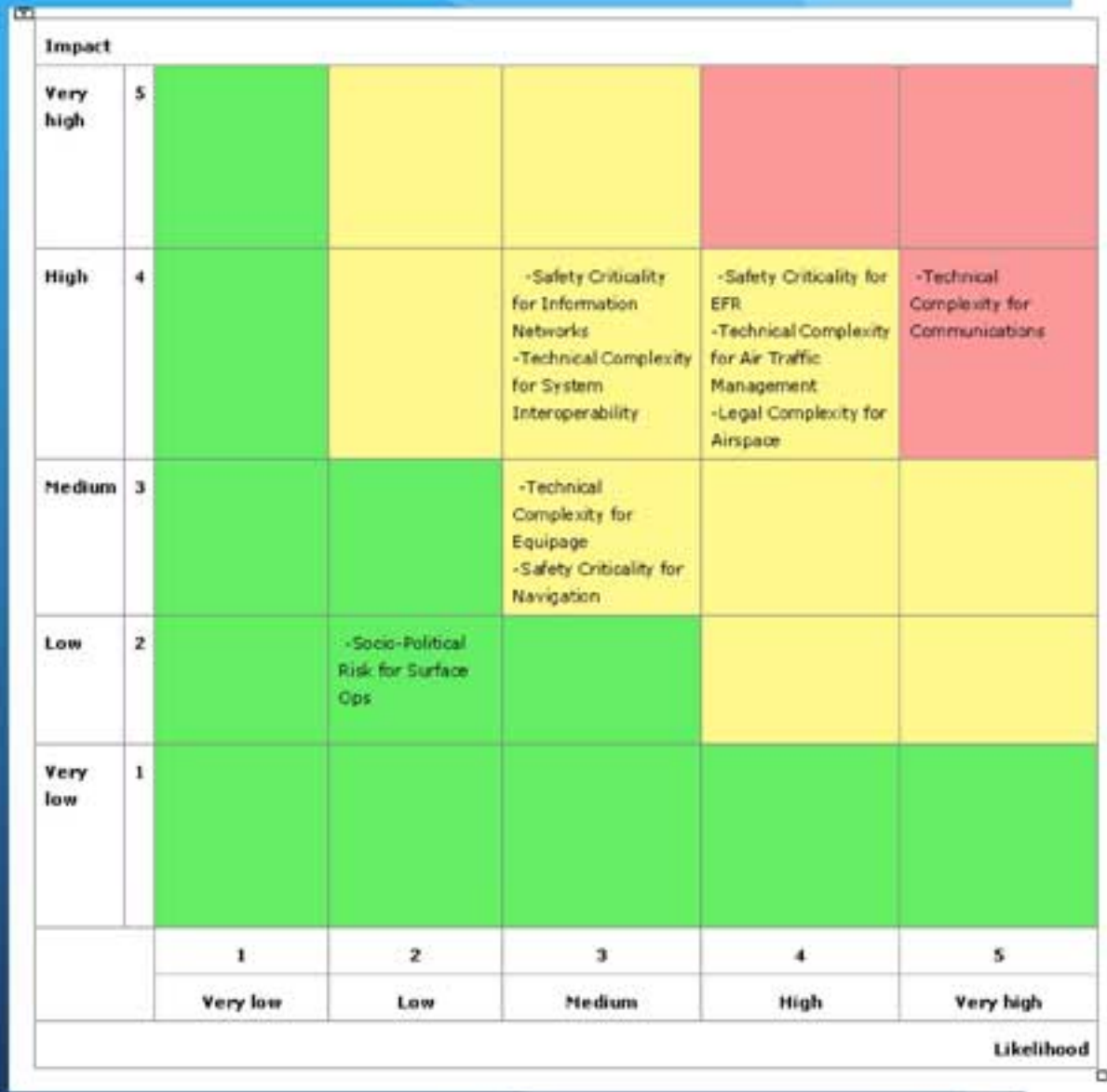
Vulnerability Calculation Engine

Risk based Guidance and projected results for each step in the transition

Risk Scorecard



Risk Map for Air Traffic Management Processes



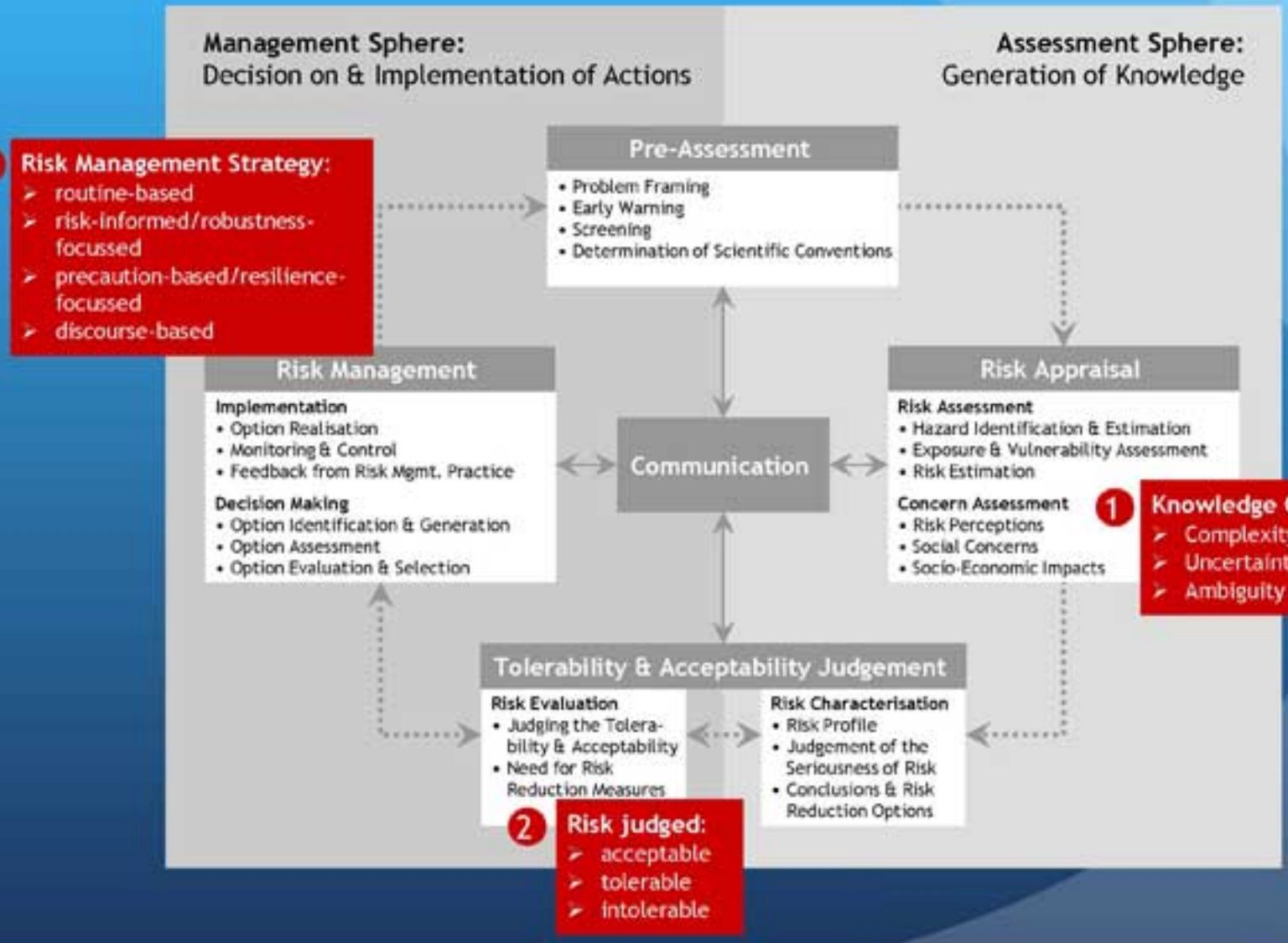
Impact						
Very high	5					
High	4			-Safety Criticality for Information Networks -Technical Complexity for System Interoperability	-Safety Criticality for EFR -Technical Complexity for Air Traffic Management -Legal Complexity for Airspace	-Technical Complexity for Communications
Medium	3			-Technical Complexity for Equipage -Safety Criticality for Navigation		
Low	2		-Socio-Political Risk for Surface Ops			
Very low	1					
		1	2	3	4	5
		Very low	Low	Medium	High	Very high
						Likelihood

The Concept of Risk Governance

- … refers to the processes, conventions and institutions that determine how
  - power is exercised in the management of resources and interests
  - important decisions are made and conflicts resolved
  - various stakeholders are accorded participation
  - actors from governments, corporate sector and civil society join forces to promote and regulate innovations in technology and society

- Principles of "good governance" include
  - Accountability
  - Effectiveness/Efficiency
  - Participation
  - Transparency
  - Strategic Vision/Focus

Risk Governance Framework



WHAT IS RISK GOVERNANCE?

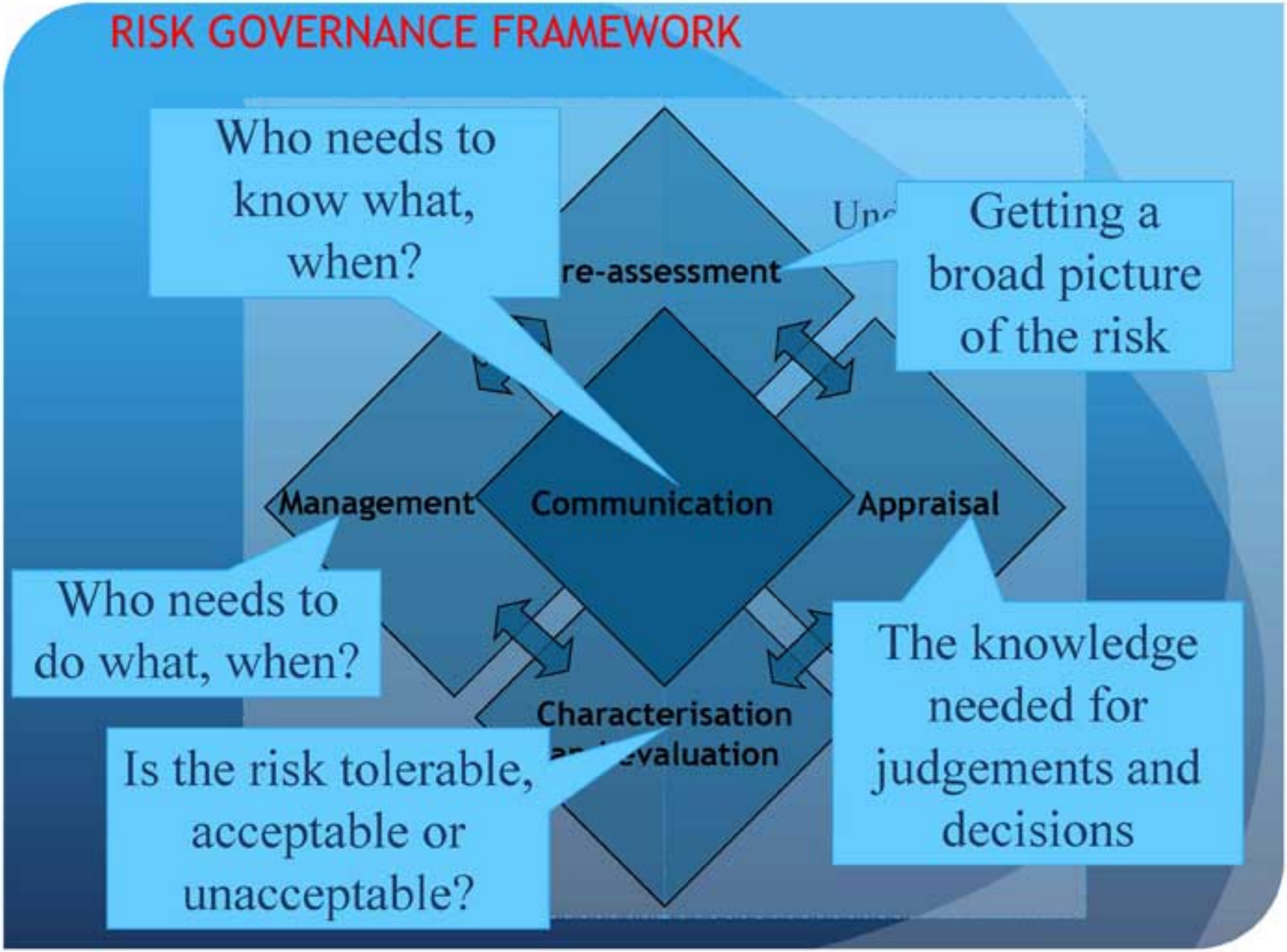
- ***Governance*** refers to the actions, processes, laws, traditions and institutions by which authority is exercised and decisions are taken and implemented.

- ***Risk*** is an uncertain (positive or negative) consequence of an event or an activity with respect to something that humans value

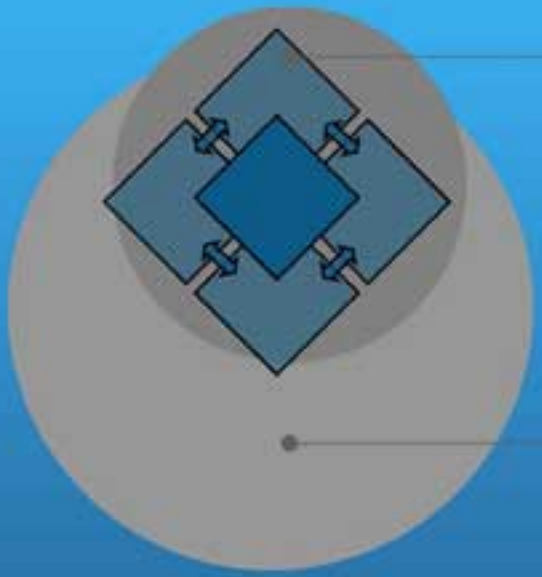
- ***Risk governance*** refers to the actions, processes, laws, traditions and institutions by which decisions about risk handling are prepared, taken and implemented

- ***Best practice in risk governance*** integrates the principles of good governance within the traditional risk-handling process.

RISK GOVERNANCE FRAMEWORK



RISK GOVERNANCE INCLUDES AND IS SENSITIVE TO CONTEXT



Core Risk Governance Process

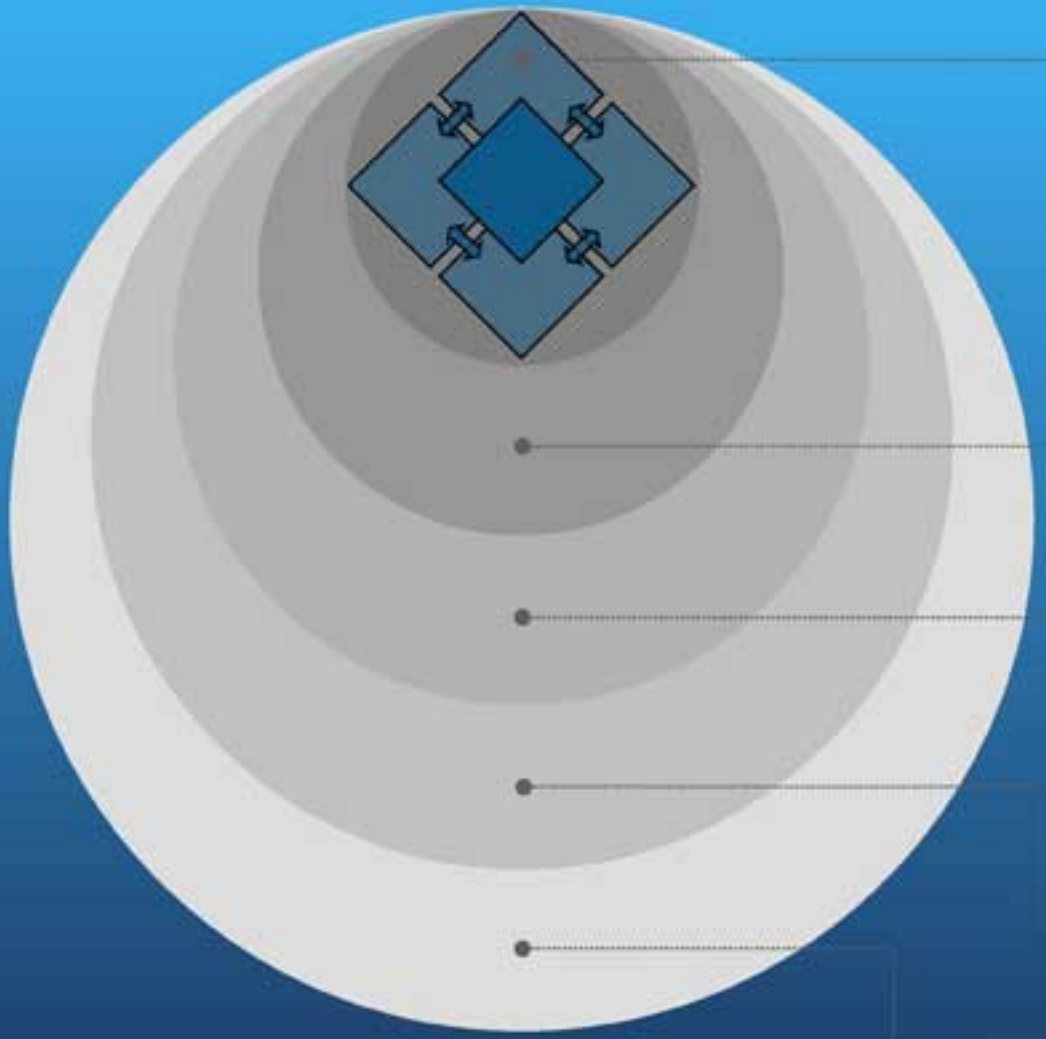
- pre-assessment
- risk appraisal
  - -- risk assessment
  - -- concern assessment
- evaluation: tolerability / acceptability judgement
- risk management
- communication

Organisational Capacity

- assets
- skills
- capabilities

Most risk handling processes are done in this context only

RISK GOVERNANCE GOES MUCH FURTHER



Core Risk Governance Process
- pre-assessment
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- evaluation: tolerability / acceptability judgement
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Organisational Capacity
- assets
- skills
- capabilities

Actor Network
- politicians
- regulators
- industry/business
- NGOs
- media
- public at large

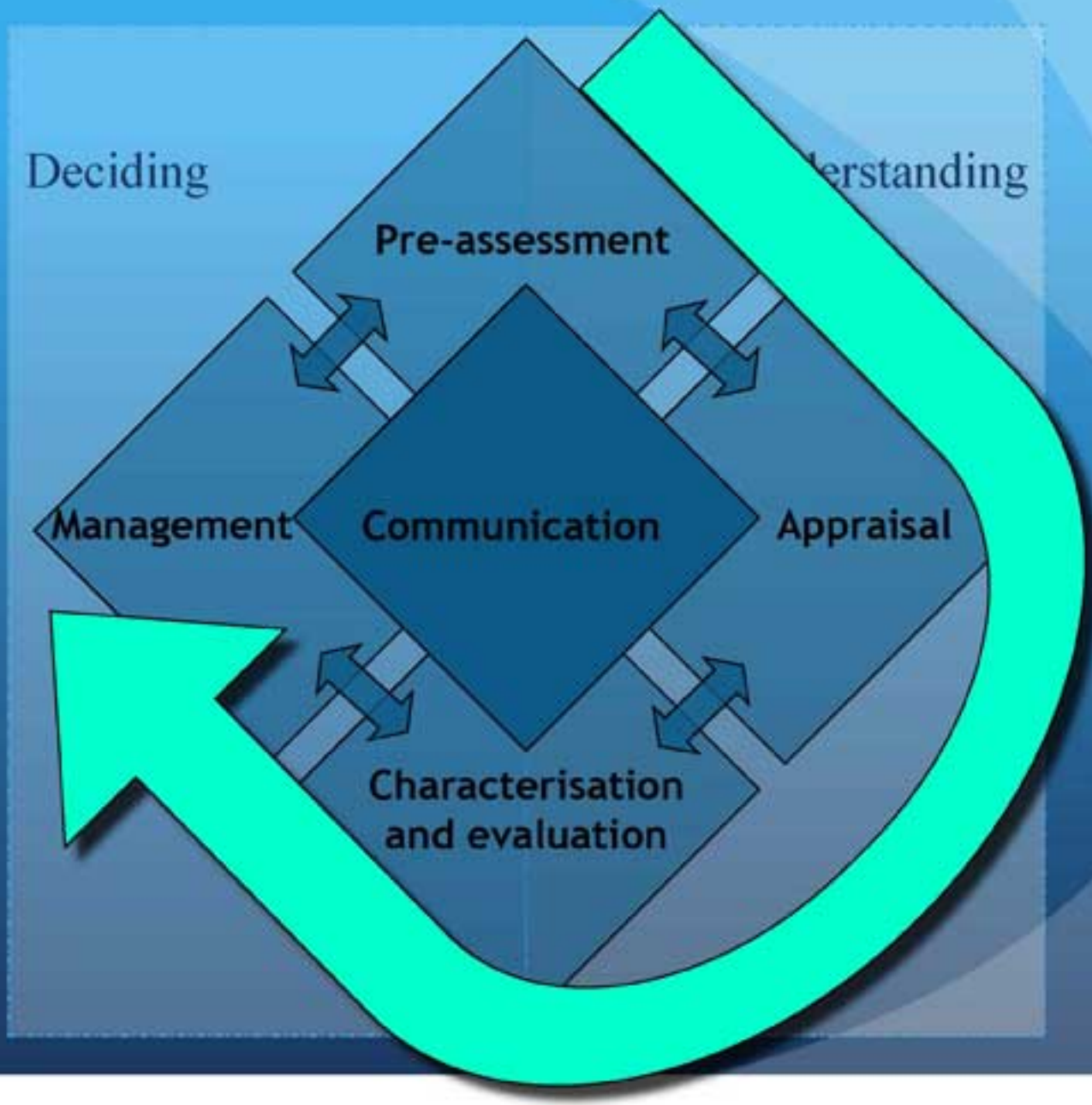
Social Climate
- trust in regulatory institutions
- perceived authority of science
- degree of civil society involvement

Political & Regulatory Culture
- → different regulatory styles

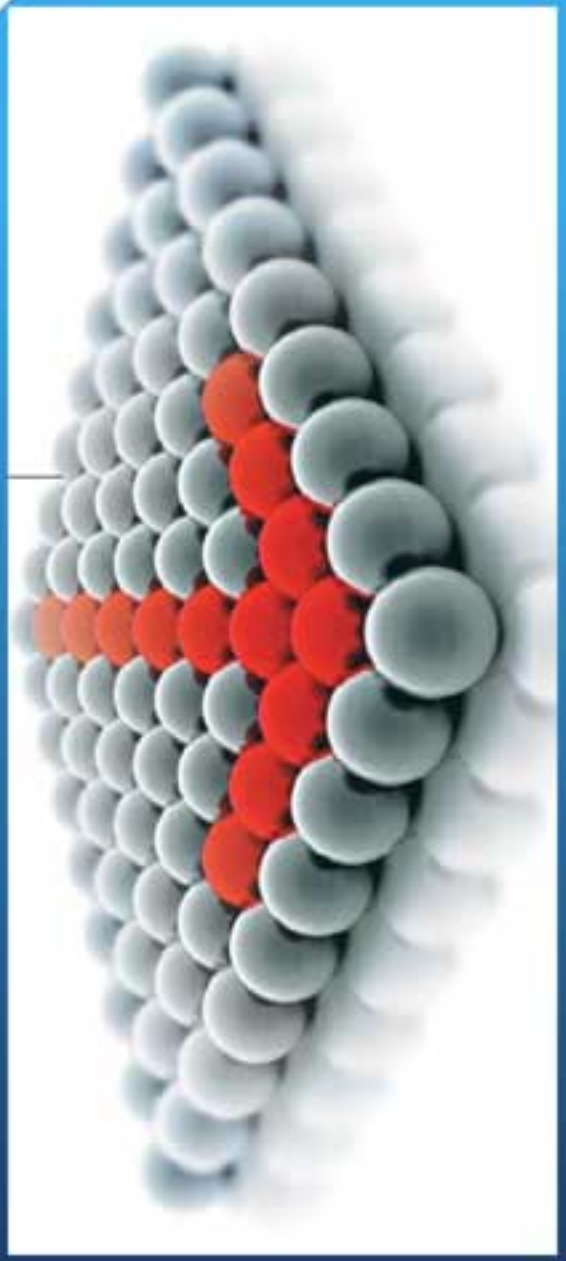
CONVENTIONAL RISK HANDLING

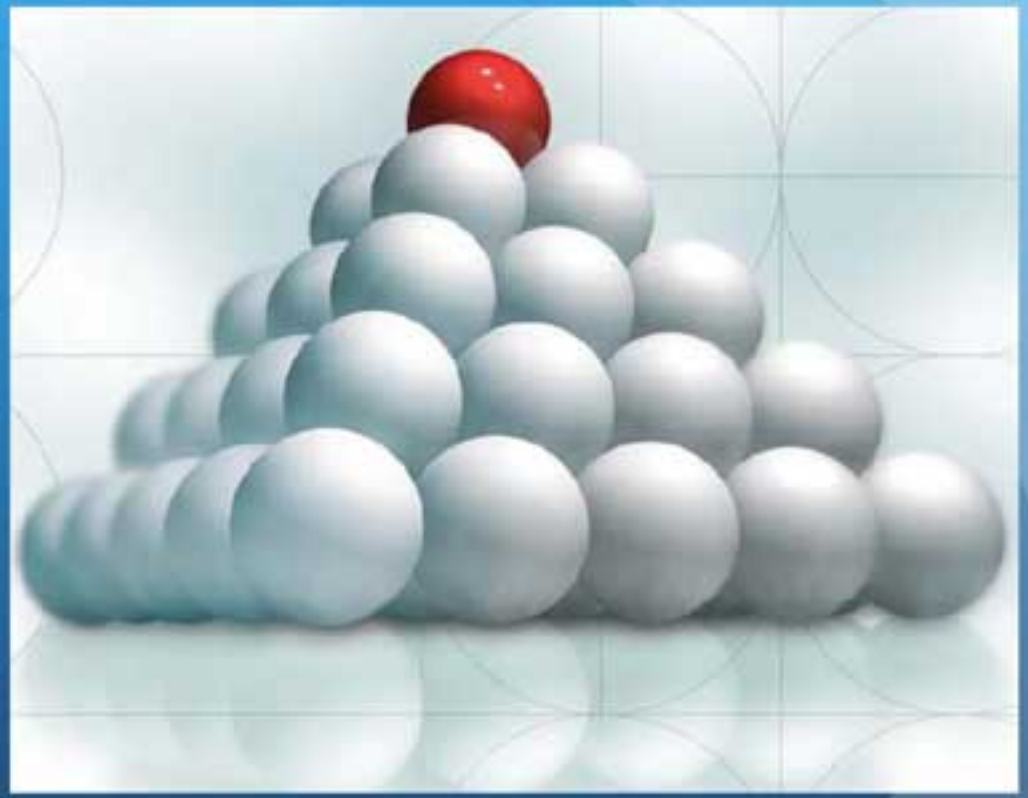
Most risk handling processes do not go beyond these steps

RISK GOVERNANCE FRAMEWORK

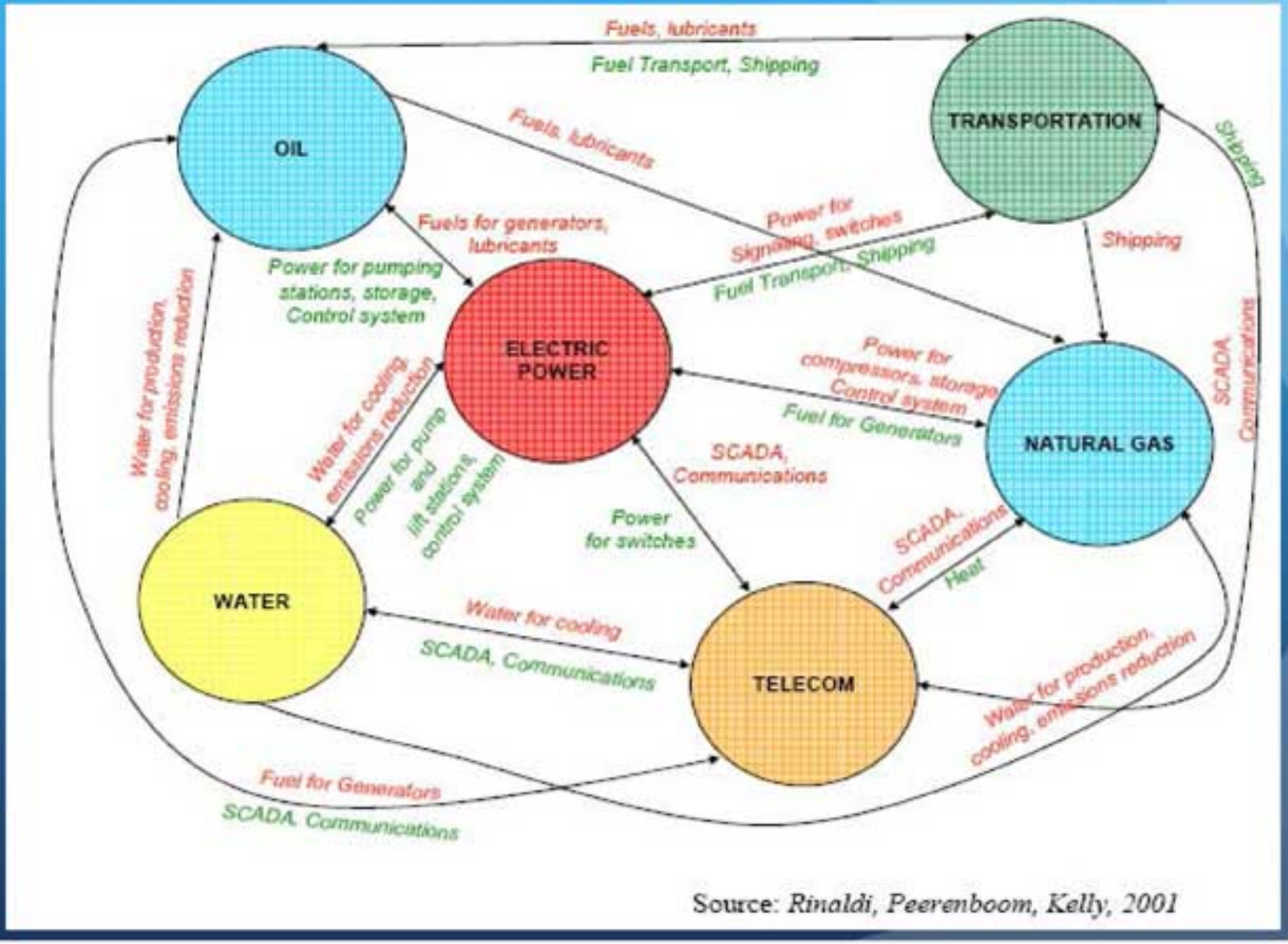


Evolution for Critical Infrastructures





Interdependencies



Source: *Rinaldi, Peerenboom, Kelly, 2001*

Assessment Matrix for the Five Selected Infrastructures

* *Natural hazards, construction work, etc.*

** *Potential of cascading trans-national effects*

Protecting coupled critical infrastructures: Understanding and governing complexity

Complexity

- **System complexity (Klir)** is proportional to the amount of information necessary to:
  - Describe the "vital" system
  - Resolve uncertainty associated with the system

- **Complexity** can be viewed as:
  - A function of the observer (internal)
  - A function of the system (external)

Klir, (1985), Architecture of Systems Problem Solving

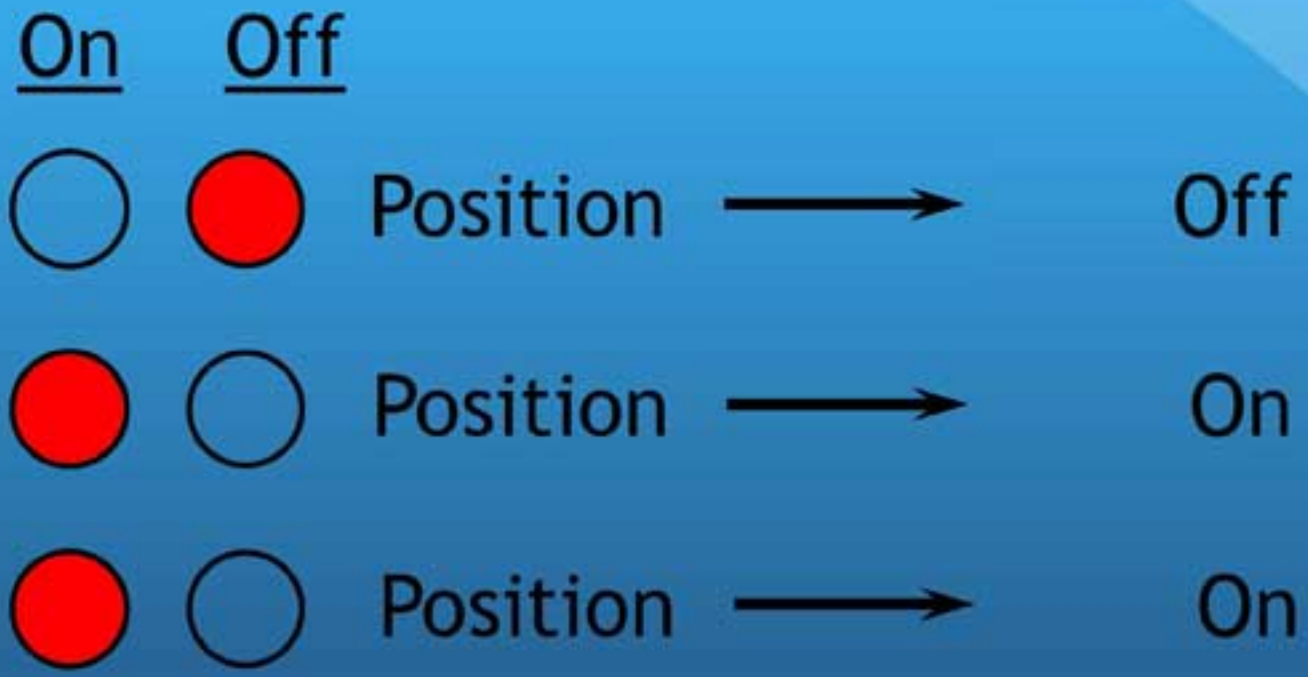
Complexity

- Variety is a mathematical measure of complexity for a non-trivial simple system

$$V = z^n$$

V : Variety
n : Number of elements
z : the number of possible states of each element

Calculating Complexity

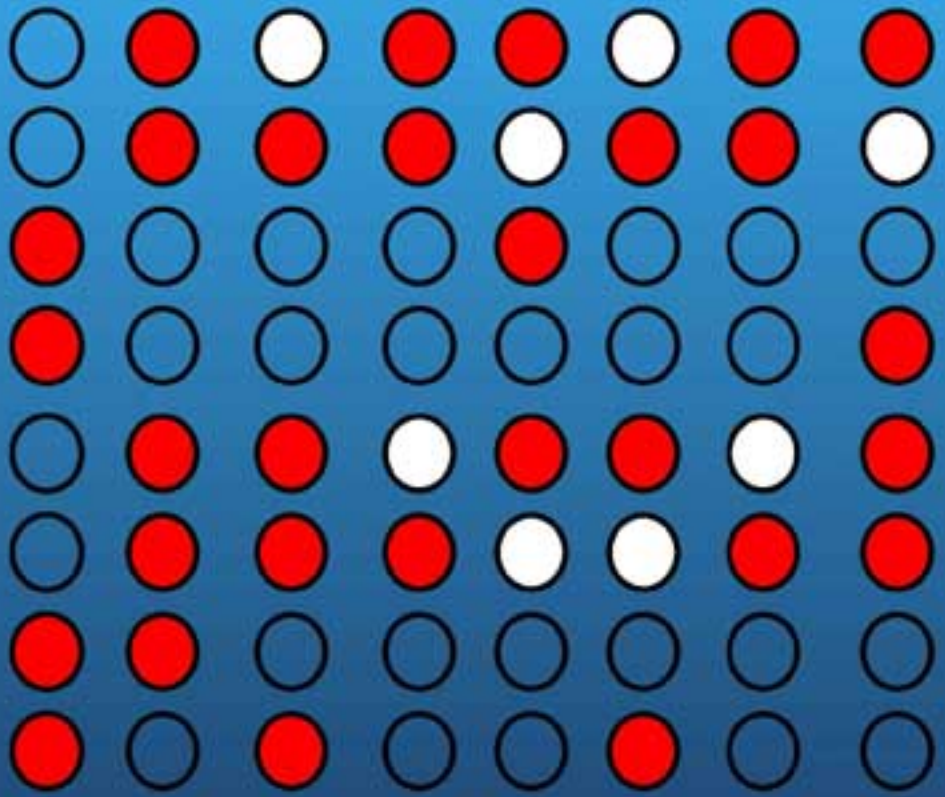


$n = 3$

$z = 2$

$$V = z^n = 2^3 = 8$$

Calculating Complexity



Calculating Complexity

$$V = z^n = 2^{64}$$

$V =$
18,446,744,073,710,000,000

$\approx$ 18.5 Quintillion