Identifying spatial regime shifts using Fisher information

Shana Sundstrom, Tarsha Eason, and Craig Allen

Introduction

Boundary detection in terrestrial systems tends to be data intensive, statistically challenging, and can require laborious ground-truthing. Remotely-sensed data is poor at distinguishing physically similar but floristically different vegetation. Boundary definitions can vary depending on user goals, and large and small-scale human landscape modifications further muddy an already challenging problem, as it is typically vegetation communities that define ecological boundaries (Omernik, 1987).

Our goal was to assess the utility of Fisher information (FI) in identifying spatial boundaries between U.S. ecoregions, using terrestrial animal community data. Animal communities are likely to respond more rapidly than plants to direct anthropogenic and climate change, so may be a better index of changing biotic and abiotic conditions.

Methods

Fisher information is an information theory approach that collapses the behavior of multiple variables into an index that tracks changes in dynamic order. Although there are well developed traditional regime shift indicators, such as variance, skewness, kurtosis, and critical slowing down (AR1), they can be problematic because they:

- Can have inconsistent and contradictory results
- Cope poorly with multivariate data, which better reflects system complexity
- Have high data requirements
- Require the *a priori* selection of the relevant system-defining variable

Even the Variance Index, developed to capture dominant variance trends in multivariate systems (Brock and Carpenter, 2006), can be difficult to interpret.

Fisher information addresses many of the above issues, and may be an alternative methodological choice when the system is complex and the defining variables are unknown or multiple.

Data consisted of the species abundance list for 30 Breeding Bird Survey (BBS) routes from 2007 (Sauer, 2014). The routes represent a transect sweeping east from the Southern Rocky Mountains across the Central Plains and then north into the Northern Lakes and Forest ecoregion of northern Minnesota. The routes passed through 4 distinct ecoregions, as defined by Omernik (1987).

Results

Fisher information was able to detect the spatial transition between the four ecoregions (Figure 2), whereas the traditional regime shift indicators were not (Figure 1).

The CV (Figure 3) for each regime and transition between regime indicates that community structure has the most variability between the Southern Rocky Mountain and Plains ecoregions, and between the Plains and Northern Lakes and Forest, whereas the differences between the two Plains communities are minor.

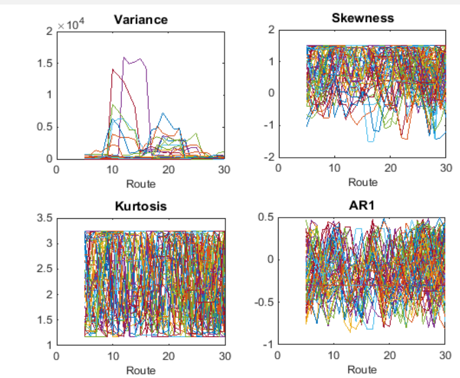

Figure 1 Traditional indicators applied to the BBS data. Each colored line represents a species at a particular BBS route noted on the x-axis. While there are distinct periods of increasing variance for some of the species, this pattern is not true in all cases. The snarl of non-interpretable lines highlights the inability of these methods to handle multivariate data.

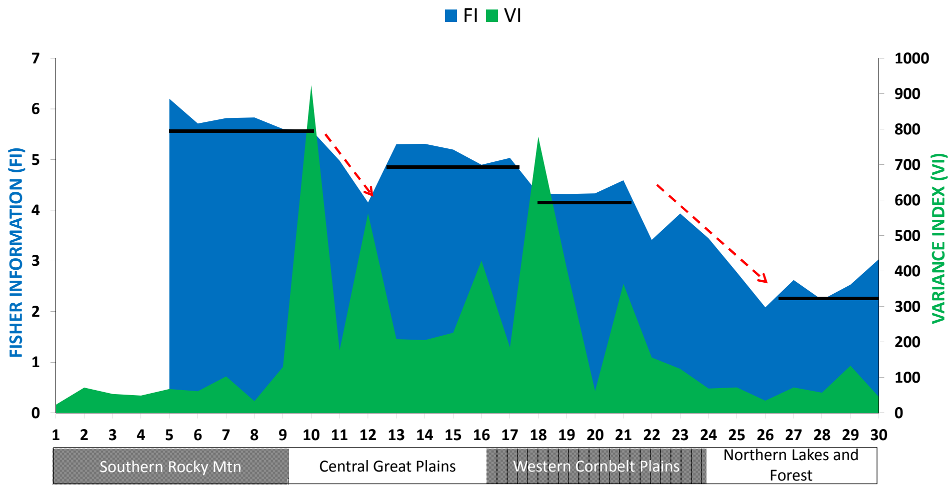

Figure 2 Spatial regimes, defined as having a ~ stable FI trend, are shown with a horizontal black line. Transitions between regimes, as defined by declining FI values, are shown with a red arrow. The FI regimes are largely coincident with the 4 ecoregions defined by the Omernik ecoregion maps (Southern Rocky Mtns, Central Great Plains, Western Cornbelt Plains, and Northern Lakes and Forest), but also suggest that there is some mismatch between the on-the-ground reality, and the maps. The spikes in the Variance Index tend to occur at the beginning and end of a regime shift but would be more difficult to interpret as a solo indicator.

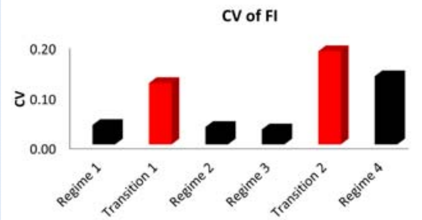

Figure 3 The coefficient of variation captures the high level of variability as community structure transitions from one ecoregion to the next. Regime 4, which is the Northern Lakes and Forest ecoregion, is inherently more variable than the other ecoregions as it is a mosaic of forest and wetland. FI captures these differences nicely.

Conclusion

Fisher information was able to clearly identify spatial regimes and transitions between regimes with a paucity of animal community data. This has promise as both a boundary detection method, and a way to track and provide early warning signals of shifts in animal communities, as is expected to occur as a result of climate change or other anthropogenic disturbances. Although the Variance Index supported the FI results, it would be difficult to interpret by itself, as it does not reveal whether there is a stable regime between two peaks, or is merely capturing a transition. The traditional indicators are generally not very useful when assessing complex, multivariate systems.

Finally, to the extent that animal community structure represents a spatial regime, our results indicate that ecoregion maps should be used with caution, as they do not appear to reflect ecological reality.

Acknowledgments

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References Cited

Brock WA, Carpenter SR. 2006. Variance as a leading indicator of regime shift in ecosystem services. Ecology and Society 11.
Omernik JM. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118–25.
Sauer JR, Hines J, Fallon JE. 2014. USGS Patuxent Wildlife Research Center. North American Breeding Bird Survey, 1966-2012. http://www.pwrc.usgs.gov/bbs. Last accessed 01/01/2011.

Resilience in Social – Ecological Systems

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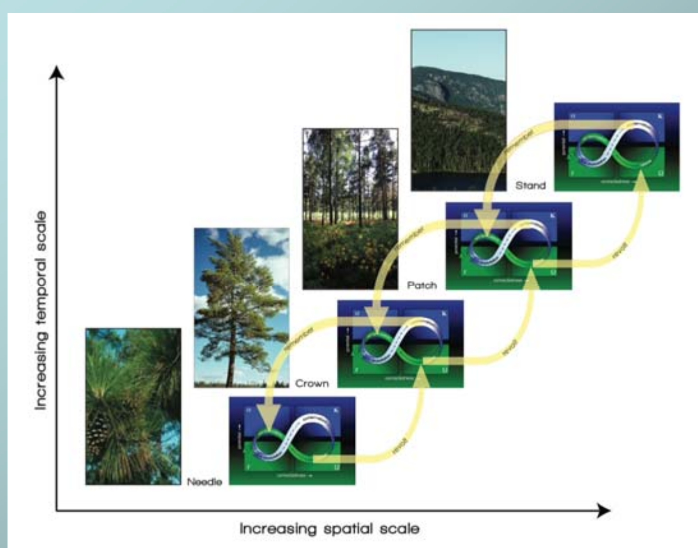
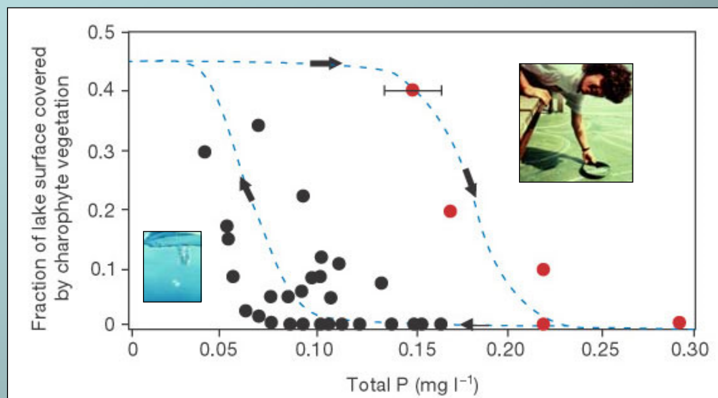


Hysterisis in complex systems can make undesirable states difficult to manage into a desirable state.

Hysterisis: When the Path Out is not the same as the Path In



Resilience

A measure of the amount of “disturbance” needed to “flip” an ecosystem from one stable state to a different stable state

Hard Coral ↔ Algae

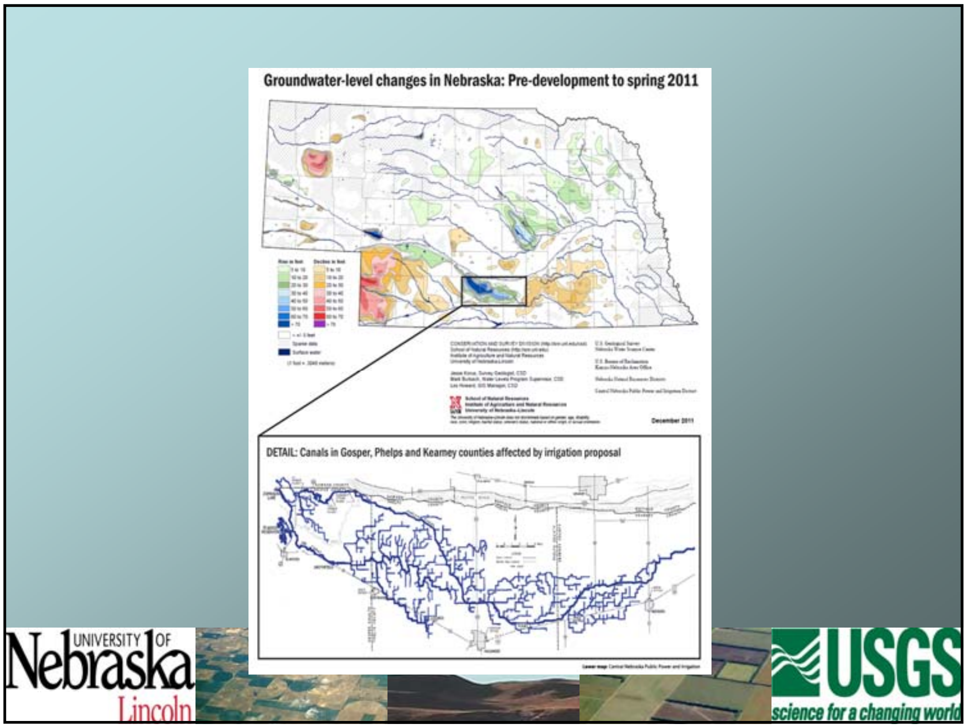
Resilience, Social-ecological Systems

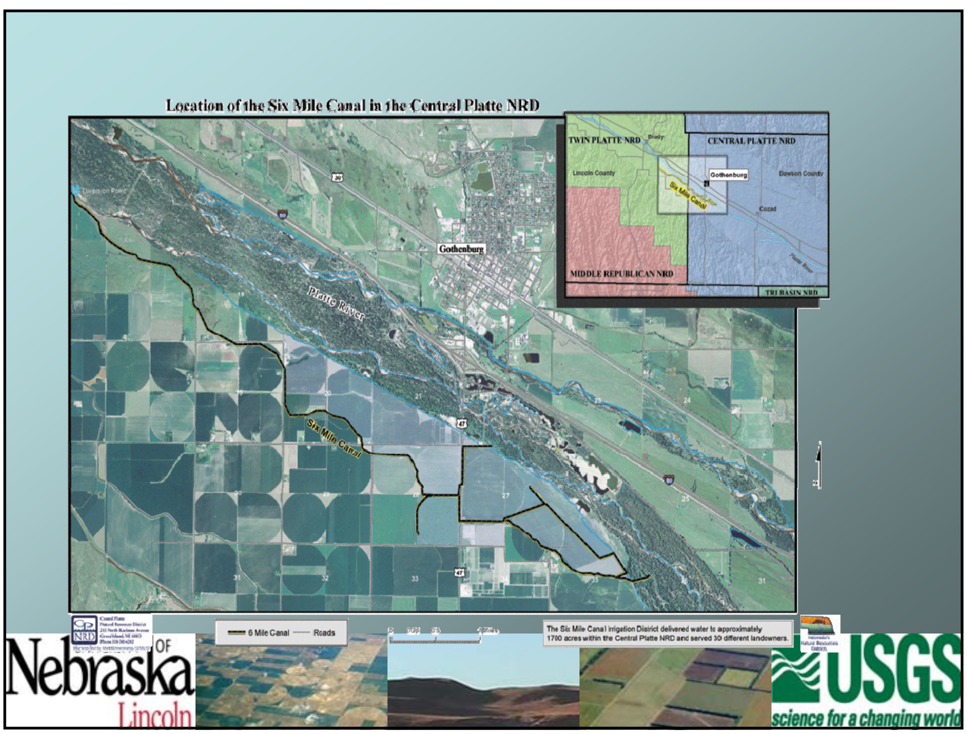
Humans are intricately linked with ecosystems
and
Ecosystems are heavily influenced by humans

Resilience

It is in humanities best interest to maintain systems and enhance their resilience (when in desirable states)

Platte River Historically


Groundwater-level changes in Nebraska: Pre-development to spring 2011
December 2011
DETAIL: Canals in Gosper, Phelps and Kearney counties affected by irrigation proposal
UNIVERSITY OF
Nebraska
Lincoln
USGS
science for a changing world


Location of the Six Mile Canal in the Central Platte NRD
TWIN PLATTE NRD
CENTRAL PLATTE NRD
Lincoln County
Gothenburg
Dawson County
Cozad
MIDDLE REPUBLICAN NRD
TRI BASIN NRD
Gothenburg
Platte River
Six Mile Canal
6 Mile Canal
Roads
The Six Mile Canal irrigation District delivered water to approximately 1700 acres within the Central Platte NRD and served 30 different landowners.
UNIVERSITY OF
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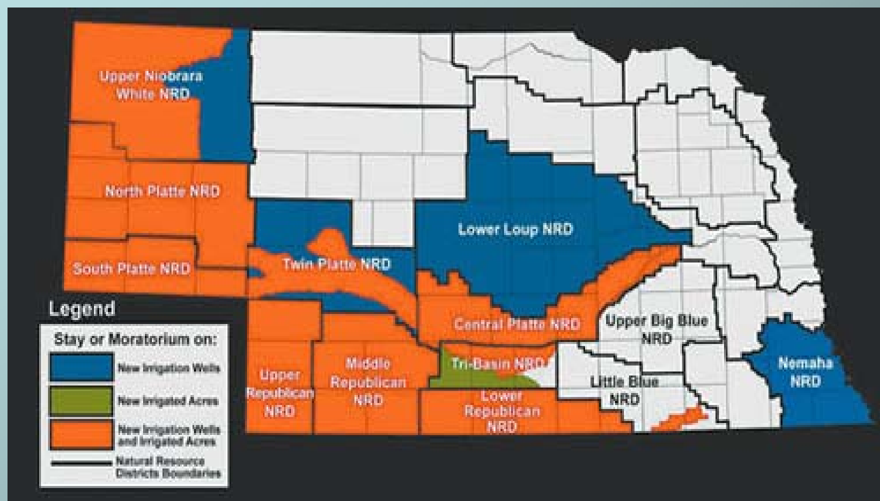
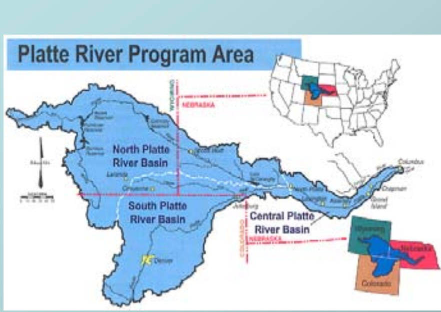
science for a changing world



Platte River Today

Platte River Today



Hysterisis – What’s it mean for management?

Social Resilience

Social disruption can override the best engineering (e.g., Syria)

Undesirable ecological states can also have large effects built environments (e.g., Hurricane Katrina)

Useful to explicitly assess tradeoffs among axes of resilience

Transformations possible, human induced regime change from less desirable to more desirable states.

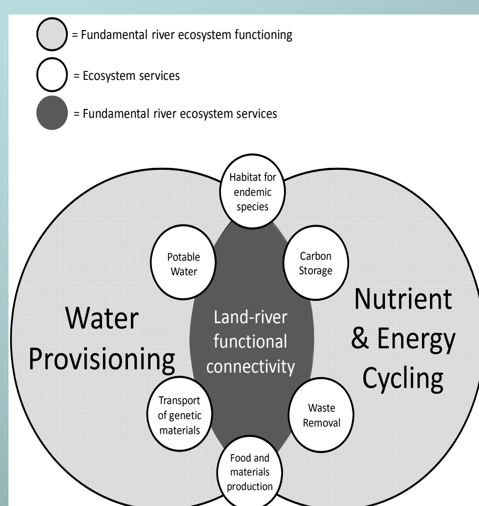
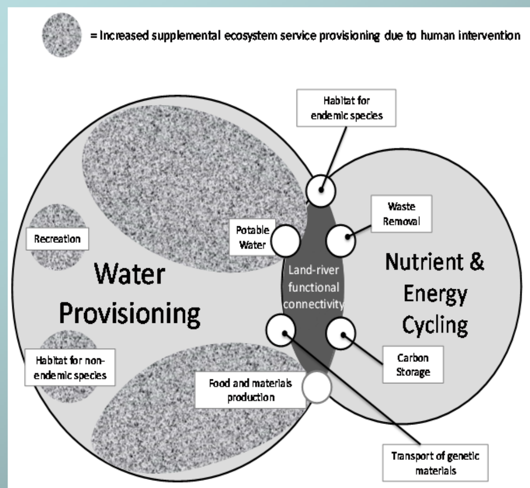


Figure 2.a A conceptualization of ecosystem services generation from the pre-European settlement Platte River system. Nutrient and energy cycling and water provisioning are fundamental system features that form the functional basis of a river ecosystem. The pre-European Platte River provided the fundamental ecosystem services of carbon storage, waste removal, food and material generation, gene flow for aquatic populations, increasing genetic diversity among, and potable water for drinking, washing and cooking, and key habitat for native species.



igure 2.b A conceptualization of ecosystem services generation from the post-European settlement Platte River system. This conceptual figure reflect how water provisioning (through dams, diversions and reservoirs) is augmented to meet supplemental ecosystem services of industrial, municipal and agricultural water needs.

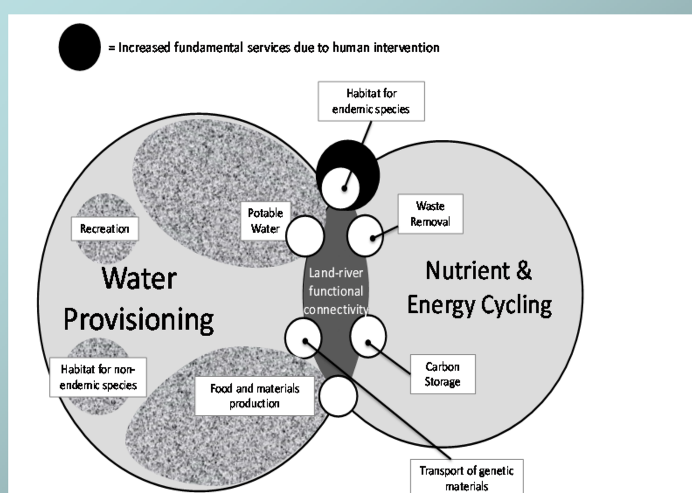


Figure 2.c The introduction of the Endangered Species Act (ESA), National Environmental Protection Act (NEPA) and Platte River Recovery Program (PRRIP) lessened the appropriation of water, increased land-river connectivity and fundamental ecosystem services, and funded the direct creation of sandbar habitat, represented by the black space.

Nemec, K. T., J. Chan, C. Hoffman, T. L. Spanbauer, J. A. Hamm, C. R. Allen, T. Hefley, D. Pan, and P. Shrestha. 2013. Assessing resilience in stressed watersheds. *Ecology and Society* 19(1): 34. http://dx.doi.org/10.5751/ES-06156-190134

E&S

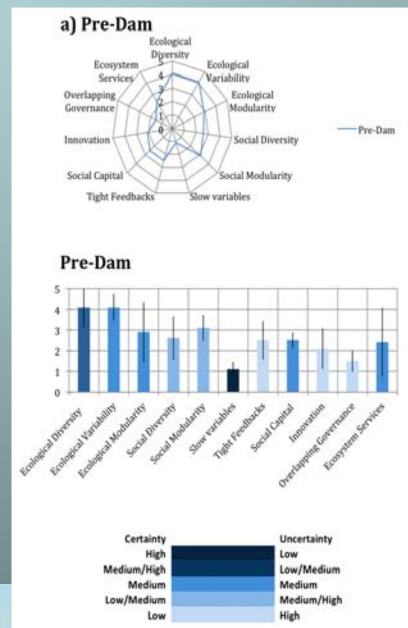
Research

Assessing Resilience in Stressed Watersheds

Kristine T. Nemec[1], Joana Chan[2], Christina Hoffman[2], Trisha L. Spanbauer[1], Joseph A. Hamm[4], Craig R. Allen[5], Trevor Hefley[2,6], Donald Pan[7] and Prabhakar Shrestha[2]

ABSTRACT. Although several frameworks for assessing the resilience of social-ecological systems (SESs) have been developed, some practitioners may not have sufficient time and information to conduct extensive resilience assessments. We have presented a simplified approach to resilience assessment that reviews the scientific, historical, and social literature to rate the resilience of an SES with respect to nine resilience properties: ecological variability, diversity, modularity, acknowledgement of slow variables, tight feedbacks, social capital, innovation, overlap in governance, and ecosystem services. We evaluated the effects of two large-scale projects, the construction of a major dam and the implementation of an ecosystem recovery program, on the resilience of the central Platte River SES (Nebraska, United States). We used this case study to identify the strengths and weaknesses of applying a simplified approach to resilience assessment. Although social resilience has increased steadily since the predam period for the central Platte River SES, ecological resilience was greatly reduced in the postdam period as compared to the predam and ecosystem recovery program time periods.

Key Words: *ecological resilience; Platte River; resilience assessment; social-ecological system; social resilience*



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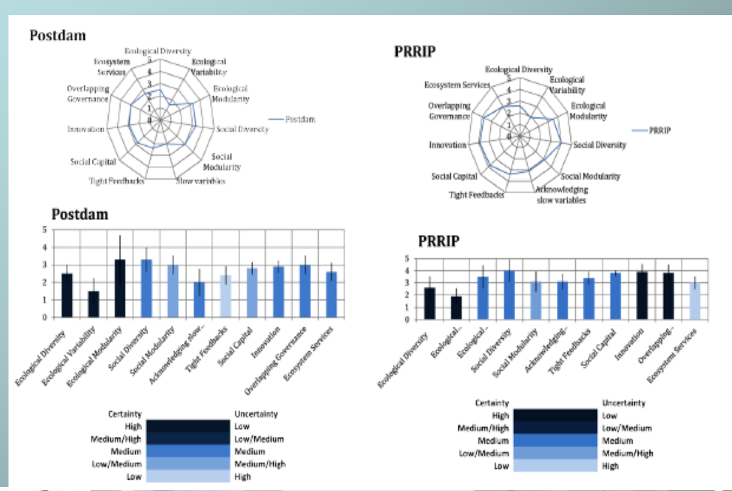
Climate Change Workshop 2007

USGS science for a changing world



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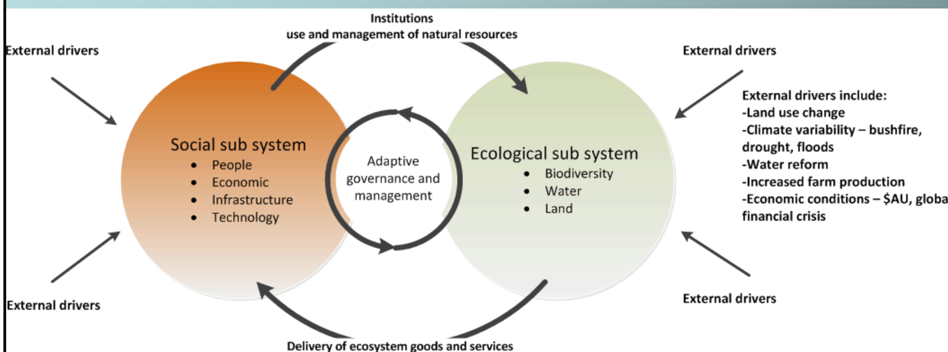
Social-ecological systems framework

With participation and empowerment at every level and in every sphere



Goulburn Broken Catchment Management Plan, Australia
http://www.gbcma.vic.gov.au

Transformation

- Transformability: *"The capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable"*

www.resalliance.org

Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social–ecological systems.

Climate Change Workshop 2007

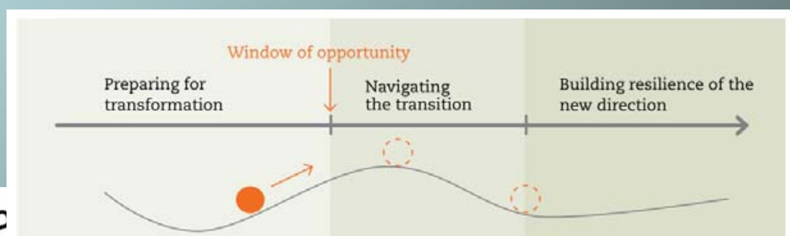
Transformability

- preparedness to change
  - getting beyond the state of denial

- options for change
  - new ‘trajectories’ - emerge from support for experiments, novelty, continual learning

- capacity to change
  - levels of capitals (including ‘social capital’), higher-scale support - **governance**

Capacity to make use of ‘windows of opportunity’



Folke et al. 2009 In: Principles of Ecosystem Stewardshi

Resilience-Based Approaches to Critical Infrastructure Safeguarding

Integration of Risk and Resilience into Policy

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RISK AND RESILIENCE INTEGRATION INTO POLICY






When politicians tell me we have to control and problems can not happen again…

I would like to answer politicians just as a researcher/scientist…

https://www.youtube.com/watch?v=9FDizB9Z3Eo

RISK AND RESILIENCE INTEGRATION INTO POLICY

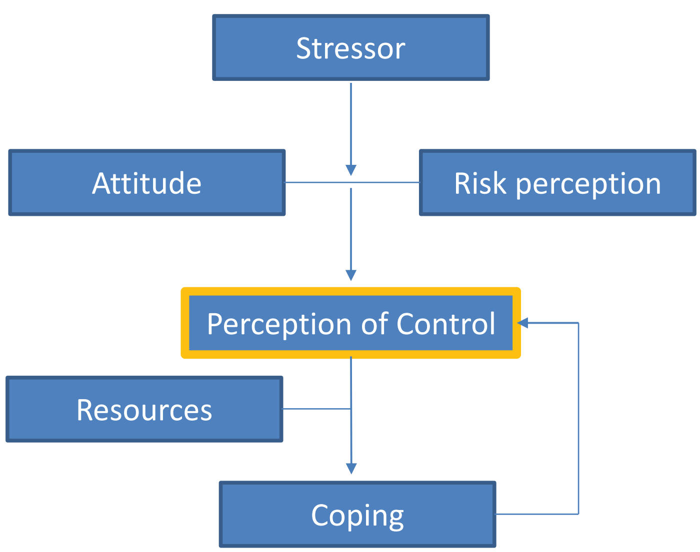
POLICY
1.Politics: (1) The basic **principles** by which a government is guided.
(2) The declared **objectives** that a government or party seeks to achieve and preserve in the interest of national community.
2.Insurance: The formal contract issued by an insurer that contains terms and conditions of the insurance cover and serves as its legal evidence.
3.Management: The set of basic principles and associated guidelines, formulated and enforced by the governing body of an organization, to direct and limit its actions in pursuit of long-term goals. See also corporate policy.

PUBLIC POLICY - Declared State **objectives** relating to the health, morals, and well being of the citizenry. In the interest of public policy, legislatures and courts seek to nullify any action, contract, or trust that goes counter to these objectives even if there is no statute that expressly declares it void.

WHAT GOES TO POLICY AND HOW???

RISK AND RESILIENCE INTEGRATION INTO POLICY

Well, in fact this is not an answer we or the politics want to provide to people. Principle of politics – PROMOTE PERCEPTION OF CONTROL



RISK AND RESILIENCE INTEGRATION INTO POLICY

RESILIENCE - CONCEPT ASSUMPTIONS

*Resilience is the **ability** of a system to absorb, respond, and adapt to events causing disruption*

- Outcome which can be present in higher or less degree
- Evolving
- Context specific

This means resilience can increase or decrease due either

- to changes on the system or
- to changes on the context.

RISK AND RESILIENCE INTEGRATION INTO POLICY

*Resilience is the ability of a system to **absorb, respond, and adapt to events causing disruption***

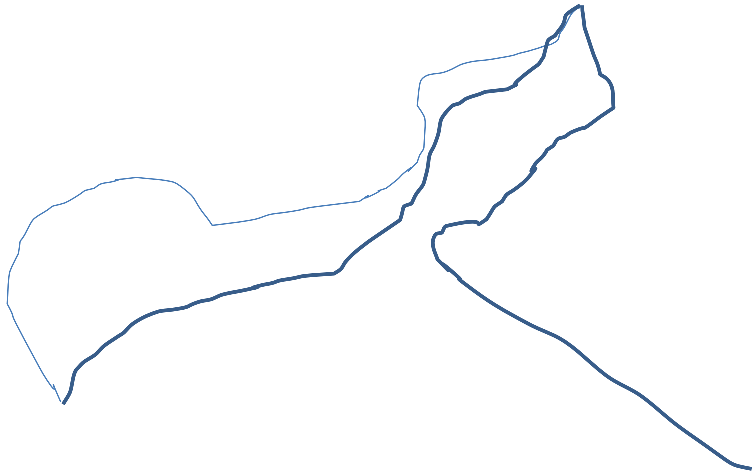
RESILIENCE – IMPLICATIONS OF CONCEPT ASSUMPTIONS

- Manage to prevent disruption (prevent loss of control)
- Manage to stop/minimize disruption/damage (stop losses)
- Manage to reestablish functions (reestablish control)

and in all previous cases you manage to **continuous improvement**, be better every time!

We can get there through different ways and policies. We already have some policies that promote resilience even if they do not state it directly

RISK AND RESILIENCE INTEGRATION INTO POLICY



We can get RESILIENCE through different ways.

We already have some policies that promote resilience even if they do not state it directly

RISK AND RESILIENCE INTEGRATION INTO POLICY

Managing for Sustainable Development

Risk Management

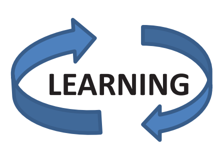
...

Crisis Management

Emergency Planning and Response

Business Continuity Management

...



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RISK AND RESILIENCE INTEGRATION INTO POLICY

RESILIENCE – WHAT IS NEW IN THE MORE RECENT YEARS…

- We do not know all risks
- We cannot foresee all scenarios
- UNCERTAINTY

Increases perception of risk

How to integrate this in policies and regulations?

- Planning for the unkown
  Plan for what we know and beyond!
- Even though we cannot foresee everything we can improve our abilities that allow us to respond to unforseen situations/events

Reestablishes perception of control

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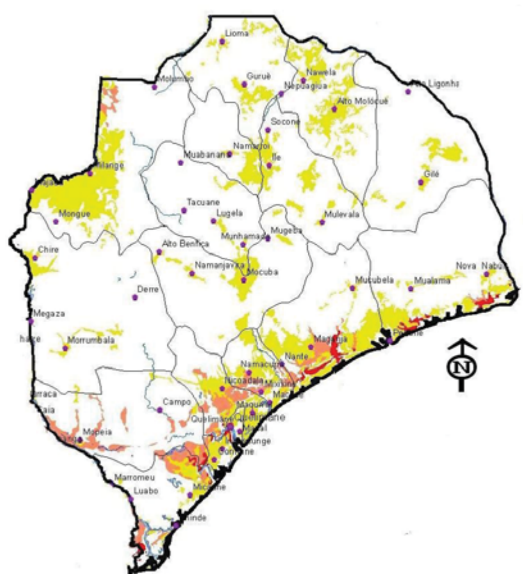
RISK AND RESILIENCE INTEGRATION INTO POLICY

We already started to develop policy for the unknown – preparing for the uknown…

- External Development Aid policies focus on building resilient societies.



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RISK AND RESILIENCE INTEGRATION INTO POLICY

- Example of Indonesia

'After the tsunami the aid community saw an opportunity to rebuild better based on unprecedented funding whereas Indonesians saw opportunities for institutional reconstruction and better governance.'

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RISK AND RESILIENCE INTEGRATION INTO POLICY

CHALLENGES TO POLICIES TO COME…

- Consider different types of systems
  - Individuals/organizations/communities/municipalities/countries…

- Allow to take systems' characteristics and development/maturity stage into account

- Integrate different perspectives:
  - Interdisciplinary (the better solution from social perspective may be very bad environmentally, the best environmental solution may be not economic viable…)
  - Governance, and local people desire (not only to make people happy but to make sure they keep up the efforts)

- …. (continues)

RISK AND RESILIENCE INTEGRATION INTO POLICY

CHALLENGES TO POLICIES TO COME…

- ….. (continuing)

- Aim for new, better state of equilibrium
  - Good vs bad resilience (when do the change happens? What is it required to happen? And what is the impact for policy?)
  - Take into account present and future needs of generations, and this may mean create new capacity

- Allowing decentralized response
  - Allowing context/systems specific response
  - Take the most of network for response (people knowing each other, relying less on communication systems)
  - Reduce response time

- …. (continues)

RISK AND RESILIENCE INTEGRATION INTO POLICY

CHALLENGES TO POLICIES TO COME…

- ….. (continuing)

- Consider the impacts over existing framework
  - What impacts on insurance?

- Accept uncertainty and develop ability/capacity/knowledge to respond to unexpected (education, culture, perception…)
  - Communication on risk/response
  - Be prone to, embrace, expect and enjoy change/uncertainty
  - Focus on coping, on the ability to respond to new situations, to bounce back
    - Good vs bad coping

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RESILIENCE ANALYTICS

A Data-Driven Approach for Enhanced Interdependent Network Resilience

Kash Barker, PhD
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University of Oklahoma

RISK-BASED SYSTEMS ANALYSIS LABORATORY

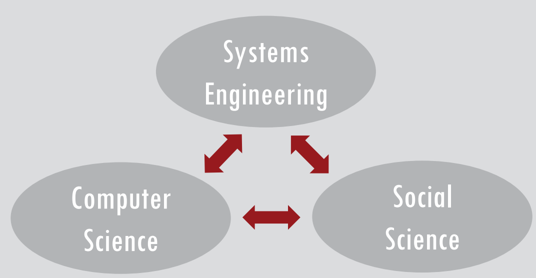
RESILIENCE ANALYTICS

RESILIENCE ANALYTICS

- A multi-disciplinary, multi-university project funded by the National Science Foundation

Resilience Analytics: A Data-Driven Approach for Enhanced Interdependent Network Resilience

Funded under awards 1541165 and 1541155 from the NSF division of Civil, Mechanical, and Manufacturing Innovation



RESILIENCE ANALYTICS

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Business Info Tech
Virginia Tech

Computer Science

Charles Nicholson
Industrial and Systems Engr
University of Oklahoma

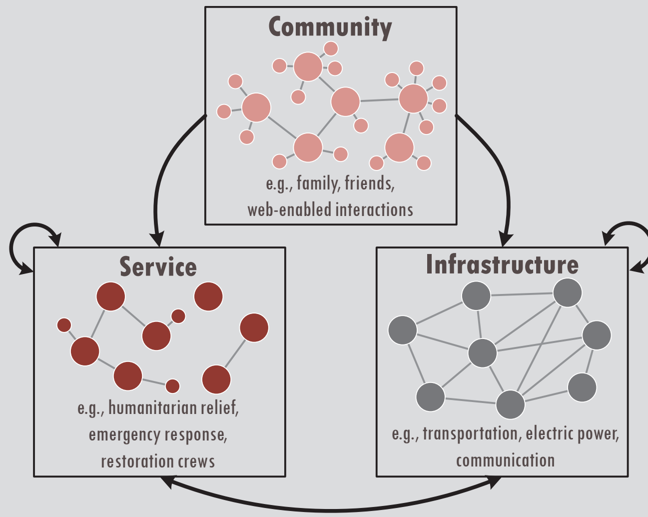
Cornelia Caragea
Computer Sci and Engr
University of North Texas

RESILIENCE ANALYTICS

- We define the term **resilience analytics** to be the systematic analysis of data that focuses on understanding, visualizing, designing, and managing interdependent infrastructures to enhance their resilience and the resilience of the communities and services that rely upon them [Barker et al. 2016]

RESILIENCE ANALYTICS

- We want to examine how community-sourced data can be dynamically integrated into priorities for interdependent cyber-physical-social networks to improve their resilience



The UNIVERSITY of OKLAHOMA
School of Industrial and Systems Engineering

RESILIENCE ANALYTICS

- Research Component 1: Modeling the Behavior of Interdependent Cyber-Physical-Social Networks
  - Develops a data-driven optimization framework that captures the key interdependencies of the three network types to understand interdependent resilience
  - Enables the study of how resources can be allocated and tradeoffs made to prepare for and respond to disruptions in interdependent infrastructure

The UNIVERSITY of OKLAHOMA
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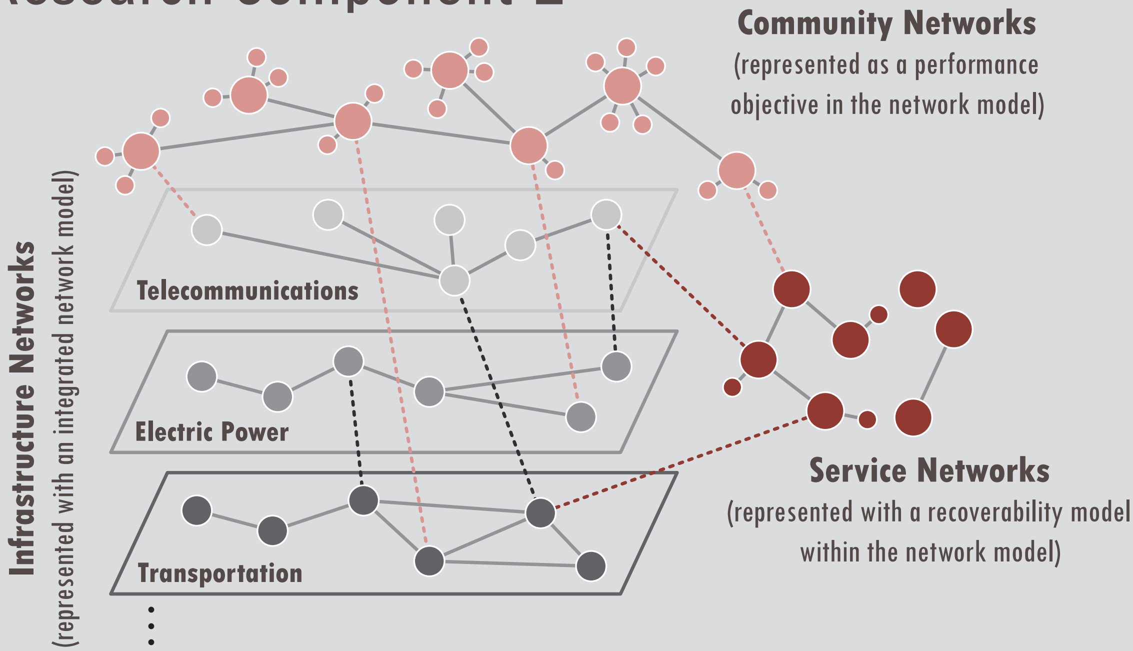
RESILIENCE ANALYTICS

- Research Component 1

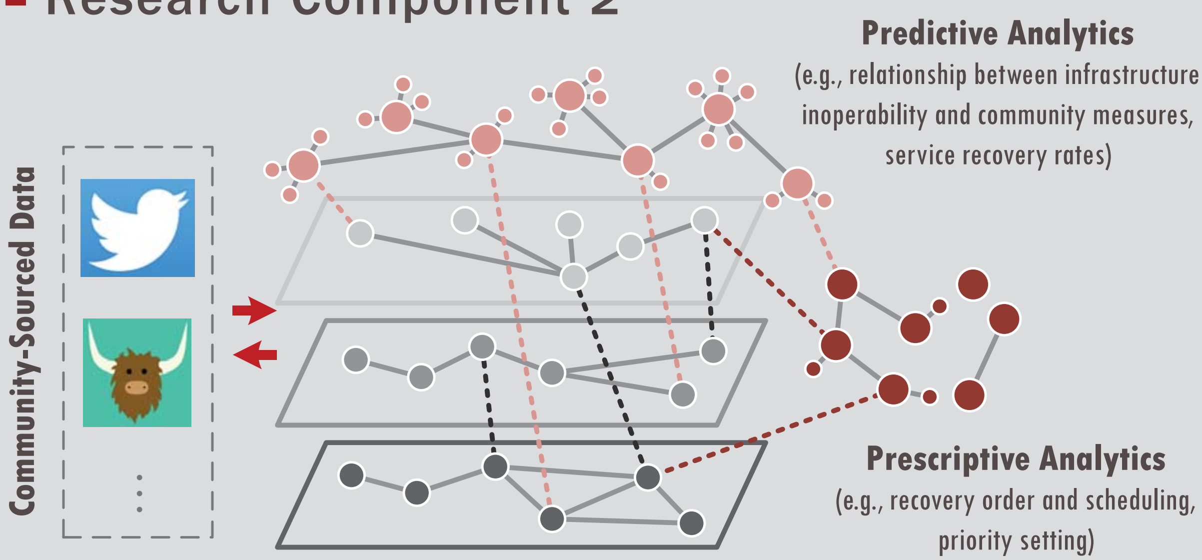


RESILIENCE ANALYTICS

- Research Component 2: Monitoring Community Networks for Cyber-Physical-Social Network Behavior
  - Develops a community-sourced analytics framework that integrates social media feeds, GIS data, and dynamic service network information
  - Drives descriptive, predictive, and prescriptive analytics to support improving the resilience of interdependent infrastructure networks, and ultimately, of community networks

RESILIENCE ANALYTICS

- Research Component 2



RESILIENCE ANALYTICS

- Several **applications** are on-going for different research elements
  - Hurricane Sandy Twitter analysis, social media trend comparison with electric power recovery
  - Predictive modeling of network vulnerability based on network characteristics, ultimately to use in recovery optimization
  - Port of Virginia USA analysis, intermodal transportation network planning, **among others**
- We're looking for **international collaborators** for further application areas!

END OF PRESENTATION

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RISK-BASED SYSTEMS ANALYSIS LABORATORY

RESILIENCE ANALYTICS

Protection of critical bridges and tunnels (SKRIBT^{Plus})

founded by: Federal Ministry of Education and Research

Reference to SKRIBT

The project is based on the results of the previous project “Protection of critical bridges and tunnels as part of roads” (SKRIBT) and takes up the newly identified questions during the past project course.

Situation and Motivation

Germany stands out due to a very high density of traffic. Tunnels and bridges are important components of the transport infrastructure but also liable to break down. In case of an incident there could be enormous feedback effects on the system.

Innovative protection technologies

Construction measures (innovative materials and structures).

Operationally measures (innovative detection technology and an improved event management).

In SKRIBT already developed structural, operational and organizational measures are further developed and optimized in its protective effect for combinations of various measures.

Operating and safety innovations are demonstrated at selected buildings.

Application aid for specific target groups

For building owners and operators:

- Automated evaluation for explosions during bridge construction phase
- Simplified statical design rules
- Methodology for owners for risk assessment/ for protection measures
- Method for evaluation of safety measures of buildings

For emergency services:

- Guide crisis-management

For users:

- Guidelines for improvement of user behavior

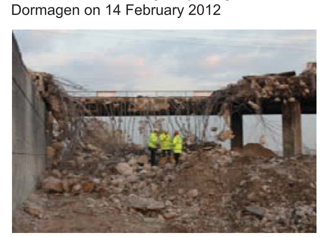
Fire protection

An emphasis in the project were investigations into the fire security of bridges and tunnels. Among others large scale fire tests confirmed previously developed numerical models.

Real Event

A possible safety relevant scenario, in addition to a variety of other scenarios, is a fire under a bridge. This can be triggered by an accident, by a targeted assassination or by a reckless action of individuals. A current example is the fire under a bridge in Dormagen on the BAB A57 on 14/02/2012. Supply plastic pipes were stored under the bridge and had been lighted with brand accelerators. The fire led to a huge smoke development which took the view completly away from the drivers causing a multiple collision with several persons injured and one dead. The fire caused such a huge damage to the bridge that it had to be demolished and replaced. The result was a two-month total closure of the highway with significant traffic disruptions on the alternative routes. The economic losses lie significantly above the costs of demolition and restoration of the bridge.

Fire incident on the highway bridge in Dormagen on 14 February 2012



Bridge demolition after the fire incident

Contact

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bast Federal Highway Research Institute · Federal Office of Civil Protection and Disaster Assistance · Fraunhofer EMI · HOCHTIEF SOLUTIONS AG · PTV GROUP the mind of movement · Schüßler-Plan · SIEMENS · RUB Ruhr-University Bochum · University of Stuttgart · Julius-Maximilians-Universität Würzburg

Resilience-Based Approaches to Critical Infrastructure Safeguarding
NATO Workshop
26-29 June 2016, Ponta Delgada, Azores, Potugal

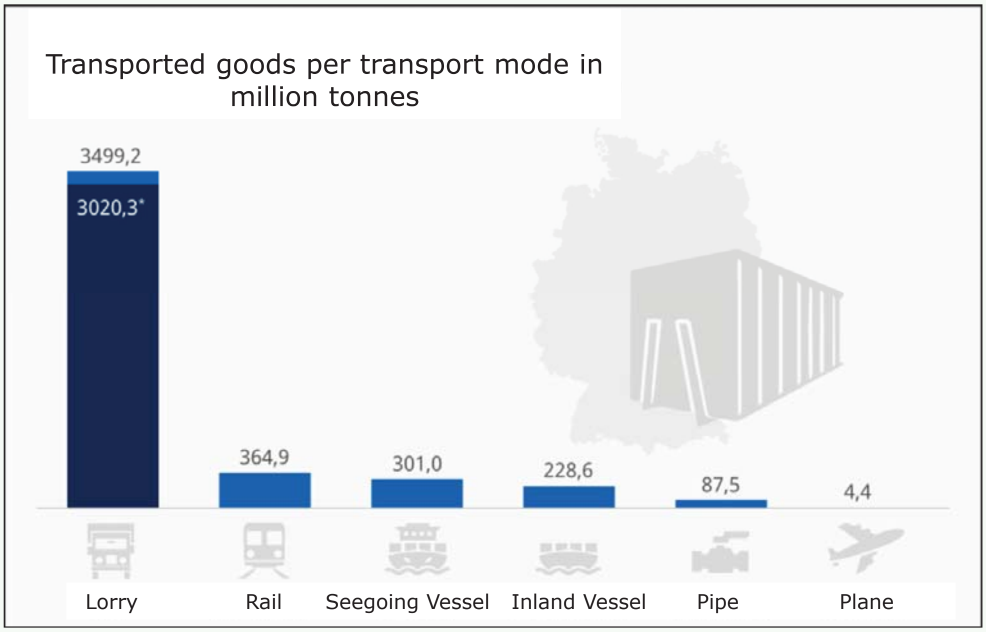
Quantifying Resilience

Ulrich Bergerhausen

Federal Highway Research Institute, Germany

Germany

Freight transport in Germany



German road net

Total road network in Germany: **644.288 km**

Main road network

- Highways: 12.600 km
- National roads: 40.400 km
- State roads: 86.600 km
- District roads: 91.600 km

Civil structures
(under federal government`s construction and maintenance obligation)

- Bridges: 39.000
- Tunnels: 250

Holistic Approach and Indicators

- **Construction**
  reconstruction costs
  out of service time

- **User**
  fatalities

- **Traffic**
  additional travel time
  contaminant loads (CO_2, NO_X)
  regional economy

Quantifying Resilience

Example: Scenario fire under a bridge

- Highway bridge: Part of A 57 near Dormagen between Cologne and Düsseldorf
- 2 lanes / direction
- underneath:
  industrial train und agricultural road
- „commuter highway" in NRW
- ca. 70.000 cars / day

Example: Scenario fire under a bridge

- Fire at a bridge near Dormagen in the night from 13.02. to 14.02.12

• Smoke moved upon the bridge
• Multiple collision
• Deconstruction of the bridge

• 15 injured, 1 dead person

Example: Scenario fire under a bridge

- Bridge demolition from 24.02 to 25.02.2012

• concrete break-up to small chips
• sandy concrete structure
• easy removal from reinforcement
• lack of bond

• low concrete strength
• 25 to 45% strength reduction of the steel

Quantifying Resilience

Example: Scenario fire under a bridge

- Commissioning of the temporary bridge on 07/04/2012 (less than 8 weeks after fire event)

Quantifying Resilience

Example: Scenario fire under a bridge

- Reconstruction 10 Mio €
  Temporary bridge
  New bridge

- Economic costs over 5 years for additional travelling time and contaminant loads (CO_2, NO_x)
  - Case A: 40 Mio €
    Speed reduction
    from 100 to 60 km/h
  - Case B: 90 Mio €
    capacity reduction of 30 %

Issues
in Critical Infrastructure Safeguarding
(military systems)

CHEVARDIN VLADYSLAV
PhD, Wireless security Leading Researcher.
Centre for Information and Communications Technology of
Military institute of telecommunications and information technologies.
Ministry of Defence of Ukraine

PLAN

1. Known facts intrusion into infrastructure of Ukraine.
2. Cybersecurity. Formal cybersecurity documents of Ukraine.
3. National cybersecurity system of Ukraine. The National systems of cybersecurity
4. Issues in critical infrastructure safeguarding (military systems).

KNOWN FACTS INTRUSION INTO INFRASTRUCTURE OF UKRAINE

May 2014
Hacking site of data-processing system of the Central Electoral Commission

May 2014
Hacking information system companies of Transport Infrastructure

August 2014
Hacking resources of government departments (BlackEnergy + 0-day)

October 2015
Hacking media resources different companies. Deleting video archives, blocking workplaces. (BlackEnergy)

December 2015
Hacking resources of power companies. blocking and violating working of automation systems of electrical stations. Disconnecting lot of people. (Blackenergy)

January 2016
Hacking attempt of Airport information system (BlackEnergy)

2014
NATO and Ukrainian media websites were hit with (DDoS)

2014
Spamming military subscribers through GSM networks

2014
Spamming military subscribers through social networks

2015
Ukrainian website Ministry of Defence were hit with (DDoS)

2015
Spamming military subscribers through GSM networks

2015
Spamming military subscribers through social networks

2016
Ukrainian website Ministry of Defence were hit with (DDoS)

CYBERSECURITY. FORMAL CYBERSECURITY DOCUMENTS

- Information security
- Application security
- Computer security
- Network security
- Disaster recovery
- End-user education

Cybersecurity sometimes associated with information technology security, focuses on protecting computers, networks, programs and data from unintended and unauthorized access, change or destruction.
But in generally, it is a set of conditions in which all the components of cyberspace are protected from all possible threats and unwanted consequences.

Law of Ukraine On Cyber Security of Ukraine *(draft)*

Strategy of National Security of Ukraine

Information Security Doctrine of Ukraine

Law of National security of Ukraine

Law of defense of Ukraine

CYBERSECURITY STRATEGY OF UKRAINE
Approved Decree of President of Ukraine on March 15, 2016 № 96/2016

...

DSTU ISO/IEC 27031:2015
Approved UkrMetTestStandard

DSTU ISO/IEC 27032:2015
Approved UkrMetTestStandard

DSTU ISO/IEC 27033-2:2015
Approved UkrMetTestStandard

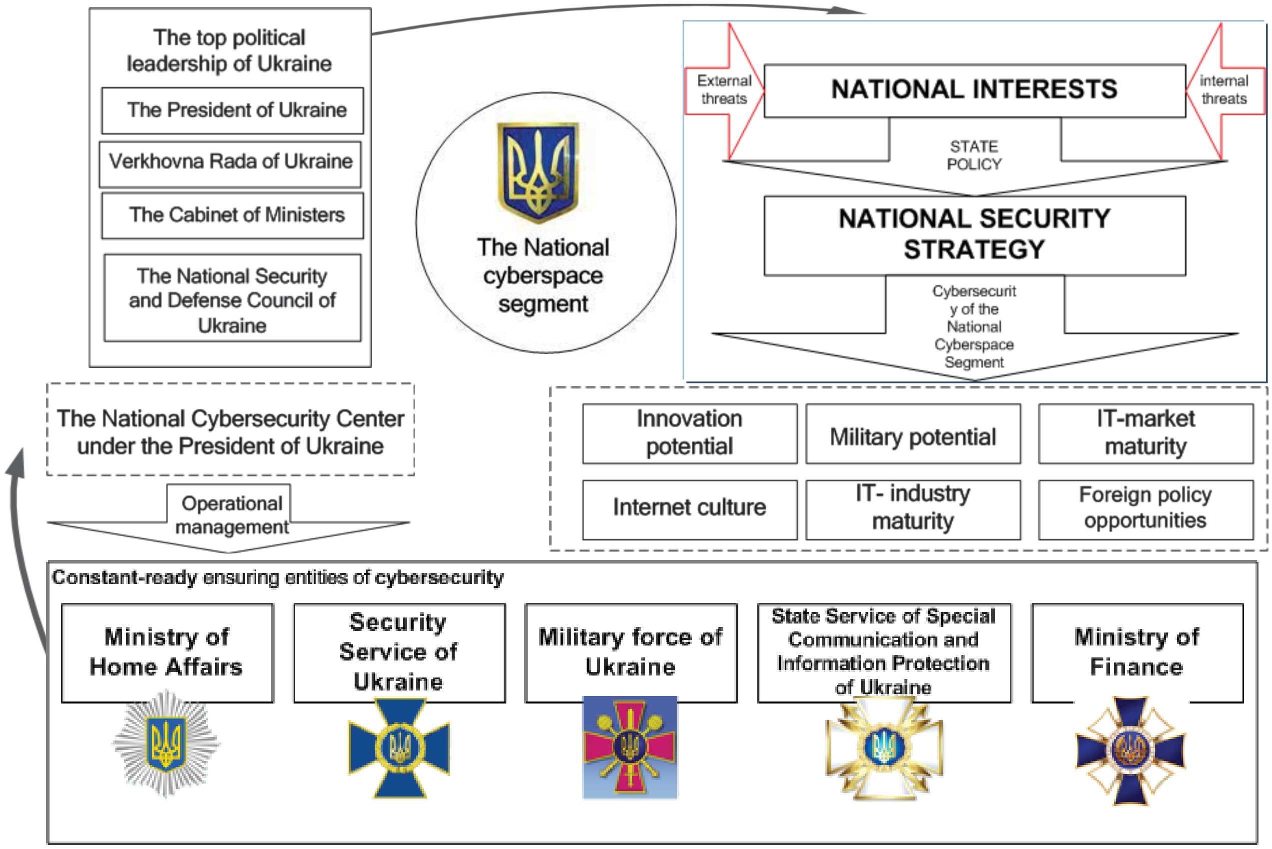
DSTU ISO/IEC 27033-3:2015
Approved UkrMetTestStandard

DSTU ISO/IEC 27033-4:2015
Approved UkrMetTestStandard

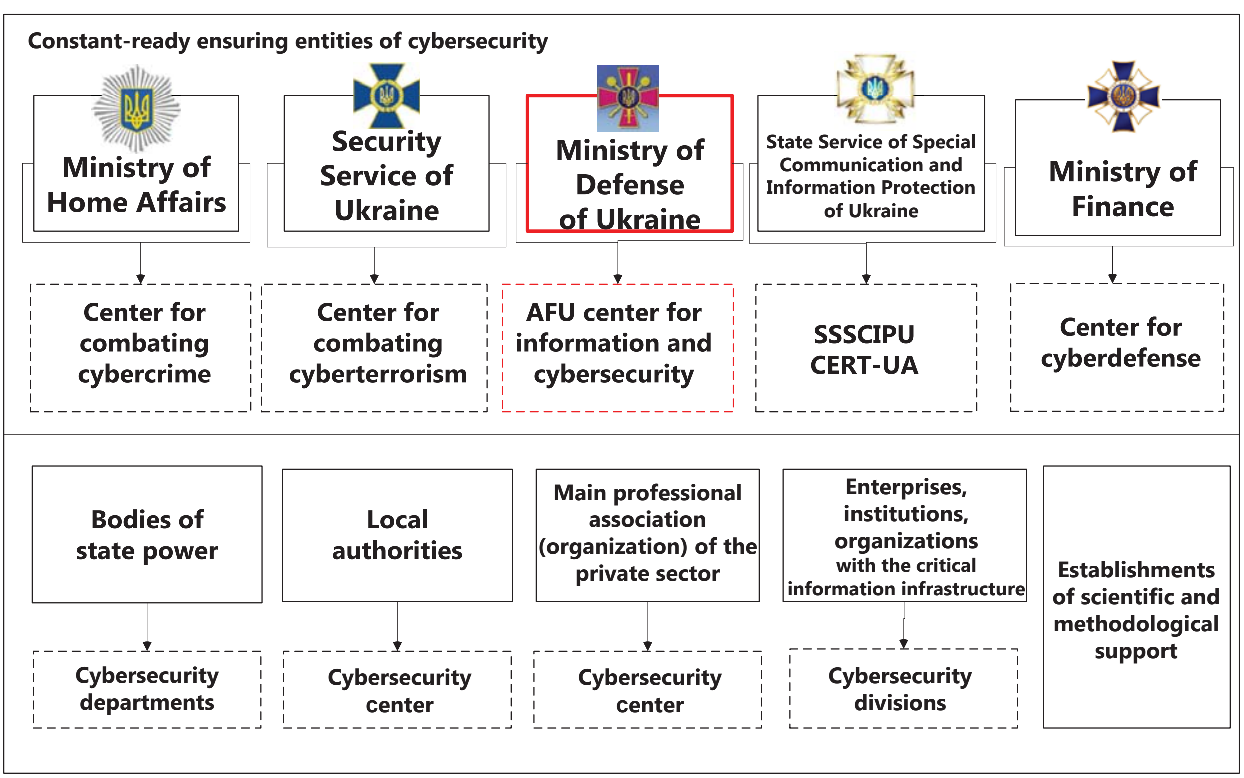
DSTU ISO/IEC 27033-5:2015
Approved UkrMetTestStandard

Development (from strategy)**:** cybersecurity units and cyber Armed Forces of Ukraine, State Special Communications Service of Ukraine, Security Service of Ukraine, cybersecurity and cyber defense in cooperation with states – members of NATO.

THE NATIONAL CYBERSECURITY SYSTEM



THE NATIONAL SYSTEMS OF CYBERSECURITY

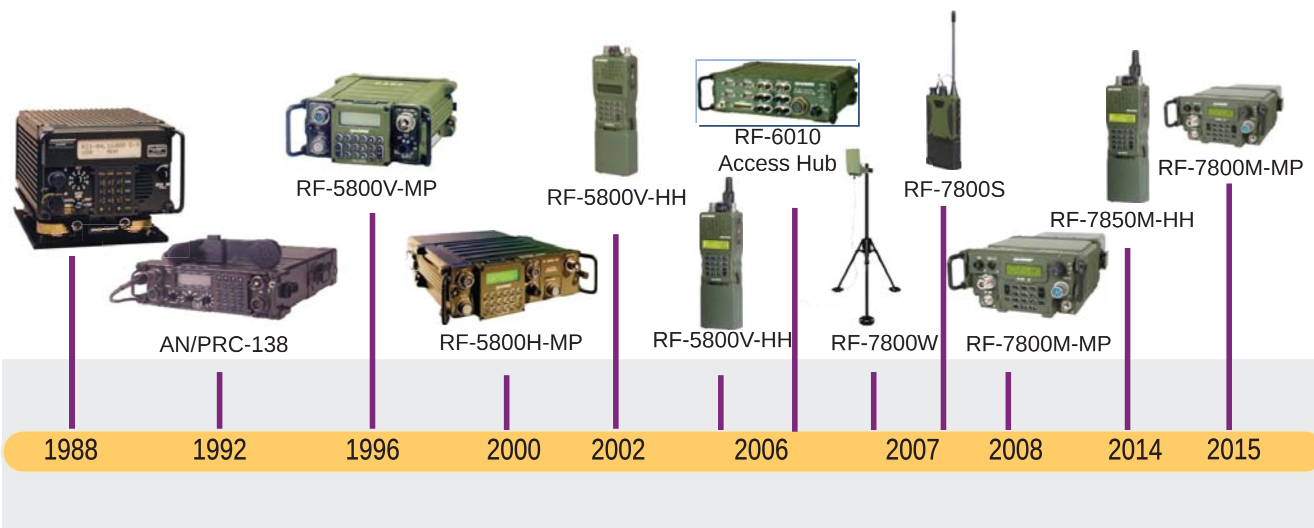


ISSUES IN CRITICAL INFRASTRUCTURE SAFEGUARDING

(military systems)

GLOBAL SOFTWARE-DEFINED RADIO HARRIS EVOLUTION

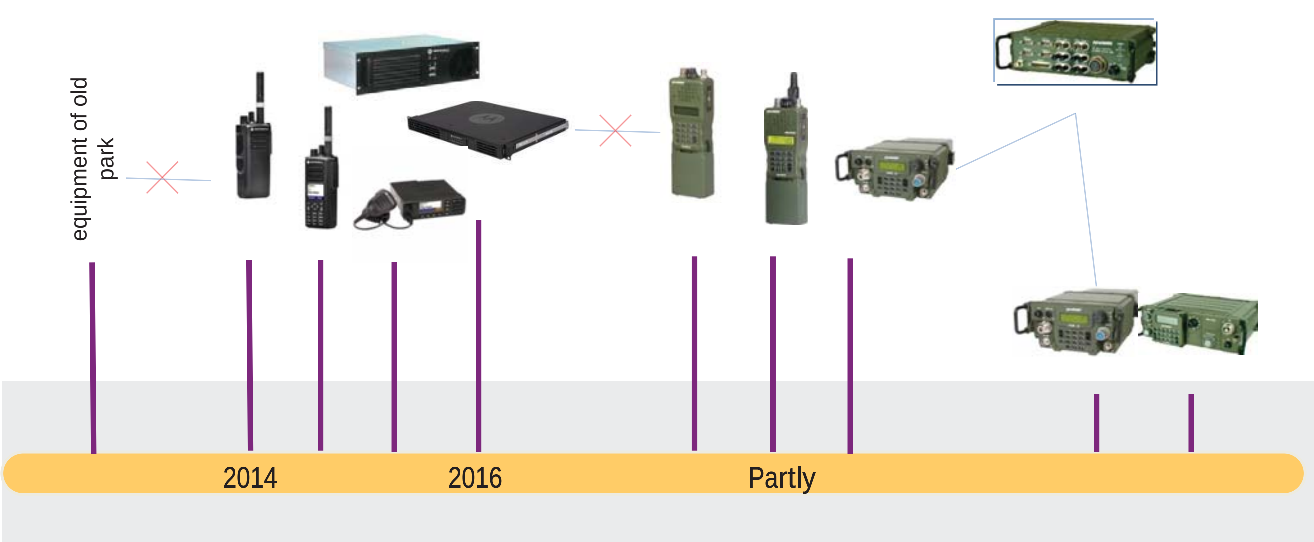
These Falcons Evolution of Harris solutions in US (in 20 years period).



ISSUES IN CRITICAL INFRASTRUCTURE SAFEGUARDING

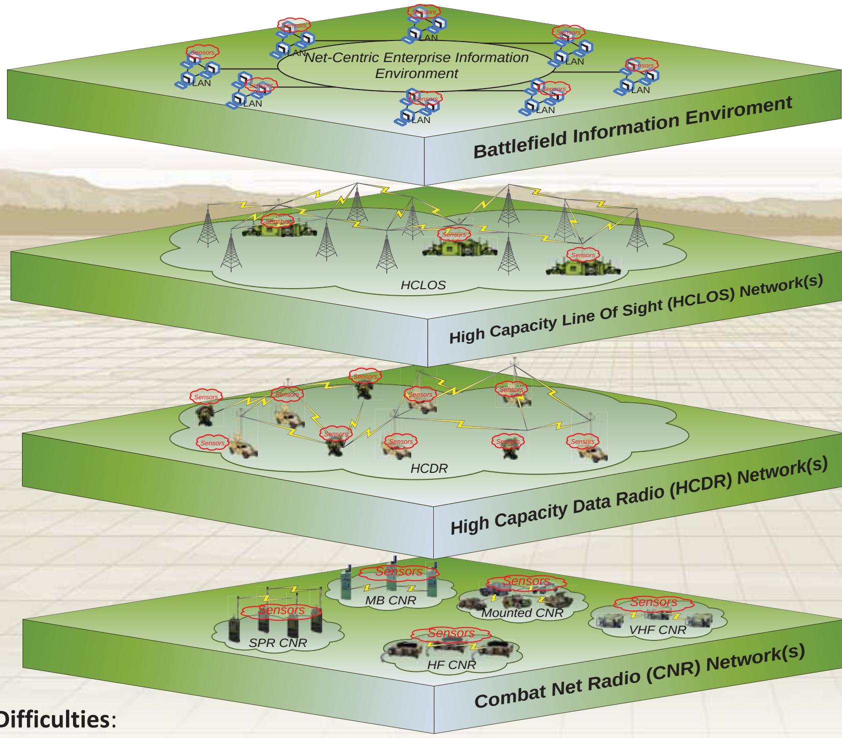
ISSUES IN TRANSPORT NETWORK BASE ON MOTOROLA AND OTHER ONES

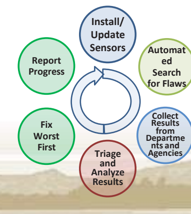
Unfortunately we didn't have so much time and enough financial support.



ISSUES IN CRITICAL INFRASTRUCTURE SAFEGUARDING

LAYERED COMMUNICATIONS





Necessity
- for efficient network monitoring we need analyze some signal parameters and some other parameters of radio network for define future strategy counteraction;
- we need have system of signaling and monitoring parameters information system base on any transport networks;
- information systems need have enough numbers of (active and passive) sensors on each level of system for detecting the changes of important system parameters.

Difficulties:
- program code for software radio stations is closed;
- equipment for modeling such systems is absent.

The participation in modern programs for building cooperative Cyber Security system in European part is our main direction of future development

Cyber Resilience Working Group *Outbrief*

Ponta Delgado, Azores

29 Jun 2016

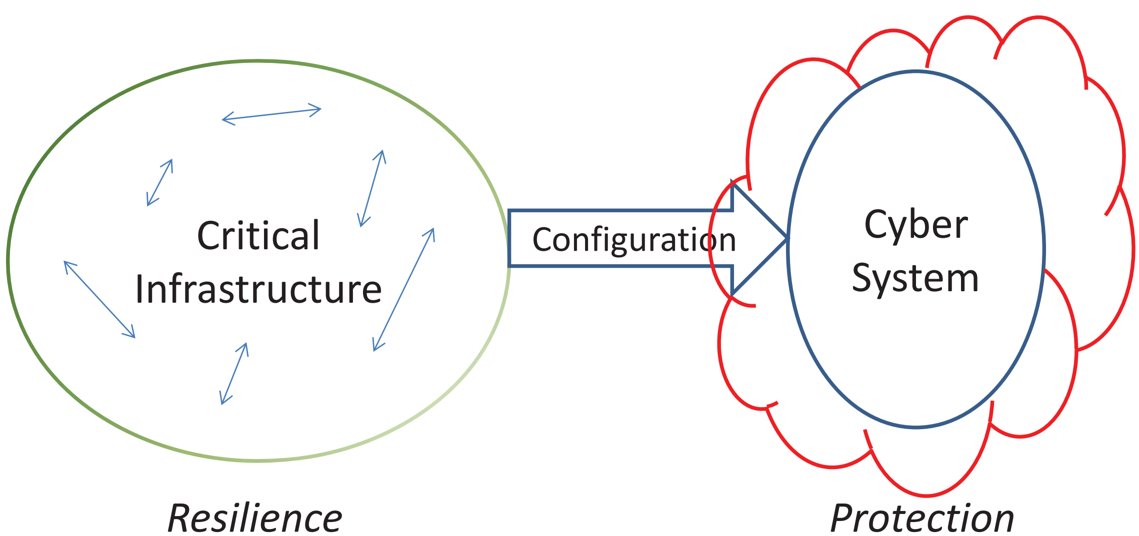
Team Members

- Dalila Antunes
- Vladislav Chevardin
- Paul Chouinard
- Zach Collier
- Marie-Valentine Florin
- Jim Lambert
- Angelo Marino
- Maria Nogal
- Paul Roege
- Bravislav Todorovic

Key Points

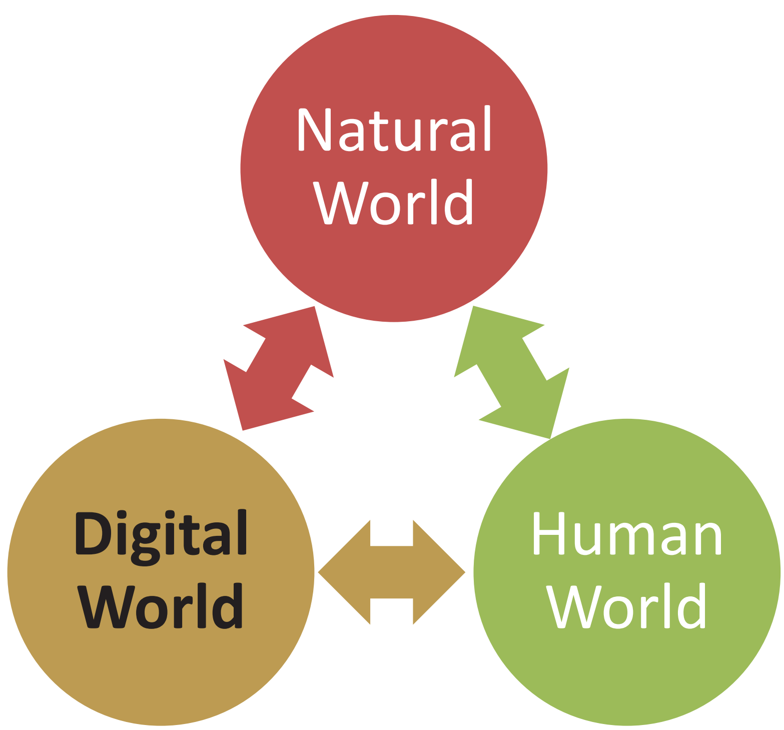
- Cyber security is treated separately and differently than essential function resilience
- Interdependencies and uncertainties suggest that cyber should be included within bounds of resilience analysis
- Conceptual models and analytical methods needed to allow integration of environmental, human and cyber worlds
- Need to identify touch points and provide information to right advocates

Current Model



Risk Management Hierarchy

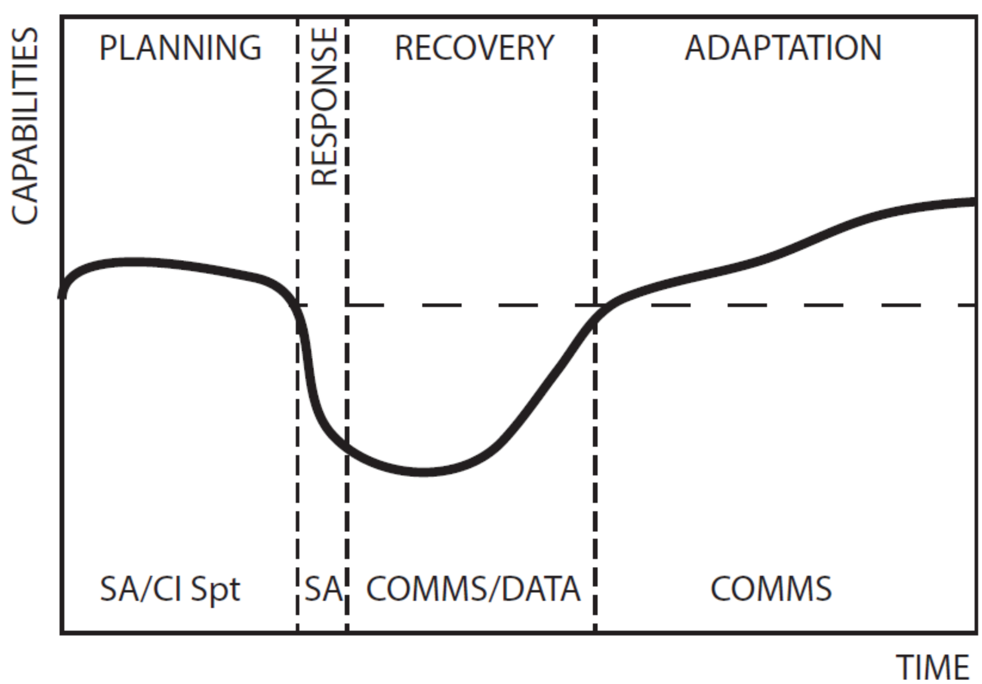
Interactive Reality



How should cyber functions interact with functional domains to support resilience?

- Surveillance/Monitoring/Alerting
- Threat/risk Assessment
- Situational Awareness
- Collective Decision Coordination
- Communication – Organizations
- Public Information
- Threat Isolation/containment
- Supply Chain/Resource Coordination
- Forensics/learning

Importance of Cyber Systems over Event Timeline

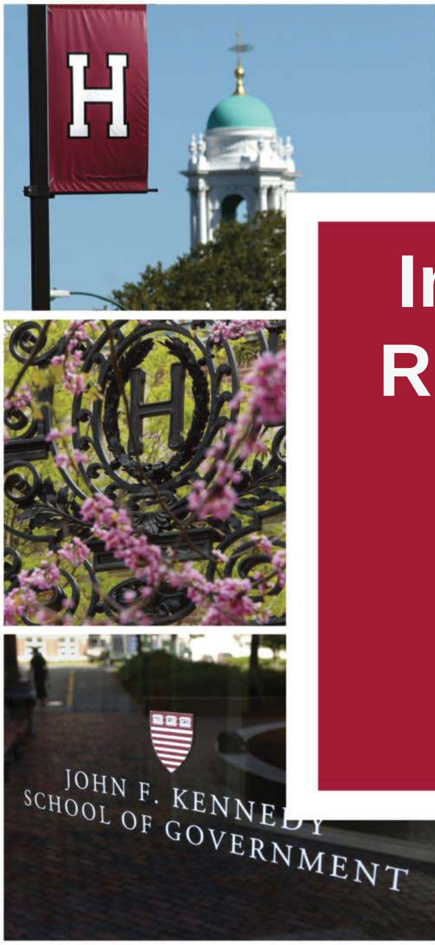


Draft Chapter Outline

1. Situation – cyber effectively separated from resilience conversation
2. Discussion
   - security is different from resilience
   - policies and literature tend propagate separation
3. Desired model & methods – allowing integration of digital world with human/physical world
4. Application examples, e.g.,
   - Manufacturing
   - Transportation
   - Military
5. Recommendations
   - Policies
   - Research
   - Development of standards, metrics, guidelines

Prospective Elective Chapters

- Conceptual methodology to represent cyber systems for integration into other domains – *Todorovic*
- Integrating Cyber & Transportation domains in modeling - *Nogal*
- Using operational/management views to support cyber & other domain analysis – *Chouinard/Roege*



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Integration of Risk & Resiliency into Policy

Neal Duckworth
Harvard University
Kennedy School of Government
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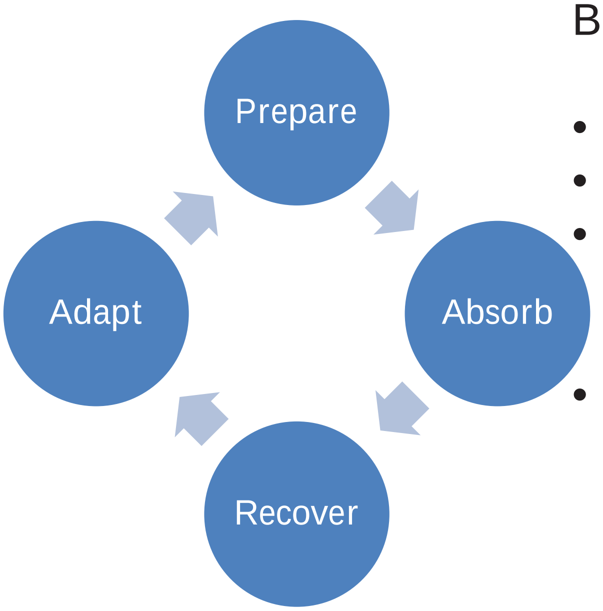
Why is Policy Important?



Building resilience is not free…

- No Policy = No Requirement
- No Requirement = No Funding
- No Funding = No/Reduced Resilience

- Funding is required for
  - Research
  - Planning
  - Exercises / Simulations
  - Building / Testing
  - More…

Definitions / Lexicon

- Words have meaning…
- Across organizations, and definitely across countries, we must strive to agree on common definitions of key terms and accepted processes
  - Resilience
  - Preparation
  - Prevention
  - Risk (Management, Assessment, Governance, etc.)

Approaches to Policy Development

- Integrate Risk & Resilience into any/all topic-related policies & strategies

- Create Own Policy

- Which is the best?

Instruments of Policy

- Organizational (agency, unit, etc.)
- National (policy, law, regulations, etc.)
- International (treaty, agreement, understanding, etc.)
  - A "strategy" can also be helpful in gaining support for resiliency

- Other…
  - Horizon 2020. EU research and innovation program with a designated "Security" area : "protect and improve the resilience of critical infrastructures, supply chains and transport modes;"

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Challenges

- There must be a political desire (or economic desire) to establish new policy.
- Do we need a new policy, or is there existing policy that is not being enforced?
- We need to connect scientists, academics and subject matter experts to policy makers/ decision-maker.
  - Writing for other academics and scientists creates good reference material, but is likely slow to produce change.
  - Write for policy makers / decision-makers sometime. Focus outcomes on recruiting non-scientists to your cause.
  - Seek media attention to speak about an academic paper.

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Challenges

- How do we clearly demonstrate/articulate that investment in resilience is a worthwhile investment and able to compete with more tangible and timely expenditure?
  – Sell the need with a combination of case studies and research
  – Understand the economic cost of building resilience and address

Recommendations for the Way Forward

- “Market” your research to non-researchers
  – Use of media
  – Social Media
  – Professional / Practitioner journals
- Ensure you are Integrated into the public / private sector
- Take advantage of crises to highlight policy gaps

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Case Study: Policy Development

Changing Behavior: Countering the Foreign Intelligence Threat

- Types of Policy Development
  - New Policies (Presidential Policy; Intelligence Community; other government agencies)
  - Changes to Existing Policies
- Ensure Policy Implementation—There were existing policies that were not being enforced (one was from 1992…)
- Insert key quotes/topics into Leadership Speeches/Testimony
- Work with Press Officer to impact Media articles & press-releases
- Present briefings at non-intelligence conferences
- Provide updates on websites
- Conduct meetings with key leaders/stakeholders

Changing Behavior: Countering the Foreign Intelligence Threat

Outcome:

- 5x new policies
- Adherence to requirements in existing policies
- Multiple mentions in the media from speeches/testimony
- Creation of a new “Center”
- Justification for budget increases
- Requirement to provide periodic reports to decision-makers
- Requirement for subordinate agencies to incorporate methodology and reporting into normal duties

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Questions?

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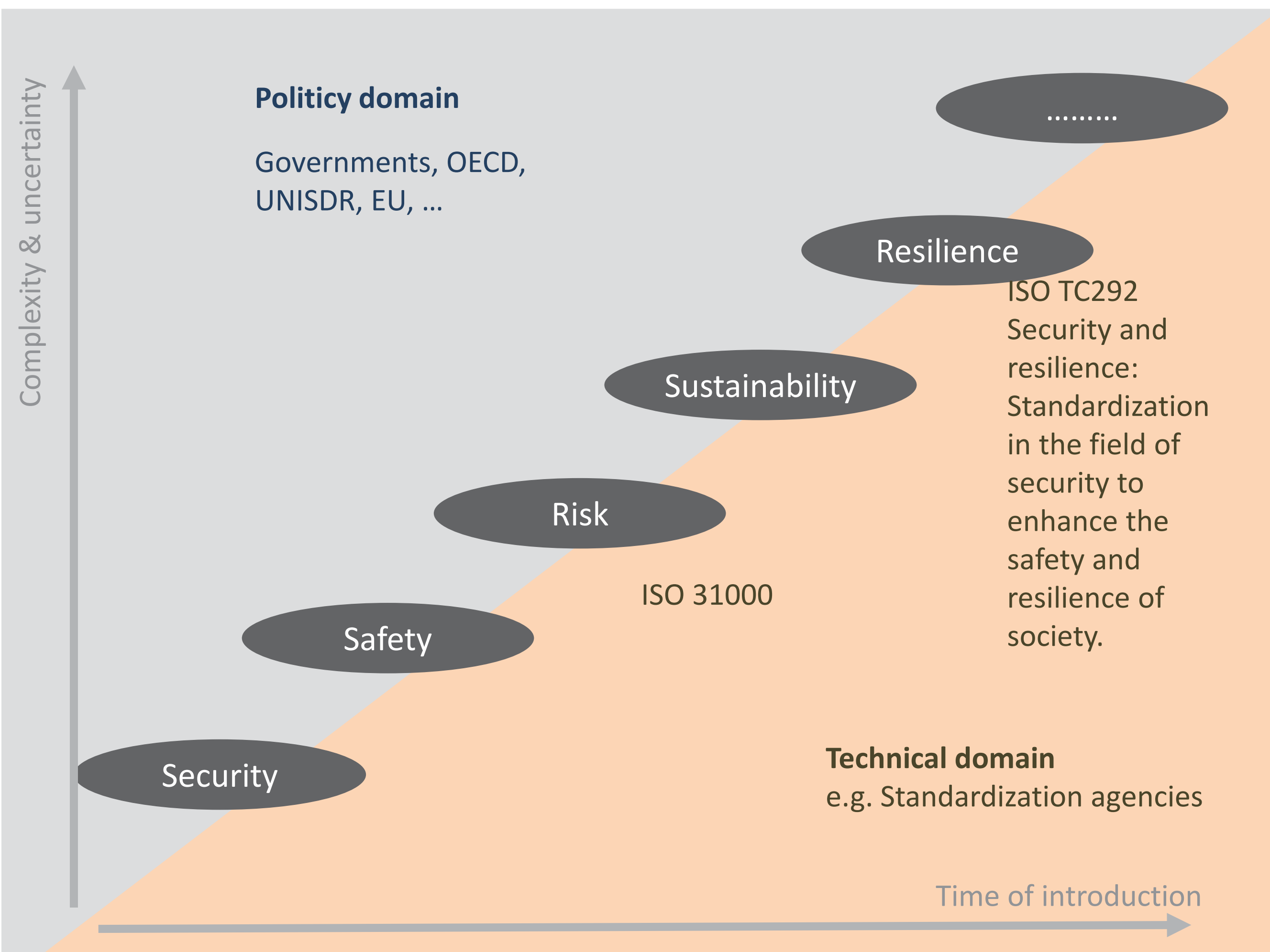
international risk governance council
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
international risk governance center
http://irgc.epfl.ch
www.irgc.org
RESILIENCE
in IRGC concepts and recommendations
Articulating risk and resilience management
from the perspective of a risk manager
Marie-Valentine Florin
marie-valentine.florin@epfl.ch
NATO resilience for critical infrastructure – 28 June 2016


Complexity & uncertainty
Politicy domain
Governments, OECD,
UNISDR, EU, …
………
Resilience
ISO TC292
Security and resilience: Standardization in the field of security to enhance the safety and resilience of society.
Sustainability
Risk
ISO 31000
Safety
Security
Technical domain
e.g. Standardization agencies
Time of introduction

In the world of risk

In the world of resilience

RISK

Negative consequence of uncertainty on something that people value (IRGC)

ISO 31000: effect of uncertainty on objectives

RESILIENCE

[Characteristic of a system that indicates its] ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events (NAS 2012)

[and transform itself if needed].

Risk analysis is used to inform a process by which resilience is built, when and as needed

In the world of risk

In the world of resilience

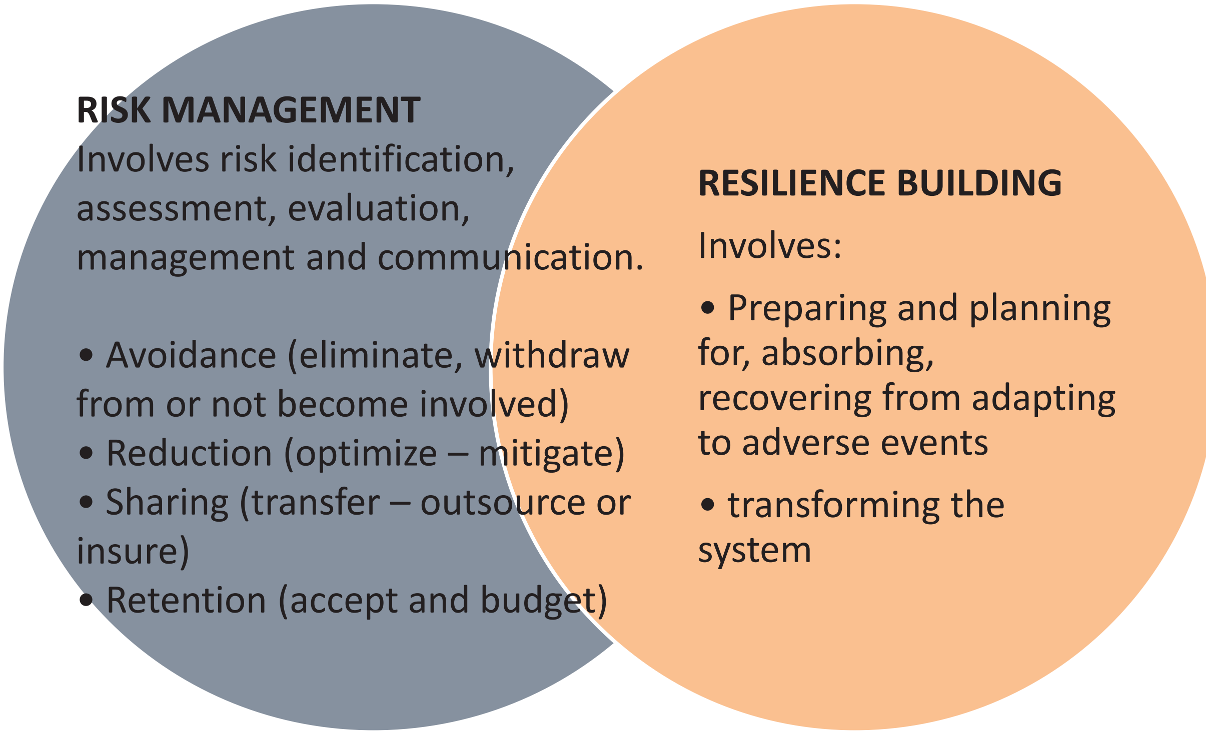
RISK

of ….. to …..

RESILIENCE

- **Specific resilience of ….. to …..**
- **General resilience:** capacity of social-ecological systems to adapt or transform in response to unfamiliar, unexpected and extreme shocks

In the world of risk | In the world of resilience



Characterizing the knowledge we have about the risk

Complexity

Refers to the **difficulty of identifying and quantifying causal links** between a multitude of potential causal agent and specific observed effects

Large infrastructure network, e.g. electricity grid, internet

Uncertainty

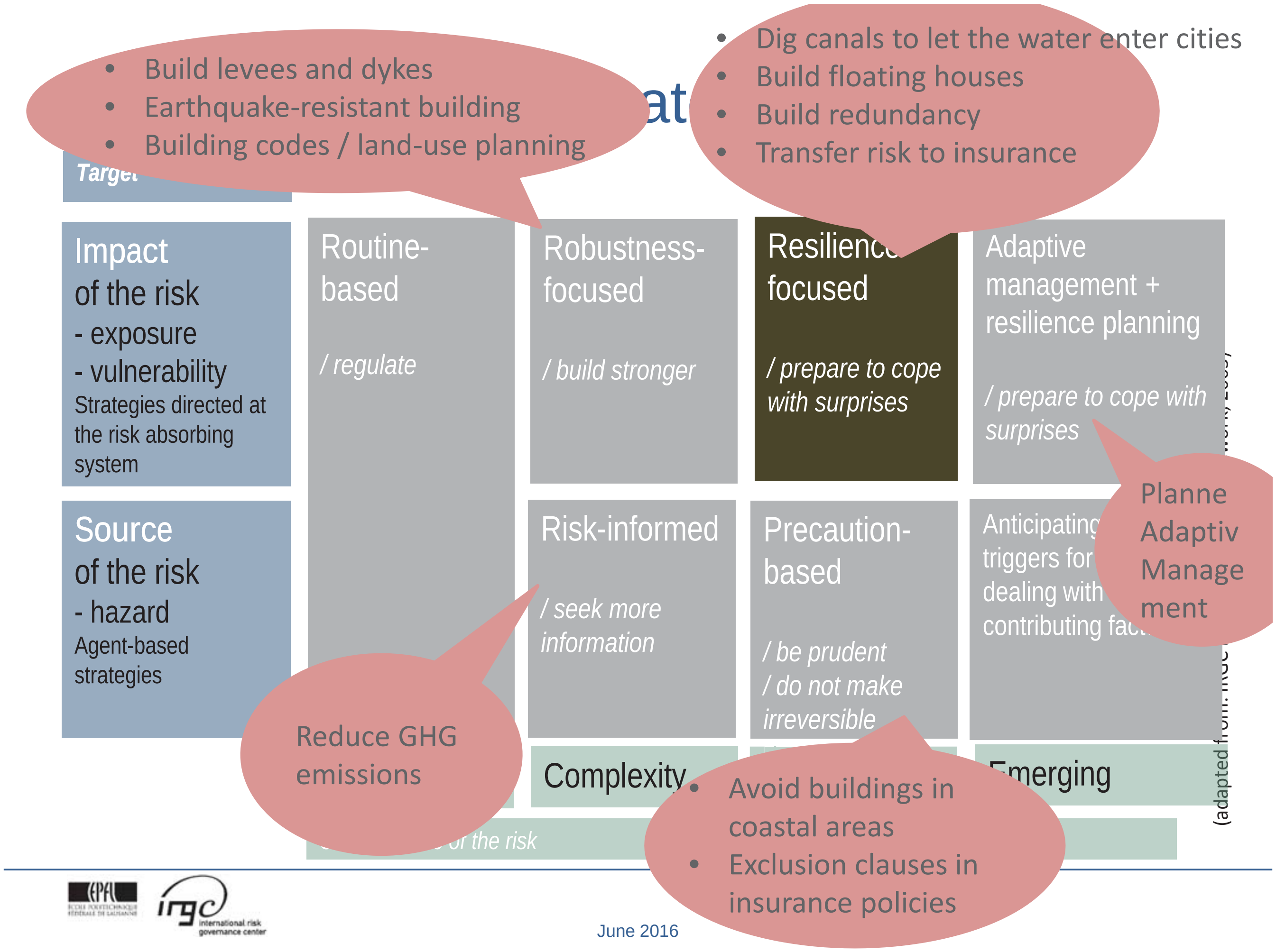
A state of knowledge in which, although the factors influencing the issues are identified, the likelihood of any adverse effect or the effects themselves **cannot be precisely described**.

E.g. climate change, biodiversity loss

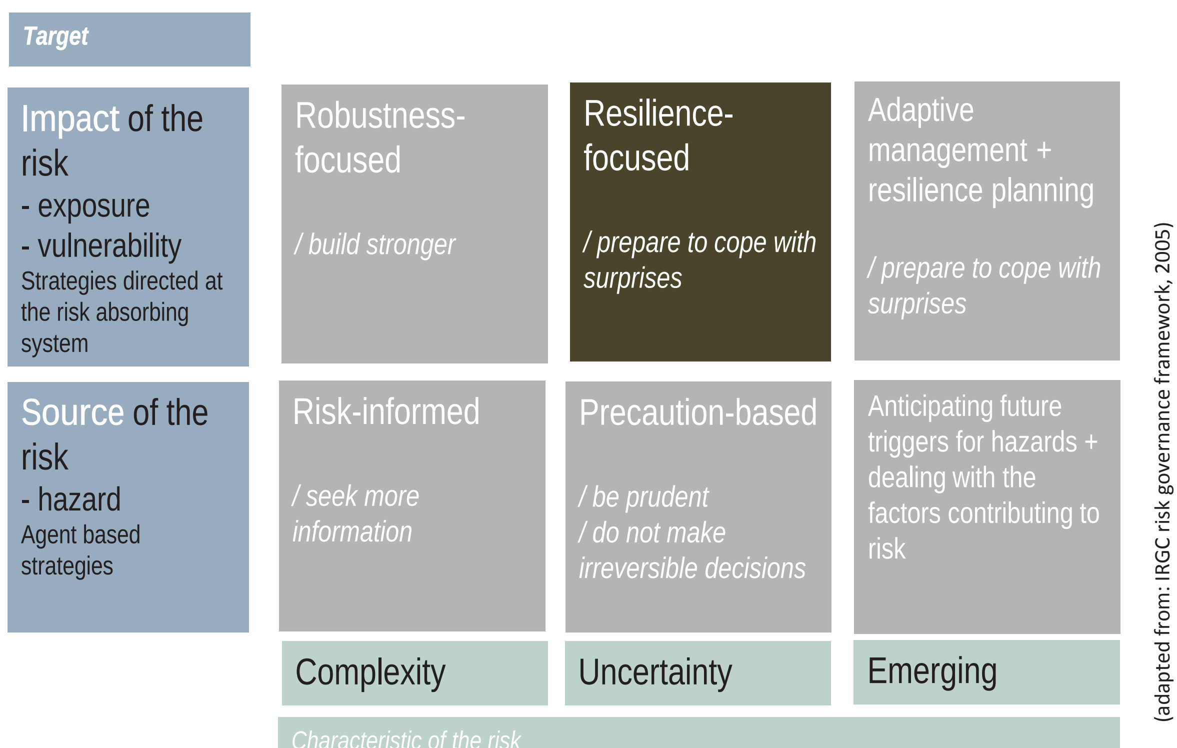
Ambiguity

Giving rise to **several meaningful and legitimate interpretations** of accepted risk assessments results

Risks related to genetically modified crops



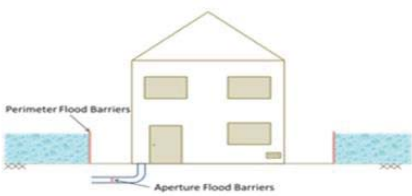
Risk Management Strategies

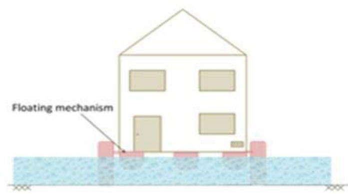


Robustness vs. Resilience

Water exclusion strategies:
Building resistance

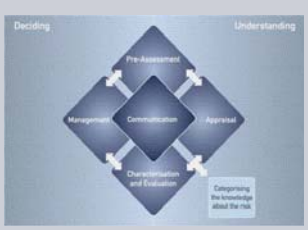
Water entry strategies :
Building resilience

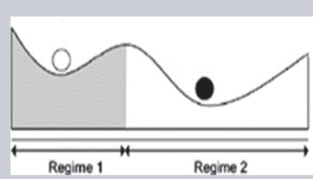




http://www.architecture.com/Images/RIBAHoldings/ http://tech.floodresilience.eu http://www.planningportal.gov.uk

Resilience in IRGC concepts





IRGC White Paper on Risk Governance, 2005:
(Risk Governance Framework)

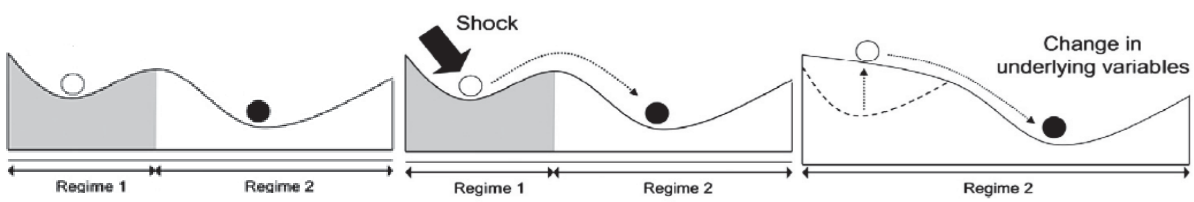
"Resilience is a **protective strategy** to build in defences to the whole system against the impact of the realization of an unknown or highly uncertain risk."

Instruments for resilience include strengthening the immune system, designing systems with flexible response options, improving emergency management, etc.

IRGC guidelines for emerging risk governance (2014)

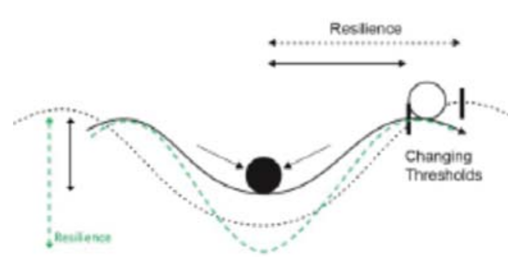
Resilience as a (dynamic, proactive) **strategy for adaptive risk management**.

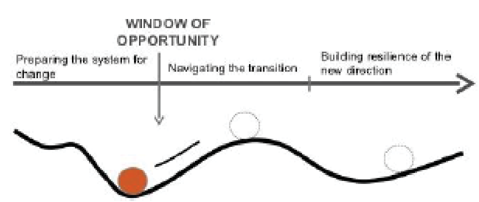
E.g. Planned Adaptive Regulation (cf. EC institutional process for ex-post impact assessment, integrating feedback from experience into the regulation, including flexibility in regulation.)



Resilience science suggests opportunities for designing and building more resilient systems that:

- are able to **avoid the risks of transgressing thresholds...**
- or can pass an irreversible threshold, so that **the system moves to a more favourable regime**
- or are **able to adapt and transform in case of unavoidable regime shifts.** Prevention, adaptation and transformation are strategic responses to, respectively
  - avert further regime shifts,
  - cope with consequences of regime shifts,
  - and redefine ways of providing goods and services while increasing system resilience





international risk governance council

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

international risk governance center

http://irgc.epfl.ch
www.irgc.org

Thank you

Marie-Valentine Florin

www.irgc.org

June 2016

Resilience Assessment Framework for Regulatory Contexts

POC: Igor Linkov (US Army Engineer Research and Development Center) Igor.Linkov@usace.army.mil

Definition

"The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."
US National Academies of Science

Necessity of Resilience-based Policies

- Acknowledges the **evolution of circumstances**
- Considers system **interdependencies** and potential for **cascading effects**
- Complexities of large-scale systems
- **Lifecycle** analysis (20-, 50-, 100-year timeframe)
- Appreciates the uncertainty and dynamics of **physical and human/social factors** and knowledge and understanding over several time horizons

Common Features Across Applications

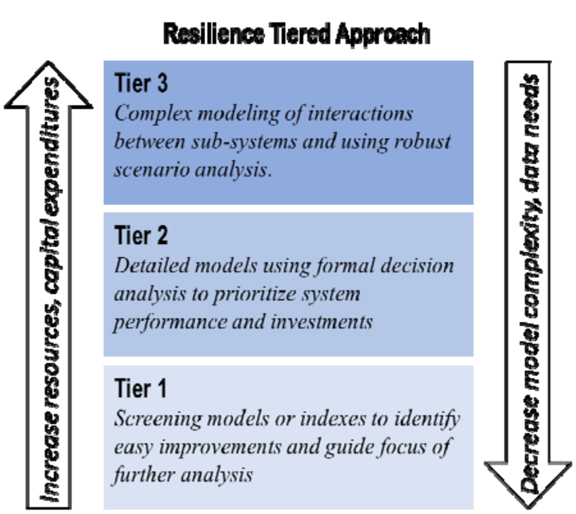
Stage	Resilience Feature	Socio-Ecological	Psychological	Organizational	Engineering & Infrastructure
Prepare	Critical function	Ecosystem services provided to society	Human psychological well-being	Goods and services provided to society	Services provided by physical and technical engineered systems
Absorb	Threshold	Used to identify natural breaks in scale	Sense of community and personal attributes	Organizational adaptive capacity	Sensitivity of system functioning to changes in input variables
Recover	Time	Emphasis on dynamics over time	Emphasis on time of disruption (i.e., developmental stage: childhood vs adulthood)	Emphasis on time until recovery	Emphasis on time until recovery
Adapt	Memory/ Adaptive Management	Ecological memory guides how ecosystem reorganizes after a disruption	Human and social memory, can enhance (through learning) or diminish (e.g., post-traumatic stress) psychological resilience	Corporate memory of challenges posed to the organization and management	Re-designing of engineering systems designs based on past and potential future stressors

Tiered Framework for Regulatory Assessment of Resilience

Risk Assessment	-v-	Resilience Assessment
risk analysis often seen as an objective and detached effort separated from risk management	*whereas*	resilience analysis in the context of potential resilience management alternatives.
tier 1 screens based on identifying components or stages with greatest risk computed.	*whereas*	tier 1 screens based on identifying critical functions of the system.

Key Concepts

- Three-tiered assessment framework parallels commonly utilized approaches for contaminant and environmental risk assessment in the US and Europe.
- Building on existing approach will enhance understanding and speed adoption.
- Resilience assessment can be applied to modern, complex system without becoming prohibitively expensive (as with risk).



Tier 1 –System-Scale Assessment
- ►Holistic assessment of system capacity for resilience
- ►Identifies system user priorities and perceived vulnerabilities
- ►Rapid assessment can be based on expert elicitation
- ►*Ex: Coastal Communities: Fox-Lent et al. (2015); Linkov et al. (2014)*

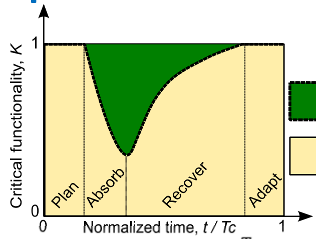
Tier 2 –System Infrastructure Assessment
- ►Separate Engineered, Ecosystem, and Community Infrastructure resilience assessment to specific set of identified hazards
- ►Based on empirical, simple models, field data, heuristics
- ►*Ex: Port/Harbor Assessment at Mobile Bay. Rosati et al. (2015)*

Tier 3 –Network Analysis Assessment
- ► Probabilistic analyses using system dynamics, network science, Bayes nets, numerical modeling methods.
- ►Calculate expected performance across a robust set of scenarios.
- ►*Ex: Bayesian Analysis of Jamaica Bay, Hurricane Sandy. Schultz et al. (2012)*

Resilience in Networks

Alexander A Ganin (US Army Engineer Research and Development Center, University of Virginia), **Maksim Kitsak** (Northeastern University), and **Igor Linkov** (US Army Engineer Research and Development Center)
Igor.Linkov@usace.army.mil

Concepts of Resilience

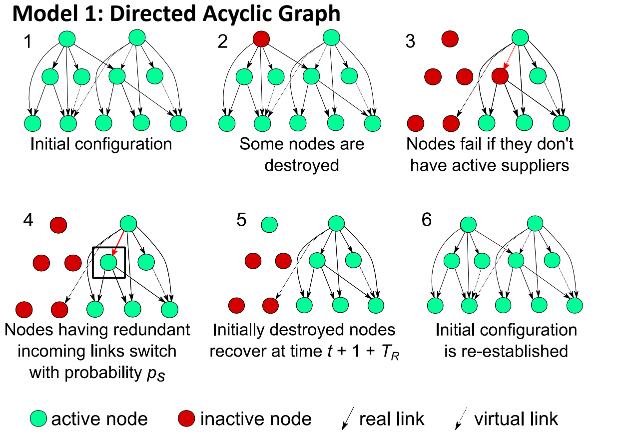


$$R \equiv R(K, \boldsymbol{E}, [0, T_C]) = \frac{1}{|\boldsymbol{E}|} \sum_{\boldsymbol{E}} \int_0^{T_C} K(t) \bigg/ \int_0^{T_C} K^{nominal}(t)$$

Network Modeling

A **graph** or **network** is a collection of points (nodes, vertices) and lines (links, edges) connecting a subset of them

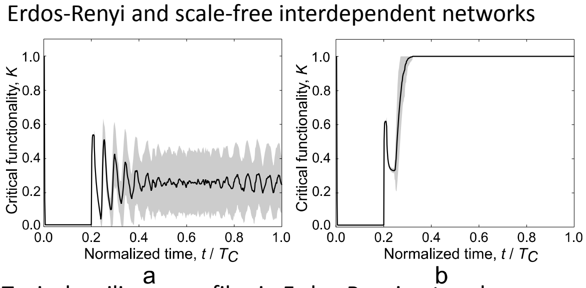
Model 1: Directed Acyclic Graph



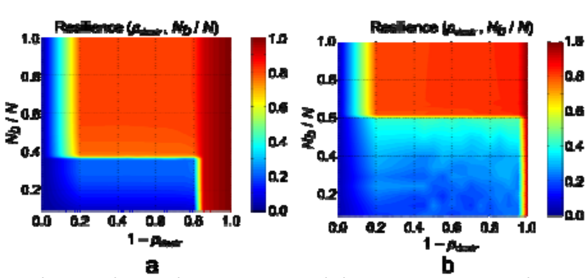
Node becomes inactive if at least one supplier is inactive.
Inactive node uses virtual link as a backup with probability p_s.
Inactive nodes reactivate after T_R steps

Model 2: Interdependent Networks

This model uses failure algorithms developed by Parshani et al for evolution of the largest connected component (giant component) in a system of coupled networks. We added recovery algorithms to that model and studied traditional Erdos-Renyi and scale-free interdependent networks



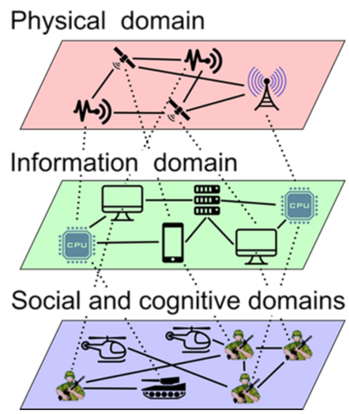
Typical resilience profiles in Erdos-Renyi networks



Resilience dependencies on model parameters in Erdos-Renyi (a) and scale-free (b) networks

Command and Control (C2) Networks Are Interdependent (DTRA Project)

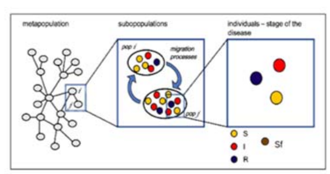
- Methods



- Expected Results
  - ► New theory, models and algorithms for optimal design of interdependent C2 systems, with the objective of making them resilient to both targeted (intentional) and random (natural) attacks
  - ► Investigation of correlations between the networks topology, nodes and links properties and the network response to the adverse events
  - ► Studies of small-scale toy model of a C2 network and of a large-scale realistic model of a C2 network.

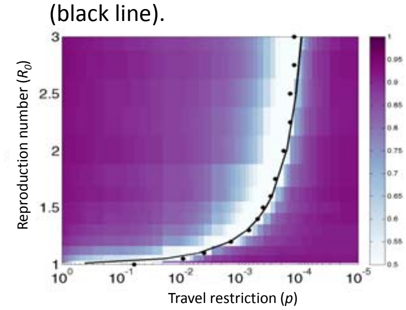
Modeling of the Optimal Selection of Strategies to Combat Epidemics

- Methods



  - ► A network of communities
  - ► Model parameters include: travel restrictions degree, disease and information spreading rates, behavioral patterns and precautions

- Results
  - ► Projection of the 3D surface in the plane (p, R_0) demonstrating the minimum value of the resilience (points) that corresponds to the theoretical global invasion threshold (black line).



How to Build a Resilient Transportation Network?

- Methods
  - ► Various Types of Adverse Events: large-scale disruptions (e.g. flood), accidents, inclement weather (snowstorms)
  - ► In a transportation network nodes represent intersections, and links are roads
  - ► Open Street Map consortium data is available for all major regions of the world
- Results
  - ► The figure below gives an example of traffic distribution for a simple model of Boston, MA transportation network

  - ► Identification of key bottlenecks and system weaknesses

Global futurearth and African futurearth AFEC

Ahmed A. Hady

Vic-Chair of **AFEC** - Cairo University

CHALLENGES

- Unite around a common research agenda for global sustainability science.
- Engage societies in new ways.
- Encourage, catalyse and synthesise high quality research to support transformation

How can we address these challenges

- By building global communities of practice around key themes in sustainability
- By promoting research that informs solutions to real problems around the world
- By bringing together researchers, policy experts, businesses, leaders in civil society and more

Our networks are...

- Global in scope but designed to inspire transformations at the local level
- Responsive to the needs of societies around the world
- Co-designed and co-produced with the people who will use the results of our research

Knowledge-Action Networks

Natural Assets

- Challenge: To inform the management of natural assets to preserve human wellbeing & biodiversity
- Status: Contributed to the 4th Plenary Session of IPBES in February
- Targets: Will launch a broad consultation by the end of 2016 to engage diverse communities of researchers and stakeholders

Oceans

- Challenge: To address the most pressing challenges to ocean sustainability through solutions-oriented research
- Status: Developing a funding strategy;
- Targets: Will assist the Belmont Forum in designing a Collaborative Research Action (CRA) on ocean sustainability

- **Research now demonstrates that the continued functioning of the Earth system as it has supported the well-being of the human civilizations in recent centuries is at risk**

Transformations

- Challenge: To understand and inform how societies can make transitions toward sustainability
- Status: Working in tandem with the ISSC Transformations project suite launched in January 2016; submitted global call for expression of interest
- Goals: Will partner on a major conference on transformations in Dundee, UK, in 2017

Water-Energy-Food

- Challenge: To explore the interactions between water, energy and food and how these relationships are shaped by environmental and social changes
- Status: Formed initial development team including partners inside and out of Future Earth
- Targets: Will complete the scoping process for initial activities in mid-2017

Finance & Economics

- Challenge: To support strategies for linking economic prosperity with social justice and a healthy planet
- Status: Organized stakeholder forum at Our Common Future Conference; confirming partnership with UNEP Inquiry for a Sustainable Financial System
- Targets: Will hold scoping webinars in early 2017

Health

- Challenge: To promote research for a better understand of the relationships between changing environments and human health
- Status: Formed initial development team; conducting formal and informal consultations with health community. Targets: Will hold Bellagio scoping workshop

Cities

- Challenge: To contribute to the transition toward sustainable urban futures where cities are more livable, equitable and resilient through solutions-oriented research
- Status: Producing a white paper to engage with the Habitat III process
- Targets: Will release a book from the Urban Fast Track Initiative to coincide with Habitat

Sustainable Development Goals

- Challenge: To promote high-quality scientific research as a tool and approach for achieving the SDGs
- Status: Co-organized two workshops, Measuring SDGs in 2015, 2016

PURPOSE OF AFRICA FUTURE EARTH COMMITTEE

The purpose of the Africa Future Earth Committee (AFEC) is to be an effective advocate for Future Earth (FE) in Africa and to be an effective advocate for African interests in the global Future Earth platform.

AFEC's roles and responsibilities, therefore, include:

1-raising awareness of Future Earth agenda, activities and opportunities in African science, policy and practice bodies; at continental, sub-continental and national levels.

2- keeping the science community in Africa up-to-date with Future Earth Science and Engagement agenda, activities and programmes and other relevant information.

3-consulting with relevant African science, policy and practice bodies on African interests and priorities within the global Future Earth initiative,

TASKS OF AFEC

1- Immediate tasks (2015-2017)

1 Assist Future Earth Secretariat to establish Future Earth Africa regional offices that will spearhead the implementation of Future Earth-aligned activities in Africa.

2- Assist FE Secretariat in defining the purpose and structure of African Future Earth offices

3- Develop the working environment needed to enable interactions between AFEC and (i) the global Future Earth platform, and (ii) relevant African bodies at continental, regional and national levels. This will include:

4- Engage with the Future Earth global platform, especially the Global Secretariat, in its various activities as it seeks to establish Future Earth going forward.

5- Assist FE Secretariat in developing a strategic vision document that describes the purpose, relevance and opportunities of/for Future Earth to African development

2 Medium Term Tasks (2017-2019)

1 Help the Africa FE Regional Center/offices; when set-up, to develop a five-year vision and complete a 5-year strategic plan of Africa Future Earth activities

2 Organize an Africa Future Earth conference in 2016 or early 2017.

2.1 Support and advise the Regional Centre/offices in seeking national, regional and international financial support for Future Earth Africa activities.

AFEC

3- Long Term Tasks (2019-2025)

1. Education and Health are a key priority in Africa and the Committee was glad to note that this theme features in the Future Earth global plan.
2. Updates on the developments/activities of Future Earth global and regional level at centers were initiated recently in Africa (Alexandria, Pretoria, and Kigali).
3. Improve the visibility of Future Earth in the Africa according to the recent situation

4. Developing a process to articulate key science and other challenges that are of prime interest to Africa to promote an understanding of the African Worldview and in the context of African Development Priorities (current and future),

The following themes were suggested:

- Technology
- new and emerging

- Sustainability including reference to the Sustainable Development Goals (SDGs)
- Natural resource use , Understanding the Anthropology of African Peoples in transitions
- Monitoring and evaluation
- Well-being and life

AFEC

AFEC Members:

CENTRAL AFRICA

1. Prof Cesar Kapseu Ngaoundere University, Cameroon Process Engineering, Chemical Engineering, Renewable Energies and Power sources

2.Prof Yacoub Halawlaw' University of N'Djamena N'Dlamena, Chad Engineering Design, Technology transfer Methodologies, innovation theory, Biotechnology of Microscopic algae, Atomic and Molecular Physics, Optics and Applications.

EAST AFRICA

3. Dr Chrispine Kowenje Maseno University, Kenya Materials and Physical Chemistry with applications in environmental remediation and bio-fuels production.

4. Prof Julius Bunny Lejju University of Science and Technology, Mbarara, UgandaEnvironmental Science (Climate change, forest ecology regeneration, rangeland management & conservation, indigenous knowledge and food security

NORTH AFRICA

5. Prof Ahmed Abdel Hady (Vice Chair) Cairo University, Cairo, Egypt Space Science and Meteorology with expertise covering solar physics and its influence on climate, solar energy and solar cells preparations, astrophysics, solid state physics, and material sciences.

6. Dr Izeddine Zorkani University Sidi Mohamed Ben Abdellah, Morocco Solid State Physics with expertise in Nanotechnology, Renewable Energies especially solar energy.

WEST AFRICA

7. Asso Prof Chidi G Osuagwu (Chair)Federal University of Technology, Owerri, Nigeria Medical Biochemist with expertise in Bioenergetics of Metabolic/Genetic Diseases and Rodoxive stress8.

AFEC

WHY JOIN US?

- International conferences to meet and share ideas (physical and virtual)
- Route to engage with international policy processes
- Part of an international community committed to transformation and a coordinated research agenda
- Intellectual frameworks for co-design solutions-based research
- International support for media, communications, capacity building, young scientist career development

Resilience-Based Approaches to Critical Infrastructure Safeguarding

NATO Workshop

26-29 June 2016, Ponta Delgada, Azores, PORTUGAL

Panel: Resilience needs in Partner Countries

Ahmed A. Hady

Dept. of Astronomy & Space and Meteorology

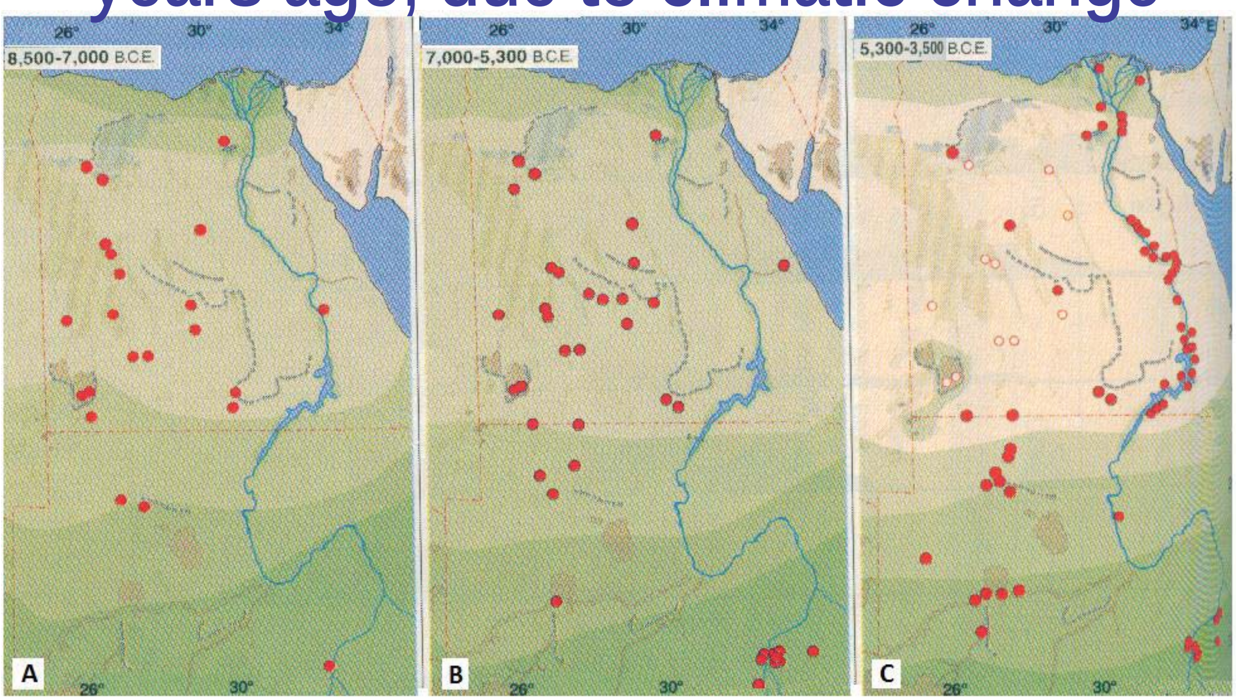
Faculty of Science,

Cairo University, Egypt

aahady@sci.cu.edu.eg

Cairo University, 110 years old , about 25 thousand of teaching staff , 300 Thousands students , it have branched in Sudan, Lebanon and Kazakhstan.

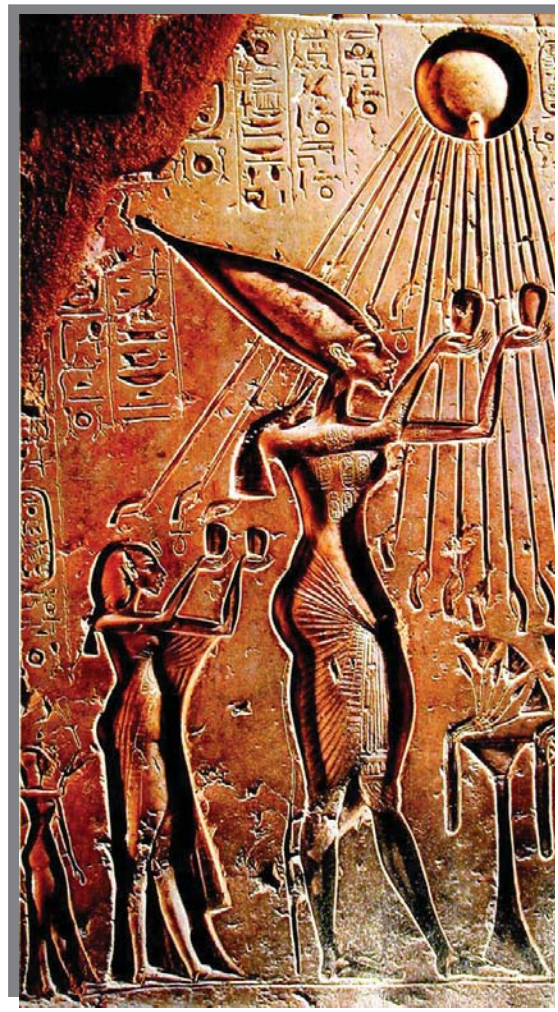
Movements of Egyptians ,12 thousands years ago, due to climatic change

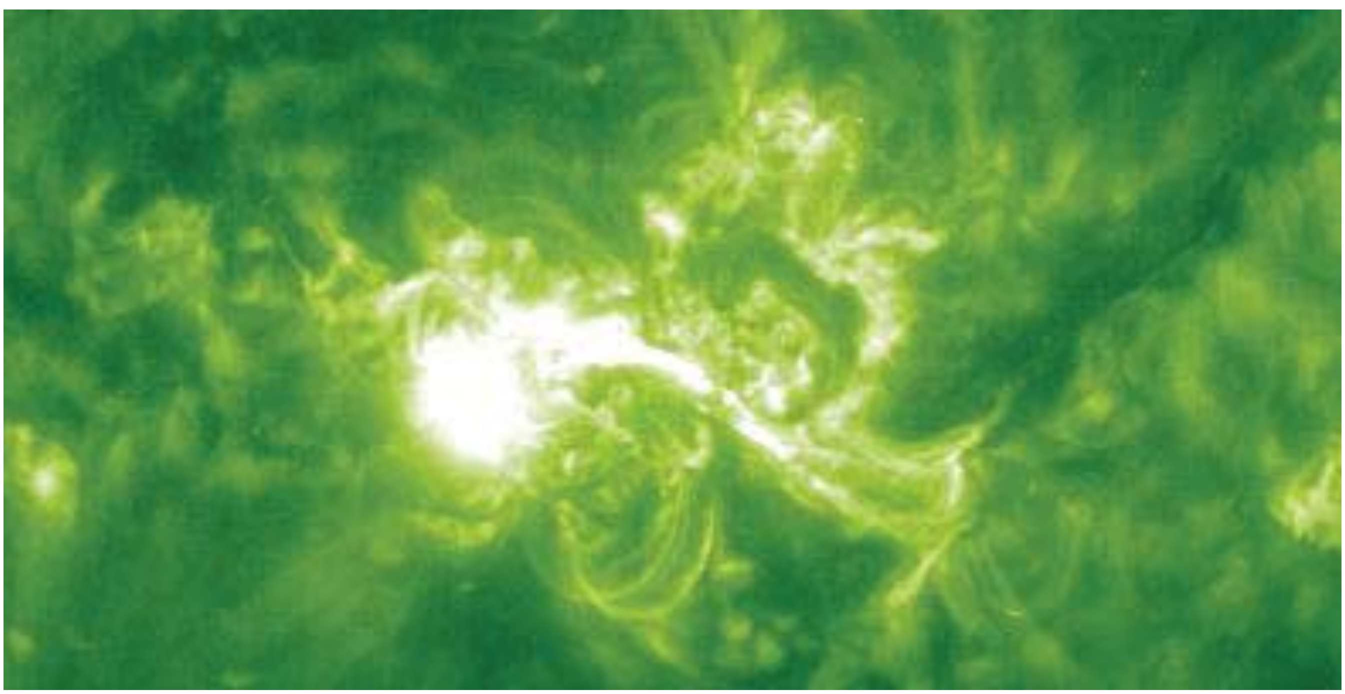


- Map of the archaeological sites in the western Desert in 8500-700 B.C.E. (part A), 7500-5000 B.C.E.(Part B) and then during 5300- 3500B.C.E.(Part C). (Kuper & Kroperlin 2006).

The Ancient Egyptians

The Solar radiation is the source of all life on the Earth



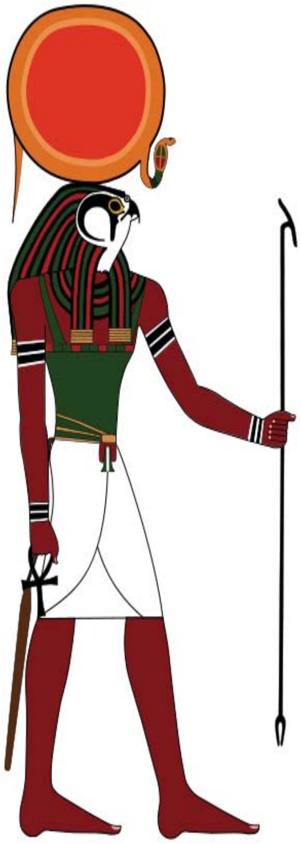


The most active one: region 10486

SoHo EIT X-Ray Flare (X 17.2/4B)

28 October 2003

The values of the Solar activity were known since Pharaohs era



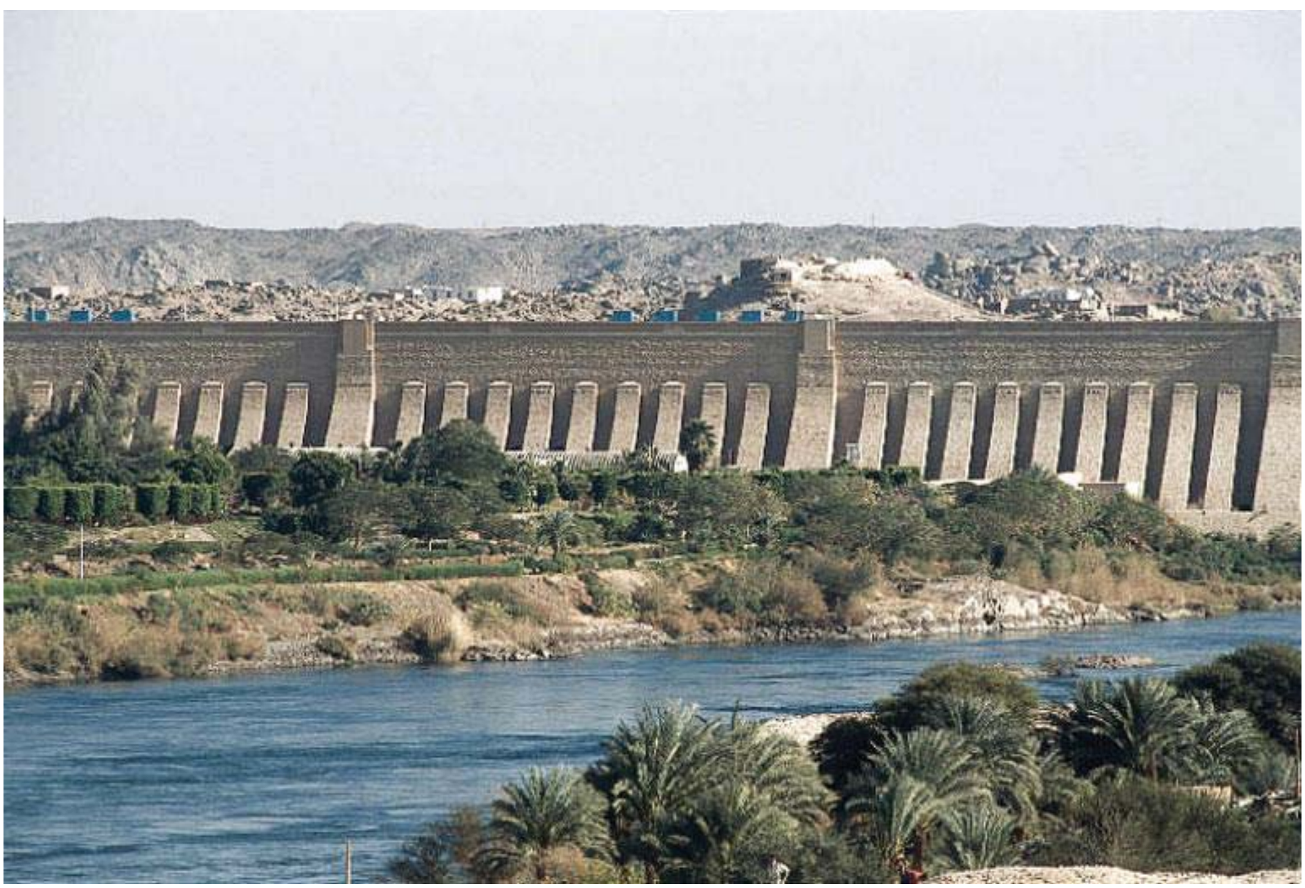
Starting from the beginning of the life

The Sun is the God

Resilience needs as a national dimension

- The population of Egypt grow quickly, closes to 100 Million; it's a big disaster on the critical infrastructure.
- The resilience needs for critical infrastructure safeguarding especial that have international dimension like Suez Canal,
- Then there are special Early Warning Group working to managing and facilitate the solution before, during and after any disaster risk, with helps by Egyptian military

The High Dam in Aswan is one of important infrastructure, and it's safeguarding is very important for us, then there is special research institute in site, working to improve its situation, and study the expected disasters.



Resilience needs in Partner Countries

"Global Dimensions"

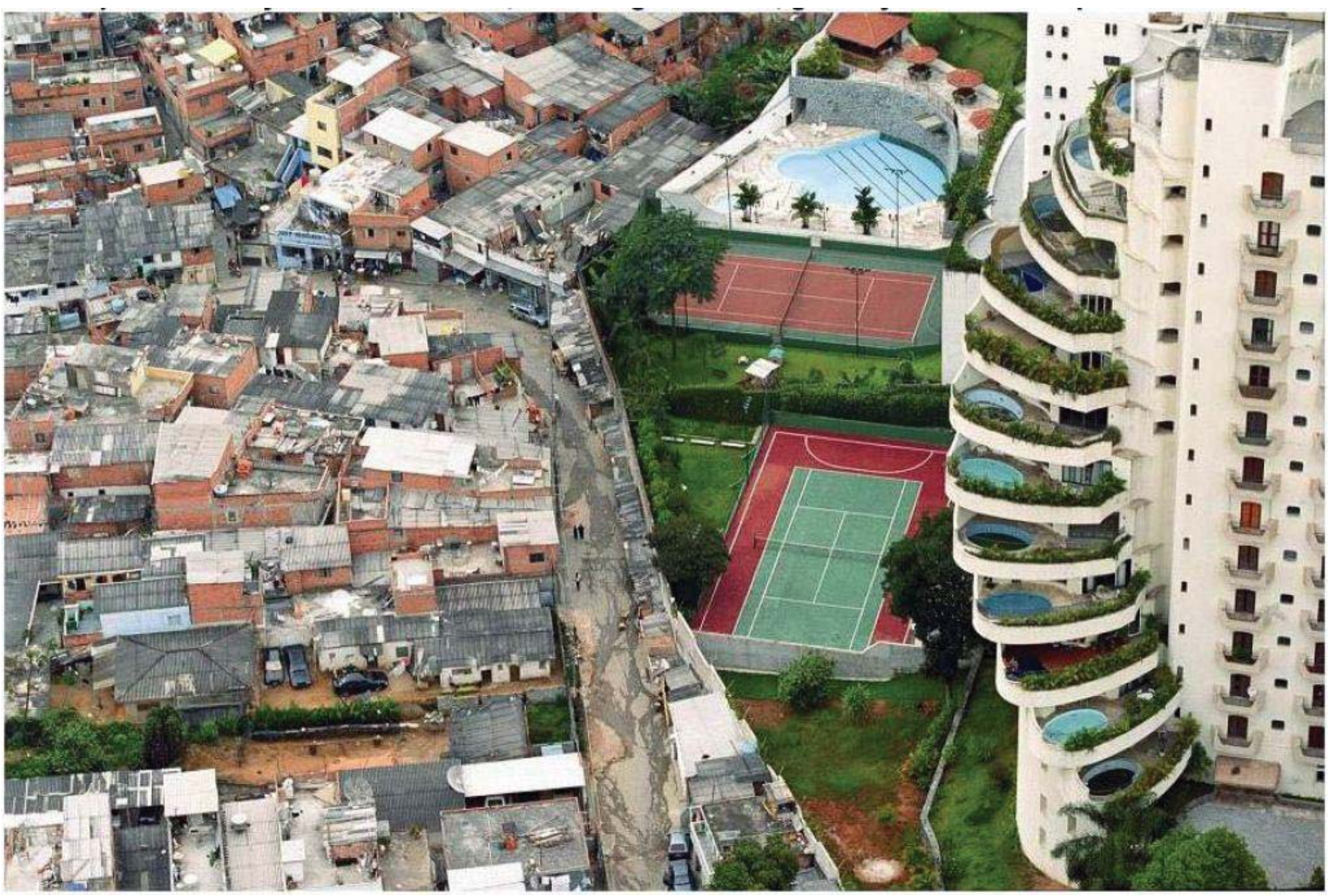
a. What do we really need?

b. Control population explosion can be help!!

c. **Improve the life standards around the world, can be help!!**

It causes a huge risk on critical infrastructure

Improve the life standards around the world will help in decreasing the risk on Critical infrastructure .



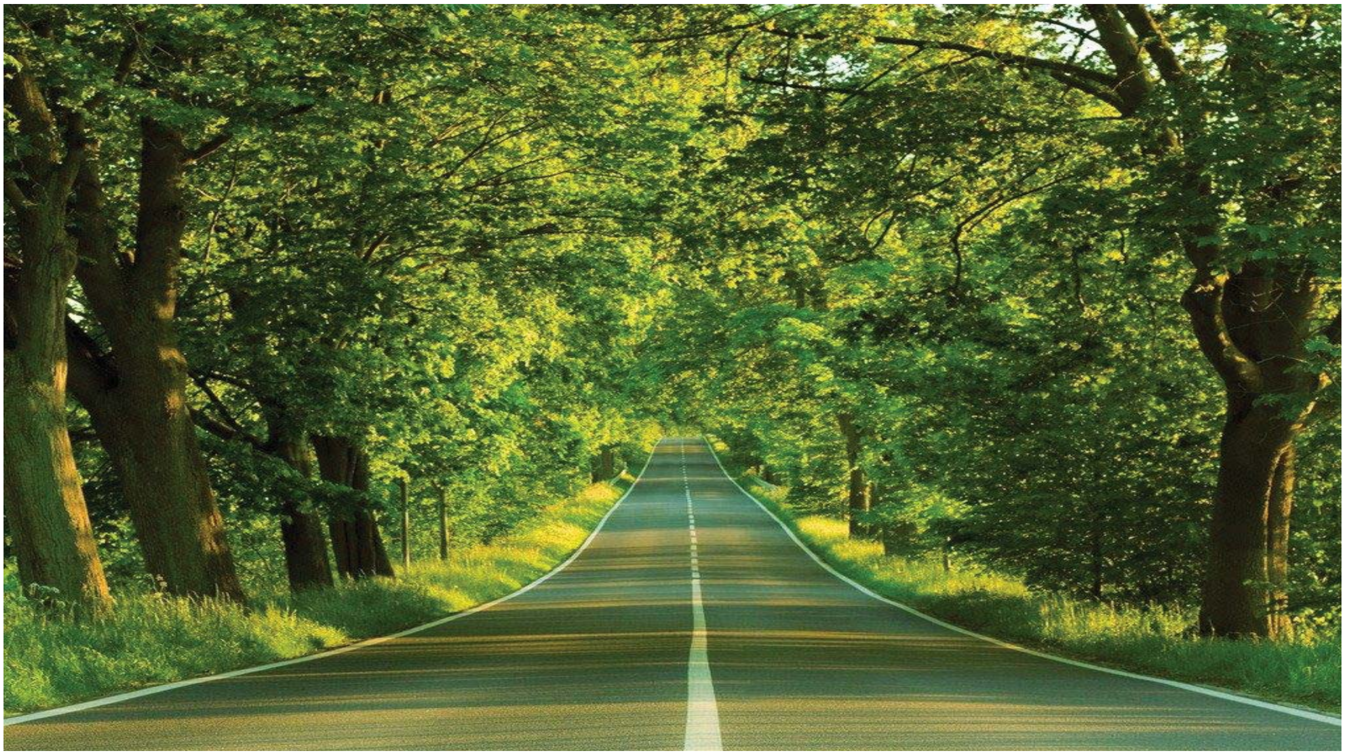
Resilience needs in Partner Countries

Regional Dimensions: we need the following,

- Resilience for exchange the information with partner countries in the field of **terrorism** and **sabotage**.
- Common Strategy for partner countries in critical infrastructure.
- Initiate a Technical Support Working Group for the partner countries.

- Establish an early "Warning Unit" for the partner countries.
- Exchange the experience will reduces the risk of disasters in critical infrastructure as a result of inexperience and the misuse operating.
- Establish a scientific system for predicting the risks to critical infrastructure in Partner Countries
- Working to **reduce** and **avoid** risks that the critical infrastructure exposed to natural disasters, by providing enough information about natural disasters and cooperation with partner countries to facilitate the fast transition during disasters.
- Reduce the **misuse** of critical infrastructure or the excessive use of its abilities

- **life on earth is the great valuable task must be preserved and developed constantly.**
- **Reserving the Earth for a better human life.**



Thank you for your attention !

EU H2020-project DARWIN

Adapt to survive

DARWIN: Expect the unexpected and know how to respond

This project has received funding from the European Union´s Horizon 2020 research and innovation program under grant agreement 653289.

www.h2020darwin.eu @darwinh2020

Project Coordinator: ivonne.a.herrera@sintef.no
DARWIN Community of Practitioners (DCoP): rebecka.forsberg@regionostergotland.se
Dissemination Manager: Ciara.Eustace@carrcommunications.ie

In recent years crises and disasters, such as Eyjafjallajökull in 2010, Deepwater Horizon in 2010 and Fukushima Daiichi in 2011, have made it obvious that a more resilient approach to preparing for and dealing with such events is needed.

DARWIN will develop state of the art and evolving resilience management guidelines, innovative tools and training modules for crisis management. These results aim to support those with responsibility for protecting the population or critical infrastructure (CI), from policy development to practical implementation.

Photo: Exercise Stellan, 2008. Katastrofmedicinskt Centrum (KMC), Linköping.

PROJECT OBJECTIVES

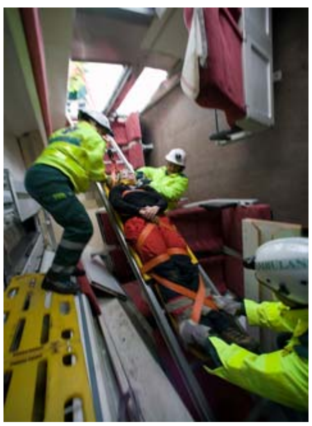


Photo: Kunskapscentrum i katastrofmedicin (KcKM), Umeå.

Photo: Fiumicino tower at night. ENAV.

DARWIN Resilience Management Guidelines (DRMG) will be developed and operationalised to cover all stages of crisis management: before, during and after the crisis. DARWIN Manifesto: "The DRMG are guiding principles to advise CI stakeholders in the creation, assessment, and improvement of its own guidelines, procedures and practices. The DRMG help to develop a critical view on CI´s own crisis management activities (management of resources, procedures, training, etc.) based on resilience management concepts. They are not prescriptive."

The DRMG will be reviewed and evaluated by the DARWIN Community of Practitioners (DCoP) as well as by performing pilot studies in the two domains of air traffic management and healthcare. The DCoP will be composed of representatives from different sectors.

EXPECTED RESULTS

- Catalogue of resilience concepts and requirements for resilience management guidelines.
- Generic DARWIN Resilience Management Guidelines (DRMG).
- DRMG guidelines adapted to the specific domains of healthcare and air traffic management.
- Tools for simulation and serious games.
- Processes and storage which facilitate easy access and update of the guidelines.
- Pilot demonstrations.
- Training modules on resilience guidelines.
- DARWIN Community of Practitioners (DCoP). Interested in joining? Contact KMC!

PROJECT PARTNERS

SINTEF

DEEPBLUE consulting&research

Istituto Superiore di Sanità

FOI

Technische Universität Braunschweig

ENAV

Carr Communications

Ben-Gurion University of the Negev
אוניברסיטת בן-גוריון בנגב

ADAPT TO SURVIVE

Infrastructure Risk and Resilience: Starting discussion

Resilience-Based Approaches to Critical Infrastructure Safeguarding – NATO Workshop, 26-29 June- Azores, Protugal

Moderator Ivonne Herrera (SINTEF)

DARWIN participants: Ivonne Herrera (SINTEF), Rogier Woltjer (FOI)

THE PROJECT LEADING TO THIS APPLICATION HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAM UNDER GRANT AGREEMENT 653289.

Risk and Resilience

1. Identify risk & build a defensive fortress

2. Comparing paper model with reality

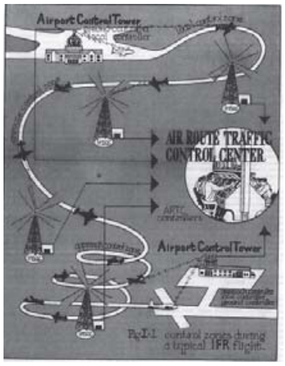
3. Widening the angle of attack

4. Survive exceptional events

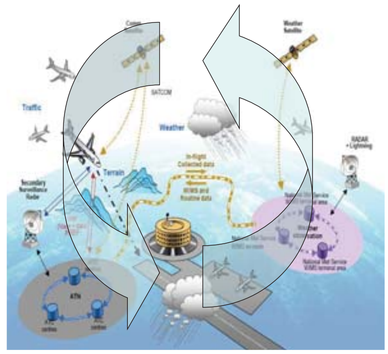
Source: Amalberti, R. 2013

ADAPT TO SURVIVE

Simple linear…complex interactions…increase of interdependencies



Human engineering for an effective air navigation and air traffic control system
Ref.: Fitts, 1951,

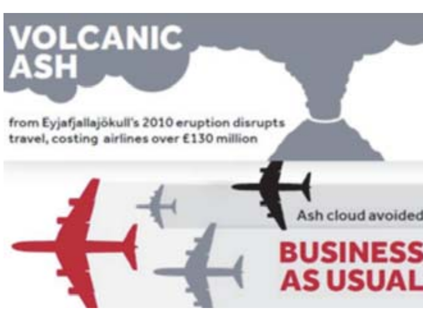


Single European Sky System Wide Information Management System (SWIM)

Multiple Remote Tower Center
for Røst and Værøy at Bodø, Norway.
Ref.: AVINOR, SESAR

DARWIN …Critical infrastructure and social structures from policy to practice

Challenge: effect of crisis on critical infrastructures and social structures



The driver
Hidden interdependencies
The difficulty
Handling surprises and cascades

Current methods
Linear thinking dealing with expected situations

The need
Escaping oversimplifications
Addressing complexity
Emergence
Lack of standards
Mainly theoretical developments

Resilience Engineering

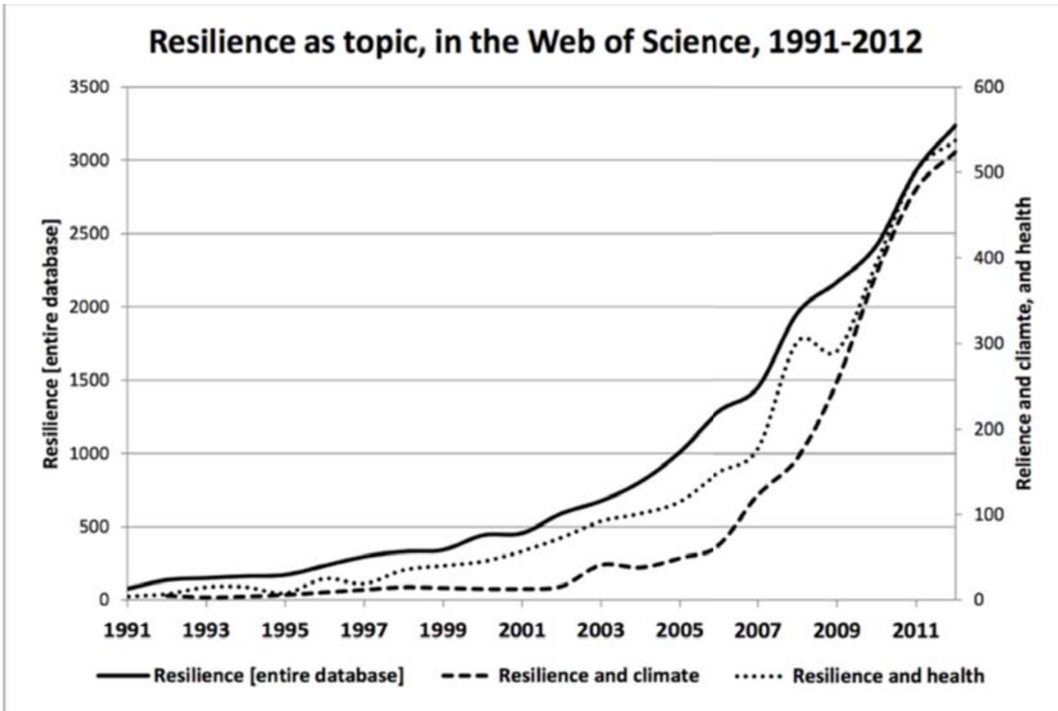
- ”The ability of the systems to adapt to changing conditions in order to maintain a system property” (Leveson et al, 2006).
- "A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions. (Hollnagel, 2014)"
- “Graceful extensibility to stretch near or beyond when surprises occurs, a positive capability. Sustain adaptability to manage and regulate, governance and architect systems/ organizations” (Woods, 2015)

DARWIN solution: Resilience Engineering and Community Resilience

Resilience as “The ability to resist, absorb, accommodate to and recover from the effects of disturbances and changes in a timely and efficient manner, including through adaptation and restoration of basic structures and functions (UNISDR, 2009; Hollnagel, 2011)”.

- Graceful extensibility the capability to stretch/extend capabilities to operate…prepared to be surprised
- Sustained adaptability manage/regulate adaptive capacities… governance and architectures of tangled layered network considering tradeoff spaces
- Community resilience and the human dynamic of crisis situations
- Intercultural issues will be considered in order to enhance the capacity response of involved professionals

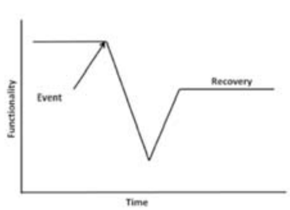
DARWIN Systematic Literature Review CI -Review 2015 – 300 definitions

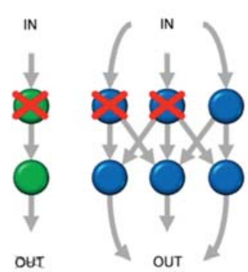


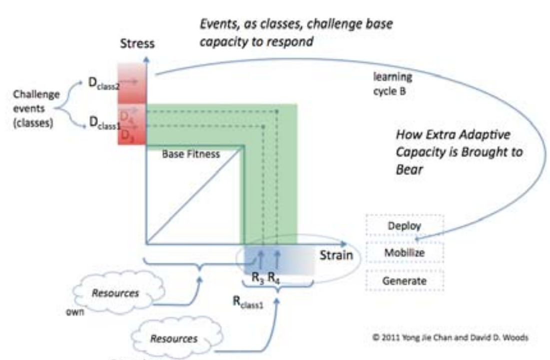
Source: Longstaff, 2015

Linear simplifications

Adaptive Universe







Resilience as

Resilience as

Rebound from a traumatic event

Resilience as

Robust expand base adaptive capacity to handle more, **well-modeled disruptions**

- **Graceful Extensibility** the capability to stretch/extend near and beyond boundaries
  how to be prepared to be surprised

- **Sustained Adaptability** manage/regulate adaptive capacities . governance and architectures that tend to find hard limits in tradeoff spaces

Source: Woods 2015

Thank you for your attention

Concepts, methods, strategies and practices specific for Infrastructure risk and Resilient CIs?

Enhancing Resilience in Critical Infrastructure Services

THE FLOW OF EVERYTHING

Table of Contents

How do we see the Systems?

- Flows of critical services to a functional society
- Human capacity to recover, adapt, become/sustain resilience
- Analysis of flows – network analysis tools and control framework
- Inseparable socio-technical-ecological systems
- Dragon king perspective

How do we assess resilience?

- Range of approaches from simple to complex depending on complexity and data availability
- Dealing with uncertainty and ambiguity, inadequate data
- Improve understanding of the behavior of systems outside of any particular threat
- Complex network theory tools- topology, flows, stressing systems with disruptions, scenarios
- How to monitor what is changing
- Understanding adaptive capacity
- Describing interdependencies

How do we understand the behavior of systems under a broad range of multi-hazard scenarios?

- Emerging hazards
- Using parallel processing of hazards on the control framework
- Preparing for the unknown
- Scenarios across temporal and spatial scales
- Sources of resilience and brittleness
- Opportunities for improvement
- Tools for complex system analysis - scenario generation and system behavioral response
- Tools requires because complex analysis is beyond the cognitive capacity of humans

How to engage and communicate resilience assessment outcomes?

- To regulators, policy makers, stakeholders, public
- Developing a narrative for the media and politicians
- The power of stories
- Role of scientists in translational communications

How do we transfer knowledge and engage continuous learning?

- Use of simple analogies
- Experiential learning
- Multi-disciplinary sharing
- Knowledge transfer within disciplines
- Things known and forgotten
- Visualizations as decision support tools

> “The Best Chapter!”

Key Ideas: Technological Concepts

- Resilience services, not functions
- Everything can be considered as flows: ideas, people, energy, etc; infrastructure enables these flows
- Adaptive management / capacity for ongoing adaptation
- Positive aspect of resilience – to survive, adapt and transform
- Be proactive, prepare, ongoing analysis of changing conditions. → allows us to constantly test the control framework
- Test the control framework with respect to technological, societal, organizational, economic, and environmental performance
- We have vulnerability functions, but critical lack of data to develop recovery functions. – what is an acceptable level of recovery, what quality services is acceptable? What are the ethical issues of prioritizing recovery
- Cognitive limitations on the number of nodes and links – exceeds human abilities, requires tools to enable assessment of complex systems
- Necessarily requires multi-disciplinary assessments and approaches

---

Key Ideas: The Human Component

- Leverage international efforts and develop synergies

  (over-focus on Europe)
- Bring players together on shared values/ desired outcomes
- Critical stakeholder and community engagement
- learning / knowledge management/ tech transfer
- Enabling and supporting critical community involvement through a narrative; community-based, story telling
- Prepare for and support for families as part of a resilience plan – support individual resilience
- Understanding and working out jurisdictional responsibilities
- Impact of digital personal communication on resilience planning, response, and recovery

Introduction

- Frame the big challenges
- Describing the scope of the system – in time and space
- Setting the context – history of the system
- Stakeholder –
- Risk management → ← resilience assessment

Timeline

- June 30 – Cate will send email list
- July 8 – Cate will send outline with rough notes
- July 31 – all send written sections with references to Cate in Word document
- Aug 8 – Cate sends complied version to Hans and Kirk
- Sep 4 – Draft sent to team
- Sep 30 – input from all to Kirk/Hans/Cate
- Oct 20 – Sarah will edit
- Oct 30 – Chairs send mostly final draft to all
- Nov 20 – Done!

Operationalizing resilience capabilities deployment in the Emergency Management Cycle - *framework*

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The approach is being developed in the framework of the EU financed project 'Resilience Capacities Assessment for Critical Infrastructures Disruptions' (READ). It integrates the resilience capabilities of Critical Infrastructures (Cis) into the Emergency Management (EM) Cycle (prevention/mitigation, preparedness, response, and recovery), which allows explicitly addressing resilience improvement measures while planning to cope with CI disruptions.

Resilience capabilities are defined as enablers of activities and functions that serve the resilience goals.

Resilience capabilities' space

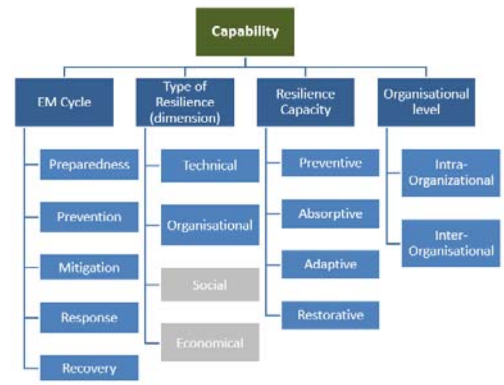
System types	Phases of the Emergency Management Cycle			
	Prevention/ Mitigation	Preparedness	Response	Recovery
Technical				
Organizational				
Social				
Economic				
Resilience goals & activities to serve goals	*Prevent* disruption	Maintain & sustain resilience capabilities	*Absorb* shock & *adapt*	*Adapt* & *restore*

A *resilience capability* is further broken down into three related compounds: *assets*, *resources*, and *practices/routines*.

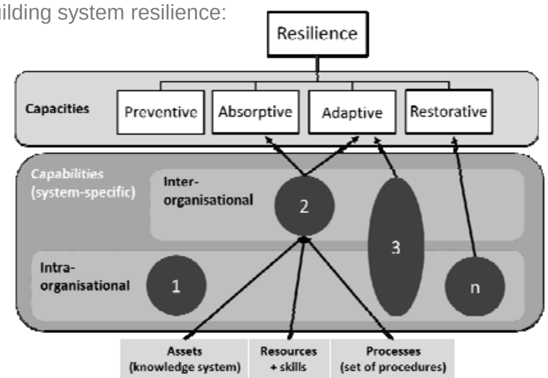
Capability: Provision of access to required information		
Compounds	**Definiton**	**Example**
Asset(s)	*an item of ownership that has value to the CI that serves a given community or value to the community itself; assets include both physical entities as well as intangibles such as knowledge systems.*	Information (can be paper medium, e-repository, audio records, etc.)
Resource(s)	*a tool or competence required to carry out given tasks or achieving given objectives, including making use of assets to achieve individual and shared goals.*	Tools such as communication links, computer terminals, competencies to operate and make use of these
Process(es)/ Routine(s)	*the way things are done, possibly codified as an explicit procedure or a pattern of activities with no explicit procedure.*	Procedures, tacit background knowledge & know-how. Examples may be instructions for getting access to the target information which may include authorisation, credentials for e-access, etc.

As EM involves a number of responders that should act in concerted actions under emergencies, two other levels of resilience capabilities should be distinguished: *intra-organisational* and *inter-organisational resilience capabilities*.

Below is an overview of resilience capabilities classification:



Building system resilience:



Capability building cycle

It is the process through which the system resilience is enhanced.

1) The current state of the resilience capabilities is assessed – situation AS IS;

2) A Gap Analysis is performed where the gaps in the capabilities are identified considering the accidents and related system vulnerabilities. Based on the analysis, a target value for each capability is deliberated.

3) The objectives are set, and the implementation plan is decided upon.

4) The resilience capabilities are reassessed and reviewed after a single improvement cycle (this is also the first step of the next planning cycle).

All of these are implemented in the *READ Tool* for resilience capability assessment

Learn about the READ project
http://www.read-project.eu

EU Programme 'The Prevention, Preparedness and Consequence Management of Terrorism and other Security-related Risks (CIPS)'

Operationalizing resilience capabilities deployment in the Emergency Management Cycle – *READ tool*

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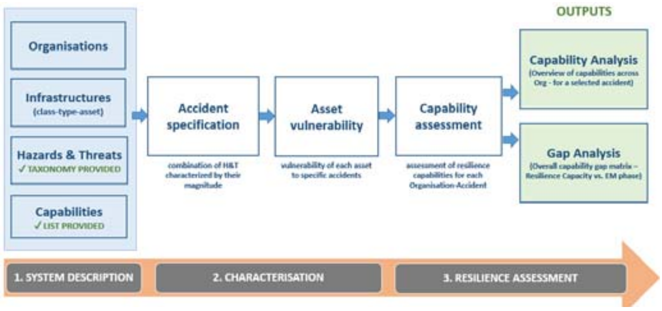
The key features and functionalities of the tool that translates the READ framework for the integration of CI resilience capabilities into the EM set-up are presented.

The tool prototype was implemented in MSAccess™.



1. System and Organisational Context Specification

The characteristics of the system under analysis and the organisations involved in the EM are specified. In this part, the users should go through a few setup steps:

- Specification of each single organization, classified by type and role;
- Specification of the technological infrastructure (Classes, Types and Assets);
- Specification of relevant Hazards & Threats – a taxonomy is provided;
- Documentation of the existing types of capabilities and their classification – a proposed (and editable) list is provided

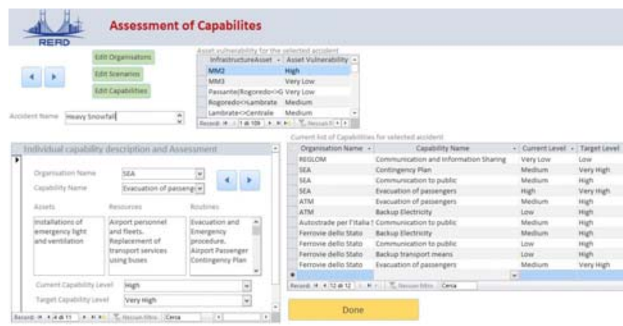
2. Characterisation

Consists of two steps:

- Accident Events Specification, where different possible future events can be described and documented as the scenario of reference for the next assessment and planning phases (e.g. electrical blackout event, heavy snowfall, etc.).
- Asset Vulnerability Analysis, where for each asset its vulnerability is defined for each of the accidents of interest.

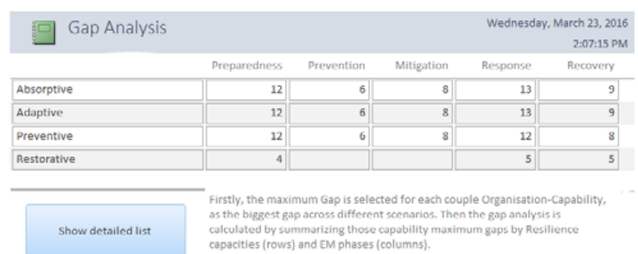
3. Assessment of Resilience Capabilities

Referring to a specific accident event at a time, the users assign different types of capabilities to organizations, describing in which way the capability is specifically implemented in each organisation (assets-resources-routines). An assessment is also given on the current and the target (i.e. desired) level of this capability as planned by the corresponding organization. The capability assessment is done considering the vulnerability of assets to the accident in question.



Capability levels					
Missing	Very Low	Low	Medium	High	Very High
0	1	2	3	4	5

After all the capabilities are assigned to organisations and the assessment completed, it is possible to have an overview of the current state of the overall system. The Resilience Capacity Analysis function shows the distribution of specific capabilities throughout the organization types and levels, as well as their compounds for selected accident events.



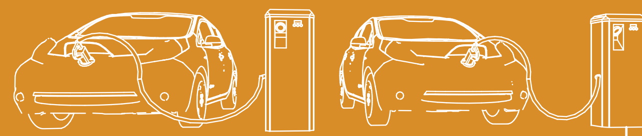
	Preparedness	Prevention	Mitigation	Response	Recovery
Absorptive	12	6	8	13	9
Adaptive	12	6	8	13	9
Preventive	12	6	8	12	8
Restorative	4			5	5

The test case, based on a piece of data collected for preparation of a full pilot case in Lombardy Region (Italy), demonstrated the applicability of the approach and the functionalities of the software tool. The proposed approach and the tool were used to support the preparedness and collaborative planning activities in the context of the public-private partnership on CI Resilience in Lombardy Region. Thanks to a unified model and capability classification, different actors – energy or transport operators, first responders, etc. – were able to represent their resilience capacities in a way that is more understandable by the partners and usable for joint emergency planning. It also demonstrated the power of the proposed approach in fostering multi-agency and multi-stakeholder collaboration, and information sharing.

Learn about the READ project
http://www.read-project.eu

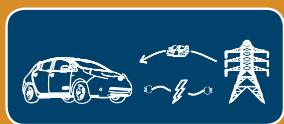
EU Programme 'The Prevention, Preparedness and Consequence Management of Terrorism and other Security-related Risks (CIPS)'

Simulation of an Electric Vehicle Fleet to Forecast Availability of Grid Balancing Resources



Background

Offers fleets of electric vehicles as resources for vehicle-to-grid (V2G) commerce



What is V2G?

V2G technology enables electric vehicles to interact with the electric grid through bidirectional chargers. Batteries of the vehicles serve as shock absorbers for the grid, helping to assure grid frequency subject to short-term (~ 2 seconds) fluctuations of supply and demand.

How does the V2G market work?

V2G fleet operators must commit kW capacity to the grid an hour in advance. This represents a bid. A larger bid allows the vehicle owner to earn a greater profit from this e-commerce transaction. However, failure to meet a committed bid results in penalties.

Why use electric vehicles?

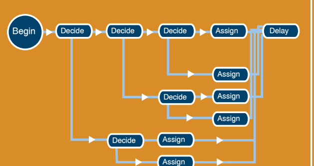
The market for electric vehicles is growing as electrified vehicles are predicted to make up an increasing portion of global car sales in coming years. While engaging in V2G, electric vehicles would generate revenue, thereby offsetting a portion of the initial high cost of electric vehicles and making them more affordable for consumers.

Why use fleet vehicles?

Fleet vehicles can be ideal resources for frequency regulation when they have predictable driving schedules. This is important considering that bids are made before driving schedules effecting available battery capacity are known with certainty. The ability to predict fleet resource availability mitigates the risk of engaging in this type of e-commerce transaction. Additionally, fleet vehicle batteries can be aggregated together to accommodate grid demand.

Approach

Enables grid operators to forecast fleet availability in a complex cyber-physical system



Inputs

Fleet sizes up to several hundred vehicles and logistics/driving schedules were inputs to the model. Schedules are based on observational case studies and fleet-vehicle data consisting of approximately 150 days. Fourteen months of public-signal data for frequency regulation in the mid-Atlantic region were used to model the signal.

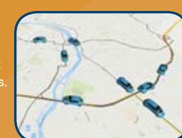
Assumptions

An agent-based simulation was developed with parameters that are adaptable to different fleet operators, operating rules, technology, behaviors, and markets.

- All vehicles in the model are treated as independent and identical.
- Each vehicle has its own charger.
- Vehicles leave for trips between 8AM and 5PM.
- Vehicles travel at a constant speed and the battery depletes at a constant rate.

Design

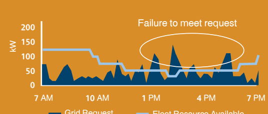
The probability of vehicles leaving the charging station varies based on the hour of the day. The length of the trips are based on 8 different trip archetypes of varying distances. An exponential distribution is used to randomize which trip is taken by each vehicle.



	P(Leave)	x P(Trip Type)	x P(Time at Destination)
(2 mile)	.00952	.417	exp(39.7)
(4 mile)		.083	exp(18.6)
(6 mile)		.167	exp(62.8)
(10 mile)		.000	exp(55.0)
(15 mile)		.083	exp(128.3)
(20 mile)		.083	exp(75.3)
(30 mile)		.083	exp(71.0)
(40 mile)		.083	exp(92.0)

Results

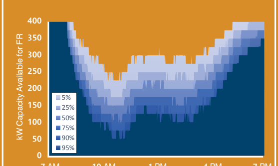
Evaluates risks and opportunities for transactions in the e-commerce market for V2G, with variable demands from grid and fleet operators



The figure above shows periods where available fleet resources are insufficient to meet requests from the regional grid operator.

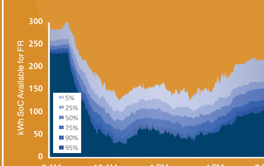
Vehicle kW resources

The power (kW) capacity is a direct function of the number of vehicles at the charging station. In the figure, a darker shade represents higher certainty that a given amount of power will be available for V2G.



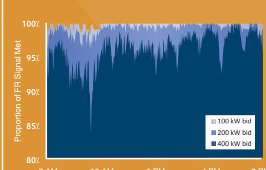
Vehicle kWh resources

The figure shows aggregate battery state of charge (kWh) for vehicles at charging stations over time. Monitoring state of charge provides additional insight because cars may return to stations with too much or too little energy to respond effectively to grid service requests.



Fleet response to grid signal

The figure shows fleet grid service performance over the course of many repetitions, identifying opportunities and risks at different capacity bid amounts.



Conclusion

Assures fleet profitability through an improved forecast of resource availability for grid balancing services

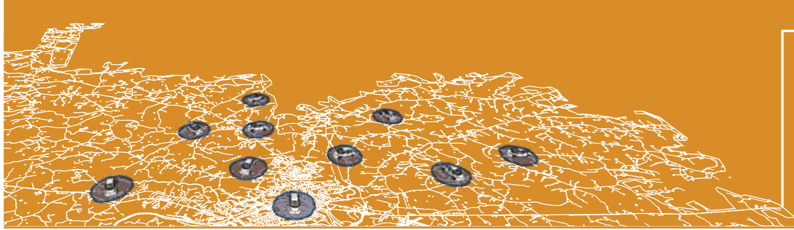
Value added for grid service providers

- Provide the ability to determine whether the available resources are able to accommodate the grid's demand.
- Allow for modifications in order to compare different situations (e.g., varying sizes of fleets and levels of vehicle utilization).
- Evaluate the risk and payoff as a result of increasing bids based on input fleet parameters.

Adapting to volatile markets and technologies

The model can be extended to perform further analysis in these areas:

- Predictive bid optimization.
- Complex charging behavior to increase availability of vehicles for drivers.
- Aid in the planning and mitigation of risk when implementing V2G in emergent conditions such as markets, technologies, logistics schedules, operating rules, and user behaviors.



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Scenario Identification and Analysis for Preliminary Engineering of Erosion Protection in Alaska

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Motivation

"…serious erosion that is threatening the viability of the community, or, in some cases, significant resources are being expended to minimize those threats. The erosion issues in these communities warrant immediate and substantial Federal, State, or other intervention."
– Alaska Baseline Erosion Assessment, March 2009[1]

This project was motivated by the threat of serious damage to the livelihoods and welfare of Alaska communities. Using a multi-criteria project prioritization approach, we have identified the projects and scenarios of emergent conditions that require the most urgent attention. Users of this tool will include *residents, local governments, scientific experts, policy makers and any other stakeholders*.

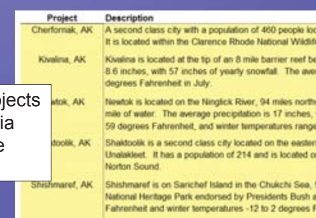
The Alaska Baseline Erosion Assessment provided data and an initial problem statement for use in the decision-aiding automated workbook.

Technical Approach

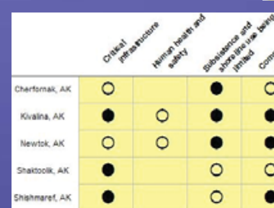
The approach of this effort is to combine multiple criteria decision analysis (MCDA) with scenario analysis in an automated workbook to identify which emergent conditions most impact the severity of coastal erosion among hundreds of Alaska villages.

Criteria	Relevance
Critical infrastructure	***
Human health and safety	***
Subsistence and shoreline use being limited	**
Community setting/geographic location	*
Housing and population	*
Housing in parallel	**
Environmental hazard	***
Cultural importance	*
Commercial/non-residential	**

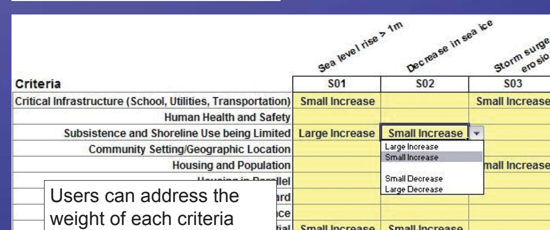
Nine criteria are used in the MCDA tool, and the user can decide the relevance of each.



Over 160 Alaska village projects are scored across the criteria indicating the severity of the potential coastal erosion.



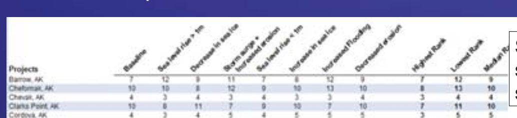
The projects are assessed by the criteria on a scale of *no or low impact, medium impact*, and *high impact* using empty cells, unfilled circles, or filled circles.



Users can address the weight of each criteria under previously defined scenarios.

Results and Discussion

Decision makers can use these results to determine which projects and scenarios require the most attention based on the data input. In the analysis, the highest scoring project indicates that it is the most needful of further engineering efforts. The user can adjust the inputs multiple times in order to gain insight on the effects of the scenarios on the project and scenario prioritization.



Scores and statistics are shown under user-designed scenarios for each project.

Scenario	Rank
Sea level rise > 1m	1
Increased Flooding	2
Decrease in sea ice	3

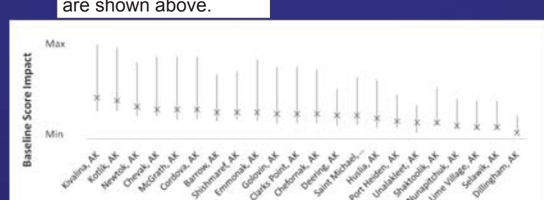
Scenario	Rank
Increased Flooding	5
Storm surge + Increased erosion	6
Sea level rise > 1m	7

The three highest and lowest impact scenarios are shown above.

Baseline Statistics

Ordered Projects	Score	Rank
Kivalina, AK	28	1
Kotlik, AK	26	2
Newtok, AK	22	3
Chevak, AK	20	4
McGrath, AK	20	5
Cordova, AK	20	6
Barrow, AK	18	7
Shishmaref, AK	18	8
Selawik, AK	8	21
Dillingham, AK	4	22

Projects are displayed both by table and graph formats according to baseline rank. The height of the vertical bar in this graph represents the influence of the scenarios to the severity of erosion, and "x" denotes the result under the baseline scenario.



The results include:

- Highest scoring projects
- Lowest scoring projects
- Most influential scenarios
- Least influential scenarios
- Ranges for each project under scenarios
- Orderings of all projects by score/rank
- Orderings of all scenarios by score/rank
- Statistics for projects and scenarios

Highest scoring projects are: (using baseline)		
	1	Kivalina, AK
	2	Kotlik, AK
	3	Newtok, AK
	4	Chevak, AK
	5	McGrath, AK

Lowest scoring projects are: (using baseline)		
	1	Dillingham, AK
	2	Selawik, AK
	3	Lime Village, AK
	4	Nunapitchuk, AK
	5	Shaktoolik, AK

Acknowledgments: The authors thank Dr. Igor Linkov and Laure Canis (ERDC- US Army Corps of Engineers), Bruce Sexauer (Alaska District US Army Corps of Engineers), and Dr. Jeffrey Keisler (University of Massachusetts, Boston) for their guidance and feedback.

[1] U.S. Army Corps of Engineers. (March 2009). *Alaska Baseline Erosion Assessment*. USACE Alaska District, Elmendorf Air Force Base, Alaska, USA.

Prepared for the 2010 Systems and Information Engineering Design Symposium, Charlottesville, VA

Evaluating Preparedness and Resilience Initiatives for Distressed Populations Vulnerable to Disasters in Rio de Janeiro, Brazil

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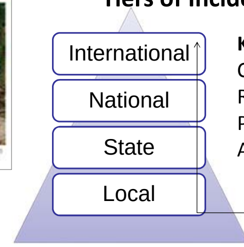
Motivation and Purpose

- The occurrence of landslides in Rio de Janeiro **killed 900 individuals** and resulted in economic **losses exceeding one billion dollars** in 2010-2011 [1].
- Flood losses in recent years have approached **10% of the GDP** of the entire nation [1].
- Our purpose is to **assess** and **develop recommendations** to improve the Brazil plan for **multiple disaster emergencies**.

Background

- The *Defesa Civil* of Rio de Janeiro has implemented programs to address disaster risk reduction [2].

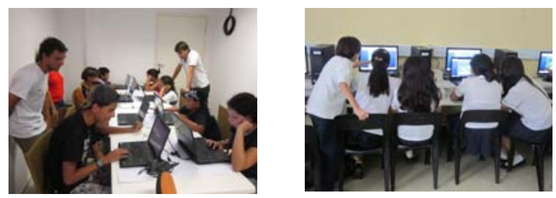
Tiers of Incident Response



Key Response Factors:
Coordination
Risk communication
Public communication
Additional resources

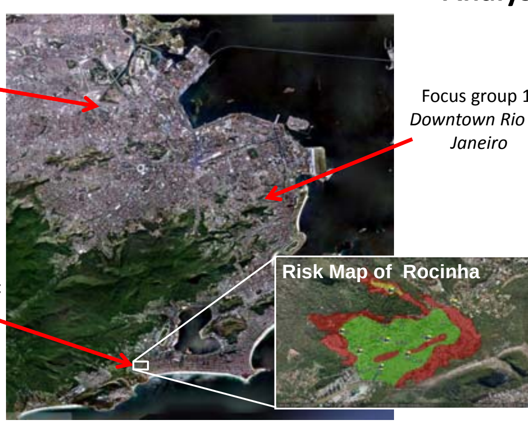
Phases of the Effort

- Study of population behaviors through six hours of focus groups and survey analysis.
- Requirements analysis of Hyogo Framework for Action (HFA) versus the current initiatives of the *Defesa Civil* of Rio de Janeiro [3].
- Scenario analysis of multiple disaster events with prioritization tool.
- Design and simulation of locations of support points (*pontos de apoio*) in favelas.



Focus Groups playing the UN game Stop Disasters Now!

Analyses and Results



6 hours were spent performing focus group exercises with instructional games with residents of favelas in three locations.

Behaviors and Focus Group Analysis:

- Results of the population behavior analysis with focus groups in the favelas allowed for categorization of responses into behavioral scenarios of interest to emergency planners.

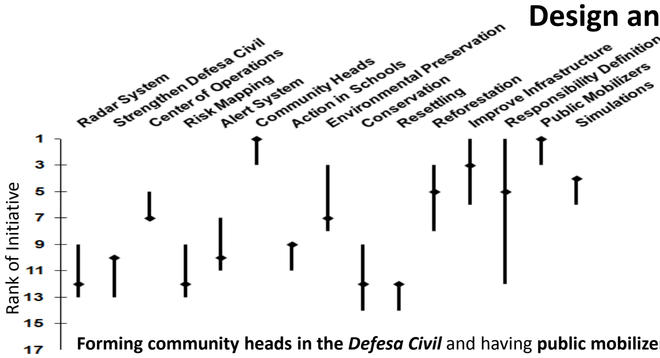
Objectives and Requirements Analysis:

- Requirements analysis of the objectives of the Hyogo Framework and the initiatives by the *Defesa Civil* informed the sensitivity analysis of multiple scenarios performed by the prioritization analysis tool.

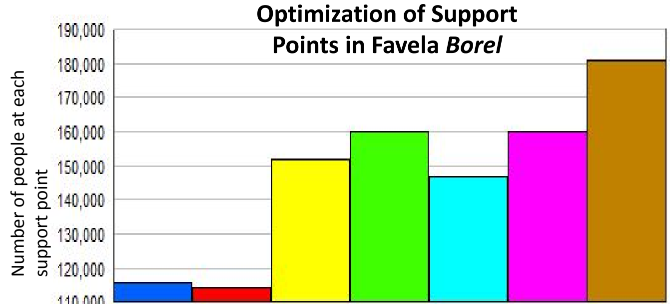
Scenario and Priority Setting Analysis:

- The sensitivity analysis allowed for a comparison of the robustness of initiatives by the *Defesa Civil* to determine which multiple scenario test cases vary significantly from the baseline and the most important initiatives for consideration under a confluence of disaster events.

Design and Implementation



Forming community heads in the *Defesa Civil* and having **public mobilizers** are important to disaster management across all scenarios, the most disruptive of which is a **radiological event occurring during the Olympics**; Length of bar indicates initiative variability to combinations of scenarios.



Some support points are under-utilized while others are over capacity.

References:
[1] Salim, D. (2012, January 24). Brazil to open centre of excellence for disaster risk reduction. Retrieved from http://www.unisdr.org/archive/24792
[2] Defesa Civil do Rio de Janeiro. (2012). *Rio de Janeiro em busca da resiliência a chuvas fortes.* Rio de Janeiro. Retrieved from http://www0.rio.rj.gov.br/defesacivil/
United Nations International Strategy for Disaster Reduction. (2005, January). Hyogo framework for action 2005 - 2015: Building the resilience of nations and communities to disasters. *United Nations World Conference on Disaster Reduction.* Retrieved from http://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hogo-framework-for-action-english.pdf

The authors would like to extends thanks to the Defesa Civil of Rio de Janeiro for their cooperation; the Universidade Federal do Rio de Janeiro for providing extensive background information regarding current efforts in emergency response in Rio de Janeiro; all those involved in the organization of the focus groups including the supervisor of public schools in Rio de Janeiro, the assistant researcher at FIOCRUZ medical research center, and the director of the public library in the favela Rocinha; and the Escola Nacional de Ciências Estatísticas for providing the authors with the necessary coursework for completing their undergraduate degree.

Society for Risk Analysis (SRA)

An international interdisciplinary professional society devoted to risk analysis, including risk perception, assessment, management, and communication

About SRA

The Society for Risk Analysis is a multidisciplinary, interdisciplinary, scholarly, international society that provides an open forum for all those who are interested in risk analysis. Risk analysis is broadly defined to include risk assessment, risk characterization, risk perception, risk communication, risk management, and policy relating to risk, in the context of risks of concern to individuals, to public- and private-sector organizations, and to society at a local, regional, national, or global level. SRA includes numerous regional organizations around the world that provide opportunities for members to interact with other risk analysts near to their homes. SRA also includes many specialty groups for members to interact with risk analysts in their disciplines. A students and young professionals group is devoted to supporting students and recent graduates with an interest in risk analysis.

Goals

- Bring together individuals from diverse disciplines and from different countries and provide them opportunities to exchange information, ideas, and methodologies for risk analysis and risk problem solving
- Foster understanding and professional collaboration among individuals and organizations for the purpose of contributing to risk analysis and risk problem solving
- Facilitate the dissemination of knowledge about risk and risk methods and their applications
- Encourage applications of risk analysis methods
- Promote advancement of the state-of-the-art in research and education on risk analysis
- Provide services to its members to assist them in developing their careers in risk analysis

Our History & Governance

SRA was established in 1980 and has grown significantly since its founding. The Society has held an annual meeting continuously since 1981. SRA's flagship journal, *Risk Analysis: An International Journal*, has been published continuously since 1981 and is the leading scholarly journal in the field of risk analysis.

SRA has a 15-member council that provides oversight of the Society. Councilors are elected by the membership and serve a three year term. Regional organizations and specialty groups have their own leadership with governance structures determined by the organization or group and approved by the SRA Council.

SRA also has a strong code of ethics policy that covers members conducting themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the risk analysis professions.

Our Membership

There are nearly 2,000 members of SRA worldwide. Members are from academia, government, industry, consulting, and non-governmental organizations. This diverse membership makes SRA a particularly relevant forum for the discussion of leading issues in risk analysis.

Specialty Groups

SRA includes 15 Specialty Groups that foster the exchange of information in specific areas. These groups meet at the Annual Meeting and periodically throughout the year, develop thematic conferences and workshops, give student merit awards, and participate in other SRA activities. These groups include:

- Applied Risk Management
- Decision Analysis and Risk
- Dose-Response
- Ecological Risk Assessment
- Economics & Benefits Analysis
- Emerging Nanoscale Materials
- Engineering & Infrastructure
- Exposure Assessment
- Foundational Issues in Risk Analysis
- Microbial Risk Analysis
- Occupational Health and Safety
- Risk and Development
- Risk Communication
- Risk Policy and Law
- Security and Defense

Worldwide Impacts

SRA's regional organizations allow members to interact with colleagues near where they live. A regional organization is a group assembled in any "geographically appropriate" area, which may include a city, country, groups of countries, or other geographic regions. The number of SRA regional organizations is growing; they now operate on six continents and more are being developed.

Membership Benefits

- Be a part of a growing and thriving community characterized by a shared commitment to excellence in risk analysis theory and practice
- Receive copies of the journal *Risk Analysis*
- Receive periodic newsletters to stay up to date on activities of interest
- Join or host SRA sponsored webinars
- Be part of our social media on Twitter or LinkedIn
- Review available educational materials developed by SRA
- Use the membership directory to quickly find contact information for other members
- Attend SRA supported meetings and workshops or conduct workshops with SRA sponsorship
- Students attend a workshop for only $35 *(regularly about $300)*

Who Should Join

Professionals from a wide range of institutions including federal, state, and local governments; small and large industries; private and public academic institutions; not-for-profit organizations; law firms; and consulting groups. Students and Young Professionals are especially welcome. SRA professionals include:

- Risk analysts
- Ecological and environmental scientists
- Economists and management scientists
- Emergency preparedness and response planners
- Engineers
- Health scientists
- Government and regulatory officials
- Journalists
- Lawyers
- Natural and physical scientists
- Policy analysts
- Public administrators
- Safety officers
- Social, behavioral, psychological, and decision scientists
- Statisticians and computational scientists
- Toxicological and pharmacological scientists
- Transportation and infrastructure scientists

Why Join

With 2,000 members globally, the SRA provides an international network, spanning the U.S. and close to three dozen other countries, that will help you connect with risk professionals around the world.

Membership will enable you to:

- Learn about the latest risk-related research, methods and practice
- Become familiar with international, national, and regional policies on risk analysis
- Network and exchange ideas with professionals in the risk analysis field
- Pursue educational opportunities for career development and more….

How to Join

Determine your membership Level:

- Full Membership
- Supporting Membership
- Student Membership
- Reduced Fee Membership

You can join SRA on the website: www.sra.org

SRA

Must (Cyber) Risk Assessments Mean What They Say: Resilience Analytics for Changes of Mind

James H. Lambert

Research Professor, University of Virginia USA

President, Society for Risk Analysis

Prepared for the NATO Workshop on "Resilience-Based Approaches to Critical Infrastructure Safeguarding"

26-29 June 2016, Ponta Delgada, Azores, PORTUGAL

Department of Systems and Information Engineering
University of Virginia

Society for Risk Analysis

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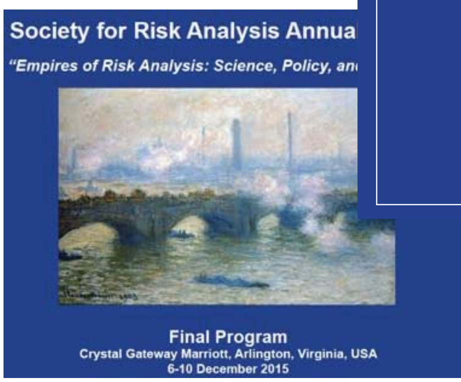
- Australia/ Zealand
- Canada
- China
- Egypt
- Europe
- Japan
- Korea
- Latin America
- Russia
- Taiwan
- Ukraine
- United Kingdom
- …

– Chicago Regional
– Columbia-Cascades
– Eastern Washington
– Metro NY/NJ/CT
– National Capital Area
– New England
– Southwestern and Central Ohio, Northern Kentucky
– Philadelphia
– Research Triangle
– Rocky Mountain
– Southern California
– Upstate New York

www.SRA.org



Acknowledgements

- IEEE Systems Council
- IEEE Systems, Man, and Cybernetics Society
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- US Department of Homeland Security
- US Federal Aviation Administration
- US Army Corps of Engineers
- Virginia Department of Transportation
- Virginia Center for Transportation Innovation and Research
- US DoD Business Transformation Agency
- Society for Risk Analysis
- National Cooperative Highway Research Program
- PIARC World Roads Association
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- Junrui Xu, M.IEEE, Michelle C. Hamilton, M.IEEE, Yue Bi, Daniel K. Codeluppi, Nelson K. Fu, Cherie R. Magennis, Akira A. Powell, Samuel D. Sisto

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- Qian Zhou[1]
- John S. Miller[2]
- Janet L. Clements[4]

[1] Department of Systems and Information Engineering, University of Virginia
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[4] All Hazards Consortium, formerly Virginia Department of Emergency Management

Motivation

Motivation

Risk has been defined …

The measure of the probability and severity of adverse effects.

W.W. Lowrance, *On Acceptable Risk* (1976)

What can go wrong, what are the likelihoods, what are the consequences

Kaplan and Garrick (1981)

What can be done in what time frames, what are the tradeoffs, and what are the impacts of current decisions on future options

Haimes (1991)

The effect of uncertainty on objectives.

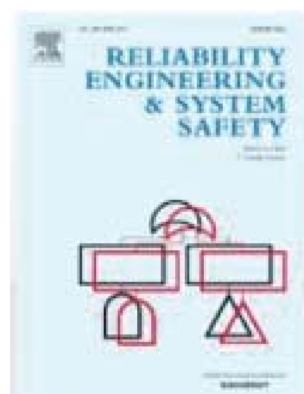
ISO 31000 (2009)

The influence of *scenarios* to *priorities*, particularly *resilience*.

Lambert et al. (2015, 2014, 2013, 2012, 2011, 2010, 2009)

Motivation (cont.)

Risk, safety, and security *programs*



- What risks are addressed
- What are the resources, horizons, regions, organizations, etc.
- How is performance monitored and evaluated

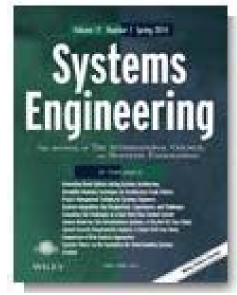
Sources: Teng, Thekdi, and **Lambert** 2012a, 2012b

IEEE Systems, Man, & Cybernetics Society

Motivation (cont.)

Scenarios **are**:

- Projected from stakeholders
- Related to aspirations or advocacy positions



Scenarios are **not**:

- Mutually exclusive or complete
- An event space
- Objective or primitive mathematical constructs
- Necessarily repeatable across experts

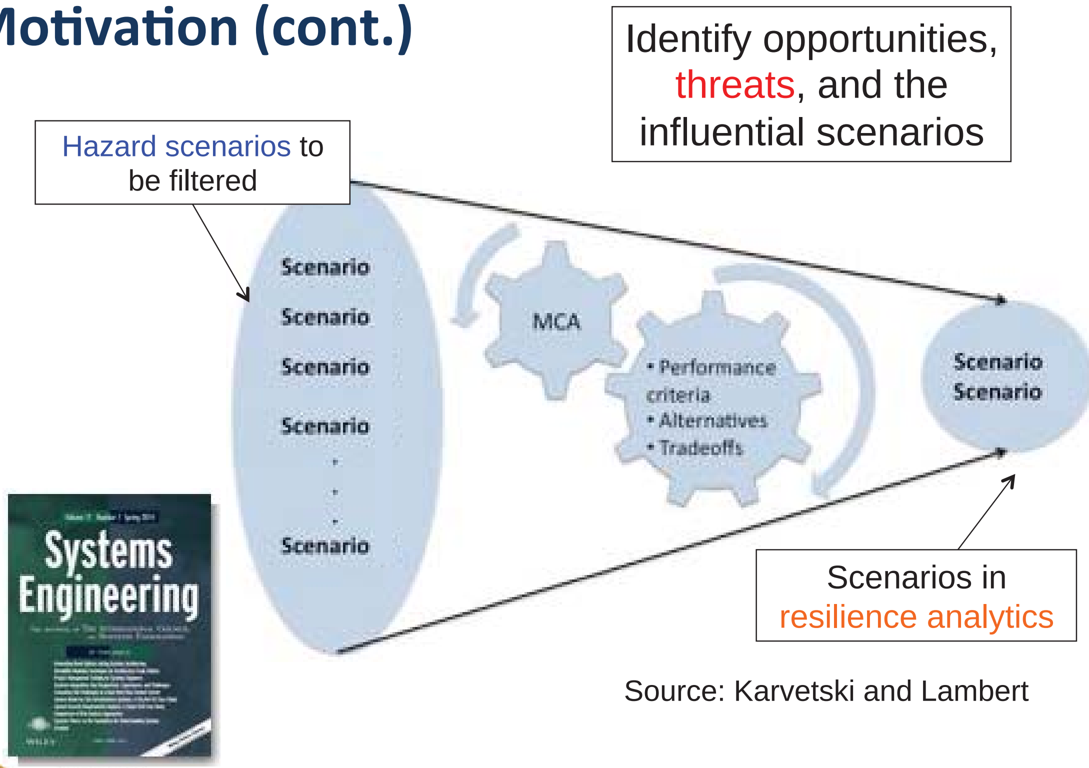
Source: Karvetski and Lambert

Motivation (cont.)

- **Regulatory**
  - New guidelines or increasingly stringent national or international trade policies.
- **Technological**
  - Immediate, unforeseen shifts in the directions of energy technologies (such as nuclear technologies, coal technologies, or promising renewable energy technologies).
- **Geopolitical**
  - Shifts in the geopolitical power relating to fossil fuels and natural gas that influence availability and costs of these energies.
- **Social/Behavioral**
  - Changes in societal viewpoints or lack of acceptance of energy legislation.
- **Climate and others**
  - Disruption of infrastructure services, commercial energy grid failures, destruction of energy systems, and deterioration of energy and other infrastructure systems.

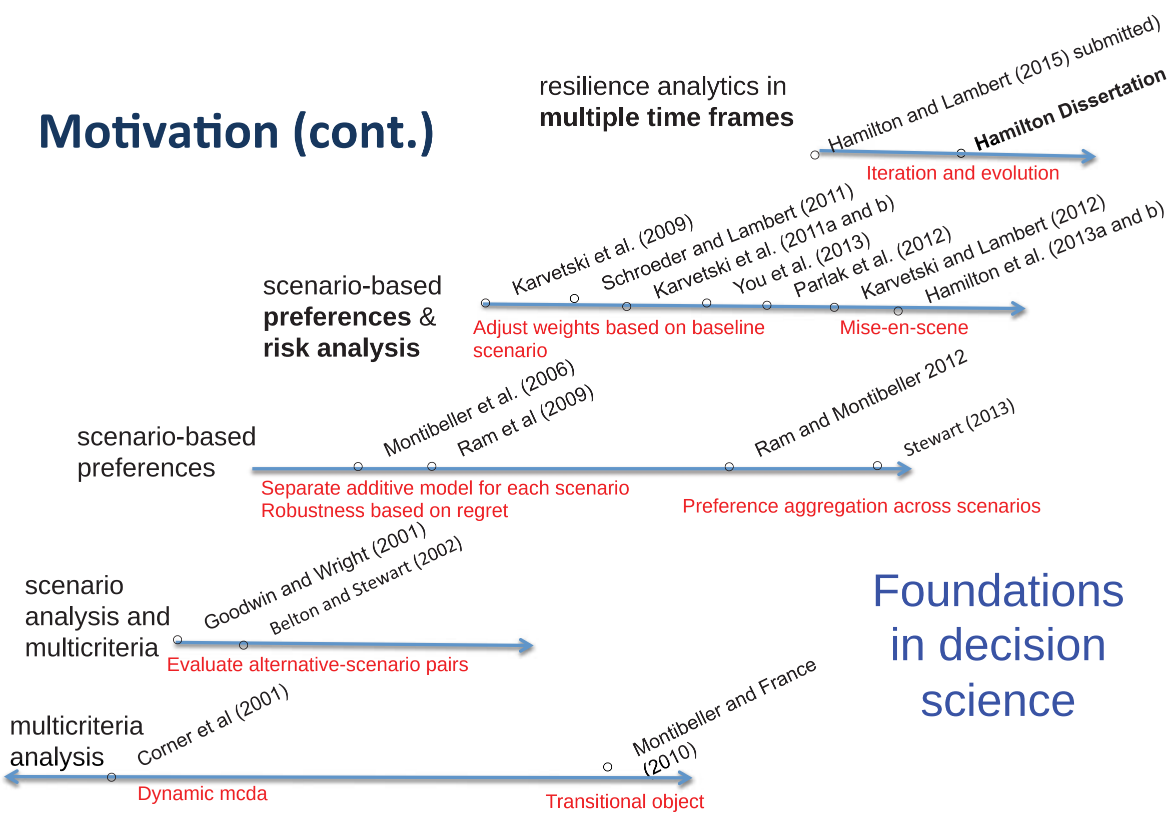
Source: Nakićenović, N. (2000). Energy Scenarios. Chapter 9 in United Nations Development Programme. United Nations Department of Economic and Social Affairs. World Energy Council. World Energy Assessment. New York 2000.

Motivation (cont.)



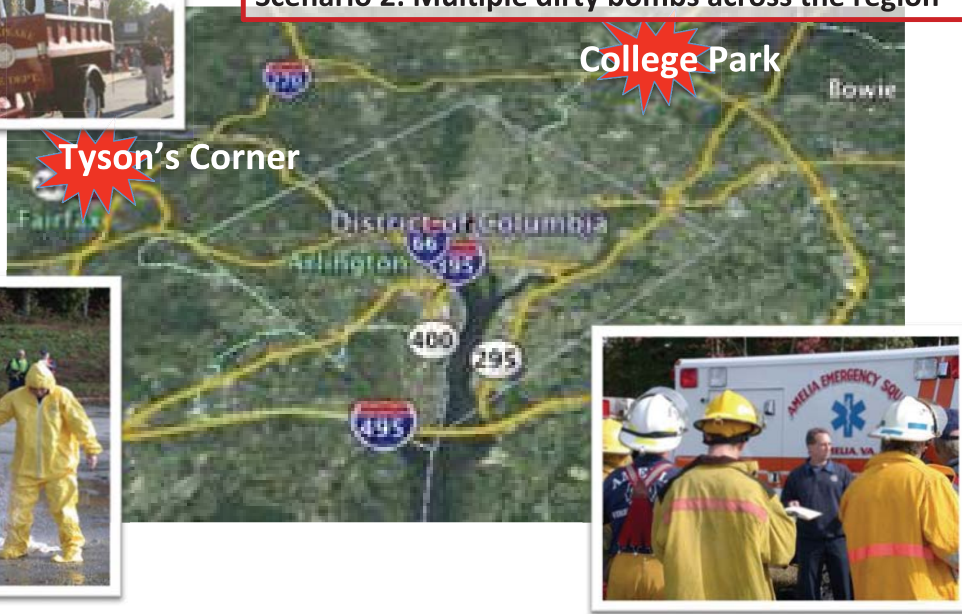
Source: Karvetski and Lambert

Motivation (cont.)

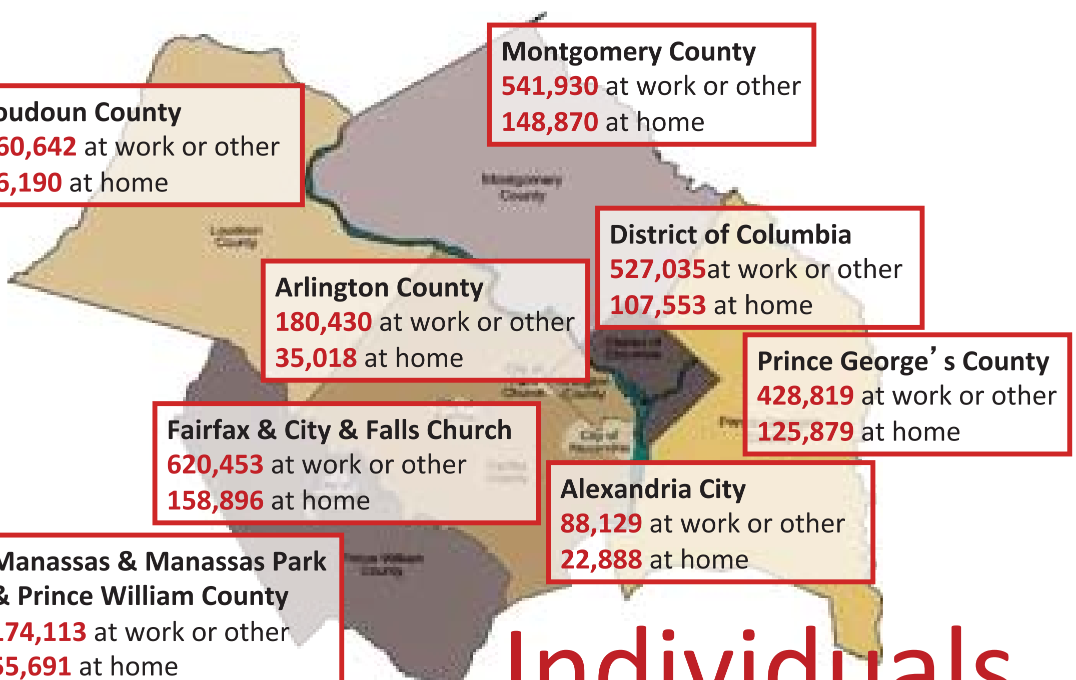


Background

Scenario 1a: One dirty bomb in Tyson's Corner, VA
Scenario 1b: One dirty bomb in College Park, MD
Scenario 2: Multiple dirty bombs across the region

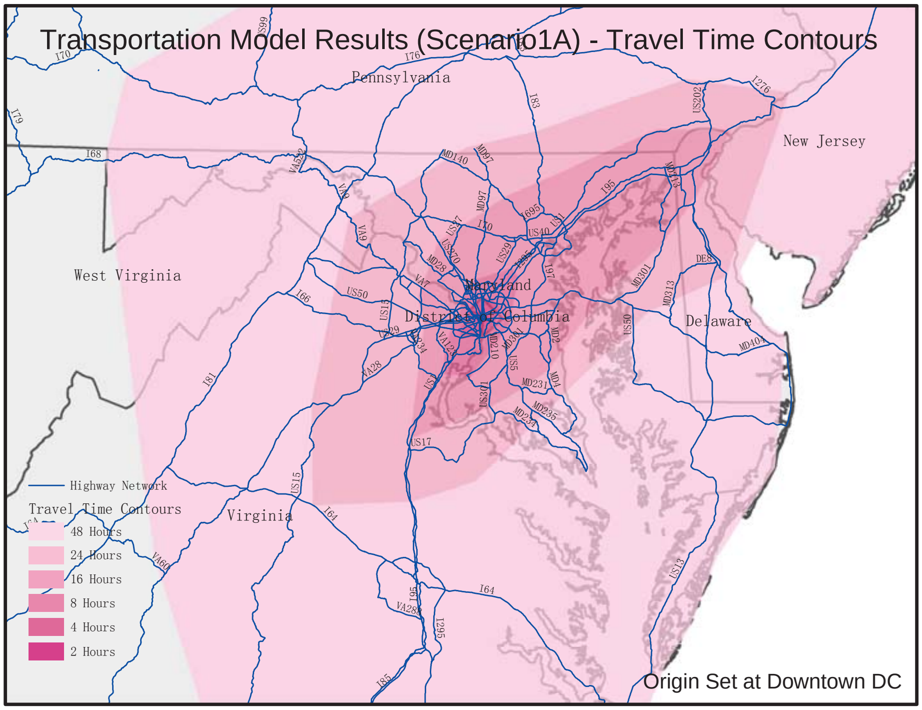


Technical Approach: Evacuation (cont.)



Individuals

Travel times



Technical Approach: Resilience Analytics

S_{01}	**A majority of affected population will lack preparedness and tend to become "walking wounded"**	This scenario assumes that the majority of affected population will lack basic preparedness such as emergency kits including essential medical supplies, food or water. There is large number of people on the streets with minor to medium level injuries.
S_{02}	**A majority of affected population will have limited access and trust in information sources**	This scenario assumes that due to various factors (either because of physica ... l factors such as having ... o information channe ... fully trust in the informa
S_{03}	**A majority of affected population will lack confidence in transportation, energy, communication or other infrastructure**	The affe ... ng the full functio ... ernet, financial services ... .
S_{04}	**A majority of affected population will have unpredictable compliance with shelter in place directions**	After a ... t it is more effectiv ... ected people are not in t ... f the detonated bomb. Affected population may not comply with the orders of shelter in place due to many reasons ranging from psychological impacts to finding a family member.
S_{05}	**Private sector workers will be willing to have unprecedented role in emergency response**	One of the major concerns is about private sector and critical workers. Since most of the critical infrastructure and key resources are operated by private sector, the worker's behaviors have a huge impact on the society. This scenario assumes that workers will not leave their workplaces and the services they provide will be uninterrupted.

Focus is on five key behavioral assumptions

Technical Approach: Resilience Analytics (cont.)

Sample of the thirty preparedness initiatives that were identified through practitioner interviews

1. Improve mobility options for **disabled and special needs populations**
2. Provide **education and training** for citizen emergency preparedness
3. Increase availability of real time public **information and advisories**
4. Improve interoperability of **emergency communications** among first responders
5. Increase stockpiles and availability of **essential medical supplies**
6. Increasing the **shelter availability**
7. Improve planning that facilitates **shelter-in**
8. **-place**
9. Increasing number of **first aid locations** along transportation routes
10. Increase capabilities for **radiological decontamination** at shelters or along transportation routes
11. Increase availability of public information on the **real time conditions of critical infrastructures**

.
.
.

Thirty strategic initiatives

Technical Approach: Resilience Analytics (cont.)

Performance criteria adapted from several sources:
- **National Preparedness Guidelines (2007)**
- **National Incident management System (2008)**
- **National Response Framework (2008)**

- Performance Criteria
  - Major Criteria
    - Public health and safety
    - Estimated cost
    - Public Preparedness
    - Environmental considerations
  - Supporting Criteria
    - Information sharing
    - Coordination across NCR
    - Coordination across ESFs
    - Capacities for sheltering and evacuation
    - Role and performance of private sector
    - Innovation, learning and adaptation

Criteria used for priority-setting among agency initiatives

Technical Approach: Resilience Analytics (cont.)

Initiatives

Criteria

Criteria	Improve mobility options for disabled and special needs populations	Increase emergency public transportation options and capacities	Provide education and training for citizen emergency preparedness	Increase availability of real time public information and advisories	Improve interoperability of emergency communic... among fi...
C.01 Public Health and Safety is addressed by this initiative.	Somewhat Agree	Somewhat Agree	Somewhat Agree		
C.02 Estimated Cost is addressed by this initiative.	Somewhat Agree		Agree	Somewhat Agree	Agree
C.03 Information Sharing and Collaboration is addressed by this initiative.			Strongly Agree	Strongly Agree	Strongly A...
C.04 Planning and Public Preparedness is addressed by...				Somewhat...	

Assessments

$$x_{ji} = \begin{cases} 0 & \text{if initiative i does not adress criterion j} \\ \text{low medium} & \text{if initiative i somewhat adresses crterion j} \\ \text{high medium} & \text{if initiative i adresses criterion j} \\ 1 & \text{if initiative i strongly adresses criterion j} \end{cases}$$

$$\Rightarrow \quad A = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix}$$

Technical Approach: Resilience Analytics (cont.)

The importance(s) of the criteria are re-assessed for each of the five behavioral assumptions

Behavioral assumptions

Criteria

Criteria	A majority of affected population will lack preparedness and tend to become "walking wounded"	A majority of affected population will have limited access and trust in information sources	A majority of affected population will lack confidence in transportation, energy, communication or other infrastructure
C.01 Public Health and Safety	Increases	-	-
C.02 Estimated Cost	Decreases	-	-
C.03 Information Sharing and Collaboration	Increases	Increases	Increases
C.04 Planning and Public Preparedness	Increases		-
C.05 Environmental Considerations	-	-	-

Shifts in importance

$$\alpha = \begin{cases} n & \text{if the importance of criterion i increases with scenario k} \\ 1/n & \text{if the importance of criterion i decreases with scenario k} \end{cases}$$

$$w_i' = \alpha \times w_i$$

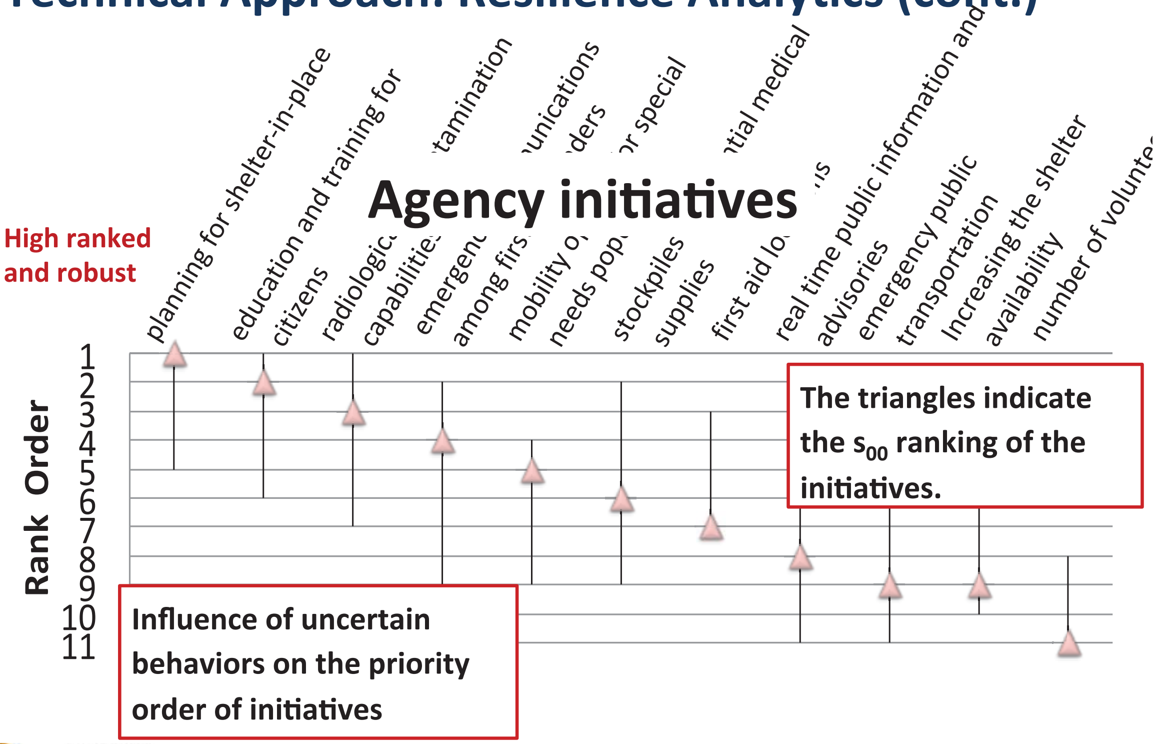
Technical Approach: Resilience Analytics (cont.)

Importance of the criteria are re-assessed (cont.)

Behavioral assumptions

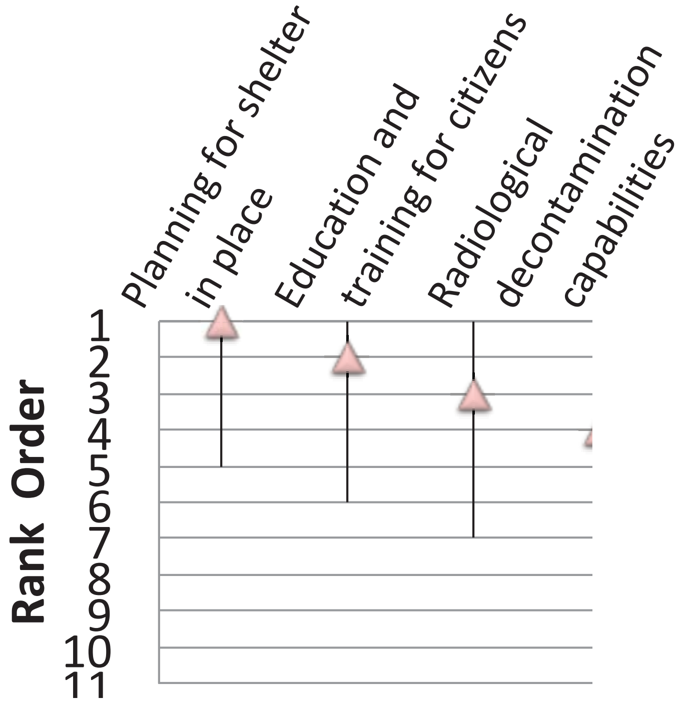
Performance criteria	*A majority of affected population will lack preparedness and tend to become "walking wounded"*	*A majority of affected population will have limited access and trust in information sources*	*A majority of affected population will lack confidence in transportation, energy, communication or other infrastructure*
C.01 Public Health and Safety	Increases	-	-
C.02 Estimated Cost	Decreases	-	-
C.03 Information Sharing and Collaboration	Increases	Increases	Increases
C.04 Planning and Public Preparedness	Increases	-	-
C.05 Environmental Considerations	-	-	-

Technical Approach: Resilience Analytics (cont.)



Technical Approach: Resilience Analytics (cont.)

Top three initiatives and the influence of uncertain behaviors on the priorities.

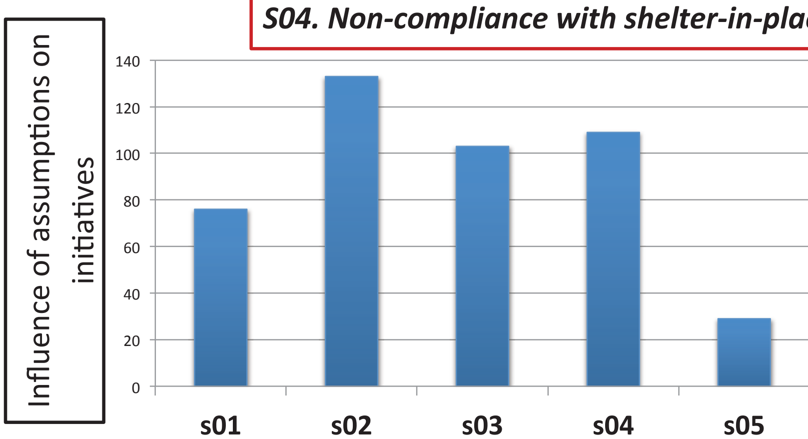


Technical Approach: Resilience Analytics (cont.)

Most influential assumptions are:

S02. ***Access and trust in information sources***

S04. Non-compliance with shelter-in-place orders



Least influential assumption is:

S05. ***Workplace behaviors of critical workers***

Technical Approach: Resilience Analytics (cont.)

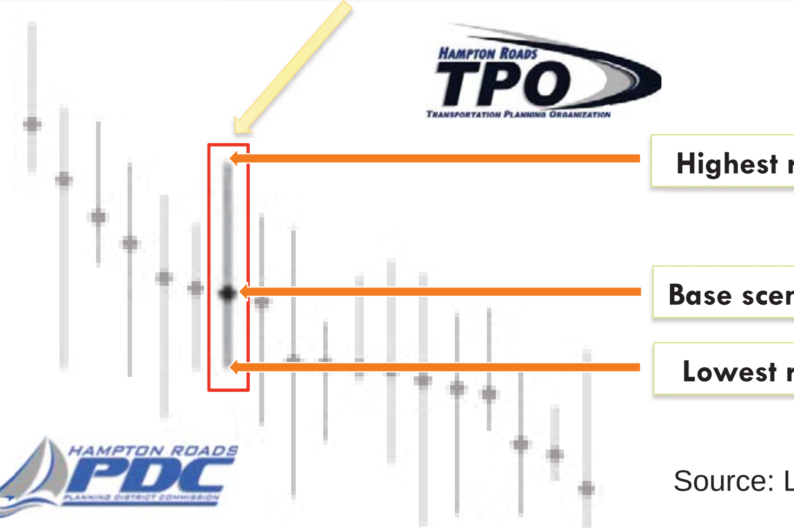
Other key results

Highest ranked initiatives	Provide **education and training** for citizen emergency preparedness Improve planning that facilitates **shelter-in-place** Increase capabilities for **radiological decontamination** at shelters or along transportation routes
Lowest ranked initiative	Increasing **number of volunteers** to help in case of emergency
Greatest increase in rank relative to no-scenario	Increase availability of **real time public information** and advisories
Greatest decrease in rank relative to no-scenario	Improve interoperability of **emergency communications** among first responders

Further Demonstrations of Resilience Analytics

Priorities for Transportation Projects

Perspective: Priority-Setting in Long-Range Strategic Plans



Source: Lambert et al. 2013

Priorities for Projects (cont.)

Dam Neck Road

Baseline Ranking	**18**
Highest Ranking	3 (S5. Traffic Scenario)
Lowest Ranking	20 (S4. Ecology Scenario)
Influential Criterion	PU-HW.C1 Congestion Level

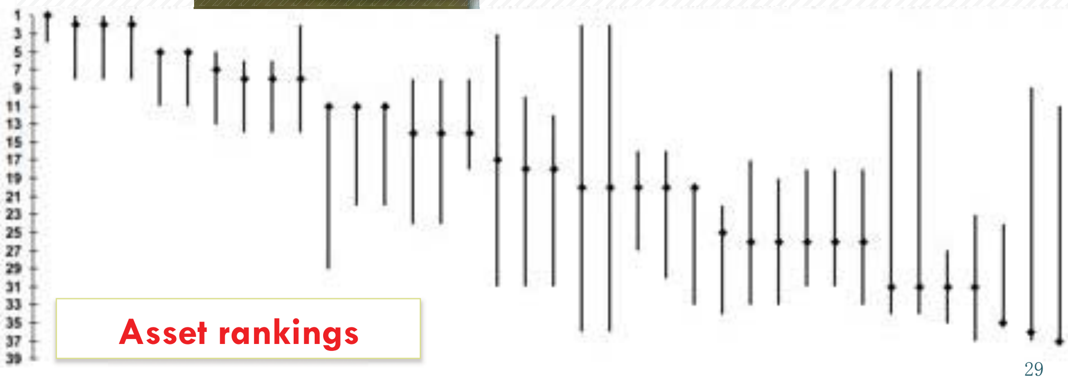
Laskin Road

Baseline Ranking	**20**
Highest Ranking	15 (S1. Climate Scenario)
Lowest Ranking	42 (S2. Economy Scenario)
Influential Criterion	PU-HW.C3 Cost Effectiveness

Priorities for Asset Management

Perspective: Priority-Setting of Infrastructure Assets

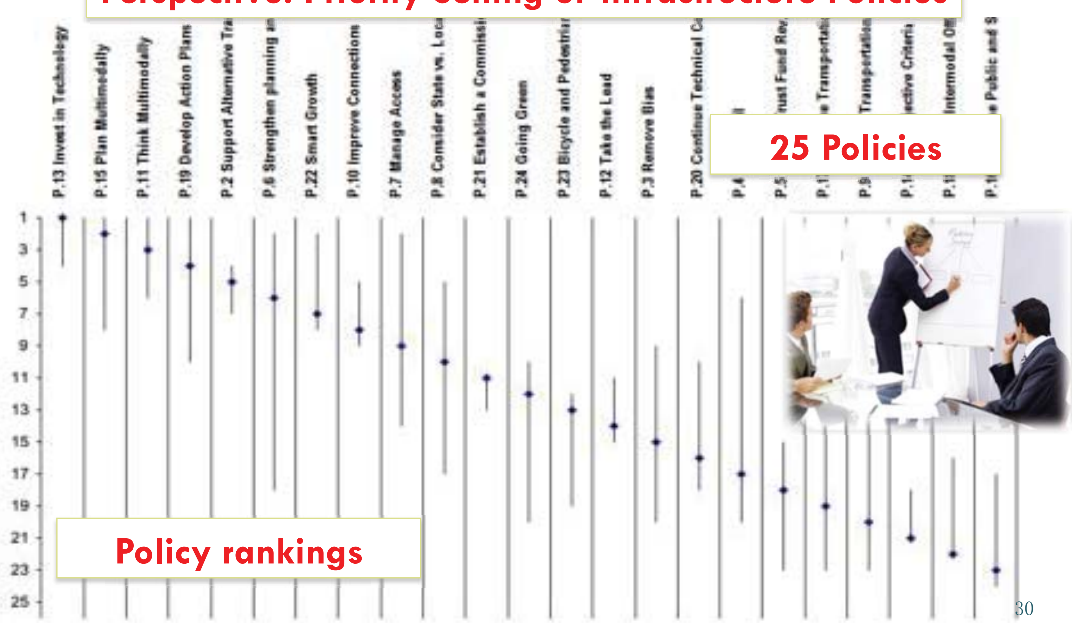
37 Assets



Asset rankings

Priorities for Agency/Industry Policies

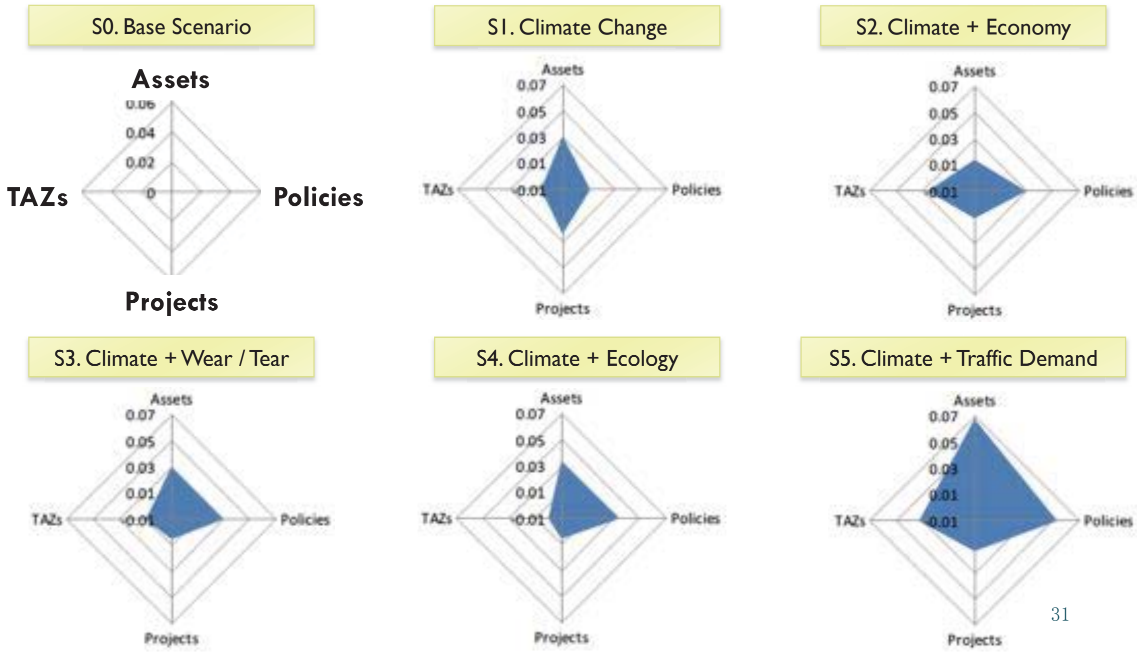
Perspective: Priority-Setting of Infrastructure Policies



25 Policies

Policy rankings

Climate and Other Emergent Conditions

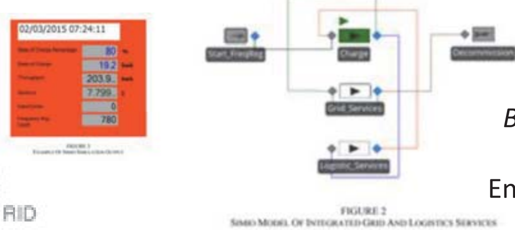


31

Vehicle-to-Grid Technology Roadmap

VEHICLE

2

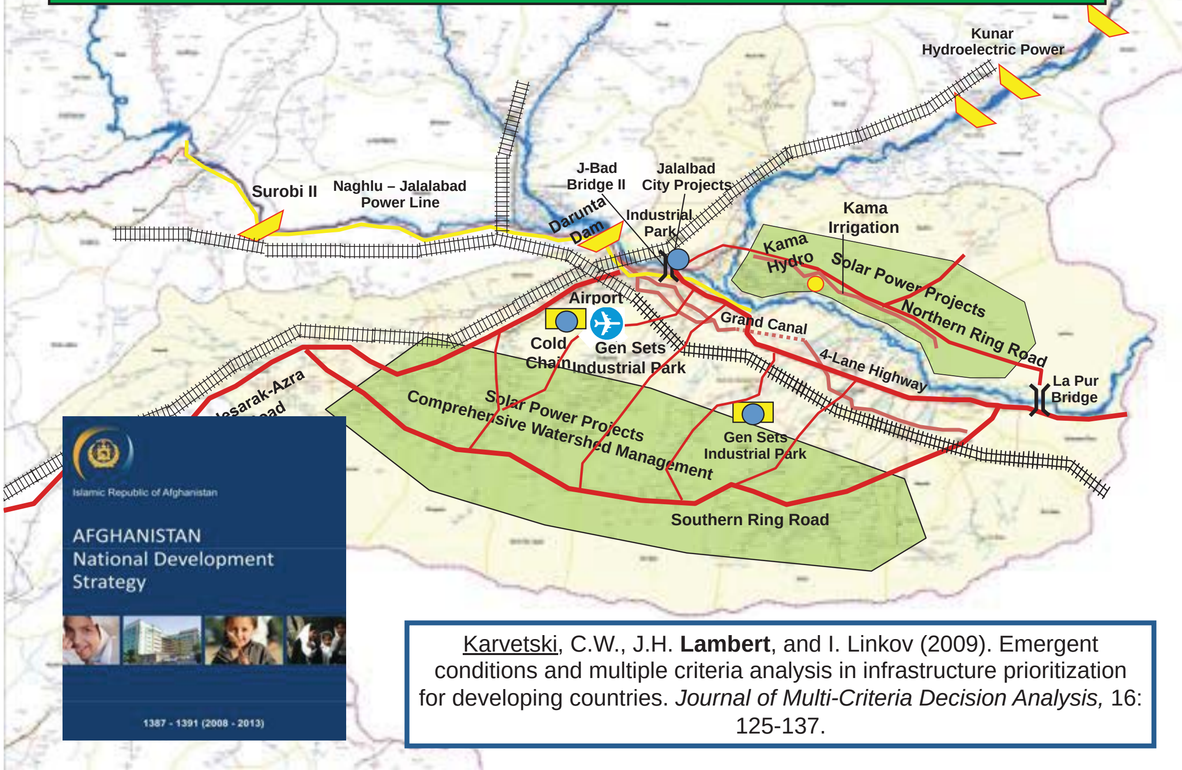


Best Paper Award, 2015 IEEE Systems and Information Engineering Design Symposium

GRID

DEPARTMENT OF SYSTEMS AND INFORMATION ENGINEERING
UNIVERSITY of VIRGINIA

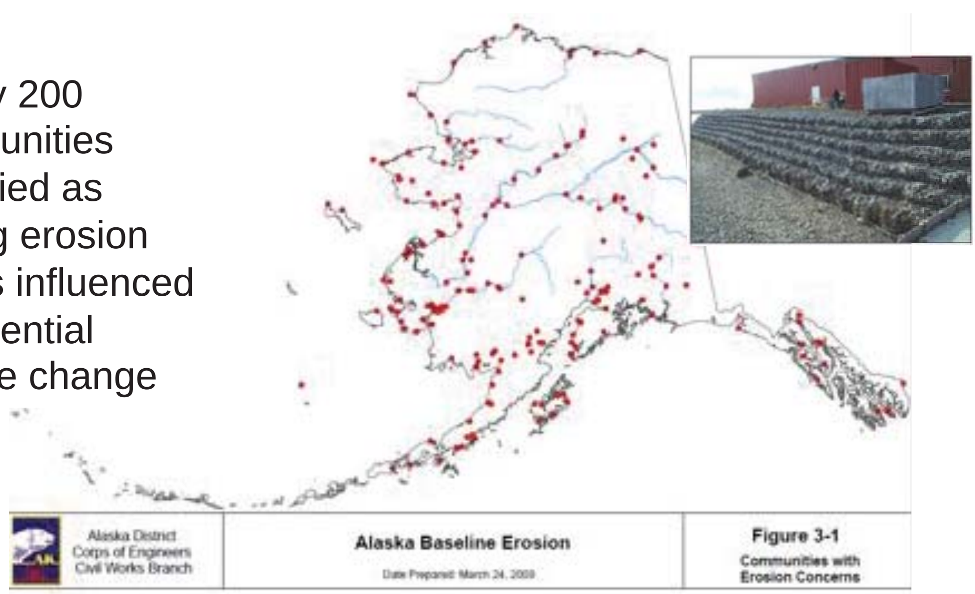
Afghanistan Sustainable Infrastructure Plan



Karvetski, C.W., J.H. **Lambert**, and I. Linkov (2009). Emergent conditions and multiple criteria analysis in infrastructure prioritization for developing countries. *Journal of Multi-Criteria Decision Analysis,* 16: 125-137.

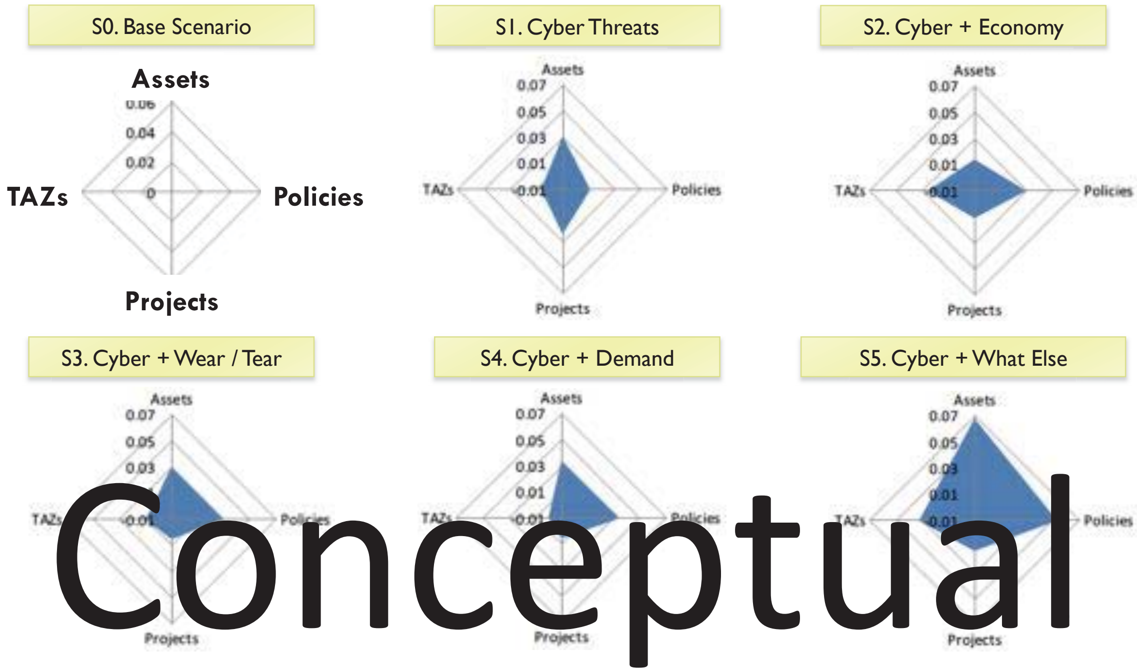
Alaska USA Coastal Erosion

Nearly 200 communities identified as having erosion issues influenced by potential climate change



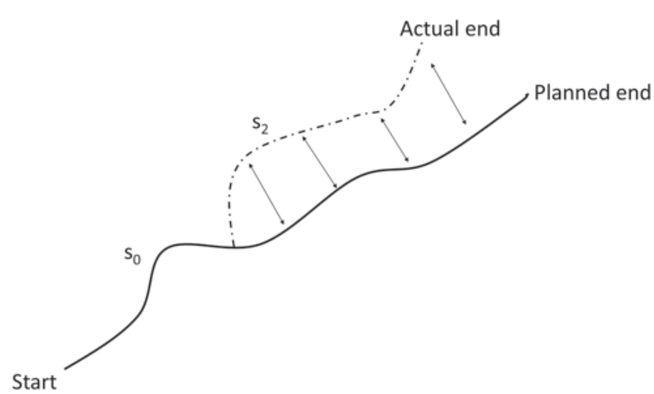
Karvetski, C.W., J.H. **Lambert**, J.M. Keisler, B. Sexauer, and I. Linkov. 2011. Climate change scenarios: risk and impact analysis for Alaska coastal infrastructure. *Int. J. Risk Assessment and Management*, 15(2/3): 258–274.

Cyber-Threats and Other Emergent Conditions



Conclusions

Cyber disruptions inform resilience, the disruption and evolution of priorities in time.



c)

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+1 434 531 4529

www.people.virginia.edu/~jhl6d

Download beta versions of software:

www.virginia.edu/crmes/energysecurity/

www.virginia.edu/crmes/fhwa_climate

NATO OTAN Advanced Research Workshop

Resilience-Based Approaches to Critical Infrastructure Safeguarding

Igor.Linkov@usace.army.mil

SRA

factor SOCIAL PSICOLOGIA E AMBIENTE

ETH zürich (FRS) FUTURE RESILIENT SYSTEMS 未来韧性系统

DECISION PARTNERS

Previous NATO Meetings

- 1997 – Magnitogorsk, Russia
  – Risks of Air Pollution
- 1998 – Kiev, Ukraine
  – Contaminated Forest/ Radiation Ecology
- 2000 – Lisbon, Portugal
  – Risk Assessment and Management; Application in developing countries
- 2002 – Anzio (Rome), Italy
  – Comparative risk assessment (CRA); Applying CRA to Middle Eastern environmental problems
- 2004 – Eilat, Israel
  – Environmental Security, Risk Assessment and Decision Analysis, Middle East
- 2005 – Thessaloniki, Greece
  – Environmental security in coastal areas
  – Risk assessment & security; contaminated sediments; invasive species & coastal restoration
- 2006 - Venice, Italy
  – Environmental security at ports and harbors
  – Critical Infrastructure, Decision Analysis, Environmental Security
- 2007 - Lisbon, Portugal
  – Decision Making and Risk Assessment tools and applications to emerging threats
- 2008 – Carvoeiro, Portugal
  – Nanotechnology Risk Assessment
- 2010- Reykjavík, Iceland
  – Climate Change Adaptation
- 2012- Reykjavík, Iceland
  – Sustainable Cities and Military Installation
- 2016- Azores, Portugal
  – Risk and Resilience

ARW Goals

- Develop framework for Resilience Analysis (including Resilience Assessment and Management), compare and contrast with Risk Analysis
- Focus on resilience quantification and policy
- Define how resilience assessment and management strategies can be integrated into management plans for critical infrastructure
- Identify specific research needs for integrating resilience and risk in the face of global change

- **Co-Directors**
  - Igor Linkov, U. S. Army Corps of Engineers, USA
  - Bojan Srdjevic, University of Novi Sad, SERBIA
  - Jose Palma-Oliveira, University of Lisbon, PORTUGAL
- **Support**
  - Valerie Zemba and Ben Trump (US Army Corps)
  - Dalila Antunes and Claudia Rodrigues (Factor Social)
  - Francisco Daniel (By Travel)
  - Sarah Thorne and Linda Murphy (Decision Partners)

ARW Process

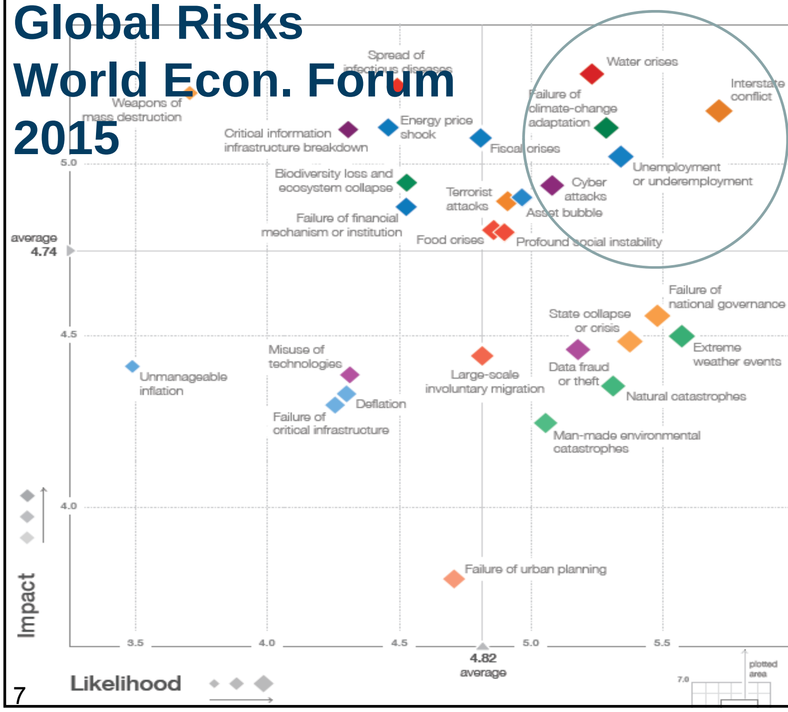
- Summarize state-of-the science in areas related to resilience and risk with focus on critical infrastructure
  - Summary presentation during workshop
  - Summary chapters after the workshop
  - Book based on the workshop
- Identify problems and propose solutions/ analytical methods
  - Working Group and Panel Discussions
- Establish collaborative teams and possible projects (including NATO ARWs)
- Have fun!

Outline

- Resilience vs Risk
  - Known Threats vs Unknown Threats and Critical Functions
  - System vs. Component, Temporality, Thresholds
- Science of Resilience?
  - Qualitative/Process
    - Resilience Abilities, Resilience Properties, Deficiencies
  - Quantitative
    - Metrics, Indices, Matrix, Network Science
- Summary of 2015 Aspen Workshop: Tiered Approach to Resilience Analysis
- Current Work at the USACE Approach
- NATO ARW Agenda

Global Risks World Econ. Forum 2015

Emerging Global Risks

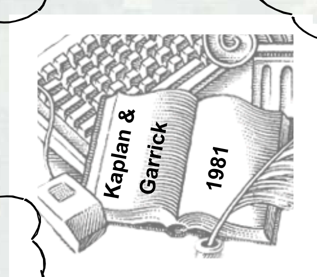


7

Risk Assessment Formulation

What can happen (go wrong)?

How likely is it?



What are the consequences?

Shortcomings of current risk-based approach to policymaking

- Focus on estimating the **probability** and **severity** of adverse effects
  - Assumes that hazards are identifiable with **known** or **quantifiable probabilities** of occurrence

Probability \ Severity	Low	Medium	High
High	Medium risk	High risk	High risk
Medium	Low risk	Medium risk	High risk
Low	Low risk	Low risk	Medium risk

Low risk · Medium risk · High risk

- Unable to account for:
  - **low-probability high-consequence events** that are unpredictable or unknowable
  - evolutions of threats and societal values over **the long-range timeframe**

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

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

Over the last few decades, our Nation has grown increasingly dependent on critical infrastructure, the backbone of our national and economic security. America's critical infrastructure is complex and diverse, combining systems in both cyberspace and the physical world -- from power plants, bridges, and interstates to Federal buildings and the massive electrical grids that power our Nation. During Critical Infrastructure Security and Resilience Month, we resolve to remain vigilant against foreign and domestic threats, and work together to further secure our vital assets, 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.

"Resilience" has been defined differently across fields

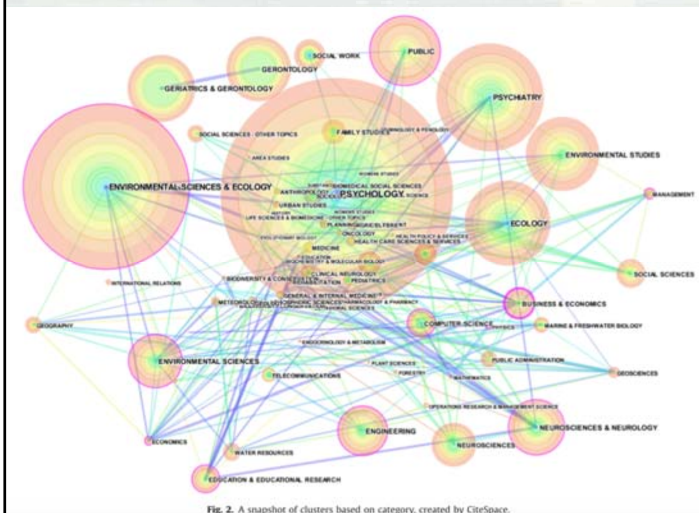
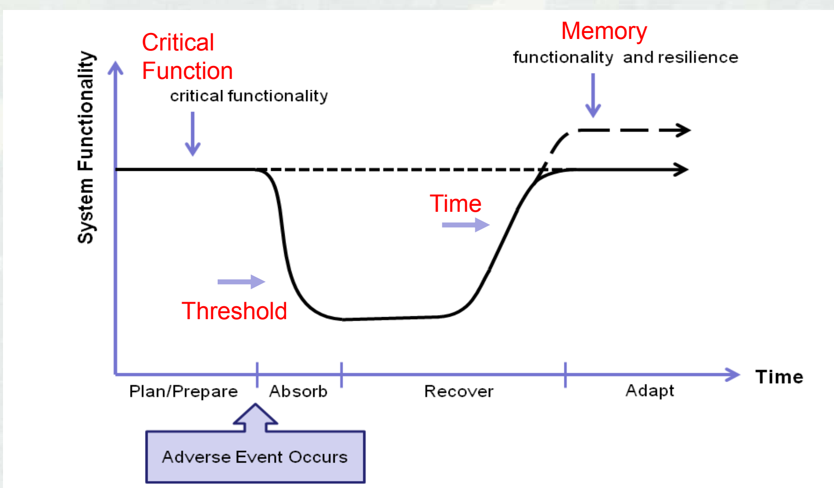


Fig. 2. A snapshot of clusters based on category, created by CiteSpace.

There is a need for resilience concepts that transcend the variety contexts and application domains

Image source: Hosseini, S., Barker, K., and Ramirez-Marquez, J.E. (2015). "A Review of Definitions and Measures of System Resilience." *Reliability Engineering & System Safety* 145 (August): 47–61.

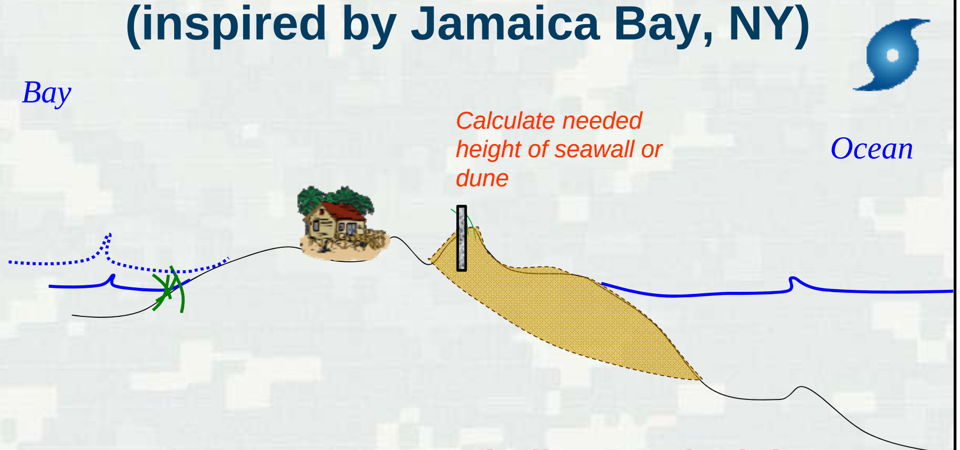
2015 Aspen Meeting: Resilience Formulation



After Connelly et al., 2016

	Resilience Feature	Socio-Ecological	Psychological	Organizational	Engineering & Infrastructure
Prepare/Plan	**Critical function**	A system function identified by stakeholders as an important dimension by which to assess system performance			
		Ecosystem services provided to society	Human psychological well-being	Goods and services provided to society	Services provided by physical and technical engineered systems
Absorb	**Threshold**	Intrinsic tolerance to stress or changes in conditions where exceeding a threshold perpetuates a regime shift			
		Used to identify natural breaks in scale	Based on sense of community and personal attributes	Linked to organizational adaptive capacity and to brittleness when close to threshold	Based on sensitivity of system functioning to changes in input variables
Recover	**Time**	Duration of degraded system performance			
		Emphasis on dynamics over time	Emphasis on time of disruption (i.e., developmental stage: childhood vs adulthood)	Emphasis on time until recovery	Emphasis on time until recovery
Adapt	**Memory/Adaptive Management**	Change in management approach or other responses in anticipation of or enabled by learning from previous disruptions, events, or experiences			
		Ecological memory guides how ecosystem reorganizes after a disruption, which is maintained if the system has high modularity	Human and social memory, can enhance (through learning) or diminish (e.g., post-traumatic stress) psychological resilience	Corporate memory of challenges posed to the organization and management that enable modification and building of responsiveness to events	Re-designing of engineering systems designs based on past and potential future stressors

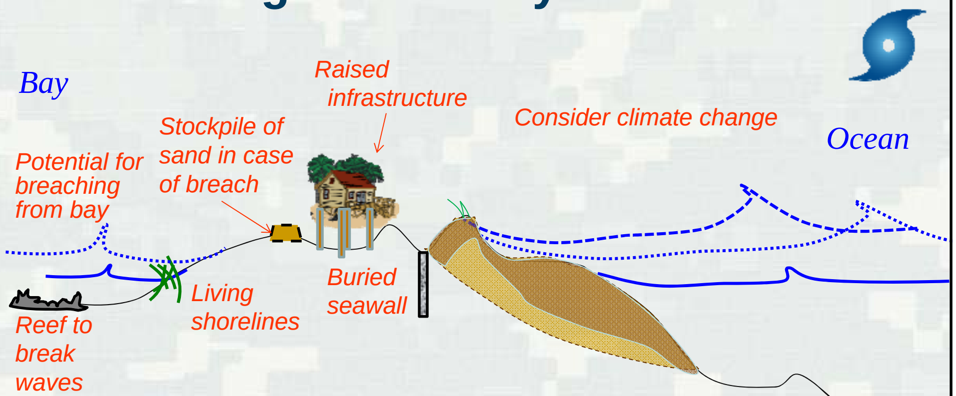
Component vs. System (inspired by Jamaica Bay, NY)



RA – Focus on Finding Weak Link:

14

Management at System Level



- Anticipate weak links and be ready to recover. *Ex: sand to close new inlets.*
- Provide diverse and redundant protection. *Ex: buried seawall AND beach/dune system.*
- Ensure availability of alternate networks. *Ex: multiple electrical power circuits.*
- Provide accessible information for rapid decision-making. *Ex: raised homes, evacuation routes*

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Critical Function – Stakeholder Engagement

- System has multiple functions, but not all of them are equally important
  - Stakeholder elicitation is required
  - Prioritization of project alternatives
  - Values, preferences
  - Public education

"We want to include you in this discussion without letting you affect it"

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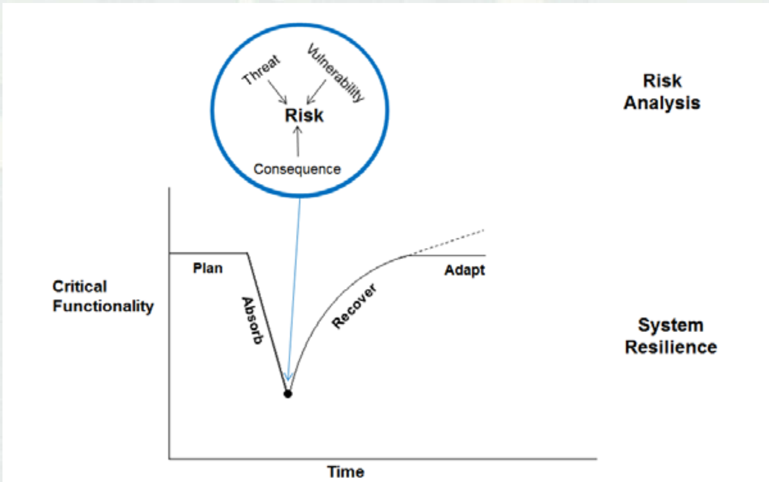
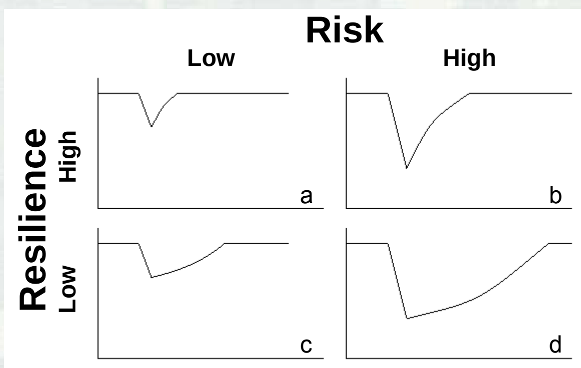
Risk and Resilience: Thresholds



After Linkov et al, Nature Climate Change 2014

Importance of Recovery



Traditional risk management focuses on planning and reducing vulnerabilities. Resilience management puts additional emphasis on speeding recovery and facilitating adaptation.

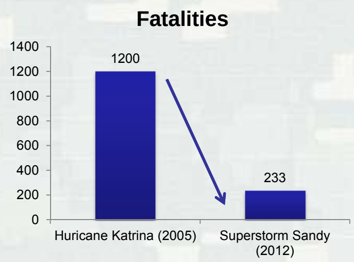
After Linkov et al, Nature Climate Change 2014

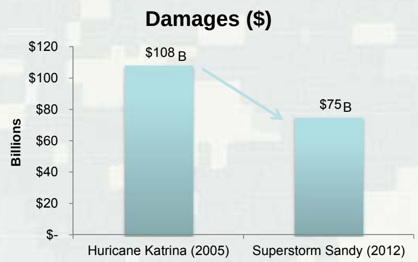
Paradigm shift from risk-based to resilience-based policymaking

Risk (Reduction) → **Resilience (Enhancement)**

Risk (Reduction)
- Preparing for potential disruptions
  - Disruptions are identifiable and predictable
- Hardening of infrastructure systems to threats

Resilience (Enhancement)
- Preparing for *recovery* from potential disruptions
  - Disruptions are unknown, low-probability events
- Flexibility of infrastructure systems



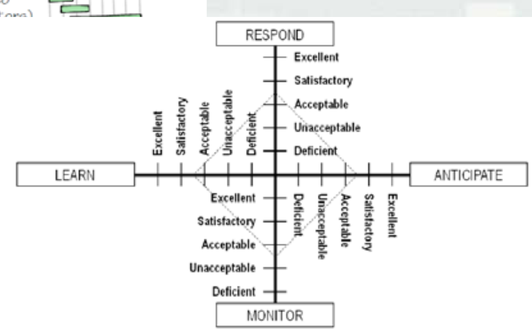


Risk-Resilience Integration

Top-Down Decision Analysis/Social Science		Bottom-Up Risk Assessment/ Physical Sci
Goal Identification and Problem Framing - *What are the goals, alternatives, and constraints?*	Management	**Risk Characterization** - *What are the risks relative to a threshold? How do they compare to other alternatives?*
Decision Model - *What are the criteria and metrics, How do we measure decision-maker values*	Modeling	**Physical/Statistical Model** - *What is the hazard? What is exposure?*
Metrics Generation and Alternative Scoring - *How does each alternative score along our identified criteria and metrics?*	Data Collection	**Data Collection** - *What are fundamental properties/mechanisms associated with each alternative?*

Linkov et al., 2014

Resilience Abilities for an Organization



After Hollnagel, 2011

Resilience as a Process

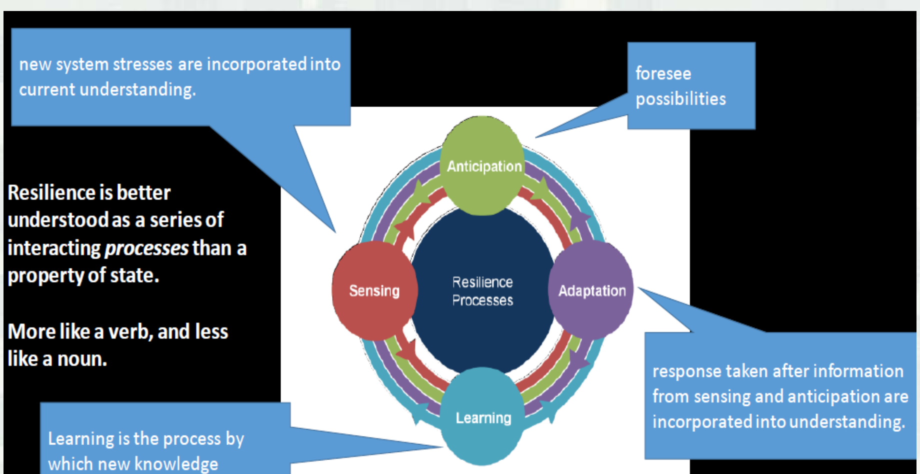
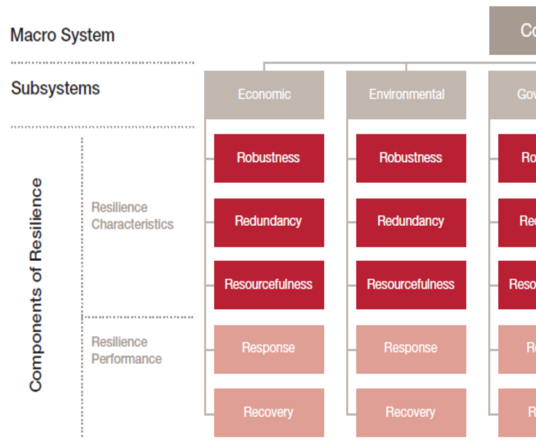


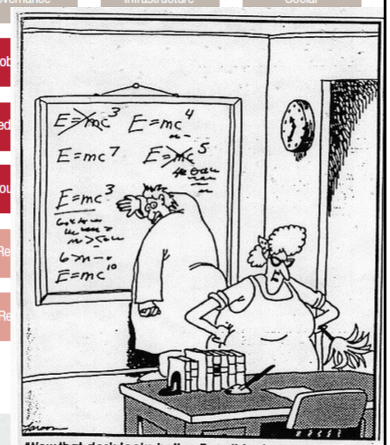
Figure 5.2. Schematic representation of the recursive process which leads to emergence of resilience in complex systems. The arrows in the figure do not necessarily mean a particular sequence between linked processes (Park et al., 2013).

Resilience as 3R, 4R, 5R…?

Figure 1 What is resilience?



Source: World Economic Forum



"Now that desk looks better. Everything's squared away, yessir, squaaaaaaared away."

UNISDR

The United Nations Office for Disaster Risk Reduction

Resilience Metrics

The Disaster Resilience Scorecard for Cities

Engage, Share Understanding and Coordinate

Essential 1: Put in place organization and coordination to understand and reduce disaster r civil society. Build local alliances. Ensure that all departments understand their role in disa

This section of the scorecard will help you assess the structure and governance of the various act prediction, mitigation, response, restoration and recovery. It looks "top-down", on the coordina that may be involved; "bottom up", on the management of and engagement with grass roots disa integration with other initiatives that may have a disaster resilience impact.

Data you will need to answer this section of the scorecard will include: organization charts; list applicable, MOUs and other role descriptions for each organization concerned; names of key ind from the organizations concerned.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measur
1.1 Organization and coordination	1.1.1 Co-ordination of all relevant pre-event planning and pr th ro al	Presence of organizational chart documenting structure and role	5 – Single point of exists with agreed

Page 5 of 56

Table 1. Recommended core performance metrics by coastal feature for Department of the Interior Resilience projects funded through the Disaster Relief Recovery Act of 2013.

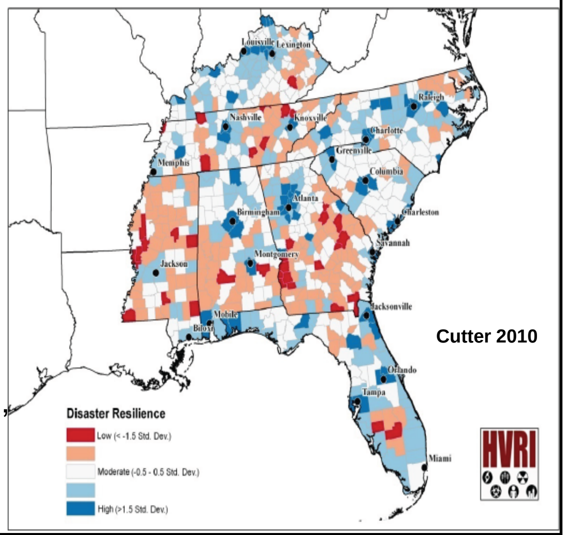
Natural and Artificial Coastal Features	Primary Objectives and Ecosystem Services	Recommended Core Performance Metrics
Beach System: Beach/Barrier Island/Dune	Beaches and Dunes: 1) Restore or improve beach habitat to enhance resilience of fish, wildlife, and plants, and their habitats (e.g., spawning, migration stopovers, critical habitats) 2) Restore/improve dune habitat to enhance resilience of coastal infrastructure by reducing flooding extent and attenuating wave energy 3) Improve/sustain beach/barrier island ecosystem and community resilience to storm surge events 4) Enhance understanding of natural system dynamics including immediate storm responses, natural recovery from disturbance events, and natural adaptation capacities and tendencies. 5) Improve recreation/aesthetics Breaches: 1) Manage breach occurrences to maximize habitat and hazard mitigation benefits at least cost	Beaches and Dunes: Biotic • Vegetation cover of dunes pre and post event • Fish and wildlife population/ recruitment/ overwintering/stopover weight/health relative to other mitigating factors (e.g. other threats throughout range: site and species specific) Abiotic • Post-storm volume of sand in the active shoreface • Recovery rates of beach and dunes Structural/Engineering • Beach width, elevation, volume, shoreline position (post-event) • Dune characterization (height, width, length, texture, substrate) Breaches: Biotic • Fish and wildlife population/ recruitment/ overwintering/ stopover weight/health changes relative to other mitigating factors (e.g. other threats throughout its range: site and species specific)

USGS

science for a changing world

Resilience Indices

- Demographic data as indicators of scale of vulnerability and resilience/ ability to recover quickly.
- Metrics in categories of : social, economic, institutional, infrastructure, and community.
- All categories equally weighted.
- Regional assessment, county level resolution.
- Spatially reported results, comparative.
- All hazards assessment



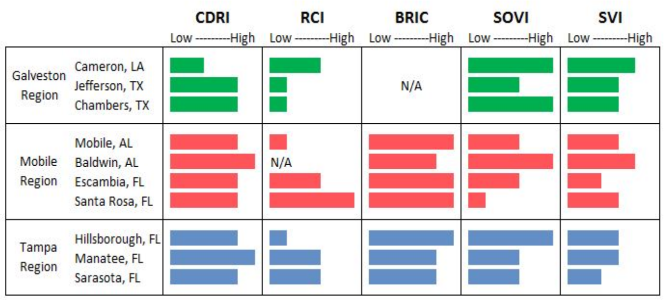
Cutter 2010

Weaknesses of Existing Methods

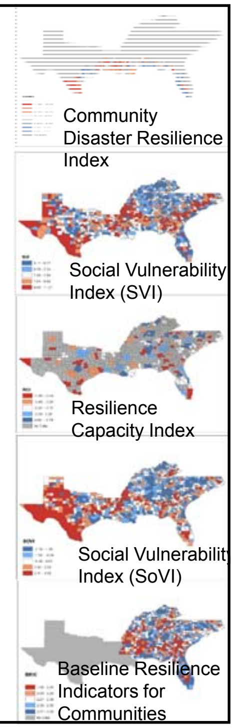
- Assessments built in ad-hoc manner based on specific expertise of agency.
- Most agencies efforts are not framed in context of larger system. These efforts are each components of the necessary changes.
- Assessments do not explicitly consider uncertainty
- Assume future impacts will reflect past impacts and that locations of past events will be equally important in future events.
- Tools largely assess vulnerability through risk metrics rather than assess resilience through capabilities to absorb, recover, and adapt.

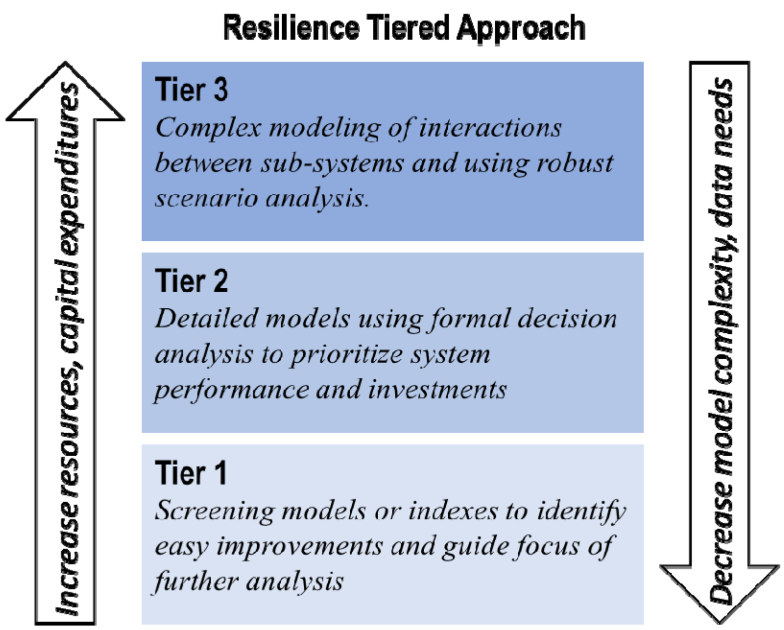
Validating Resilience

- 5 county-level resilience and vulnerability indices
- Relative rather than absolute scores
- Different aggregations of much the same data –
  - (Gini, poverty rate, vehicle access, hospitals, workforce composition, etc.)
- Adjacent counties show different patterns of relative resilience/vulnerability. What should states rely on to make investment decisions?



Bakkensen, Linkov et al (2016)





From Linkov et al, PNAS (submitted)

Tiered Approach – Aspen Meeting Summary

		Risk Assessment	Resilience Assessment
Tier I	Focus	Vulnerable components of the system	Main functions of the system
	Method	Screening level; conservative estimates for likelihood of a component failure	Generalized evaluation of overall system functionality
	Goal	Find most important threats and vulnerabilities for further evaluation in Tier 2 or assume no risk	Determine functions of system that are most important to stakeholders and system functioning
	Time	Assess component at most sensitive point in time (accumulation at end of life, co-occurrence of maximum loads)	Assess degradation of critical function during the course of an event (initial impact through recovery)
	Output	Conservative risk estimate expressed as risk in absolute units compared to risk threshold	Critical functions and pathways of failure, identified and expressed through individual metrics or indices
	Alternatives	Not considered in assessment	Not considered
		↓ *Focus on risk drivers and critical components; add fidelity* ↓	↓ *Focus on critical functions; add fidelity* ↓
Tier II	Focus	Threats and Vulnerabilities evaluation for critical components of the system	Integration of critical functions, system evolution in time
	Method	Deterministic risk models (mechanistic or statistical)	Semi-quantitative evaluation of system performance, exploration of dependencies and semi-quantitative integration of data and values
	Goal	Assess component degradation for the most probable threat to inform future management alternatives.	Assess pathways of critical function degradation over the course of events associated with different types of threat to evaluate management alternatives
	Time	Assess at most sensitive point in time	Assess over the course of an event, including recovery, identify time stage and domain of concern
	Output	Risk resulting from median and maximum exposure to most likely threat at most vulnerable component of the system	Quantitative metrics of performance associated with alternative management strategies integrated in scorecards, or multi-criteria models
	Alternatives	Not considered in assessment	Semi-quantitative comparative analysis of alternatives
		↓ *Determine if uncertainty is in range to require additional analysis* ↓	↓ *Focus on dependencies across critical functions and management alternatives* ↓

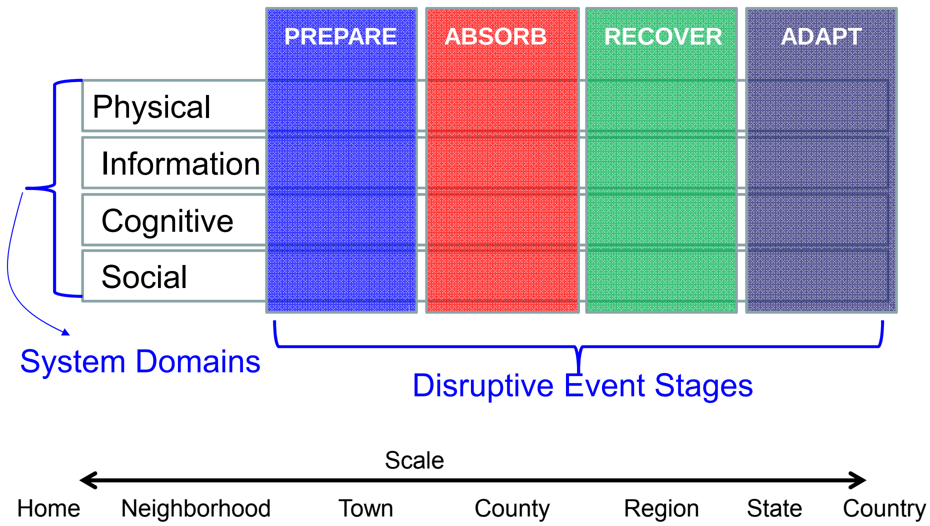
From Linkov et al, PNAS (submitted)

Tiered Approach – Aspen Meeting Summary

		Risk Assessment	Resilience Assessment
		Determine if uncertainty is in range to require additional analysis ↓	*Focus on dependencies across critical functions and management alternatives* ↓
Tier III	Focus	Uncertainty evaluation of risk, more realistic assessment with focus on critical system components	Systems approach to interconnectedness and interdependencies; resilience quantification
	Method	Probabilistic evaluation	Network analysis, portfolio analysis or other modeling tools to consider interactions between system components and functions
	Goal	Assess confidence that calculated risk is below the regulatory threshold	Quantify resilience and its comparative reduction given management alternatives. Connect to risk-based design
	Time	Assess at most sensitive point in time	Assess over the course of an event, including recovery, identify time stage and domain of concern
	Output	Probability distribution for component risks	Explicit quantification of resilience and its reduction given management alternatives in time
	Alternatives	No treatment considered	Quantitative comparative evaluation of management alternatives

From Linkov et al, PNAS (submitted)

Tier 2– System-Scale Assessment



Assessment using Decision Analysis

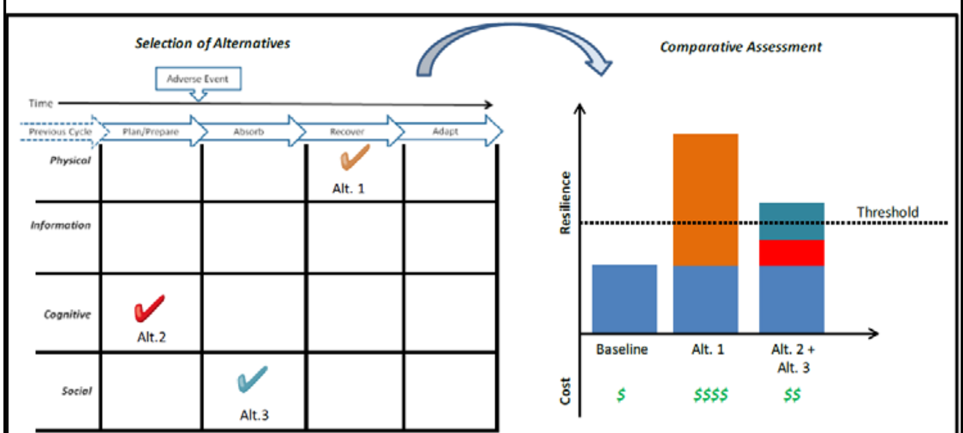


Figure 5: Comparative Assessment of Resilience-Enhancing Alternatives

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

How it works: Project Evaluation

- Baseline assessment can be used to evaluate proposed projects

	Prepare	Absorb	Recover	Adapt
Physical	71	16	60	10
Information	63	45	21	18
Cognitive	90	49	38	27
Social	82	54	12	52

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Project 1

	Prepare	Absorb	Recover	Adapt
Physical	+10	+18	+9	+32
Information	+8		+17	
Cognitive				
Social				

	Prepare	Absorb	Recover	Adapt
Physical	81	34	69	42
Information	71	45	38	18
Cognitive	90	49	38	27
Social	82	54	12	52

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Project 2

	Prepare	Absorb	Recover	Adapt
Physical				
Information		+5	+15	+22
Cognitive				
Social	+3		+12	+21

	Prepare	Absorb	Recover	Adapt
Physical	71	6	60	10
Information	63	50	36	40
Cognitive	90	49	38	27
Social	85	54	24	73

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*Projects may have (+) or (-) in other matrices

Problems with Metric-based Approaches

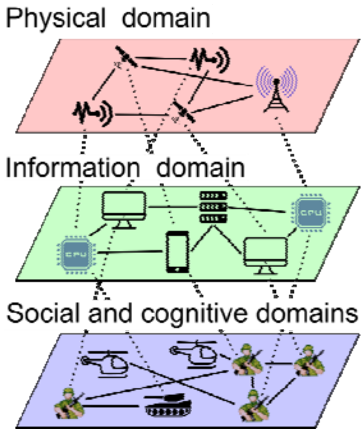
•Measuring for security remains difficult: the gap between security measures and increased vulnerabilities can be hard to close

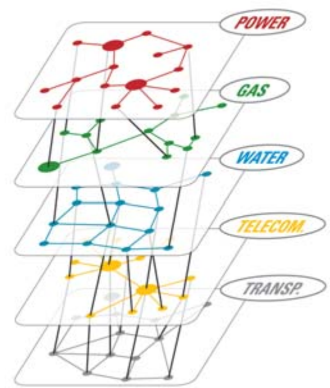
•Many measurement programs utilize data that does not contribute to informing decisions or changing behavior.

Not everything that counts can be counted, and not everything that can be counted counts.
Albert Einstein

Future: Network Science

We quantify resilience by using network science approach by considering the different domains as interdependent multiplex networks.





Why Network Science Approach?

- Most of the complex systems can be modeled as interconnected networks – as soon as a system is represented as a network it becomes a mathematical object
- Network representation allows better analysis of interplay between individual components comprising the system
- Better visualization

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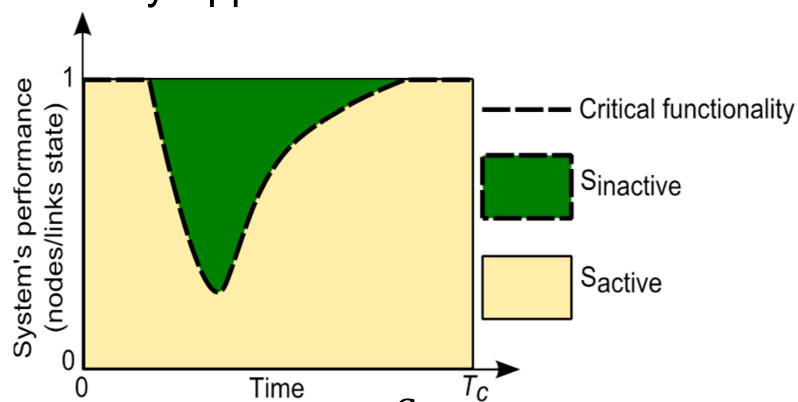
Resilience Quantification

- Based on NAS Definition
- Widely Applicable



$$R = \frac{S_{active}}{S_{active} + S_{inactive}}$$

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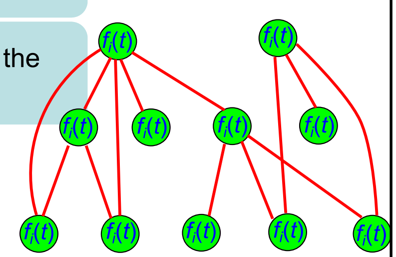
Generalized Form of Resilience

- System's *critical functionality* (*K*)
- Network topology: *nodes* ($\mathcal{N}$) and *links* ($\mathcal{L}$)
- Network *adaptive algorithms* ($\mathcal{C}$) defining how nodes' (links') properties and parameters change with time
- A *set of possible damages* stakeholders want the network to be resilient against ($\boldsymbol{E}$)

$$R = f(\mathcal{N}, \mathcal{L}, \mathcal{C}, \boldsymbol{E})$$



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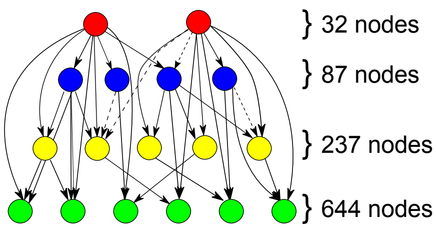
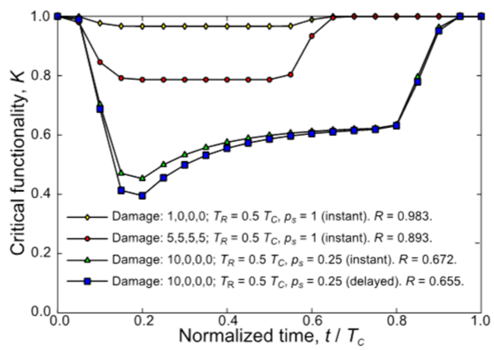
Case 1: Hypothetical Network



Hierarchical network of 4 layers with redundancy

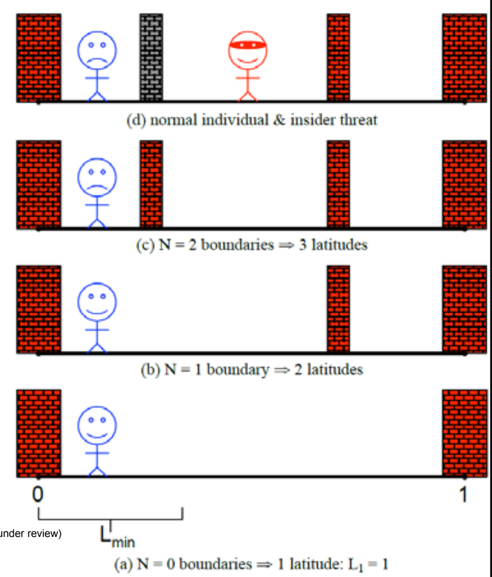


Resilience profiles for different scenarios in synthetic networks over a normalized time interval

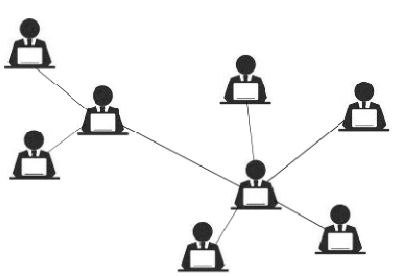
After Ganin et al., 2016

Case 2: Insider Risk/Resilience modeling

Constrained Individual Latitude



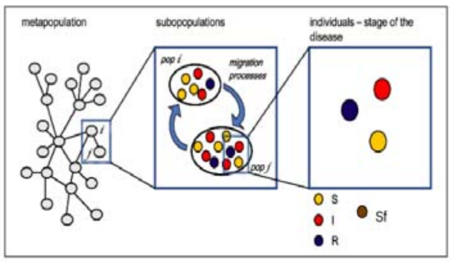
Organizational Structure



Adapted from Kepner et al (ESD, 2015, under review)

Case 3: Resilience and Epidemic Spreading

The resilience is defined as a competition process between commuters and disease spreading in a metapopulation system.



Three Behavioral Disease models

1. Local Information
2. Global Information
3. Local, belief-based spread of the fear of the disease

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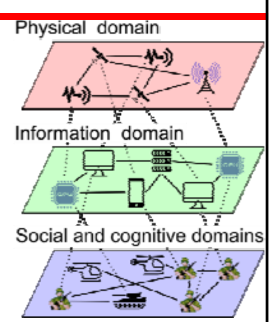
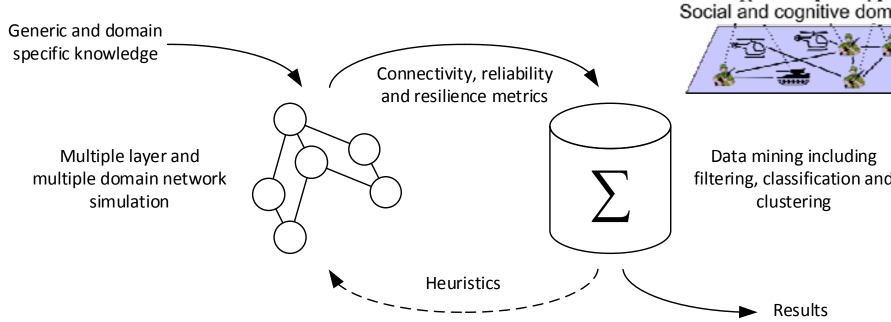
Case 4: Cyber/Physical Resilience



Operational Resilience of Command and Control Systems to Maintain Multilayered Network Functionality in Response to Large-Scale Disruptive Events



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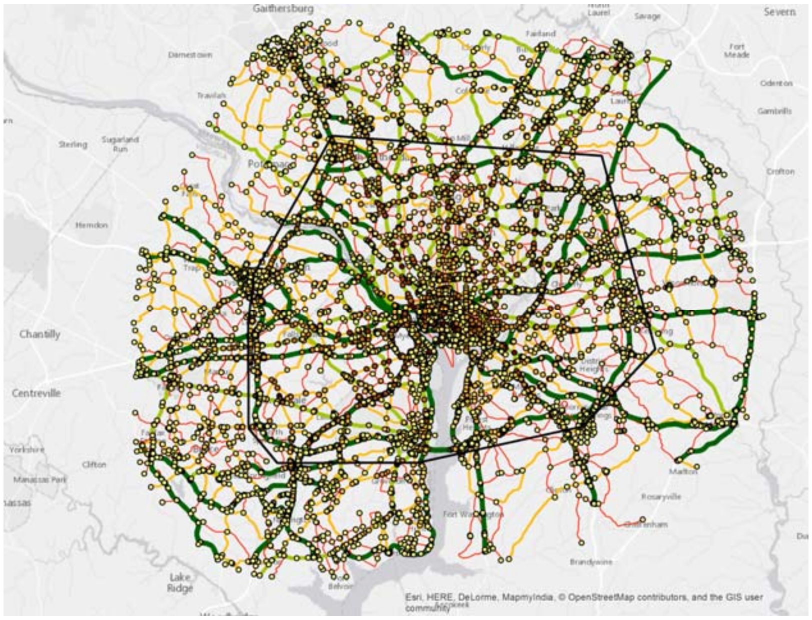
Case 6: Transportation Networks – DC



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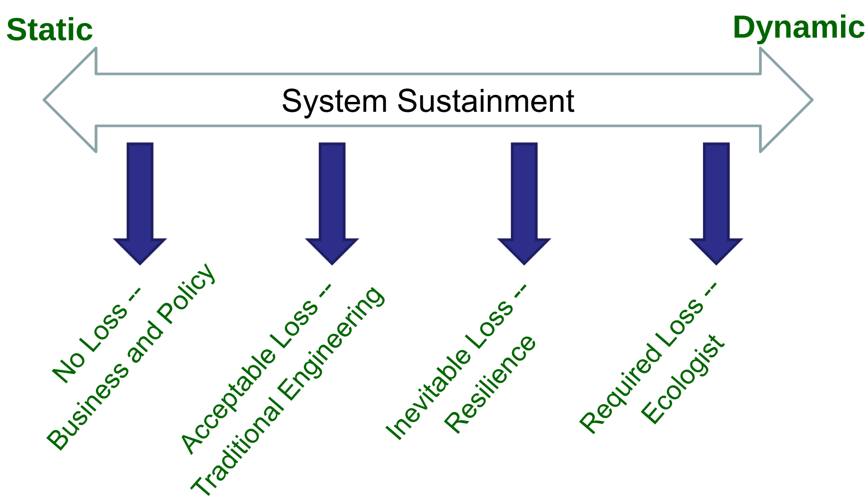
Spectrum of Approaches to Loss



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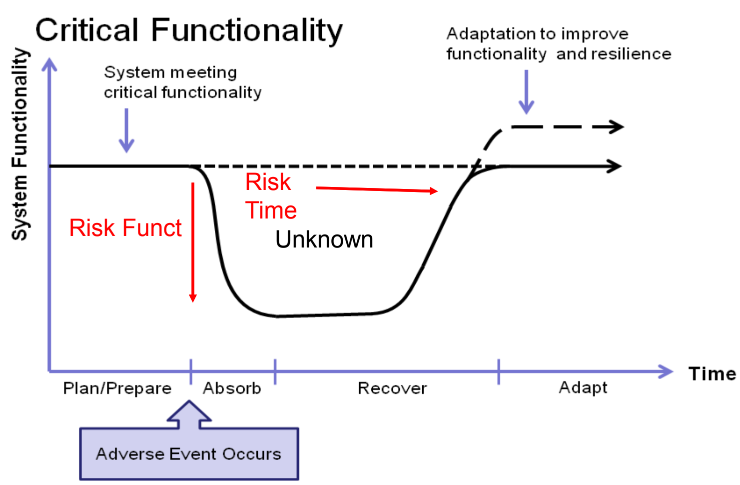
Risk/Resilience Integration?

Resilience as ...	**goal of risk management:** Many documents describe resilience as the overarching goal of protection policies and risk management as the method to achieve this goal. *Resilience replaces or complements the concept of protection*, which was previously defined as the goal of risk management activities.
	part of risk management: *Resilience is understood as a part of risk management*. Activities to strengthen resilience are needed in order to deal with the so-called "remaining risks", i.e. risks that have not been identified or underestimated and are thus not covered by appropriate protection (preventive) measures.
	alternative to risk management: Challenges the traditional methods of risk management and promotes *resilience as a new way of dealing with risks in a complex environment*. It is argued that a probabilistic risk analysis is not an adequate approach for socio-economic systems that are confronted with non-linear and dynamic risks and are themselves characterized by a high degree of complexity. Instead of preventing risks and protecting the status quo, such systems should enhance their resilience by increasing their adaptive capacities.

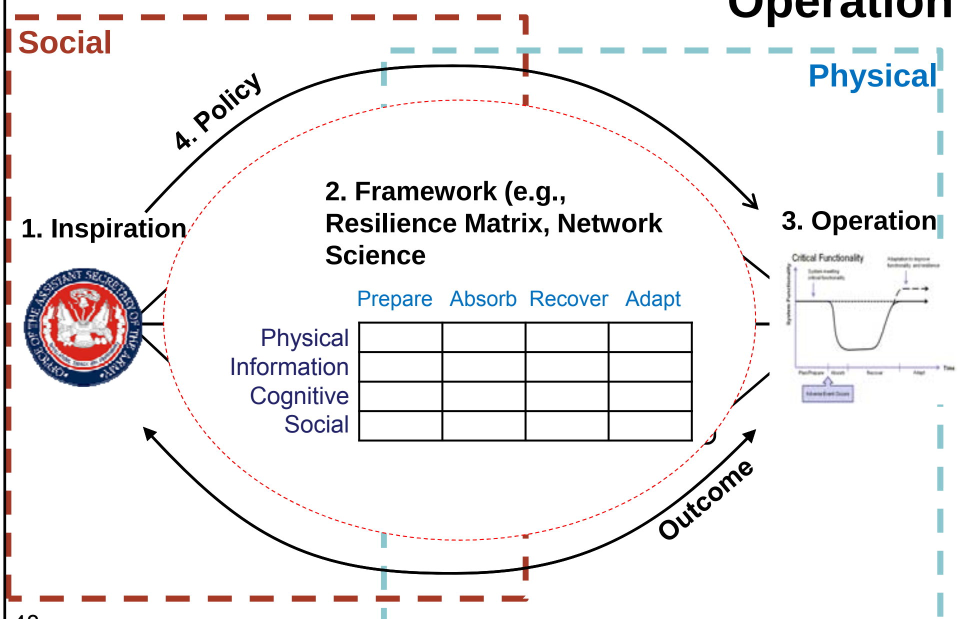
Focal Report 7 by Manuel Suter (2011) on Resilience and Risk Management in Critical Infrastructure Protection Policy: Exploring the Relationship and Comparing its Use
http://www.css.ethz.ch/publications/DetailansichtPubDB?rec_id=2207

rΣsilience
mΣtrics



Risk as Prepare/Absorb?

Resilience: From Inspiration to Operation



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spiration: USACE Resilience Strategy

What is Resilience?

"the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." Executive Order 13653

Resilience in Action: Plan, Absorb, Recover, and Adapt

Why Resilience?

Resilience is a proactive approach to reducing damages, preventing losses, and shortening critical recovery times

USACE projects prevented $13 B of damages in 2013; average annual damages avoided, 2004-2013, is $48 B.

USACE's Approach to Resilience

Mainstream project lifecycle resilience enterprise-wide to improve system and community resilience

Examples: North Atlantic Coast Comprehensive Study

Naval Station Norfolk

USACE Support to Community Resilience

With our partners, USACE provides projects, resilience assessment tools, data, and other resources

Examples: USACE Support to Silver Jackets

Studies & Projects in Jamaica Bay, NY

Framework

- Tiered Framework

	Prepare	Absorb	Recover	Adapt
Physical	90%	81%	62%	10%
Information	80%	19%	23%	75%
Cognitive	68%	95%	22%	40%
Social	76%	88%	92%	34%

- **Tier 1 – Community System-Scale Assessment**

  Linkov et al. (2014)

- **Tier 2 – Coastal System Infrastructure Assessment**

  Rosati et al. (2015)

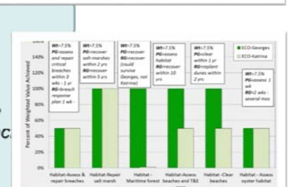
- **Tier 3 – Risk and Resilience Bayesian Network Analysis**

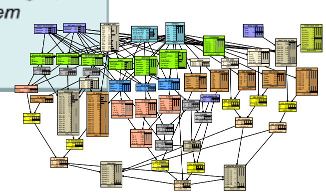
  Schultz et al. (2012)

➢ Planning
- *Rapid relative assessment of alternatives for 3x3x3 studies*

➢ Operations & Maintenance
- *Dredging & placement; structure rehabilitation; timing of multiple ac*

➢ Engineering & Construction
- *Optimization of engineering designs, adaptation measures & system operations*





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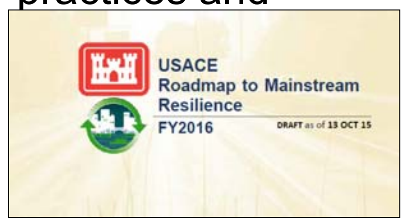
Operations

- Resilience PDT
  - Quantification
  - Standardization
  - Visualization
- Goals and indicators of improvement
- Involvement and input from all major subordinate commands (MSCs)

- Living document to capture best practices and



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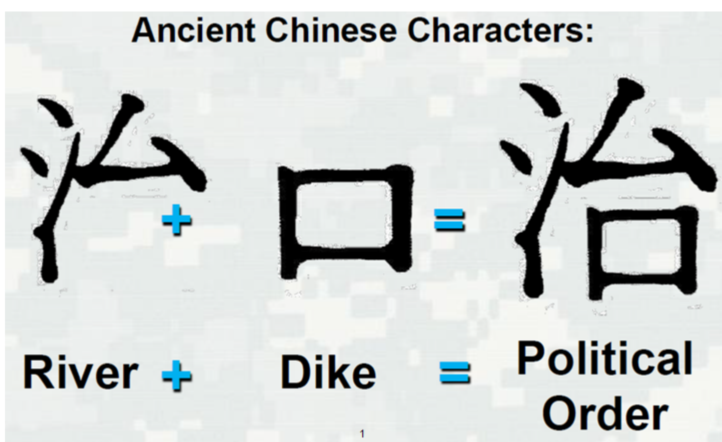
Policy – Inevitable!



52

Future: Evolution of Approaches for Flood Risk Management

Live with floods
- Individuals and small communities adapt to nature's rhythm.

Use the floodplain
- Fertile land in floodplain is drained for food production.
- Permanent communities develop on the floodplain.

Control floods
- Large scale structural approaches are implemented through organized governance

Reduce flood damages
- A recognition that engineering alone has limitations.
- Effort to increase the resilience of communities should a flood occur.

Manage risk
- Not all problems are equal.
- Risk management is an effective and efficient means to maximize the *benefit of* limited investment.

Manage resilience?
- Not all problems need to be solved
- Systems approach & integration of communities is the key

From Sayers et al., 2012

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Framework –Science of Risk and Resilience

Top-Down Resilience Assessment		Bottom-Up Risk Assessment
Goal Identification and Problem Framing - *What are the goals, alternatives, and constraints?*	Management	**Risk Characterization** - *What are the risks relative to a threshold? How do they compare to other alternatives?*
Decision Model - *What are the criteria and metrics? How do we measure decision-maker values?*	Modeling	**Physical/Statistical Model** - *What is the hazard? What is the exposure?*
Metrics Generation and Alternative Scoring - *How does each alternative score along our identified criteria and metrics?*	Data Collection	**Data Collection** - *What are the fundamental properties/mechanisms associated with each alternative?*

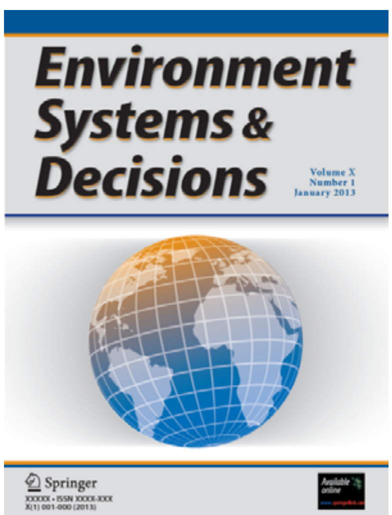
After Linkov et al., 2014

54

References

- Linkov, I., Eisenberg, D. A., Bates, M. E., Chang, D., Convertino, M., Allen, J. H., Flynn, S. E., Seager, T. P. (2013). Managing resilience to meet national needs. *Environmental Science & Technology* **47**:10108-10110.
- Park, J., Seager, TP, Rao, PCS, Convertino, M., Linkov, I. (2013). Contrasting risk and resilience approaches to catastrophe management in engineering systems. Risk Analysis 33: 356–367.
- Linkov, I., Eisenberg, D. A., Plourde, K., Seager, T. P., Allen, J., Kott, A (2014). Resilience Metrics for Cyber Systems. *Environment, Systems and Decisions* **33**:471-476.
- Roege, P., Collier, Z.A., Mancillas, J., McDonagh, J., Linkov, I. (2014). Metrics for Energy Resilience. *Energy Policy*
- Linkov, I, Kröger, W., Levermann, A., Renn, O. et al. (2014). Changing Resilience Paradigm. *Nature Climate Change*.
- Eisenberg, D. A., Park, J., Chang, D., Bates, M. E., Seager, T. P., Linkov, I. (2014). Military solutions to federal agency needs: Metrics of resilience. *Solutions*.

Call for Papers: Springer's Environment, Systems and Decisions



ESD provides a catalyst for research and innovation in cross-disciplinary and trans-disciplinary methods of decision analysis, systems analysis, risk assessment, risk management, risk communication, policy analysis, environmental analysis, economic analysis, engineering, and the social sciences.

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RESOURCE GUIDE ON RESILIENCE AND RISK GOVERNANCE

In the context of its work to improve the governance of systemic or emerging risk marked by uncertainty, IRGC is developing a web-based resource guide on resilience in the context of risk governance.

The occurrence of disasters and crises, following both natural extreme events and technology-related accidents, demonstrates the limitations of traditional risk assessment and management. In the context of risk, resilience has been discussed as both supplement and alternative to conventional risk management. Both governments and industry explicitly call for resilience-based strategies. IRGC describes resilience as a risk management strategy that is needed when there is much uncertainty about impacts, and the need to prepare to cope with surprises.

IRGC's objective with the guide is to propose a review of existing concepts, ideas and tools for integrating risk and resilience, and for measuring resilience and the effectiveness of actions taken to build it.

The guide is designed to help scientists and practitioners working on risk governance and resilience evaluation, by giving them background information on the various perspectives and guiding them to the best available literature sources. It stresses the importance of including resilience building in relation to the process of governing risk, including in research, policy, strategies, and practices. It emphasises the need to develop metrics and quantitative approaches for resilience assessment and instruments for resilience management.

This guide is composed of invited short pieces with an annotated bibliography 'for further reading'. It will be released in the summer of 2016, and available on *irgc.org/risk-governance/resilience.*

The following papers will be included.

The EPFL International Risk Governance Center organises IRGC activities, emphasising the role of risk governance for issues marked by complexity, uncertainty and ambiguity, and focusing on the creation of appropriate policy and regulatory environments for new technology where risk issues may be important. *irgc.epfl.ch*

The International Risk Governance Council (IRGC), based at EPFL, Lausanne, Switzerland, is an independent non-profit foundation whose purpose it is to help improve the understanding and governance of systemic risks that have impacts on human health and safety, the environment, the economy and society at large. IRGC's mission includes developing risk governance concepts and providing risk governance policy advice to decision-makers in the private and public sectors on key emerging or neglected issues. IRGC was established in 2003 at the initiative of the Swiss government and works with partners in Asia, the US and Europe. *irgc.org*

INTRODUCTION

Resilience: Approaches to quantification and validation
Igor Linkov. US Army Engineer Research and Development Center, USA.

PHILOSOPHY AND CONCEPTS OF RESILIENCE

Risk and Resilience Management in Social-Economic Systems
Tatyana Kovalenko and Didier Sornette. ETH Zurich, Department of Management, Technology and Economics, Switzerland.

The New Resilience Paradigm – Essential Strategies for a Changing Risk Landscape
Joseph Fiksel. The Ohio State University, USA.

A Business Continuity Perspective on Organisational Resilience
Brahim Herbane. Leicester Business School, De Montfort University, Leicester, UK.

Resilience Engineering and indicators of resilience potential
Yvonne Herrera. Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology.

Implementation and Measurement of Strategies for the Unpredictable: Improvisation and Revising the Blame Game
Patricia H. Longstaff. Syracuse University, USA.

Ecological & social-ecological resilience – Assessing and managing change in complex systems
Allyson Quinlan[1] and Lance Gunderson[1,2]. [1] Resilience Alliance, [2] Emory University, USA.

Inclusive resilience: A new approach to risk governance
Ortwin Renn. Institute for Advance Sustainability Studies, Germany.

Resilience in Three Parts
Marcus L. Snell, Daniel A. Eisenberg, Thomas P. Seager, Susan Spierre Clark, Young Joon Oh, John E. Thomas and Lauren R. McBurnett. Arizona State University, USA.

Resilience as Graceful Extensibility to Overcome Brittleness
David D. Woods. Ohio State University, USA.

On Resilience-based Risk Governance
Jianhua Xu[1] and Lan Xue[2]. [1] College of Environment Sciences and Engineering, Peking University, P.R. China, [2] School of Public Policy and Management, Tsinghua University, P.R. China.

APPROACHES, FRAMEWORKS, METHODOLOGIES

A Time-Dependent Measure of Resilience
Kash Barker[1] and Jose E. Ramirez-Marquez[2,3]. [1] School of Industrial and Systems Engineering, University of Oklahoma, USA, [2] Stevens Institute of Technology, Hoboken, NJ, USA, [3] Tecnológico de Monterrey, Guadalajara, México.

Resilience in the IRGC risk governance framework
Marie-Valentine Florin. IRGC, Switzerland.

Resilience in the IRGC Guidelines for Emerging Risk Governance
Marie-Valentine Florin. IRGC, Switzerland.

Resilience Engineering and quantification for sustainable systems development and assessment: Socio-technical systems and critical infrastructure
Ivo Häring, Benjamin Scharte, Alexander Stolz, Tobias Leismann and Stefan Hiermaier. Fraunhofer EMI, Freiburg, Germany.

A Generic Framework for Resilience Assessment
Hans Rudolf Heinimann. Future Resilient Systems at Singapore – ETH Centre, Singapore and ETH Risk Center, ETH Zurich, Switzerland.

Managing Extraordinary Risks: Proactive and Reactive Strategies
Patrick Helm. Department of the Prime Minister and Cabinet, Wellington, NZ.

Organizational Resilience – How do you know if your organization is resilient or not?
Leena Ilmola. International Institute for Applied Systems Analysis (IIASA), The Global X-Network, Austria.

Principles for Resilient Design – A Guide for Understanding and Implementation
Scott Jackson. Burnham Systems Consulting, Greater Lost Angeles Area and University of South Australia.

The quest for enterprise resilience: navigating complex systems to survive and thrive
Charley Newnham and James Crask. PwC, UK.

Aligning Different Schools of Thought on Resilience
David Yu, Suresh Rao et al. Purdue University, USA.

Resilience Analytics for Systems of Systems: Literature and Resource Guide
Heimir Thorisson and James Lambert. Department of Systems & Information Engineering, University of Virginia, USA.

Critical Infrastructure Resilience
Eric Vugrin. Sandia National Laboratories, USA.

UN City Disaster Resilience Scorecard
Peter Williams[1] and Dale Sands[2]. [1] IBM, [2] AECOM, USA.

SPECIFIC APPLICATIONS

Evidence-Driven Resilience Operationalization of Urban Transport Systems
Emanuele Bellini and Paolo Nesi. DISIT Lab, Information Engineering Dept., University of Florence, Italy.

Measuring Urban Resilience As You Build It – Insights from 100 Resilient Cities
Leah Flax, Amy Armstrong and Liz Yee. 100 Resilient Cities, Pioneered by The Rockefeller Foundation, USA.

Quantitative and Qualitative Approaches to Enhancing Resilience for Critical Infrastructure
William Hynes. Future Analytics Consulting, Ireland.

Creating Value through Resilience
Paul Roege. Creative Erg, LLC, USA.

Towards a cross-disciplinary understanding and operationalisation of resilience for environmental development
Jochen Schanze. Technische Universität Dresden and Leibniz Institute of Ecological Urban and Regional Development (IOER), Germany.

Natural Hazard Disaster Risk Reduction as an Element of Resilience; considerations about insurance and litigation
Edward A. Thomas. Natural Hazard Mitigation Association & American Bar Association Committee on Disaster Response and Preparedness.

Enhancing Community Resilience: Practical Resources in Addressing the Collaboration Gap
Stephen Walsh. Future Analytics Consulting, Ireland.

Flood Resilience
Chris Zevenbergen. TUDelft & UNESCO-IHE, The Netherlands.

AND EXPECTED CONTRIBUTIONS BY

Craig Allen. School for Natural Resources, University of Nebraska, USA.

Kristin Baja. Baltimore City Department of Planning, Office of Sustainability, USA.

Luis Abdón Cifuentes. Pontificia Universidad Católica de Chile.

Stephen E. Flynn. Northeastern University, USA.

Royce Francis. Engineering management and systems engineering (EMSE), USA.

Caroline Galvan. World Economic Forum, Switzerland.

Stefan Gössling-Reisemann. Bremen University, Germany.

Stephane Hallegatte. Climate change Group, The World Bank.

Manuel Heitor. Minister of Science, Technology and Higher Education, Portugal.

Aleksander Jovanovic. European Virtual Institute for Integrated Risk Management, EU-VRi, Germany.

Howard Kunreuther and Erwann Michel-Kerjan. Risk Management and Decision Processes Center Wharton School, USA.

Dutch Leonard. Harvard University, USA.

Kirstjen Nielsen. Sunesis Consulting LLC, USA.

José Palma Oliveira. Lisbon University, Portugal.

Roger Pulwarty. NOAA, USA.

Adam Rose. USC Price, USA.

Giovanni Sansavini. ETH Zurich, Switzerland.

Josh Sawislak. AECOM, USA.

Richard Smith Bingham. Marsh & McLennan Companies, Global Risk Center, USA.

Sydney Swanson. Urban Land Institute, Boston, USA.

Henry Willis. RAND Corp, USA.

European Commission

Funding Resilience in the EU

NATO Workshop, Azores 27.6.2016

Mr Angelo MARINO

Head of Unit

EC REA/B4 – Safeguarding Secure Societies

NOT LEGALLY BINDING

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European Commission

- *Policy context*
- *FP7 and H2020 Security Research*
- *The role of the REA*
- *Useful information*

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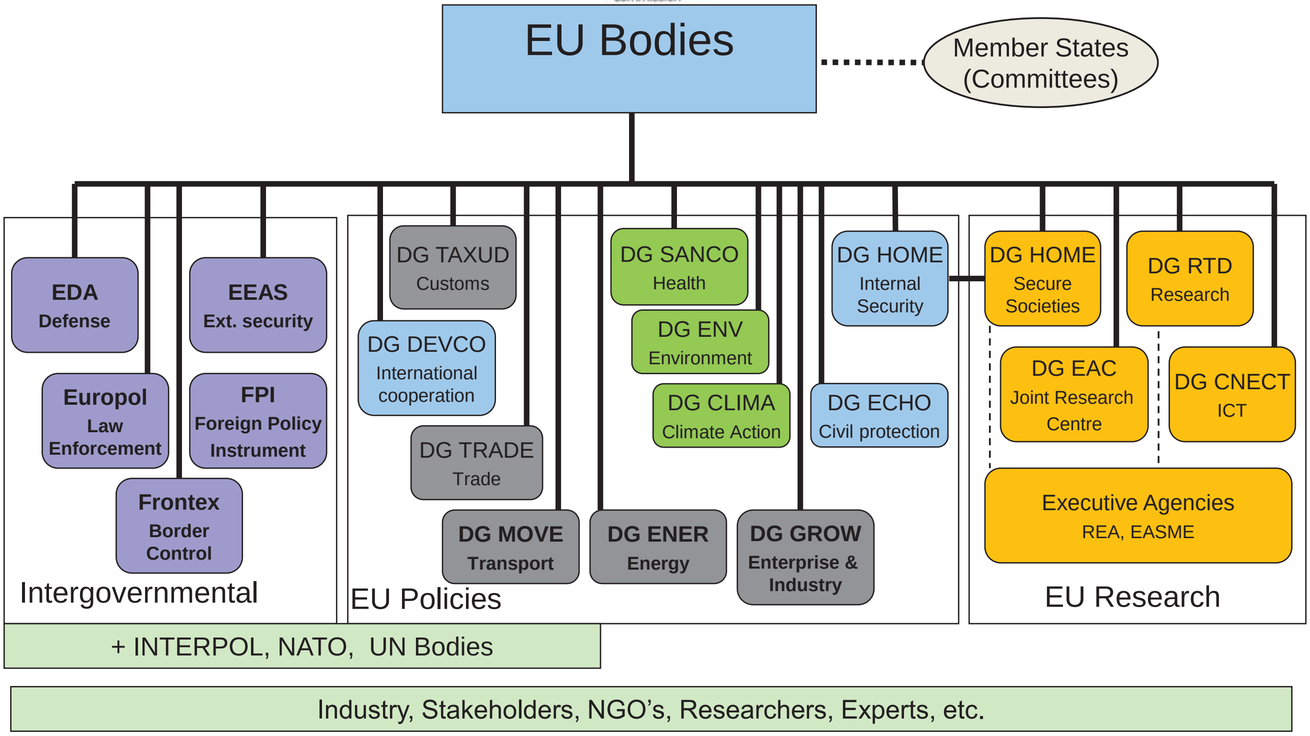

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The European Programme for Critical Infrastructure Protection (EPCIP)

Directive 2008/114/EC 8 December 2008

A procedure for the identification and designation of European Critical Infrastructures (ECI)

Measures designed to facilitate the implementation of EPCIP

- **CIWIN**
- **CIP expert groups**
- **CIP information sharing**
- **identification and analysis of interdependencies**
- **ERNCIP**
- **Research**

Accompanying financial measures

EU programme "Prevention, Preparedness and Consequence Management of Terrorism and other Security Related Risks" for the period 2007-2013

(CIPS)

Horizon 2020 Secure Societies

Support for Member States concerning National Critical Infrastructure

Contingency planning

External dimension

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Directive 2008/114/EC

European Critical Infrastructure (ECI)

- Means critical infrastructure located in Member States, the destruction or disruption of which would have a significant impact on at least two Member States

- Sectoral scope: energy and transport sectors.
- Sets out a 4 step approach to identify ECIs based on specific criteria
  - Cross-cutting criteria: casualties, economic effects, public effects
  - Sectoral Criteria established for Transport and Energy sectors

- Security Liaison Officer / Operator Security Plan

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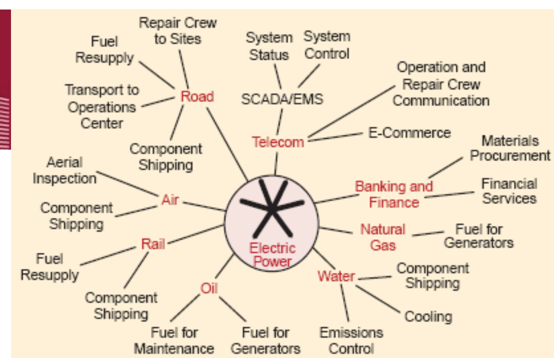
New approach to EPCIP



- **Presented in 2013 COM SWD**

- **Objective: to provide a reshaped EU CIP approach, based on the practical implementation of activities**

- **Main features:**
  - Looking at interdependencies
  - A step by step practical approach, based on 3 main pillars: *Prevention, Preparedness, Response*
  - Pilot with four critical infrastructures of European dimension: Eurocontrol, Galileo, the electricity transmission grid and the gas transmission network

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FP7 AND HORIZON 2020 SECURITY RESEARCH

FP7 Security research

Duration: 2007-2013

Total budget: 1.4 billion Euros

Total number of projects: 316

Total number of participants: 2040, from 49 countries

Directly or indirectly related to Critical Infrastructure Protection: 41 projects worth 180 million Euros in EU contribution

Horizon 2020 Security research

Duration: 2014-2020

Total budget: 1.7 billion Euros

Total number of projects so far: 93, worth 436 million Euros in EU contribution

Directly or indirectly related to CIP: 11 projects, worth 55 million Euros in EU contribution

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In particular on Resilience ...

Resilience of Urban Environments to Safety and Security Threats

DG ECHO
Civil Protection

Decision 1313/2013
EU Civil Protection Mechanism

DRS-7-2014

FIVE SELECTED PROJECTS:

RESOLUTE - 'Resilience management guidelines and operationalization applied to urban transport environment'
Coordinated by the University of Florence (IT)

DARWIN – 'Expect the unexpected and know how to respond'
Coordinated by Stiftelsen SINTEF (NO)

RESILIENS – 'Realising management guidelines and operationalization applied to urban transport environment'
Coordinated by Future Analytics Consulting Ltd (IE)

IMPROVER – 'Improved risk evaluation and implementation of resilience concepts to critical infrastructures'
Coordinated by SP Sveriges Tekniska Forskningsinstitut (SE)

SMR – 'Smart Mature Resilience'
Coordinated by the University of Navarra (ES)

Survey of worldwide approaches on disaster resilience concepts, identification of promising implementation with view to develop general resilience management guideline

Reseach & Innovative Actions (Grants ≈ 3.8 to 5 M€)

DG ENTR
Enterprise & Industry

Security Industrial policy COM(2012)417 final
Internal Security Strategy COM(2010)673 final

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Climate-related Hazards – Preparedness and Response

European Commission

DG ENV
Environment
Flood Directive
WFD (droughts), forest fires

DG CLIMA
Climate Action
EU Climate Adaption Strategy

DG ECHO
Civil Protection
Decision 1313/2013
EU Civil Protection Mechanism

DRS-1-2015

TWO SELECTED PROJECTS:

ANYWHERE – 'Enhancing emergency management and response to extreme weather and climate events'
Coordinated by the Universitat Politecnica de Catalunya (ES)

I-REACT – 'Improving Resilience to Emergencies through Advanced Cyber Technologies'
Coordinated by the Istituto Superiore Mario Boella (IT)

Potential of current and new measures and technologies to respond to extreme weather and climate events
Enhancing the response capacity to extreme events affecting security of people and assets: emergency operations, linking early warning to effective responses. **Innovative Actions (Grants ≈ 5.4 to 11.9 M€)**

DG GROW
Enterprise & Industry
Security Industrial policy
COM(2012)417 final
Internal Security Strategy
COM(2010)673 final

IPCC

UNISDR
Sendai Framework for Action

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Disaster Resilience / Crisis Management

European Commission

DG HOME
Internal Security
COM(2009) 273 final
CBRN Action Plan
+ COM(2014)247 final
CBRN-E risks

DG ECHO
Civil Protection
Decision 1313/2013
EU Civil Protection Mechanism

DG SANCO
Consumer Health
Decision 1082/2013
Serious cross-border threats to health

DG DEVCO
International cooperation
CBRN-E Centres of Excellence

DRS-3-2015

EDA
Defense

SELECTED PROJECT: Reaching Out
'Demonstration of EU effective large scale threat and crisis management outside the EU'
Coordinated by Airbus Defence and Space SAS (FR)

Demonstration on large scale disasters and crisis management and resilience of EU external assets againsts major identified threats or causes of crisis - Demo on the EU deployable capacities outside the EU to anticipate, prepare and respond to disasters. Consider interoperability and dual-use applications
Innovative Action (Grant ≈ 18.8 M€)

DG GROW
Enterprise & Industry
Security Industrial policy
COM(2012)417 final
Internal Security Strategy
COM(2010)673 final

UNISDR
Sendai Framework for Action

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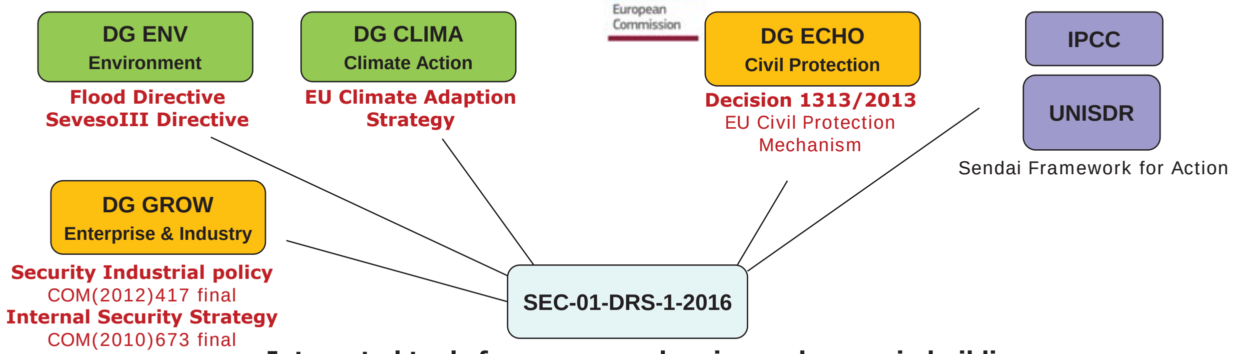
CURRENT CALL

Disaster Resilience: Safeguarding and Securing Society (1)



Integrated tools for response planning and scenario building

Insufficient interlinkage among sectors, disciplines and actors involved in disaster risk management, preventing efficient response planning and the building of realistic multidisciplinary scenarios. Needs to develop **integrated tools**, and stronger **partnerships** among research, policy, monitoring institutes, industry/SMEs and practictioners (in particular first responders). **Scope on disaster risks** (natural, accidental, or intentional) and **emergency situations** in the context of the EU Civil Protection Mechanism, consideration of IPCC recommendations and Sendai Framework for Action.

Integration of support tools that can be used by a large variety of decision-makers and first responders, building upon previous and ongoing FP7 projects and preliminary results from H2020 to **avoid duplication**. Demonstrations in **representative and realistic** environments with **invovelment** of firefighting units, medical emergency services, police departments and civil protection units.

Int. Cooperation encouraged. Development up to TRL 7 or 8.

Innovation Action (+/- 8 M€)

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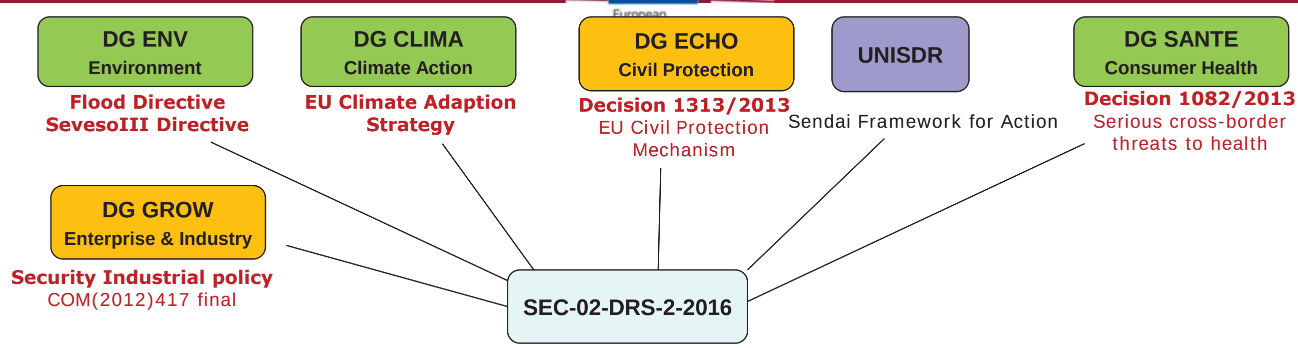
Disaster Resilience: Safeguarding and Securing Society (2)



CSA on situational awareness systems to support civil protection prepatation and operational decision making

Insufficient integration of existing technologies and prototype tools to improve situational awareness in time of crisis. Needs to **better understand** the psychological, cultural, language and societal dimenstion of **situational awareness** in order to prevent, prepare and manage crisis situations. Systems for EU, national, regional and local buyers should be cost effective and interoperable, **integrate different technologies** (e.g. sensors, EWS, communication, satellite-based systems) and demonstrate resilience and self-sufficiency. In addition, systems should be **customizable** by specific civil protection authorities and adaptable to **various risks and crisis scenarios** (e.g. range of natural hazards, industrial accidents, biohazards etc.) especially in the context of **cross-border** cooperation.

Action to **identify new and promising solutions**, develop/agree on **core set of specifications** for a given system, **on roadmap for research** still needed, and related **tender documents** upon which to base future (research services and system) procurements. Subsequent actions (PCP, PPI, others) to implement tender procedures to develop, test, validate prototypes may be envisaged.

Int. Cooperation encouraged. Development up to TRL 6.

Coordinated & Support Action (+/- 1.5 M€)

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European Commission

Current call on Critical infrastructure protection

Topic:

CIP-01-2016-2017: Prevention, detection, response and mitigation of the combination of physical and cyber threats to the critical infrastructure of Europe.

European Commission

The reasoning behind the CIP call

The lines between the physical and the cyber worlds are increasingly blurred. Recent events demonstrate the increased interconnection among the impact of hazards, of the two kinds of attacks and, conversely, the usefulness for operators to combine cyber and physical security-solutions to protect installations of the critical infrastructure of Europe: A comprehensive, yet installation-specific approach is needed

Exclusive list of CI

- Water Systems,
- Energy Infrastructure (power plants and distribution);
- Transport Infrastructure and means of transportation;
- Communication Infrastructure;
- Health Services;
- Financial Services.

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Scope

- Prevention, detection, response, and in case of failure, mitigation of consequences over the life span of the infrastructure
- All aspects of both physical and cyber threats and incidents, but also systemic security management issues, interconnections, and cascading effects.
- Sharing information with the public in the vicinity of the installations, protection of rescue teams, security teams and monitoring teams.

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Expected Impact – main points

Short term:

Analysis of physical/cyber detection technologies as well as vulnerabilities.

Mid term:

Tested solutions to prevent, detect, respond and mitigate physical and cyber threats.

Long term:

Convergence of safety and security standards, and the pre-establishment of certification mechanisms.

Eligibility criteria

At least **2 operators** of the chosen type of critical infrastructure operating in **2 countries** must be beneficiaries (possibly, but not necessarily: coordinator) of the grant agreement and should be directly involved in the carrying out of the tasks foreseen in the grant. The participation of **industry able to provide security** solutions is required.

Technical aspects

- TRL 7 – system prototype demonstration in operational environment.
- The participation of SMEs is strongly encouraged.
- International cooperation in research and innovation.
- Indicative budget: of € 8million.
- A maximum of one project will be selected per critical infrastructure.

Outlook on the 2018-2020 Work Programme

Envisaged orientation:

Enhance innovation in security by a tighter coordination between improving security of infrastructure (under Societal Challenge 7 of Horizon 2020), the security of individual elements such as means of transportation, manufacturing or energy technologies, and climate-related threats.

European Commission

Research Executive Agency

The role of the REA

Key facts

Key facts on REA

Launched in 2009

Executive Agency
- Proximity to clients
- Efficiency
- Impact
- Speed

Support
Horizon 2020 and other programmes
- Evaluation logistics, payments and participant checks for other programmes
- Horizon 2020 helpdesk

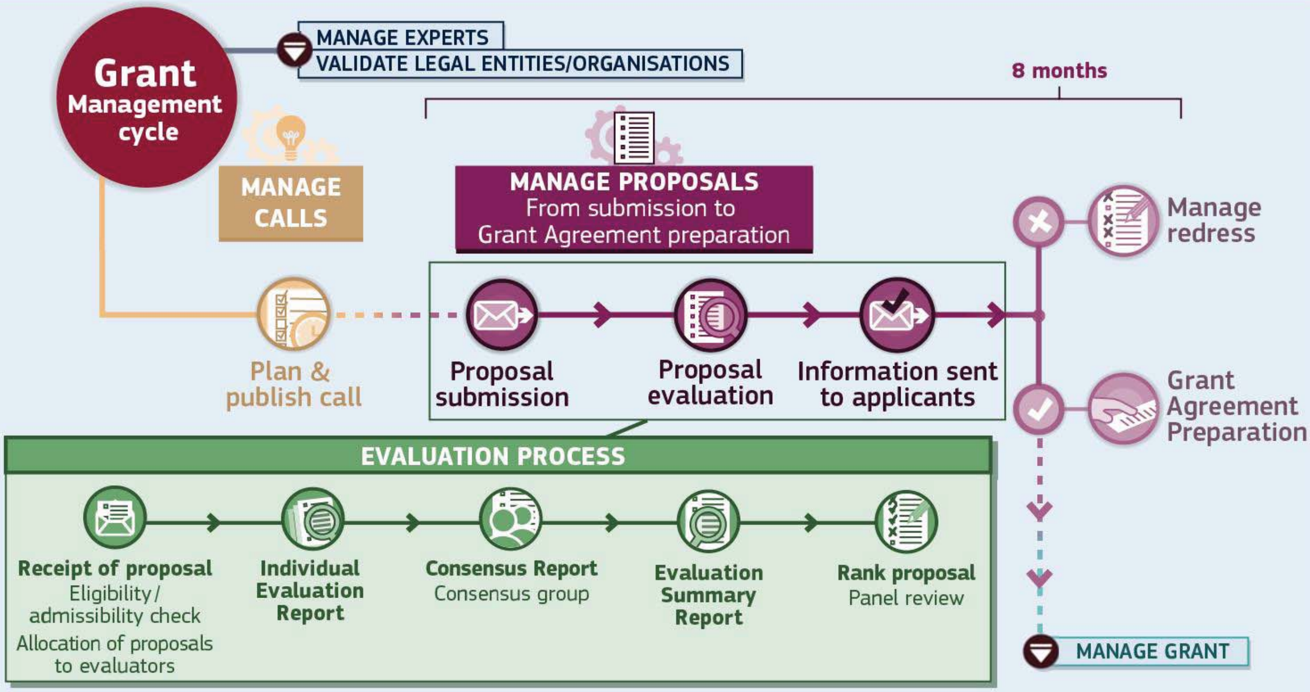
Increased budget share
- 12% in FP7
- 18% in Horizon 2020 (responsible for €17.4 bn)

Clients
- Applicants
- Beneficiaries
- Experts
- European Commission

581 staff
April 2015
764 expected by 2020

European Commission | *Research Executive Agency*

REA's services



European Commission | Research Executive Agency

Useful Information

Research Executive Agency

- **The Work Programme**

http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-security_en.pdf

- **EU Security Research**

http://ec.europa.eu/dgs/home-affairs/financing/fundings/research-for-security/index_en.htm

- **Participant Portal**

http://ec.europa.eu/research/participants/portal/desktop/en/home.html

Thank you for your attention!

angelo.marino@ec.europa.eu

REA-SECURITY-RESEARCH@ec.europa.eu

RESILIENCE-BASED APPROACHES TO CRITICAL INFRASTRUCTE SAFEGUARDING

Workshop on Methodology and Tools (aiming at resilience quantification)

Ponta Delgada, Azores, Portugal
26-29 June 2016

Example Critical Infrastructure:
Offshore wind farms

Fraunhofer EMI

CONTENT

- Objectives of Workshop
- Example inputs to Workshop I
- Proposed Structure of achieving Workshop objectives
- Glimpse on Existing text document
- Example inputs to Workshop II

Example infrastructure node

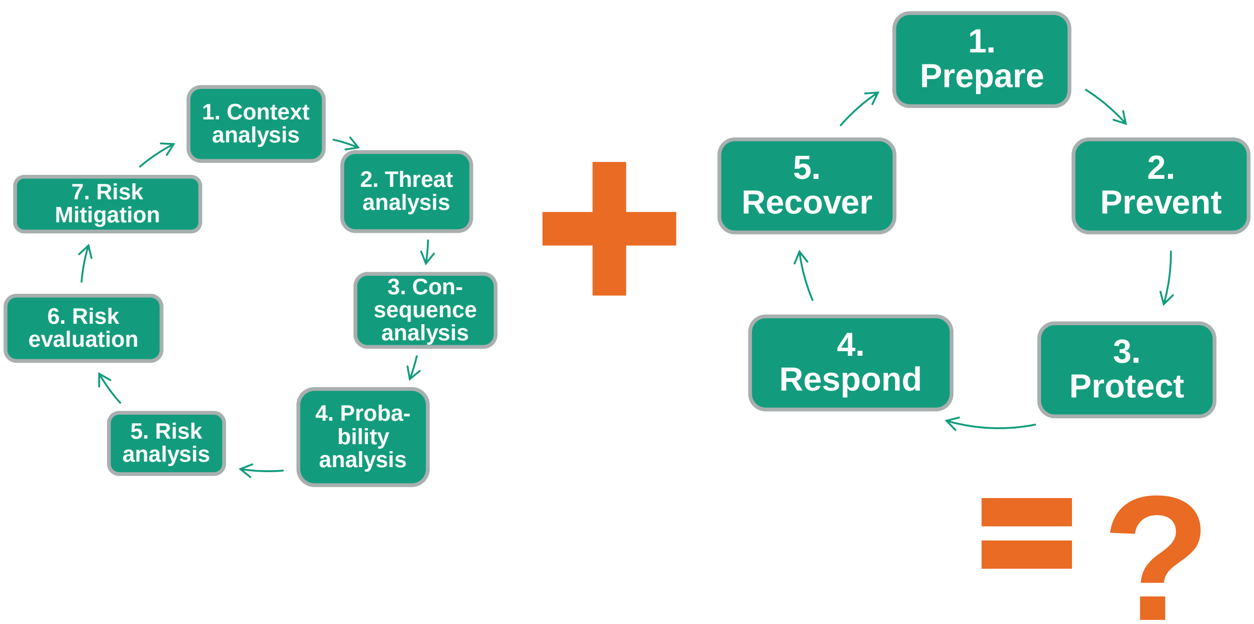
Fraunhofer EMI

CONTENT

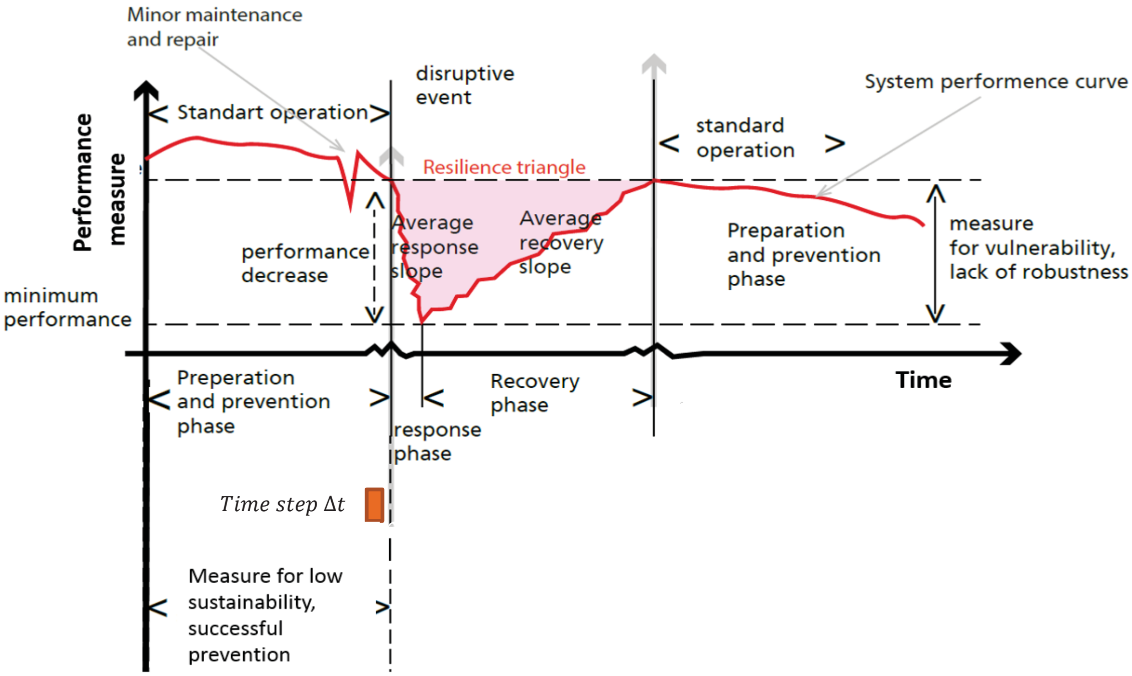
- Objectives of Workshop
- **Example inputs to Workshop I**
- Proposed Structure of achieving Workshop objectives
- Glimpse on Existing text document
- Example inputs to Workshop II

Example infrastructure node

Joint Risk & Resilience management & analysis



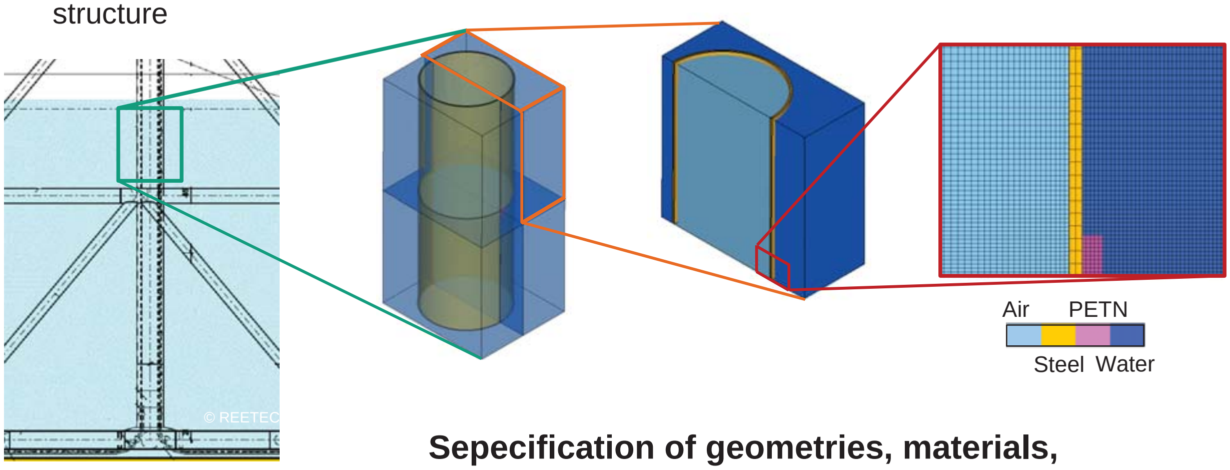
Resilience-driven Risk analysis	Protection; Response; Recovery	Resilience-informed risk computation



Fraunhofer EMI

Hazard and damage analysis;	Prevention; Protection; Response; Recovery;	Coupled continuum simulation based on CAD models;

- Sketch supply structure
- 7 m rectangle
- Further details

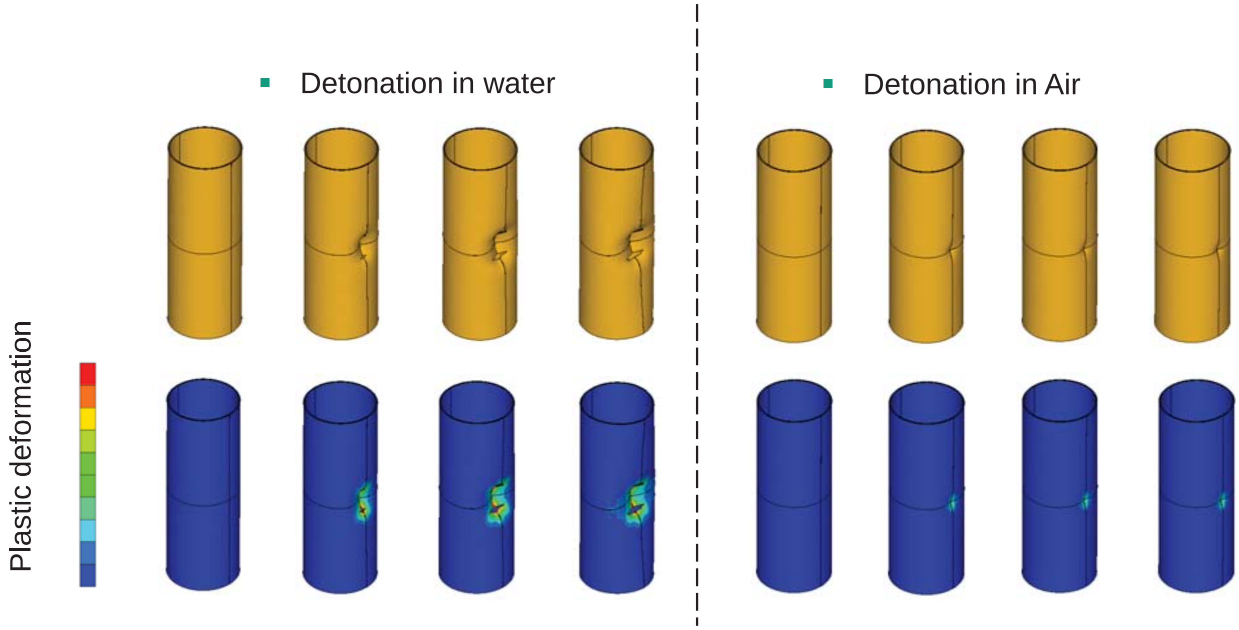


Source: Heins, O. T. Krebs, M. Baumann, G. Binder, Korrosionsschutz von Offshore-Windenergieanlagen, 2011.

Sepecification of geometries, materials, interfaces and loading

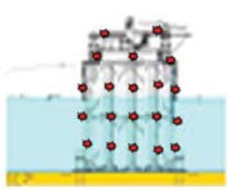
Fraunhofer EMI

Hazard and damage analysis;	Prevention; Protection; Response;	Coupled continuum simulation based on CAD models;



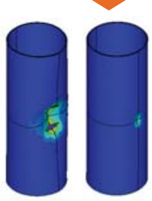
Detonation in Water results in much more plastic deformation; if cables are close to structural wall, fast electric power switch likely to be necessary

Hazard and damage analysis;	Prevention; Protection; Response; Recovery	Structural and local damage effect models; Local grid block diagrams and network model; Electric grid analysis for local and overall grid damage propagation and assessment;



Secified risk events

Damage propagation and
Effects on local offshore grid node

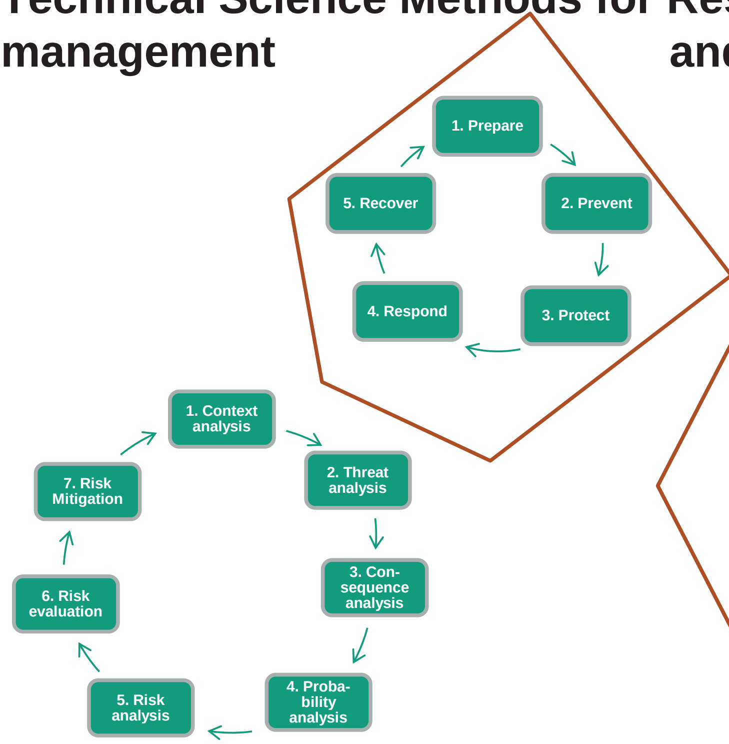


Local damage

Damage propagation in case of offshore grid node failure (Example from EU project SnowBall

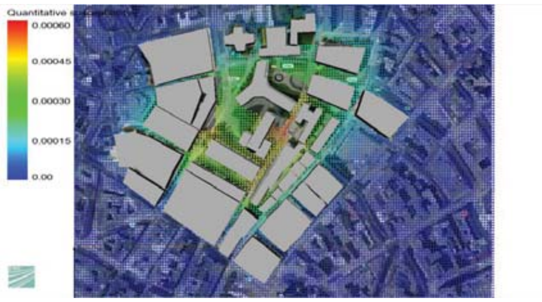
Damage analysis	Prevention; Protection; Response; Recovery	Modified Tabular Hazard analysis		
Hazard; Explosive Loading Scenario	**Location**	**Local Effect on grid node**	**Effect on off-shore grid node**	**Effect on regional grid**
Contact loading	Load-bearing Structures in Air	Minor damage	None; repair should be initiated	None
	Load-bearing Structures in Water	Destruction	Controlled switch off (due to danger of overall grid node collapse) to prevent overall electricity black out;	None
	…			
	Supply Structures in Air	Medium damage	Controlled switch off;	None
	Supply Structures in Water	Destruction	Un-Controlled switch off; Grid node should be repaired	Black out
	…			
Close-in/Near field loading	…			
Shaped charge loading / Cutter charge	…			

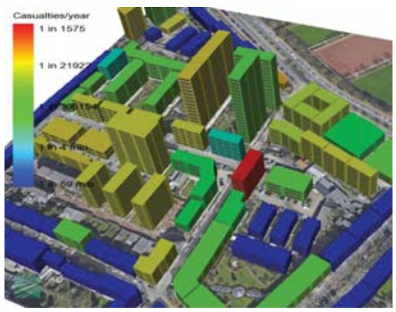
Technical Science Methods for Resilience-driven Risk management and analysis

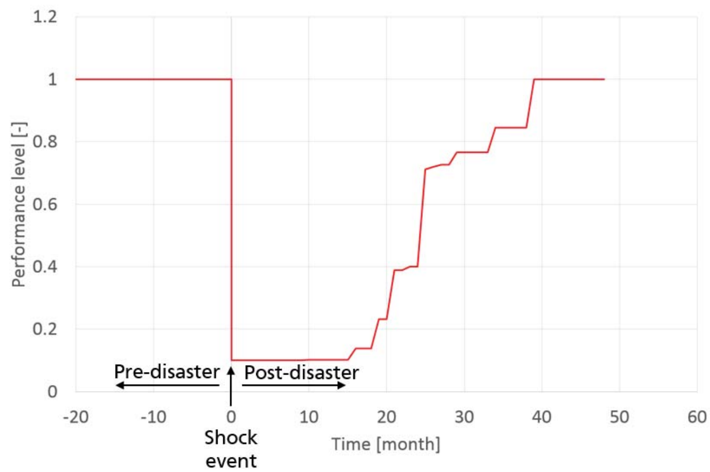


1. System description / modelling
2. Analytical / Qualitative / System/ analysis methods
3. System simulation
4. Engineering approaches
5. Experiments

Example Resilience quantification regarding terroristic threat







Calculated recovery process for set of objects

EU-Projects VITRUV, EDEN

CONTENT

- Objectives of Workshop
- Example inputs to Workshop I
- **Proposed Structure of achieving Workshop objectives**
- **Glimpse on Existing text document**
- Example inputs to Workshop II

Example infrastructure node

Proposed Workshop results paper structure: Approaches and methods for resilient quantification for designing resilient systems

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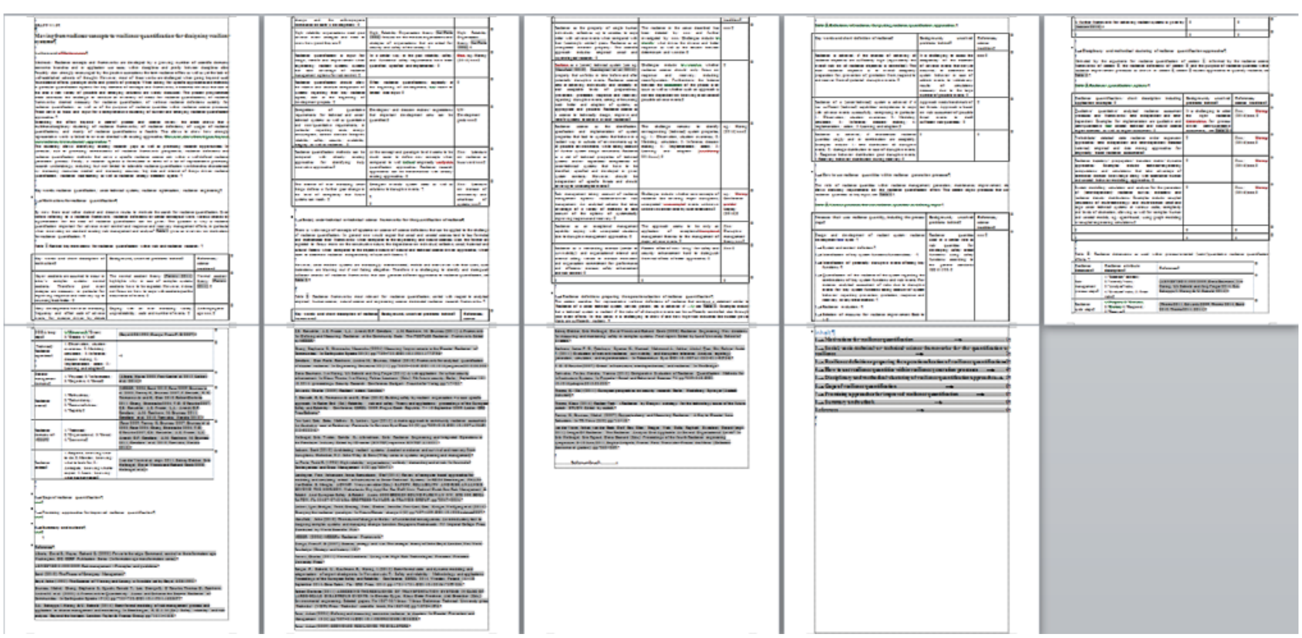
Glimpse on Workshop paper I



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Glimpse on Workshop paper II

1. → Motivations for resilience quantification

By now there exist rather distinct and decisive routes to motivate the search for resilience quantification. Even before referring to a resilience framework, resilience definitions or similar conceptual work, various strands of argumentation for the need of resilience quantification can be given. The question is: why is resilience quantification important for adverse event control and response and recovery management efforts, in particular when innovating on standard existing risk management and analysis? Table 1 gives an overview on motivations for resilience quantification.

Table 1: Ranked key motivations for resilience quantification within risk and resilience research.

Key words and short description of motivation	Background, unsolved problems behind	References; science tradition
Mayor accidents are assumed to occur in today's complex systems: normal accidents. Therefore post event strategies are necessary, in particular for improving response and recovery up to bouncing back better.	The normal accident theory (Perrow 2011) highlights why in case of complex systems accidents have to be expected. However, it does not focus on how to cope with accidents past the occurrence of events.	Normal accident theory (Perrow 2011);
Many developments hint at an increasing	Coping with an ever increasing variety,	Anthropogenic

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CONTENT

- Objectives of Workshop
- Example inputs to Workshop I
- Proposed Structure of achieving Workshop objectives
- Glimpse on Existing text document
- **Example inputs to Workshop II**

Example infrastructure node

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RESILIENCE-BASED APPROACHES TO CRITICAL INFRASTRUCTE SAFEGUARDING

Workshop on Methodology and Tools (aiming at resilience quantification)

Ponta Delgada, Azores, Portugal
26-29 June 2016

Example Network

Resilience generation process driven by resilience quantification and informed method selection

- Motivation for resilience quantification for resilience generation
- Frameworks for the quantification of resilience and other methods
- Resilience definitions for operationalization of resilience quantification
- Use of resilience (quantification) methods within resilience generation processes

- Joint/ Generic process for generation/improvement of resilience of systems, including method selection
- Taxonomy of resilience generation and quantification/assessment methods
- Assessment of Disciplinary/ methodical/ rigor/ …confidence level of methods
- Application cases
- Gaps and promising approaches of resilience generation processes and methods

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?

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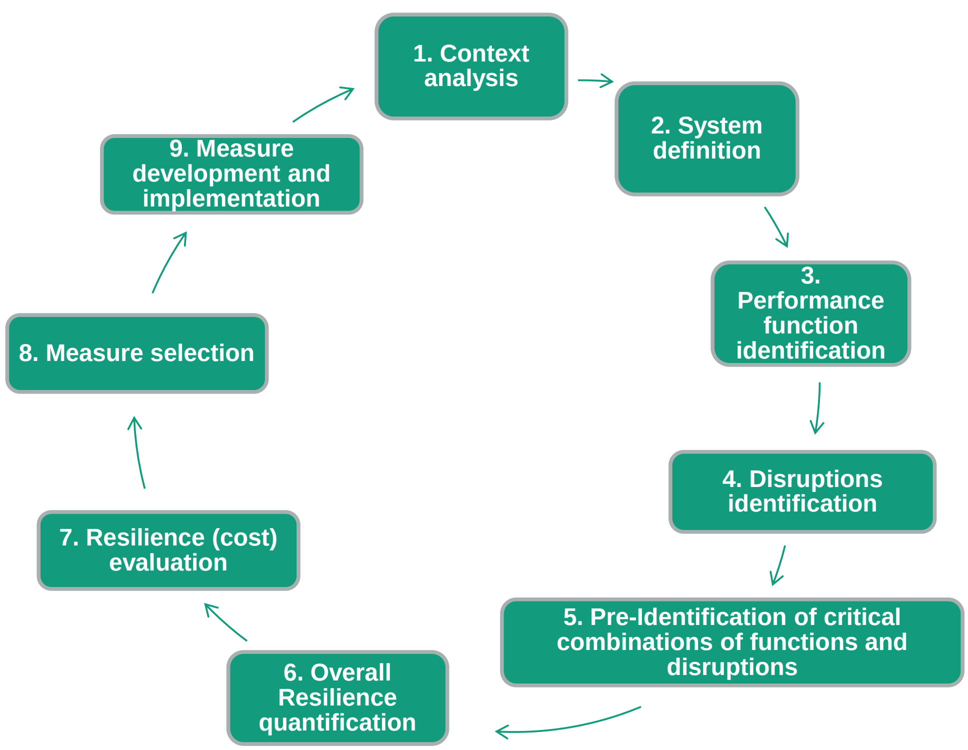
Resilience generation/management process



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Methods for resilience generation and quantification

Method, Approach
Semi-quantitative approaches
Intolerability models: Input-Output models;
Probabilistic, stochastic approaches
Network, graph, grid based modeling and simulation
Empirical-statistical approaches
Engineering-based approaches
Resilience Score cards
Event/Treat/Disrution analyis
...

Method level/rigor/confidence … classification (cont.)

Method characterization examples, where applicable	Top level charcterization of rigor of quantification/method effort		
	Low	Medium	High
Level of (deep) uncertainty	High	Medium	Low
Level of completeness	Low	Medium	High
Time effort	Short	Medium	Long
Level of confidence	Low	Medium	High
Data needed	Few	Medium	High
Level of expertise needed	Low	Medium	High
Level of quantification	Low	Medium	High
Level of modeling	Top level	Medium	Refined
Type of simulation	Abstract	Parametrized/ engineered	Predictive, coupled disciplinary

Method level/rigor/confidence … classification

Method characterization examples, where applicable	Top level charcterization of rigor of quantification/method effort		
	Low	Medium	High
Probability of resilience funcitonaltiy of system function on demand	30%	10%	3%
Availability of resilience functionality on demand	70%	90%	97%
Continuous availability of resilience function per hour	3E-05	1E-05	3E-06
Level of granularity of model resolution	Low	Medium	High
Method level categorization accoring to Igor et al.	Tier 1	Tier 2	Tier 3
Level of rigor	Low	Medium	High
Degree of confidence of method	Low	Medium	High
Degree of state of the art of method	Low	Medium	High

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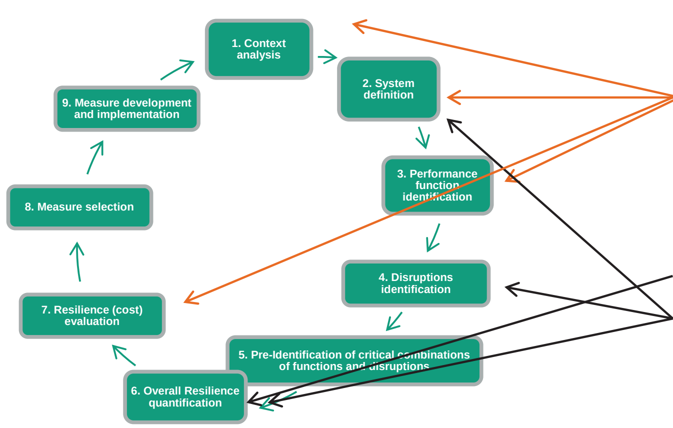
Resilience generation/management process



Method, Approach
Semi-quantitative approaches
Resilience score cards
Network/ grid/ graph based approaches
Engineering based approaches
Cyber-physical socio-technical simulation
…

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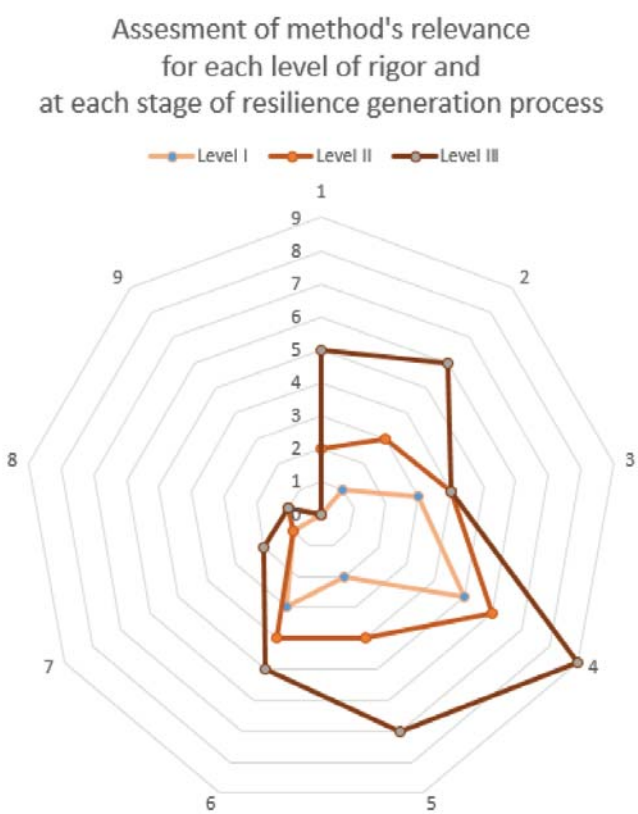
Method selection wrt. to Resilience level

Method	Sample recommendation of use of methods summarizing over all phases		
	Low	Medium	High
Functional Resonance analysis	++	+	+
Resilience score card	++	++	++
Grid-based methods	+	+	++
Engineering approaches	0	+	++
Cyber-physical socio-technical system simulation	--	0	+
…			

Single Method applicability to Resilience management phases



Method applicability to Resilience management phase

Method:	Relevance assesment according to rigor levels:								
	Level I			Level II			Level III		
Method 1	0	1	3	2	3	4	5	6	4
	5	2	3	6	4	4	9	7	5
	1	0	0	1	1	0	2	1	0
Method 2									
...									

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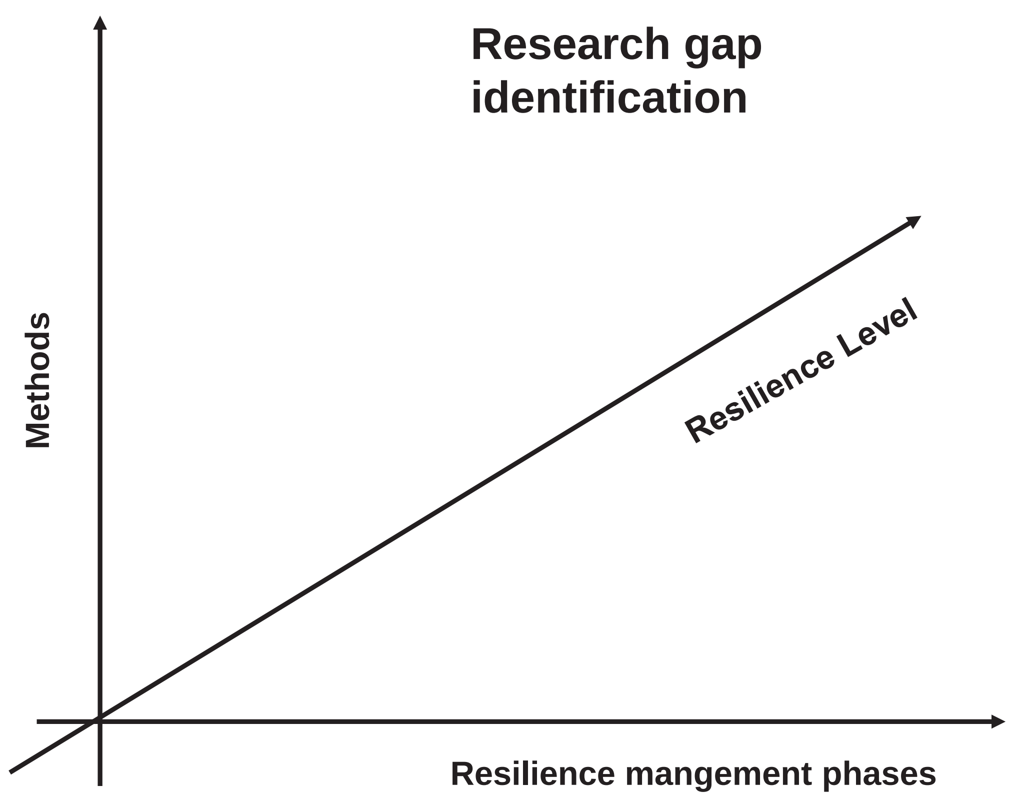
Research gap identification



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Resilience generation process driven by resilience quantification and informed method selection

- Motivation for resilience quantification for resilience generation
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OUTLOOK

- Chapter(s)
- Publication(s)

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ADVANCED RESEARCH WORKSHOP

Azores, 28th June 2016

TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
THE UNIVERSITY OF DUBLIN

THE CHALLENGE OF THE NUMERICAL ASSESSMENT OF RESILIENCE

Maria Nogal

RESILENS
RESILENS®consortium
EU Horizon 2020
Project No. 653260

RAIN PROJECT

This project is funded by the European Union

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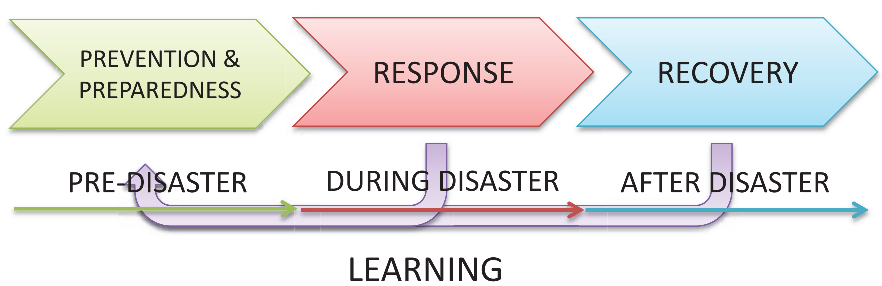
ASSESSING RESILIENCE. WHY?

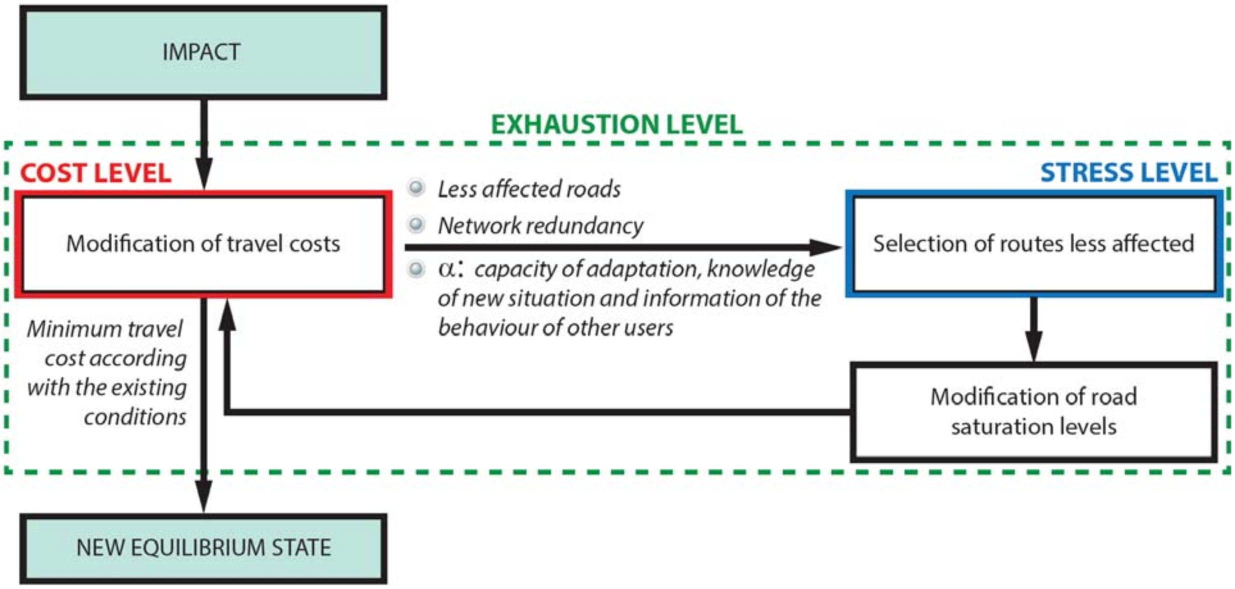
STAGES



Assumptions;

- **System of systems**. To focus on the **critical elements** and their interdependencies.
- **Analysis levels**. **Physical, operational** (performance) **and management** levels.
- **Dynamic problem**.

ROAD TRANSPORT RESILIENCE



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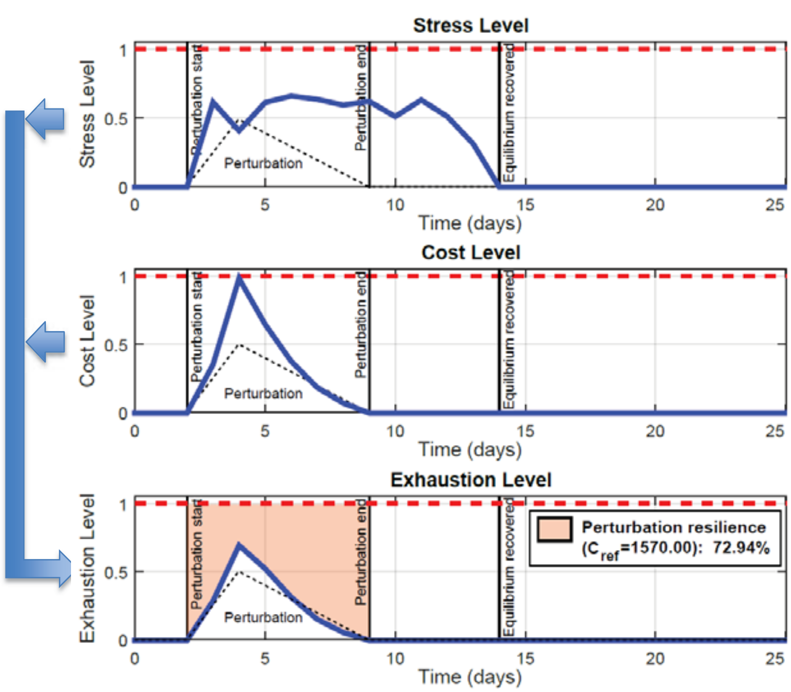
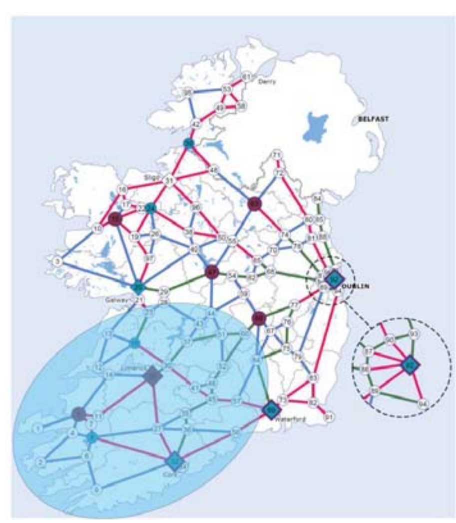
Azores, 28th June 2016

ROAD TRANSPORT RESILIENCE



α: **Capacity of adaptation** to the new situation (users information).



RESILIENCE OF A GENERAL SYSTEM

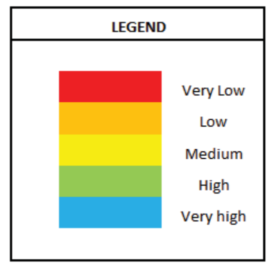
General approach to assess **numerically** the resilience of any system.

(Input)

Stage	Physical level	Operational level	Organizational level
Previous hazard	I&C	I&C	I&C
	I&C	I&C	I&C
	I&C	I&C	I&C
	I&C	I&C	-
	I&C	-	-
During hazard	I&C	I&C	I&C
	-	I&C	I&C
	-	-	I&C
	-	-	-
Post hazard	I&C	I&C	I&C
	I&C	I&C	-

Time Dimension

Holistic Approach



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RESILIENCE OF A GENERAL SYSTEM

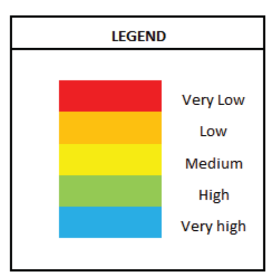
General approach to assess **numerically** the resilience of any system.

(Input)

Stage	Physical level	Operational level	Organizational level
Previous hazard	I&C	I&C	I&C
	I&C	I&C	I&C
	I&C	I&C	I&C
	I&C	I&C	-
	I&C	-	-
During hazard	I&C	I&C	I&C
	-	I&C	I&C
	-	-	I&C
	-	-	-
Post hazard	I&C	I&C	I&C
	I&C	I&C	-

(Output)

Stage	Physical level	Operational level	Organizational level	RESILIENCE per stage
Previous hazard				**Medium**
During hazard				**Medium**
Post hazard				**Medium**
RESILIENCE per level	**High**	**Medium**	**Low**	



RESILIENCE OF A TRANSPORTATION SYSTEM

TRANSPORTATION SYSTEM *(Input)*

Stage	Physical level	Operational level	Organizational level
Previous hazard	Infrastructure condition	Travel cost, delays, congestion	Network management (administration, maintenance, and provision of network)
	Redundancy	Traffic composition	Management of the information, control and communication systems
	Accessibility	Behavioural patterns of users	Adaptive logistics
	Connectivity	Intermodality	Management of the inter-modality
	-	Use of driver and passenger Information Systems	Management of the early warning systems
	-	-	Emergency plans
	-	-	Inter-systems co-operation between infrastructure operators
During hazard	Infrastructure condition	Emergency warning systems	Management of the information, control and communicating risk (road administrations – with and within countries-, contractors, communication with stakeholders)
	Remaining accessibility	Information services	-
	Remaining connectivity	-	-
Post hazard	Resources available	Capacity of adaptation of users	Capacity of adaptation of managers
	Redundancy	-	-

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Qualitative assessment based on Indicators

Two ways of filling in the table;

(a) **Indices/characteristics** rely on subjective assessments (qualitative or semi-qualitative approach).

(b) **Indicators** that quantify system attributes (e.g., reliability), which **are assumed to be related** to the resilience.

- What are **the most important indicators?**
- How much does any indicator explain the resilience (**weight**)?
- How **overlapped** are the indicators?

Qualitative assessment based on Indicators

The **STRUCTURED EXPERT JUDGMENT ELICITATION FOR DEPENDENCE MODELLING** is used to determine the dependence and overlapping between resilience and any possible indices, obtaining the structure of the dependence relations between variables.

- This approach can be used to identify **the most relevant indicators** to be considered when assessing those descriptors of traffic networks.
- This methodology will allow **quantitative approaches**, rather than the so common qualitative or semi-qualitative methods.

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THANKS

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www.rain-project.eu

www.resilens.eu

Integration of Risk and Resilience into Policy

Raymond NYER

Sources: OECD, MEEM,IHEDN,INHESJ,HCFDC,SGZDS,DRIEE

PARIS and SEINE Basin Risk and Resilience

- **1910 Centennial Flood**
- **European Union Directive (2007)**
- **French national flood risk management strategy and implementation plans according to the directive transposition law (2010)**
- **OECD Review of Risk and Resilience Policies recommendations (2015)**
- **EU SEQUANA Exercise March 2016**
- **Most recent Flood May/June 2016**

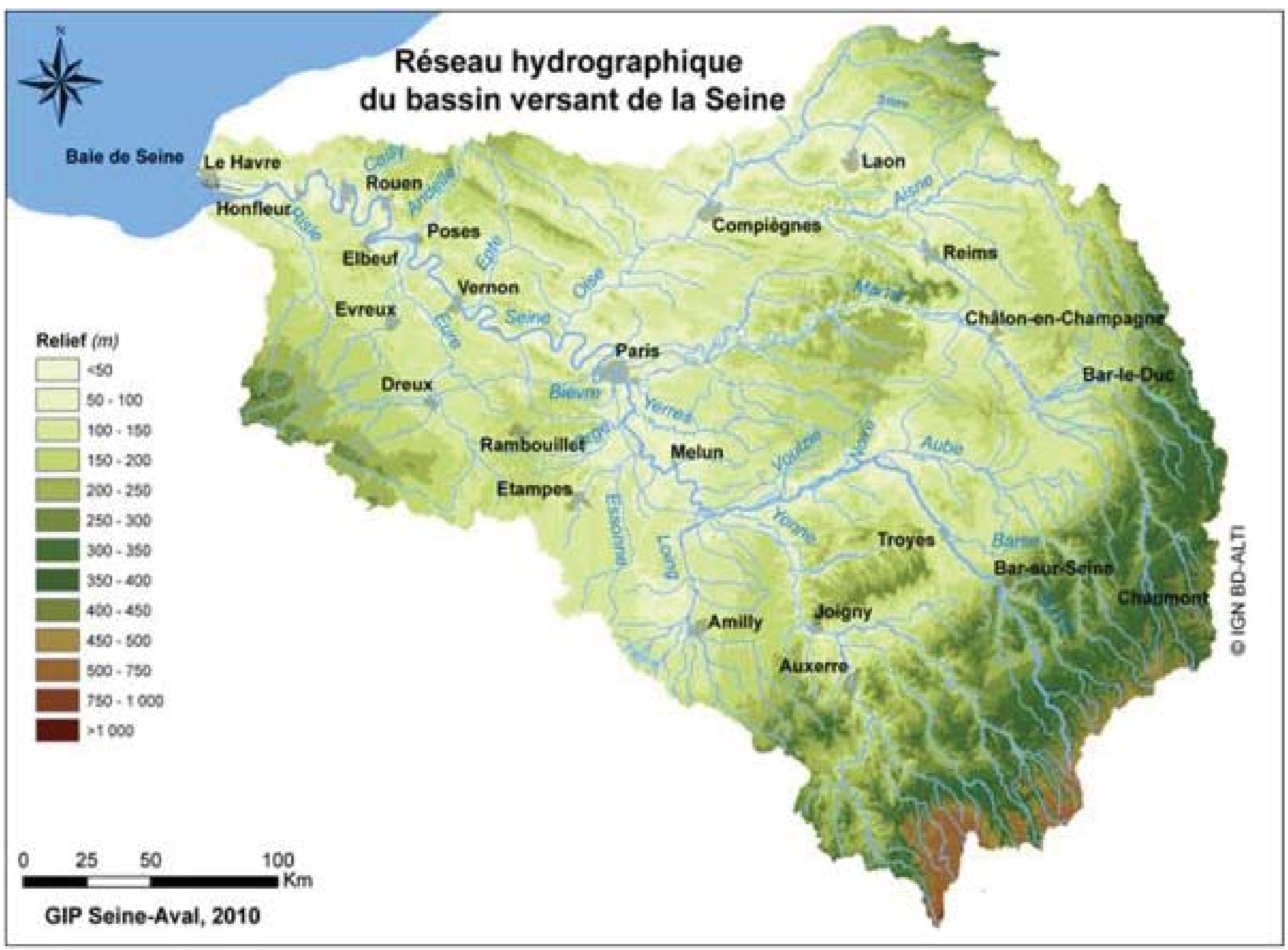


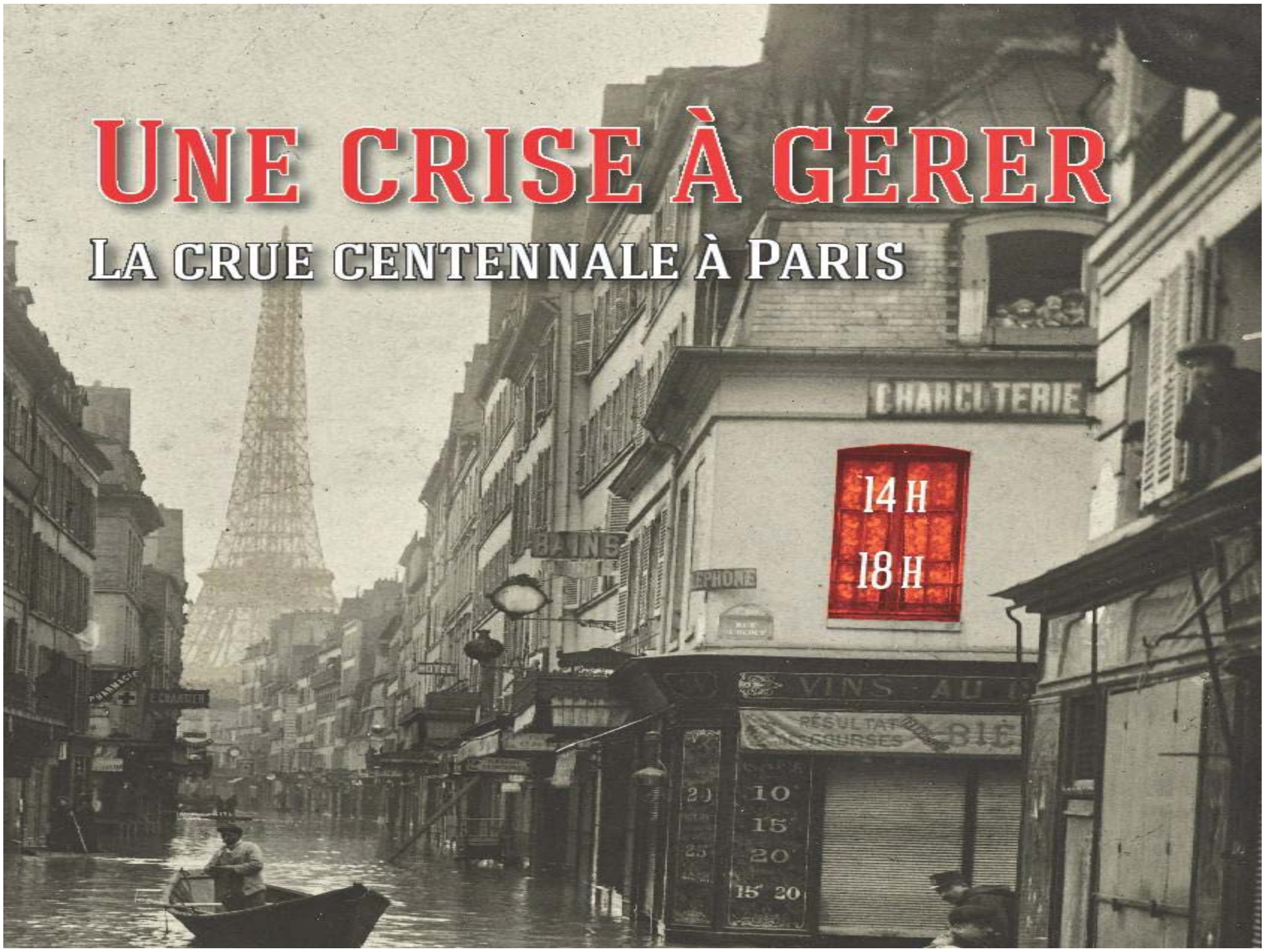
8,62 m 1910
7,32m 1924
7,12m 1955
6,18m 1982
6,10m 2016
5,20m 1999/2000
3,20 Etat d'alerte


http://lefildutemps.free.fr

1910 Great Flood

- The water got to its highest after 10 days and after 35 days the water was gone completely.
- On January 28th the water reached its maximum height at 8.62 metres (28.28 feet) above its normal level.
- Estimates of the flood damage reached some 400 million [francs](), or [$]()1.5 billion in today's money.
- 22.000 buildings and cellars , several hundreds of streets ,more than 30 metro stations and 60 km of lines , several railway stations, electric and gas distribution nodes were flooded
- More than 30.000 houses in the Seine Basin were evacuated




UNE CRISE À GÉRER
LA CRUE CENTENNALE À PARIS
CHARCUTERIE
14 H
18 H
BAINS
HOTEL


JOB

The EU Flood Directive (2007)

- Directive 2007/60/EC on the assessment and management of flood risks entered into force on 26 November 2007.
- This Directive requires Member States to **assess** if all water courses and coast lines are at **risk** from flooding, to **map the flood extent and assets and humans at risk** in these areas and to **take adequate and coordinated measures** to reduce the flood risk.
- This Directive also reinforces **the rights of the public to access this information and to have a say in the planning process.**

EU Flood Directive

- **Legal framework for integrated water management including flood risk management**.
  - •Coordination other legal acts, mainly Directive 2000/60/EC(Water Framework Directive), including cyclical implementation.
  - •Integration, covers many sectors. Land use, civil protection, dam management, strategic and environmental impact assessments, nature legislation, public consultation.
  - •Coordination across the river basin, including requirements for transboundary coordination !
  - •Flood risk management plans to cover all aspects of flood risk management, with focus on prevention, protection and preparedness, including flood forecasts and early warning systems
  - •Ultimate aim is to reduce the adverse consequences of floods.

Three stage approach

- **Preliminary flood risk assessment (maps**, experience from past floods, predictions of future floods, identification areas of potential significant flood risk) — 22.12.2011
- **Flood mapping** (= knowing areas at risk of flooding, different scenarios, flood hazard maps & flood risk maps) — 22.12.2013 *
- **Flood Risk Management Plans** (= plans to reduce flood risks, covering all elements of the flood risk management cycle) — 22.12.2015 **

Review /update every 6 years thereafter

Reporting to the Commission : 3 months after

* = date of 1st review of pressure and impact analysis under the WFD

** = deadline for 2nd cycle WFD river basin management plans

French National Flood Risk Management strategy

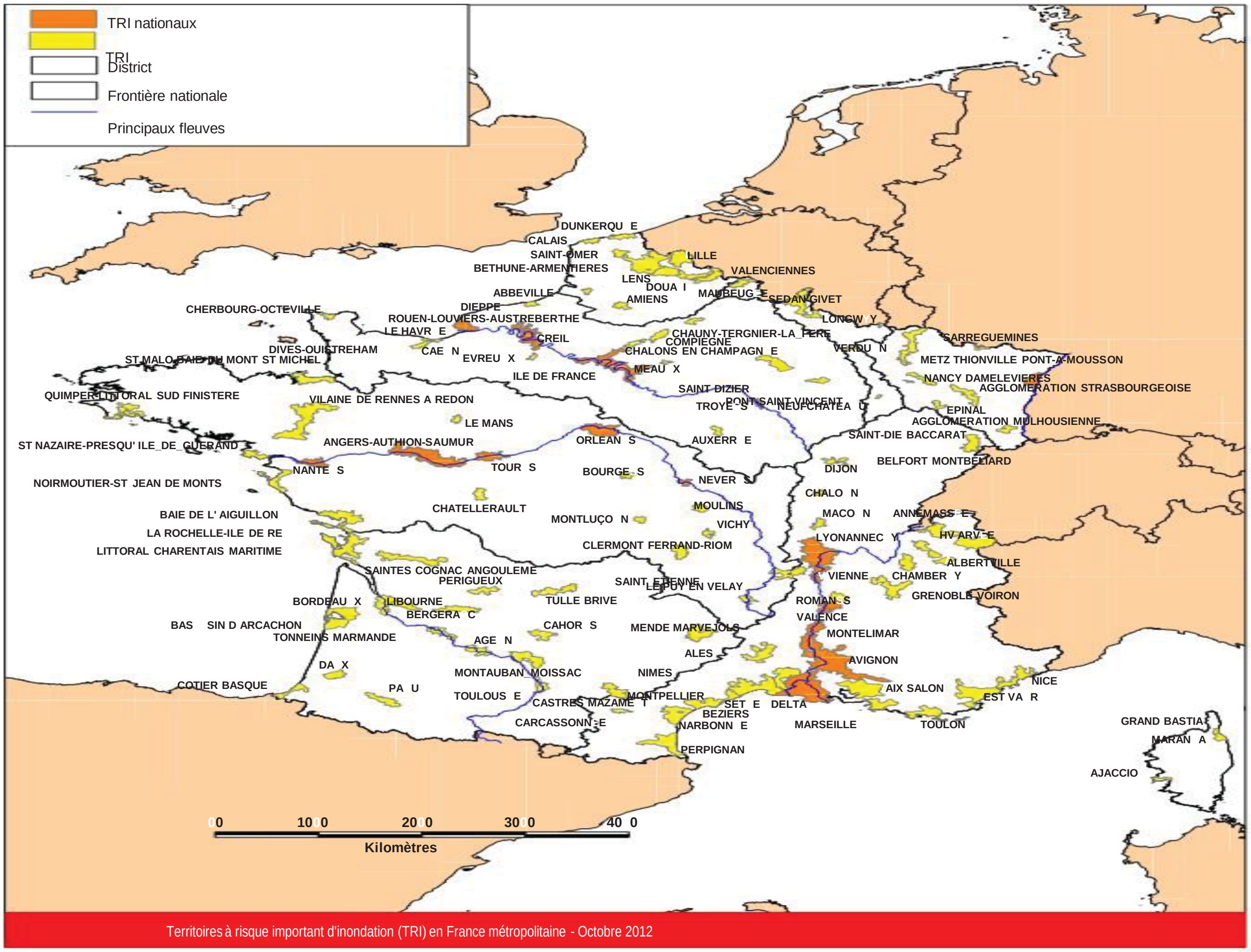
- Objectives
  - -Improving the safety of exposed population
  - -Stabilising in the short term and reducing in the long term the cost of flood damages
  - -Significantly shorten the time required by affected areas to return to normal

French National Flood Risk Management strategy

- Strategic orientations –Challenges to meet
  - -Developping governance and project management
  - -Sustainable territorial development
  - -Knowing more to act better
  - -Learning to live with floods

French National Flood Risk Management strategy

- Identification of 122 TRI (Territories with flood risks)
- Flood risk assessment and management developped for each TRI (FRMP)
- Each municipality developped its plan (PCI) consolidated at TRI level, department level , region and nation level.



Major assets at risks in the Seine Basin

463 km^2 , 830 000 inhabitants
55 700 companies representing 620 000 jobsbbbbb

Key government institutions, 295 schools, 79 hospitals, 11 637 power sub-stations, 140 km & 41 subway stations, 3 railway stations, sub-urban train, 85 bridges, 5 highways

Cultural heritage : the Seine Parisian banks part of UNESCO World Heritage, thousands of historical buildings, museums and art galleries

Evironment: wastewater stations, industrial sites SEVESO, waste disposals, oil deposits

Why an OECD Review ?

- Value of international comparison as a lever for policy change
- OECD strength in economic analysis for a comprehensive risk assessment
- Inclusive and independent policy dialogue with all all stakeholders

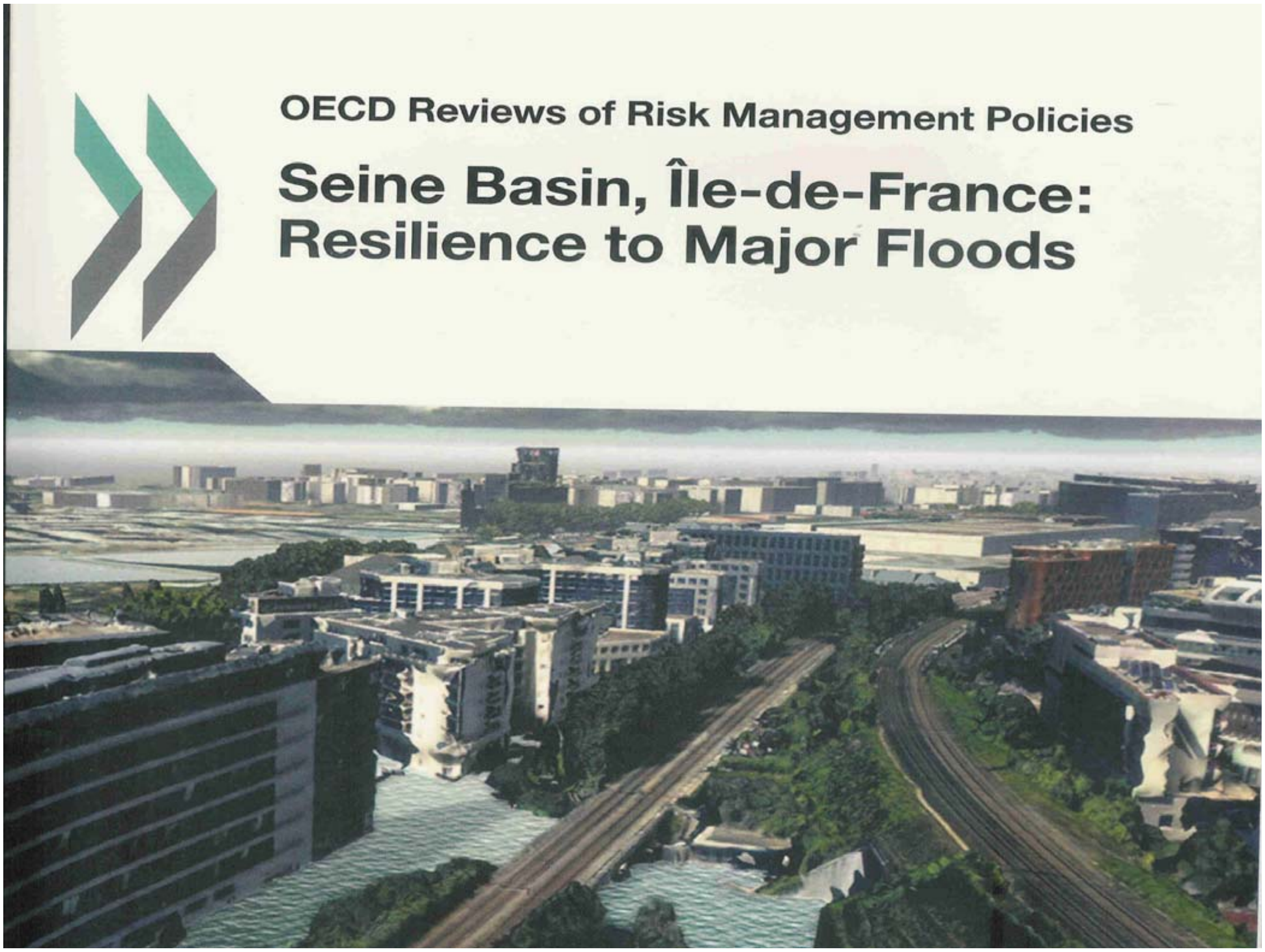
A high participation of the stakeholders

PUBLIC AUTHORITIES	PRIVATE SECTOR	NETWORK OPERATORS
Municipalities Districts Region State Public Agencies	Large corporations NGOs SMEs Bank & insurance	Transport Telecom Electricity Water

Lessons learned from international comparison

Cities or country	Year	River or event	Return period	Damages and losses (Bio €)
Prague	2002	Vlatva	500 y	3,1
New-Orleans	2005	Katrina floods		90
UK	2007	Severn & Thames	200 y	4,6
Brisbane	2011	Brisbane	120 y	11,7
Bangkok	2011	Chao Phraya	> 100 y	36,1
New-York	2012	Sandy floods	400-800 y	14,8

New-Orleans after Katrina 2005
Source: Romain Huret, 2010

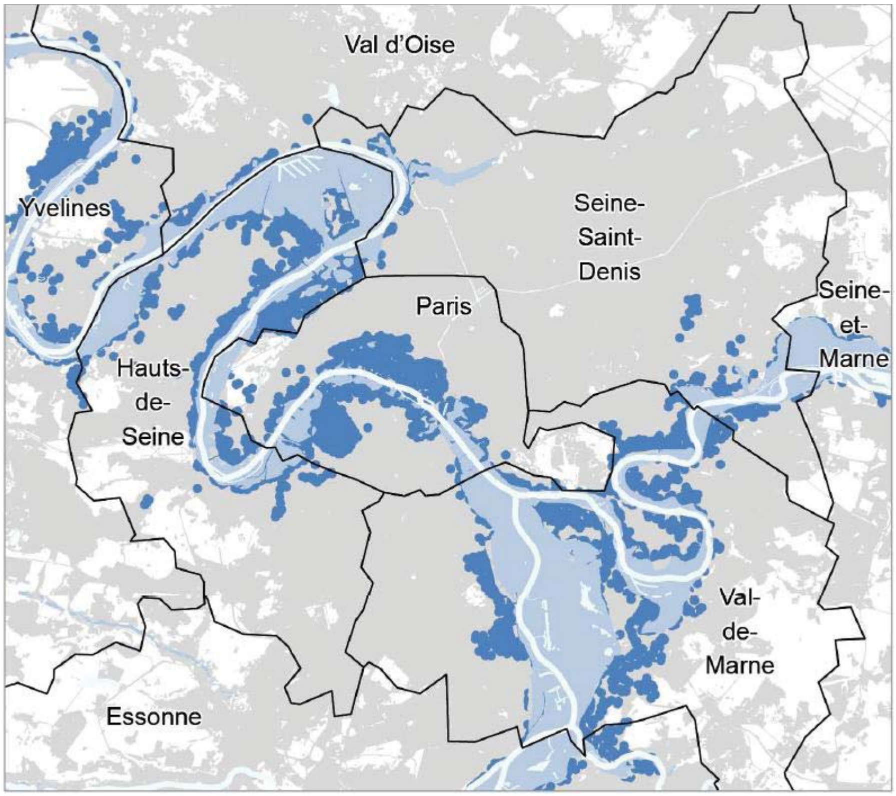


Working with scenarios around the historic 1910 flood

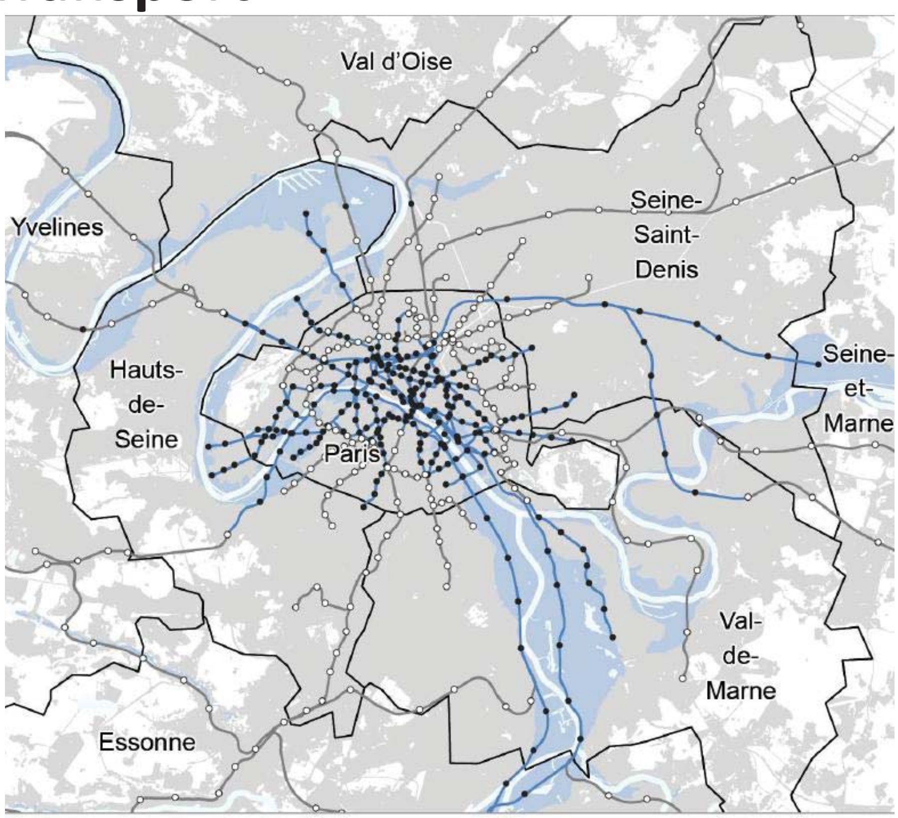
Threshold effects and existing data sources

CHARACTERISTICS	Scenario 1	Scenario 2	Scenario 3
Discharge (/ 1910)	80 %	100 %	115 %
Water level (Paris)	7,32 m (1924 flood)	8,12 m	8,62 m (1910 flood)
Duration	1 week	2 weeks	1 month
Population affected	100 000	600 000	1 000 000
Impacts on critical networks (Electricity, Transport, Water)	Partial disturbance	Large disturbance	Global disturbance
Disturbance to economic activities	2 weeks	1-2 month	2-5 month

Impacts on critical networks
Electricity



Impacts on critical networks
Transport



Key messages

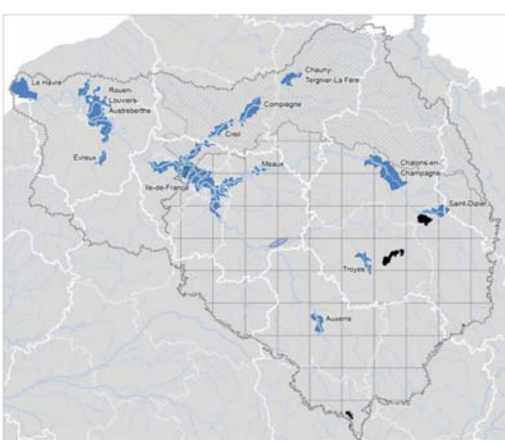
1. **EU and Countries Risk Strategies mainly focus on vulnerabilty and prevention , but Resilience should become more and more important**
2. **An effort to recalibrate, better coordinate and adjust public policies is still needed and could reduce the level of risks**
3. **Many opportunities are converging to engage an ambitious resilience strategy**

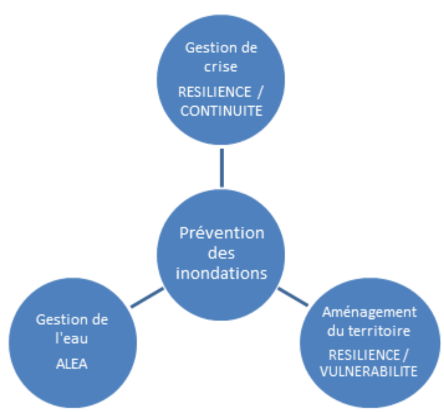
Few areas to further develop :

- ✓ **Inventing a new governance approach for prevention**
- ✓ **Reinforcing whole-of-society resilience efforts**
- ✓ **Developing a long term strategy for financing prevention**

Inventing a new governance approach for prevention

- ✓ Coherence of the legal and regulatory framework
- ✓ Roles and responsibilities of the different stakeholders
- ✓ Coordination mechanisms (different scales & policy areas





Development of a shared vision and precise objectives based on existing opportunities (EU FD)

Reinforcing prevention through whole-of-society resilience efforts

- Knowledge
- Risk culture
- Urban planning
- Critical infrastructures
- Business continuity
- Green infrastructures
- Protection infrastructures
- Storage infrastructures

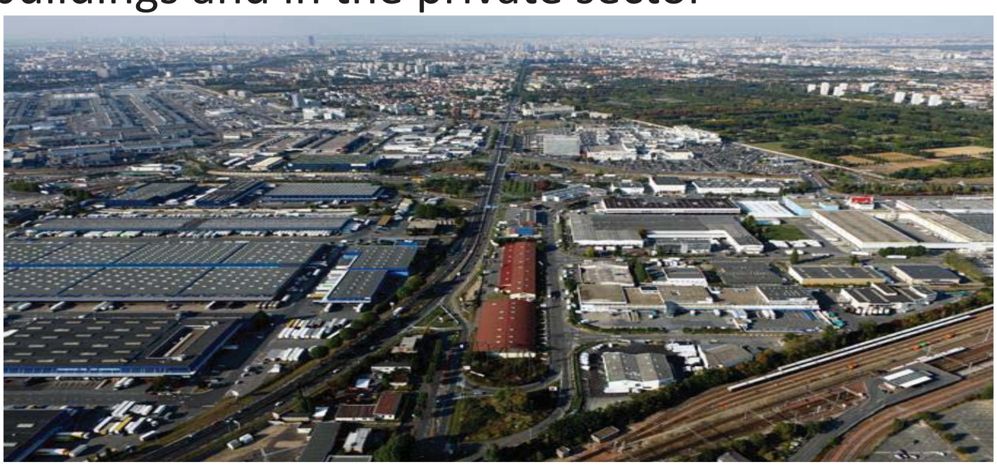
NON-STRUCTURAL (Knowledge; Risk culture; Urban planning; Critical infrastructures; Business continuity)

STRUCTURAL (Protection infrastructures; Storage infrastructures)

Principles of coherence, prioritisation, international comparison, innovation

Non structural measures for resilience
Urban planning and business continuity

- ✓ Regulatory aspects for urban planning
- ✓ Resilience of critical infrastructures
- ✓ Need to incentivise resilience in existing buildings and in the private sector



Opportunities to innovate with the Great Paris project

Financing prevention

An important risk: « tail » event & large share

- ✓ Seine flood : a significant part of mean economic damages

- ✓ A significant macroeconomic impact
  - 0.1 to 3 % cumulated GDP losses over 5 years
  - 3-30 Bio € cumulated damages over 5 years
  - ✓ **10.000 to 400.000 jobs losses following crisis**

- ✓ Existing resources and innovative financing tools for prevention
  - ➔300-450 Mio € investments per year
  - – Low contribution to Seine flood prevention
  - – What is the acceptable level of risk, how to prioritise ?

➔Long term financing strategy, cost effectiveness, equity maximising coherence and synergies across policies

The way forward

- ✓ Engaging a positive dynamic on resilience
- ✓ Implementation of the policy recommendations
- ✓ Innovative approach for flood risk assessment
- ✓ Partnership between the French Ministry of Ecology and the OECD High Level Risk Forum
- ✓ Use Good practice examples presented at the various World Water Forum (Sendai and other exposed world states)
- ✓ Use OECD Recommendation on the Governance of Critical Risksi and EU recommendations on Risk and resilience integration

The OECD Recommendation on the governance of critical risks

- **Objective**: Ensure that governments develop robust frameworks for the governance of critical risks and their resilience to major shocks

1. **A holistic approach to risk management**
2. **Risk assessment, foresight, financing framework**
3. **Whole-of-society approach to prevention**
4. **Strategic crisis management**
5. **Transparency & accountability**

EU SEQUANA 2016 exercise

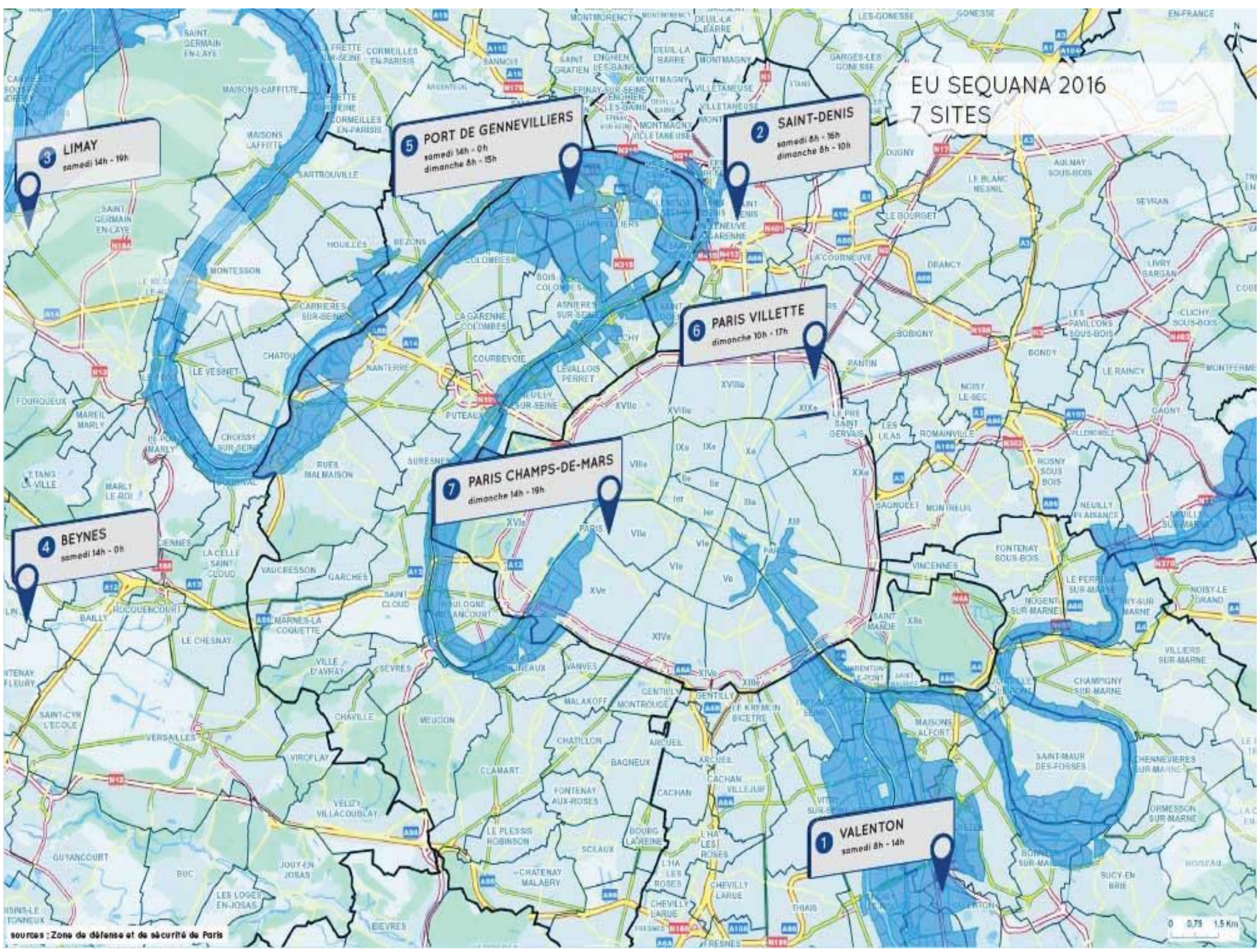
Co-financed by the European Union

EU SEQUANA (March 7 to 18th 2016)

- Objectives

  -To assemble international and national stakeholders for a flood crisis management exercise (5 EU countries and 90 french partners involved)

  - To focalize population attention on the very high criticality of possible flood occurrence
- 7 sites selected in the SEINE Basin to perform simulation
- Test of the actors coordination in the crisis mangement: (EU Civil Protection Mecanism,Regional and Departmental State Services (COD),Territorial Communities (TRI),Communes as 1rst level actors,all the other stakeholders Private and Public)



May /June 2016 FLOOD

- From May 30th To June 5th (maximun 6,10 m)
- 24000 households impacted
- 20000 persons evacuated
- around 1.5 B€ losses estimated by insurance companies
- 24 persons injured
- 4 deaths

FLOOD SIMULATION by VIGIECRUE

Thank you for your attention!

raymond.nyer@centraliens.net

ETH zürich

Giovanni Sansavini

Engineering Resilience in the Energy Infrastructure

Reliability and Risk Engineering – D-MAVT – ETH Zurich – Switzerland

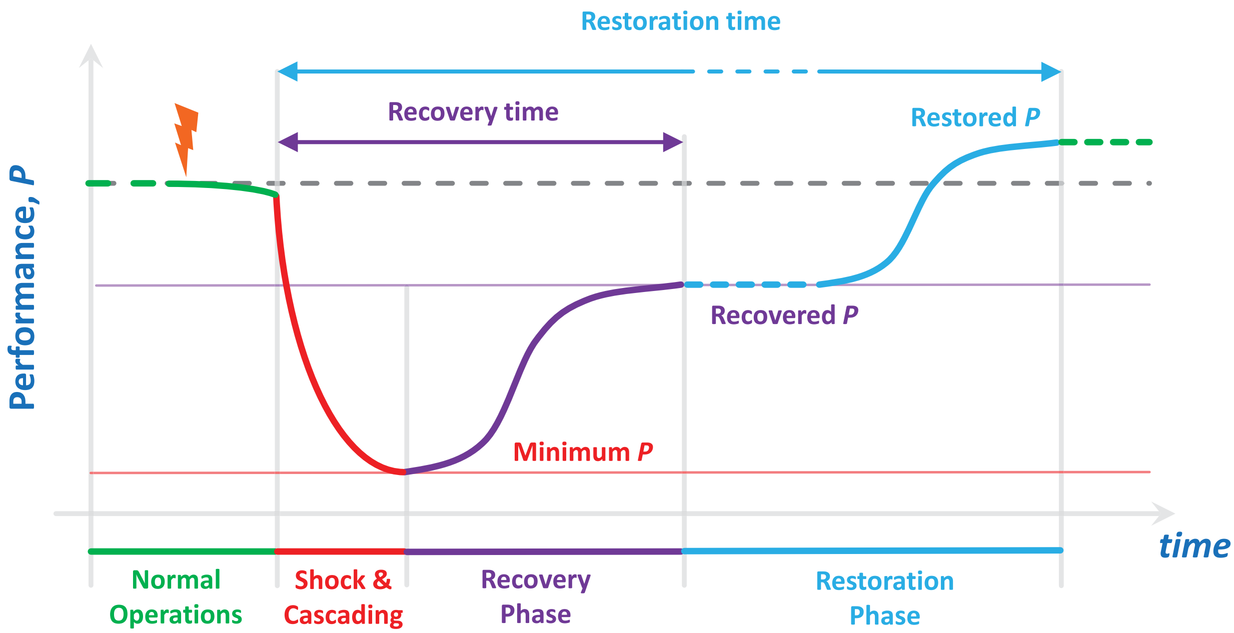
ETH zürich

RRE
Reliability and Risk Engineering

Resilience Thinking

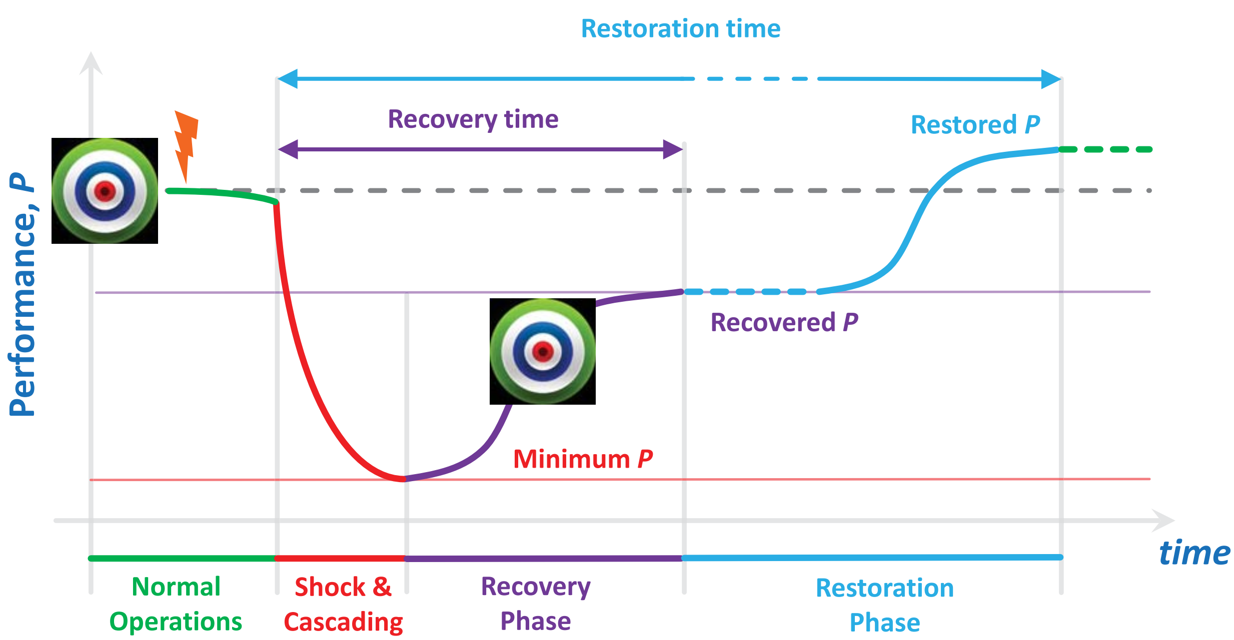
- Adds a **<u>dynamic perspective</u>** to risk by focusing on
  - the evolution of system performance after disturbances
  - surprises (“known unknowns” or “unknown unknowns”), i.e. disruptive events and operating regimes which were not considered likely design conditions
- From the ex-post assessment and mitigation of risks to the ex-ante system design process: **<u>embeds risk thinking into the design process</u>**
- **<u>Expands vulnerability</u>** (graceful degradation)
  - Beyond hardening and prevention
  - reaction/adaptation and capability of recovering an adequate level of performance
- You cannot design a bridge but you can **<u>rank</u>** different bridge designs
- Expands system boundaries -> Scope of assessment is **<u>fuzzier</u>**

Engineering System Resilience

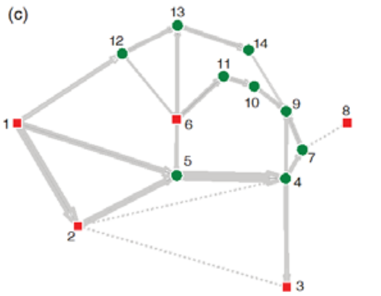


ETH zürich
RRE Reliability and Risk Engineering

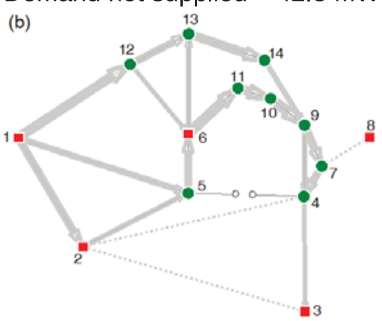
Engineering System Resilience



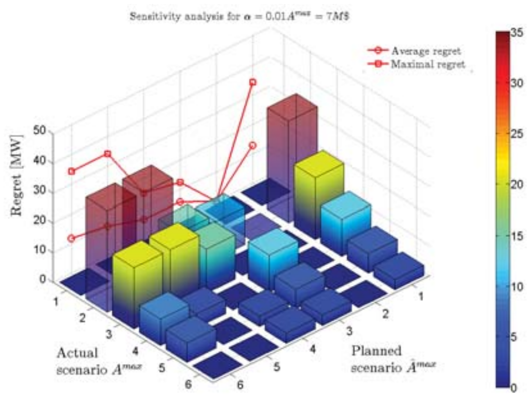
Integrated Planning of System Expansion and Recovery Devices

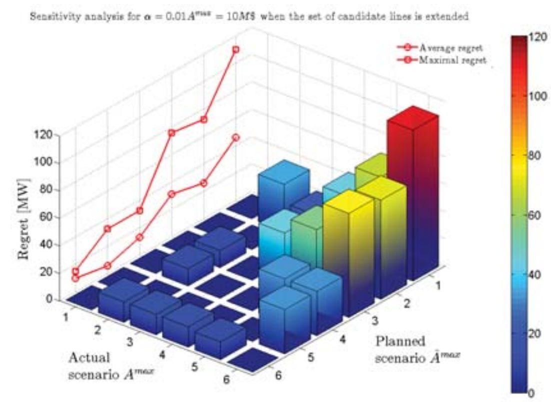


Demand not supplied = 42.3 MW



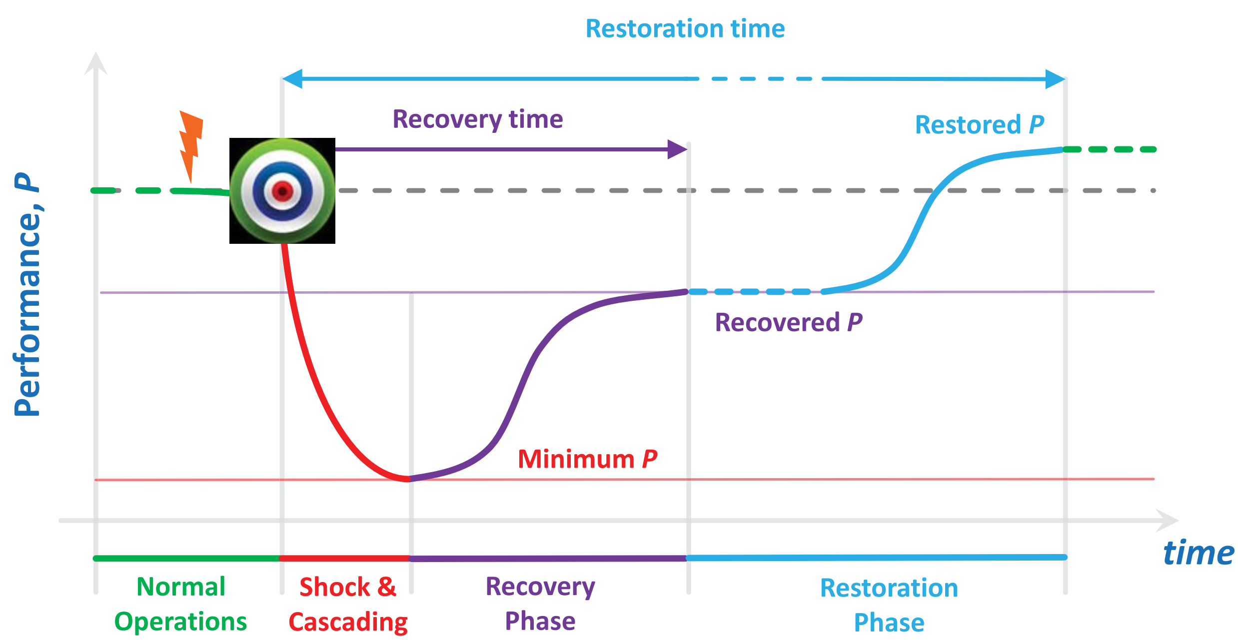
Demand not supplied = 26.7 MW



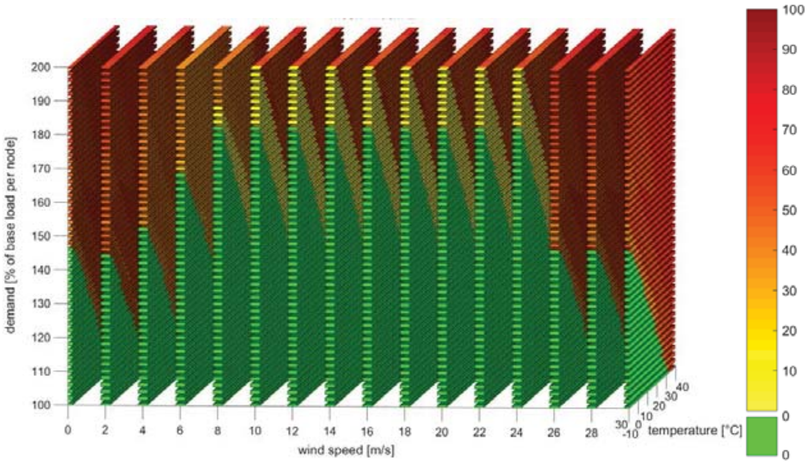


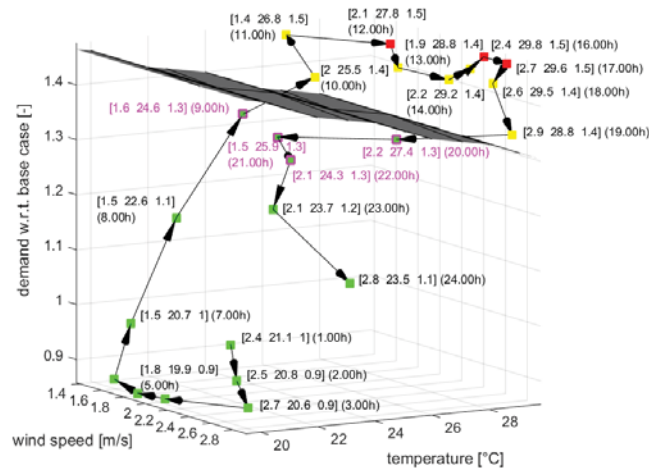
- Bridge long-term planning and short-term operations
- Switching devices reduce demand not supplied
- Constrained expansion -> Plan for small attacks
- Flexible expansion -> Plan for large attacks

Engineering System Resilience



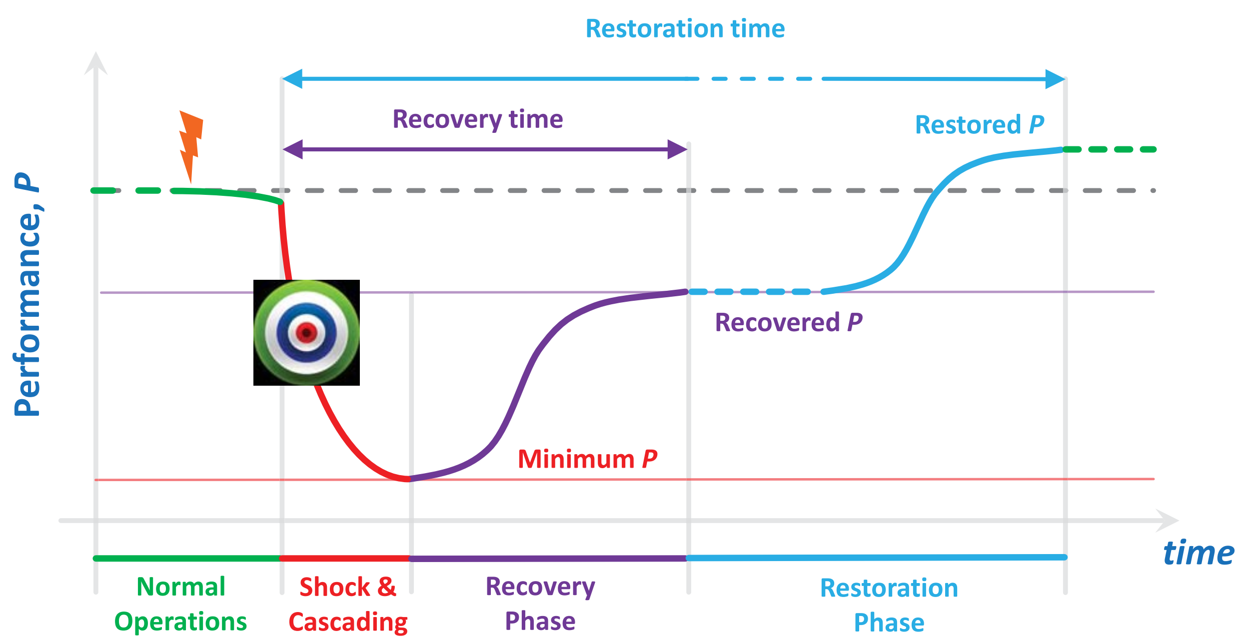
Early-Warnings and Indication of Criticality in Operations



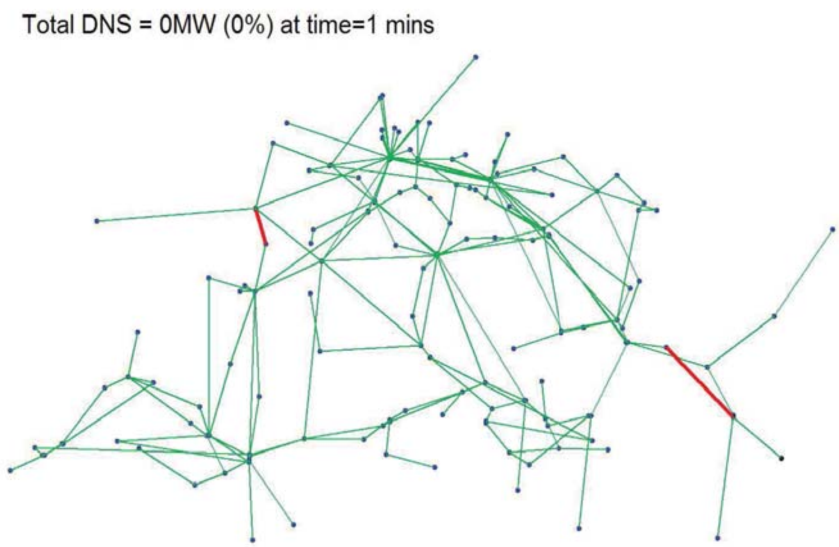


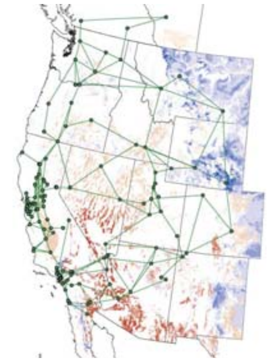
- Identification of the limit state surface in the space of the operating conditions
- Prediction of the evolutions of the operating conditions
- Basis to perform a corrective action to prevent critical states

Engineering System Resilience

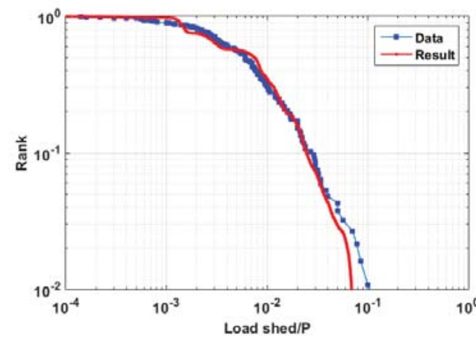


Cascading Outages in Power Systems





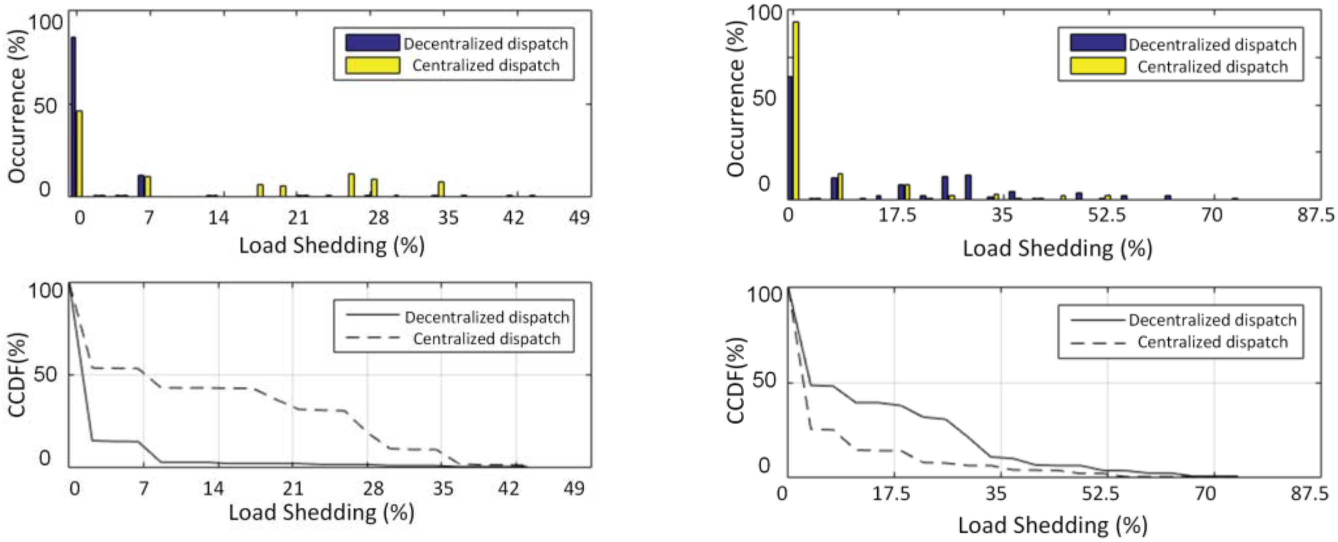
WECC network



“The System Exists Before the Disturbance” Unbundling of the Traditional Supply Chain

	Decentralized (Most European countries)	**Centralized** (U.S, Canada)	
Generation Company (Genco)	Price and schedule for supplying energy and reserve	Price for supplying energy and reserve	Generation Company (Genco)
Market Operator (EPEXSPOT)	Coordinating Energy Market	Coordinating Energy Market +Reserve Market	Independent system operator (ISO) (ISO new england, California ISO)
Transmission System Operator (TSO) (swissgrid)	Procure reserves + Account for Transmission Constraint	Account for Generation Constraint + Transmission Constraint	

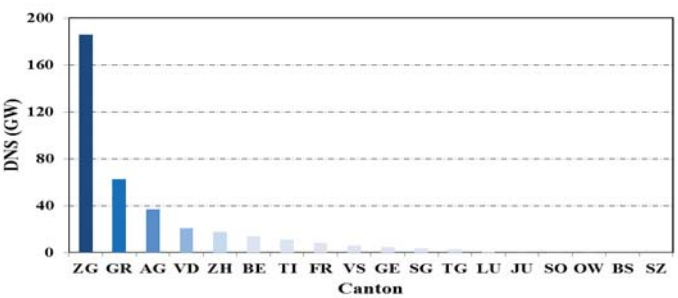
Impact of Market Structures on Cascading Outage Risk



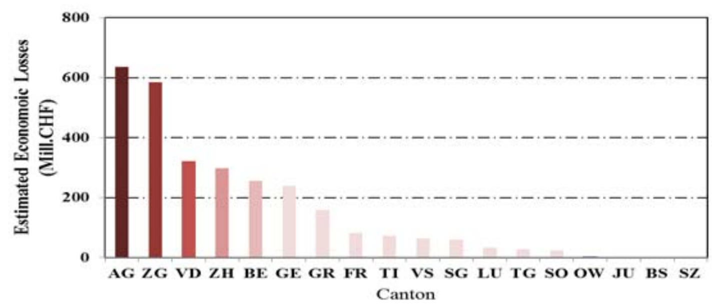
10% 30% Increment of load

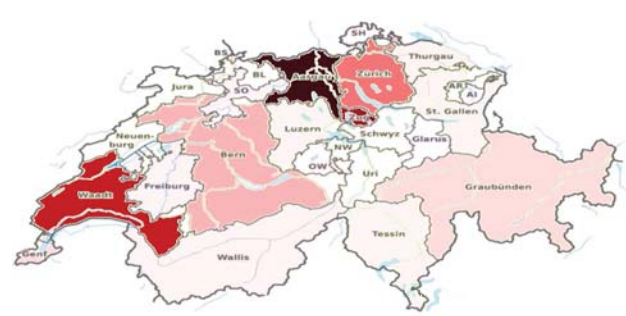
Adding the Socio-Economic Dimension to Cascades

DNS at each canton

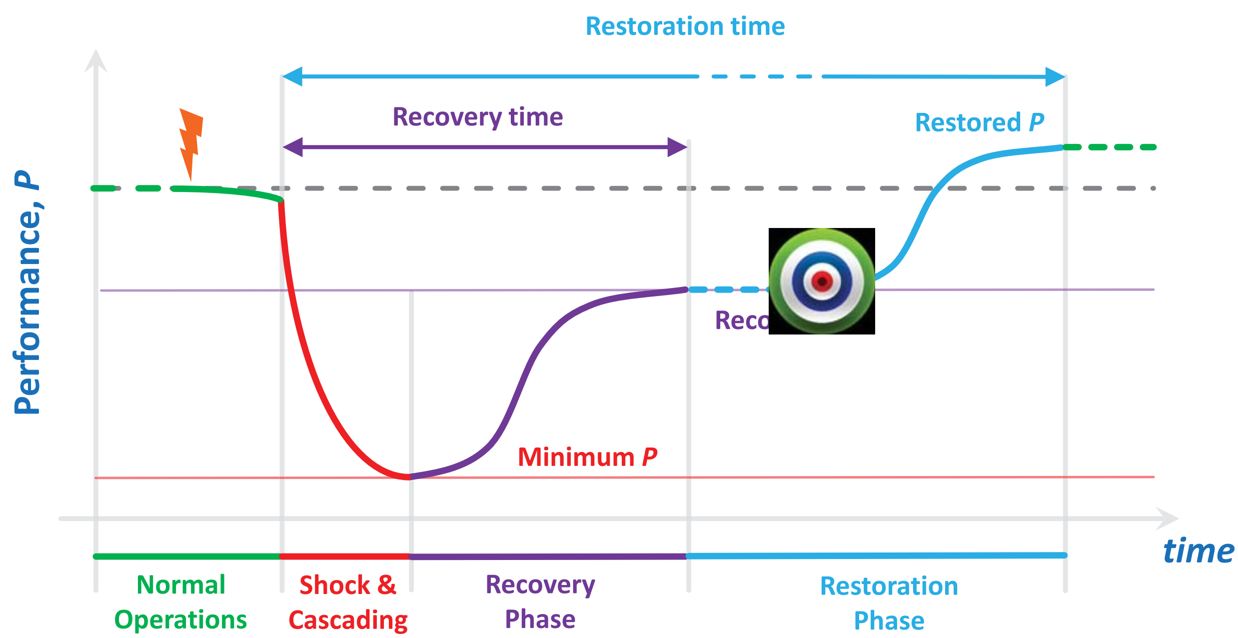


Economic losses at each canton



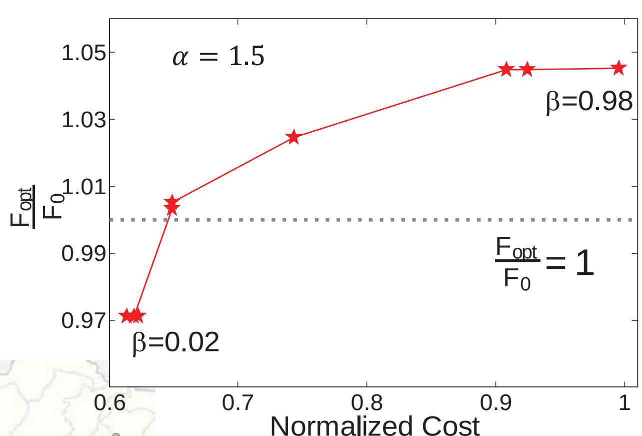


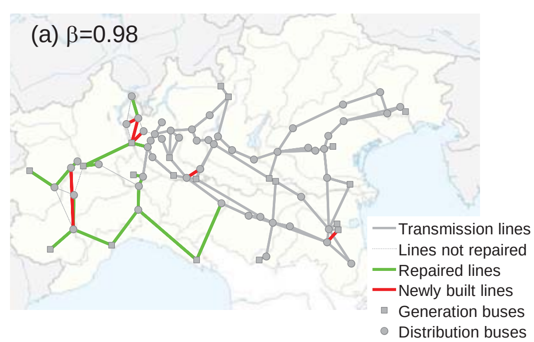
Engineering System Resilience



Optimum Restoration by Repairing and Building Anew

- Pareto front of the two objectives:
  - functionality
  - investments





- Functionality increase after disruption -> Antifragility
- Preference on costs -> Repairing
- Preference on functionality -> Building anew

Electric Power Supply System – A System of Systems

1. System under control (SUC)

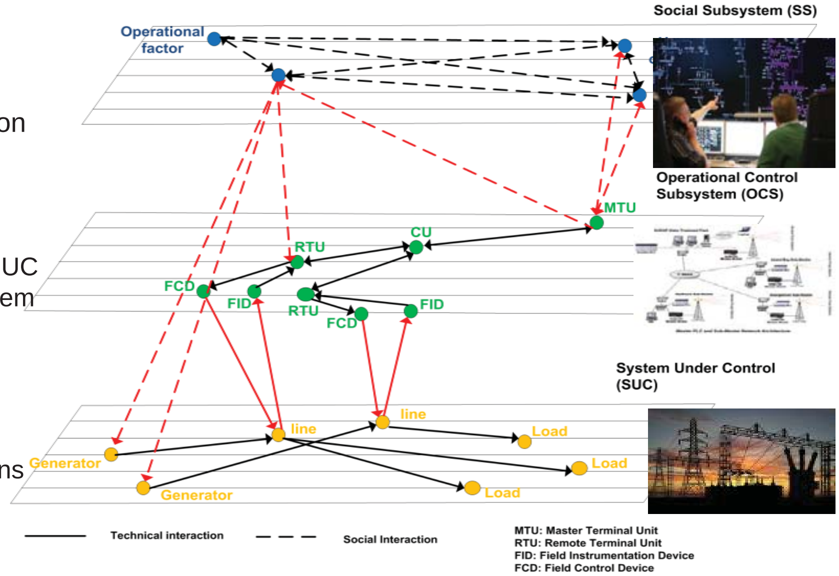
- transmission lines, generators, busbars and protection relays

2. Operational control system (OCS)

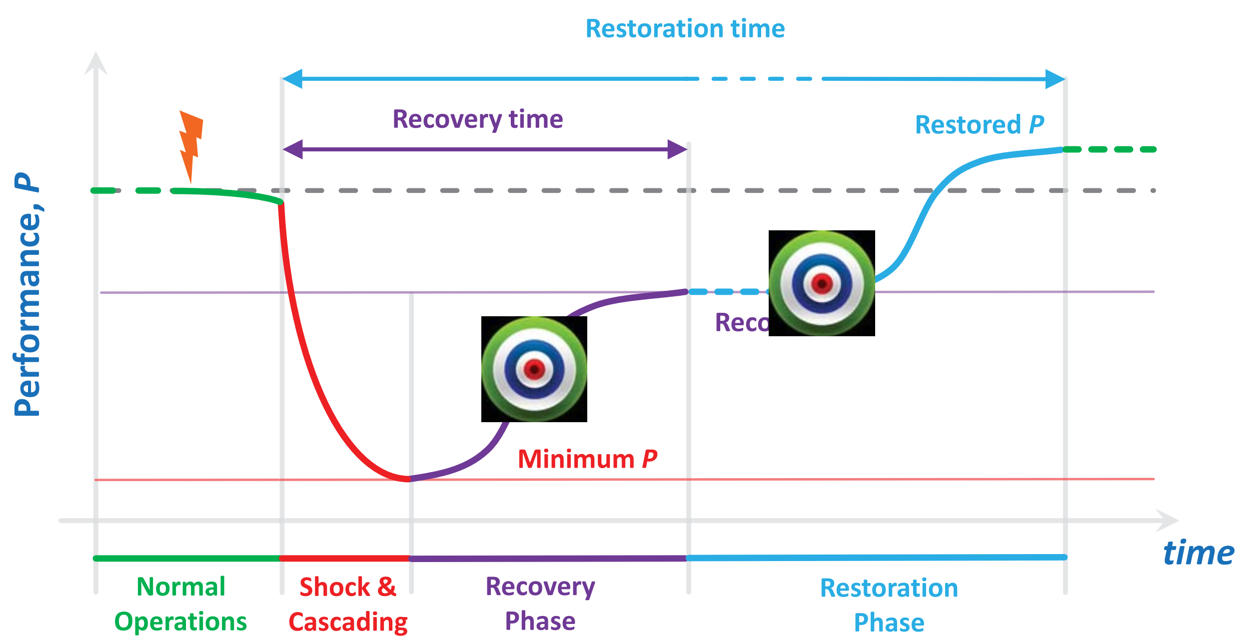
- responsible for controlling and monitoring the coupled SUC
- Supervisory Control and Data Acquisition (SCADA) system

3. Social System (SS)

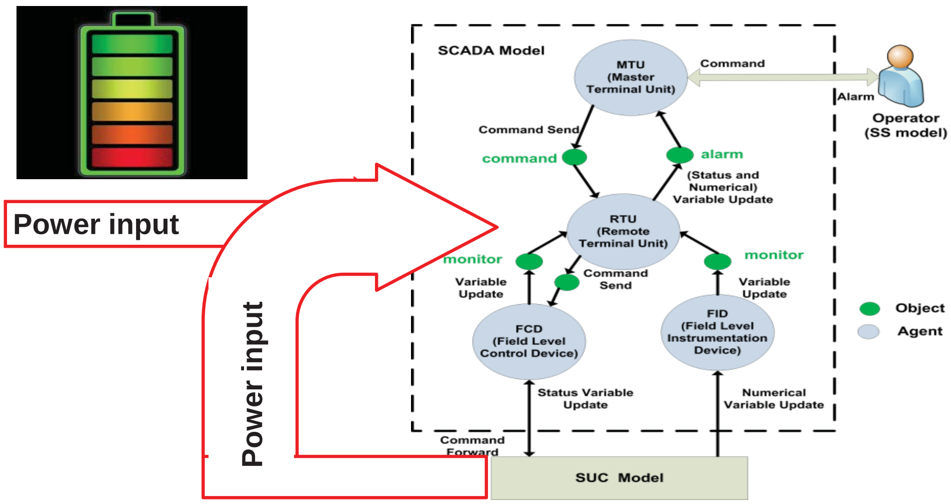
- human and organizational factors
- monitoring/processing generated alarms, switching off components and sending commands to remote substations



Engineering System Resilience



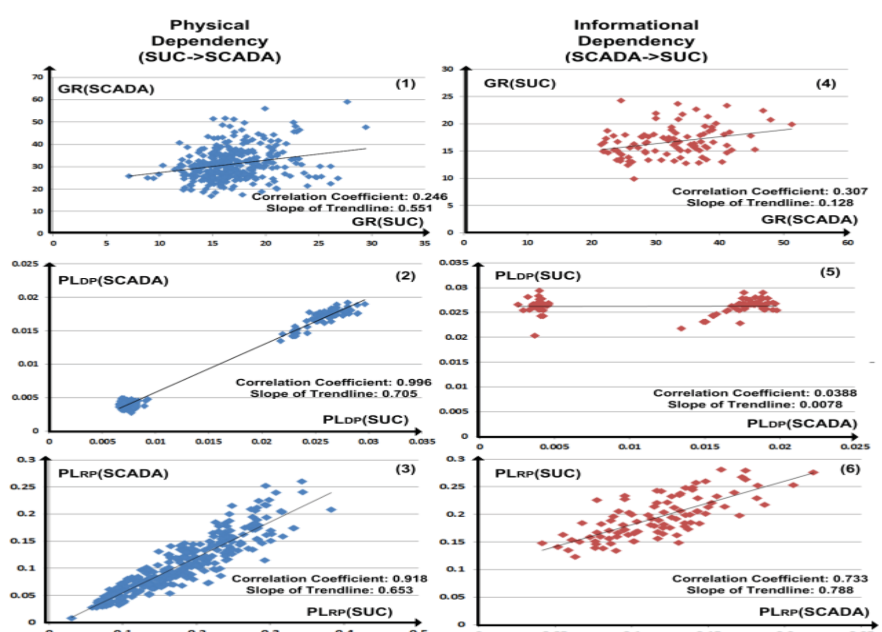
EPSS – Operational Control System



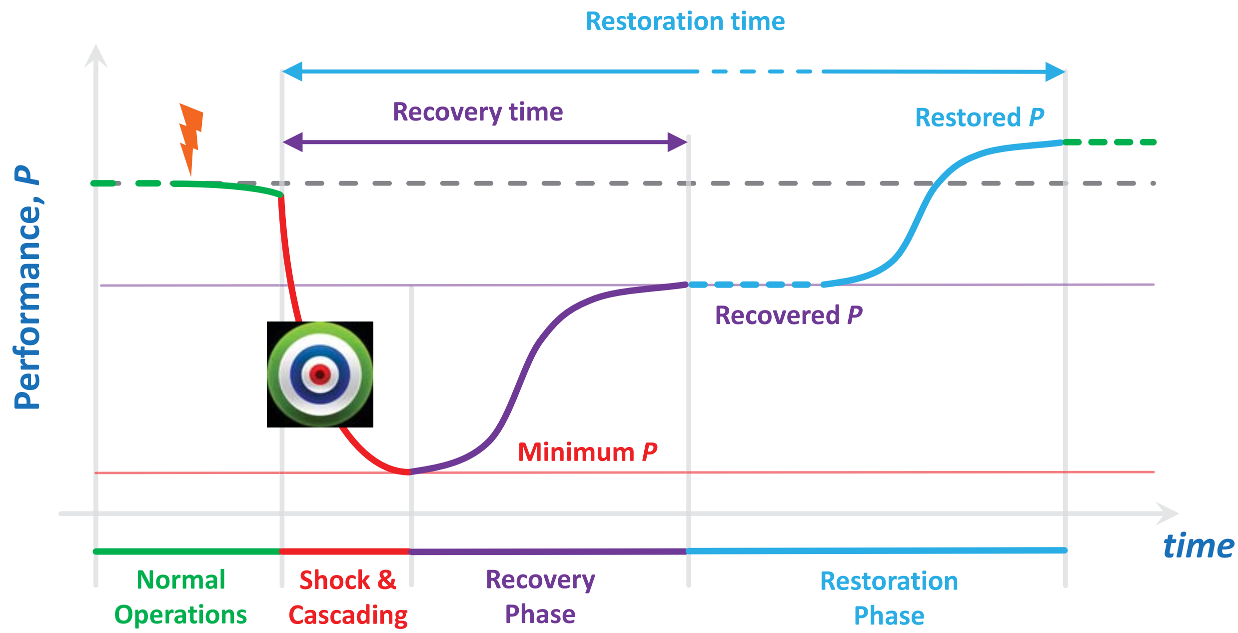
- Failure-oriented, agent-based model
- Each hardware device is modeled as an agent, which maps the status including operational and failures modes

Interdependencies and Resilience - The Bright Side

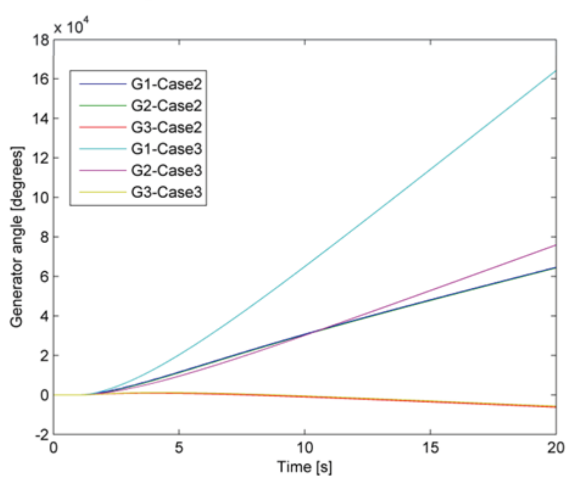
- Interdependencies among SUC and SCADA have **non-negative impacts** on resilience capabilities
- **Physical dependency** has more significant impacts on the system resilience than informational dependency
- Cyber dependency is important in decreasing the performance loss during the **restorative phase**

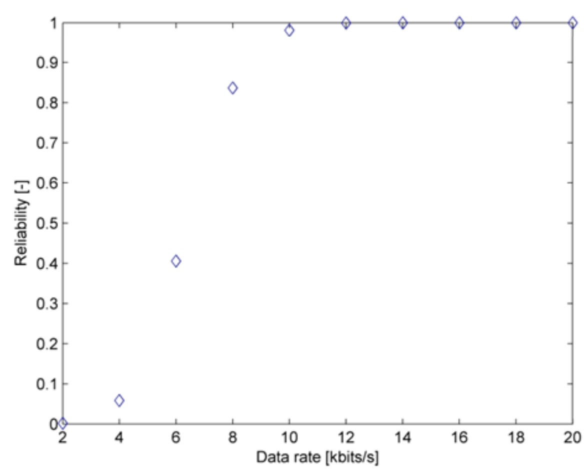


Engineering System Resilience



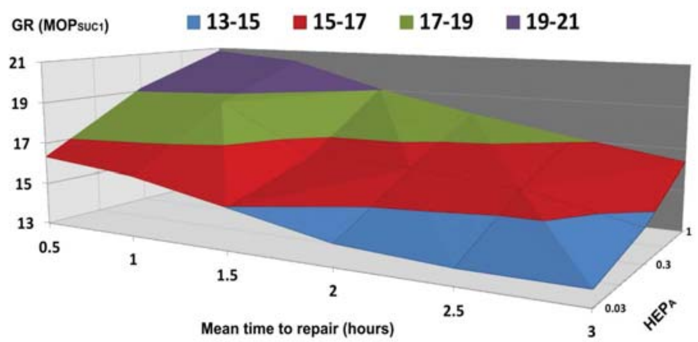
Interdependencies and Resilience - The Dark Side

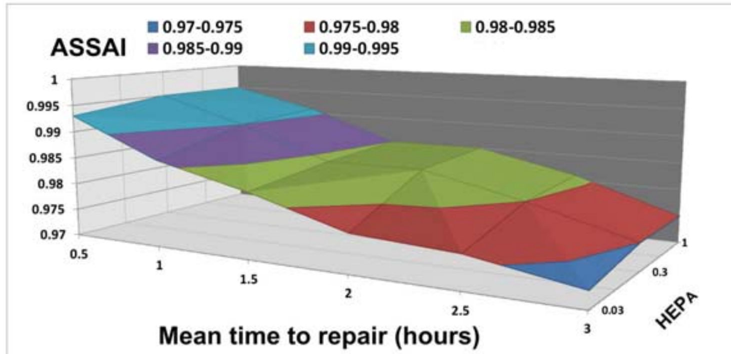




- Grid splitting mitigates generator desynchronization and instability
- Communication delays nullify grid splitting benefits
- Minimum communication requirements for effective grid splitting

Resilience vs. Reliability in System Planning



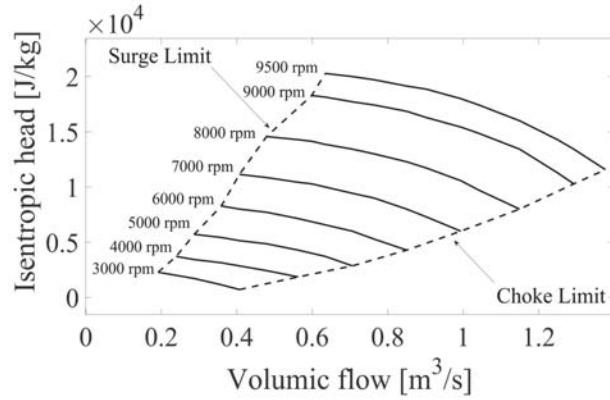


- Somehow cheating: performance during recovery neglected in reliability
- Critical functions vs. Critical level of functionality?
- The social domain (communities) adds much richer dimension and dynamics?

Security Analysis of the Operations of Coupled Electric and Gas Networks

Gas Model

- Pipeline → Transient one-dimensional flow model
  - $\frac{\partial M}{\partial x} + S\frac{\partial \rho}{\partial t} = 0$
  - $\frac{\partial P}{\partial x} + g\rho\frac{\partial h}{\partial x} + f_R = -\rho\frac{d\omega}{dt}$
- Non-pipeline elements
  - Storages
  - Pressure governors
  - Compressors →

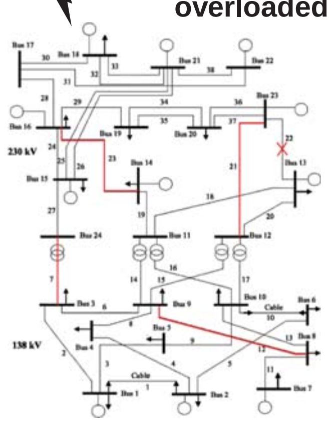


- Safety interventions
  - Minimum pressure violation
  - Progressive curtailment of GFPPs close to violation locations
  - Storage activation close to violation locations to restore pressure levels

Electric Model

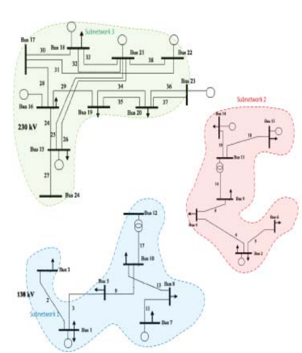
Trigger Event

- **Linear AC power flow**
- **Identify and trip overloaded lines**

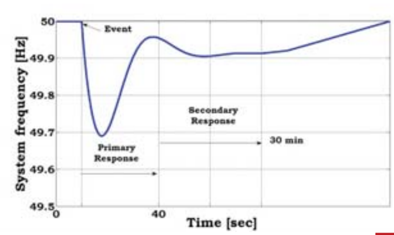


Island detection

In each island, check:
- **Frequency stability**
- **Under-voltage problem**



Safety Interventions



Power imbalance?
- **Primary/secondary frequency control**
- **Load shedding**

Cascade stops?

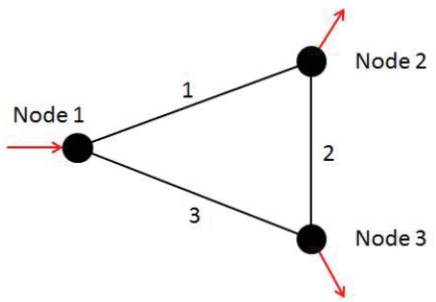
No → **Trip new overloaded lines**

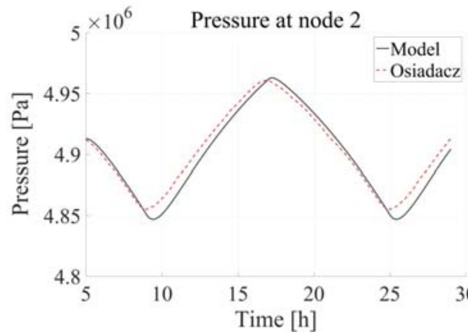
Yes → **Output demand not served (DNS)**

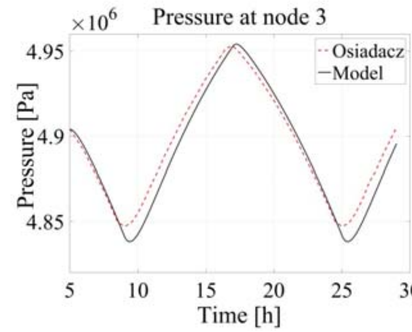
Gas Model - Validation

- Validation is performed via comparison with test cases in
  - *'Andrzej Osiadacz. Simulation and analysis of gas networks. Gulf Publishing Company, 1987'*

- Validation test case







Maximum relative error < 0.2%

Security Analysis of the Interdependent Systems

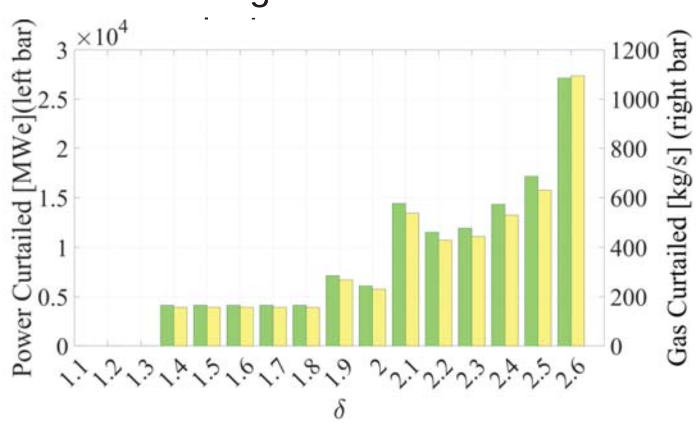
- Great Britain

Gas Network
- *89 pipes*
- *9 pressure regulators*
- *9 storage facilities*
- *21 compressor stations (5 electrically driven)*

Electric Network
- *98 lines, 29 nodes*
- *57 power plants (23 gas fired PP)*
- *Generation capacity 80 MW*
- *Peak demand 52.7 MW*

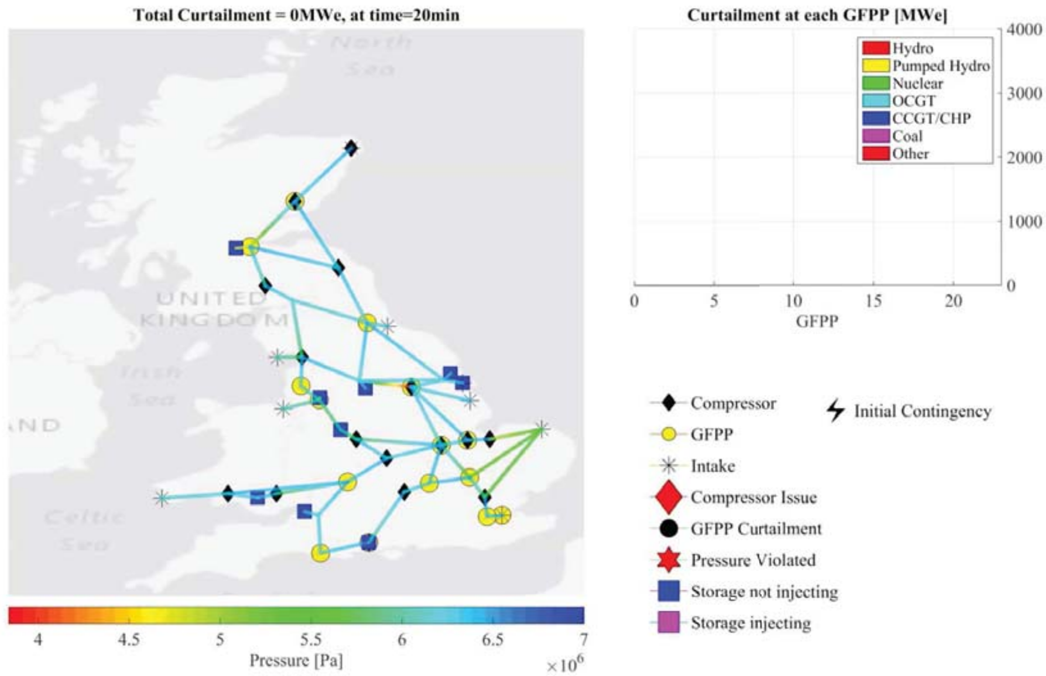
High pressure gas network (red), high voltage electrical network (green), GFPP (purple) and compressors (blue)

1. Extreme gas network working conditions



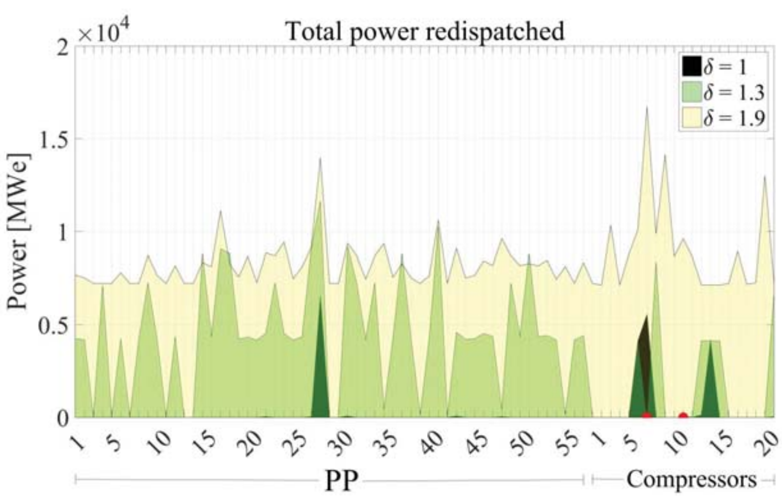
2. Failure analysis of the single component

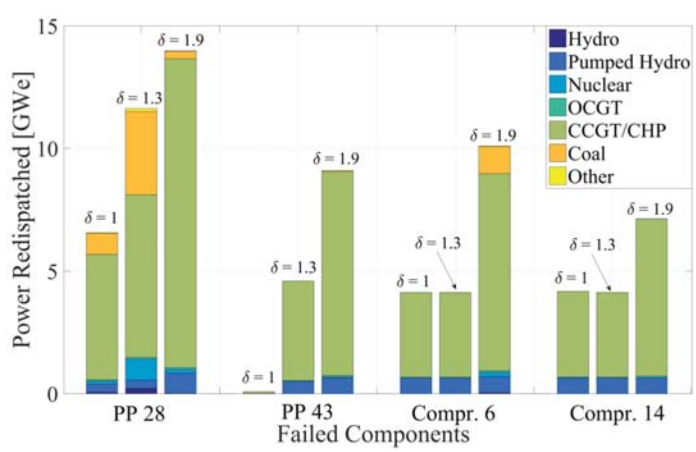
Removing PP 17 – Disruptions to Operations (δ = 1.3)



Single Component Failure Analysis

- Total power redispatched due to instabilities following removals
- Analysis of power redispatch to other generation technologies

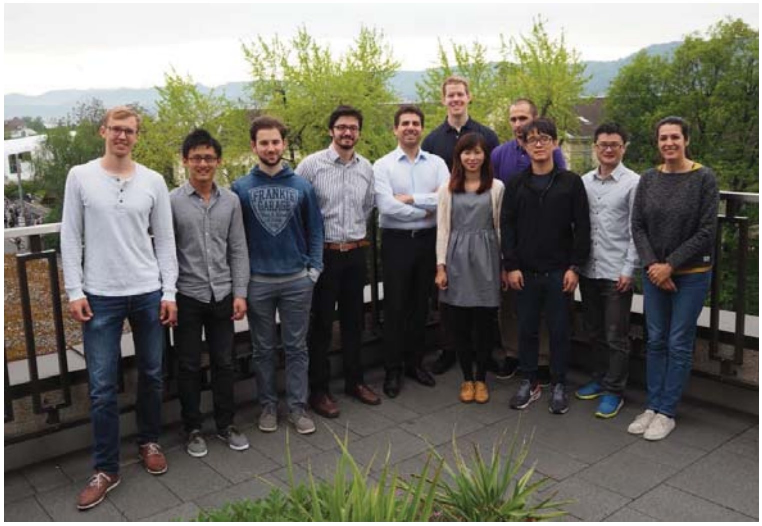




Thanks!

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

KTI/CTI
Die Förderagentur für Innovation
The Innovation Promotion Agency
Energy



ETH RISK CENTER

(FRS) FUTURE RESILIENT SYSTEMS 未来韧性系统
SINGAPORE-ETH CENTRE 新加坡-ETH研究中心

Energy Science Center

Swiss Re

SCCER – FURIES
Shaping the FUtuRe SwIss Electrical InfraStructure

European Commission
Horizon 2020
European Union funding for Research & Innovation

INTEGRATIVE EDUCATION MODEL FOR RESOURCES AND CRITICAL INFRASTRUCTURE PROTECTION BASED ON MCDA IN SENSE OF RISK ASSESSMENT, RESOURCES VALORIZATION AND THREAT RANKING

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Pavla Jurišića Šturma Street, No 33, 11000 Belgrade, Serbia

1. The importance of critical infrastructure reflecting the risk and magnitude of adverse event

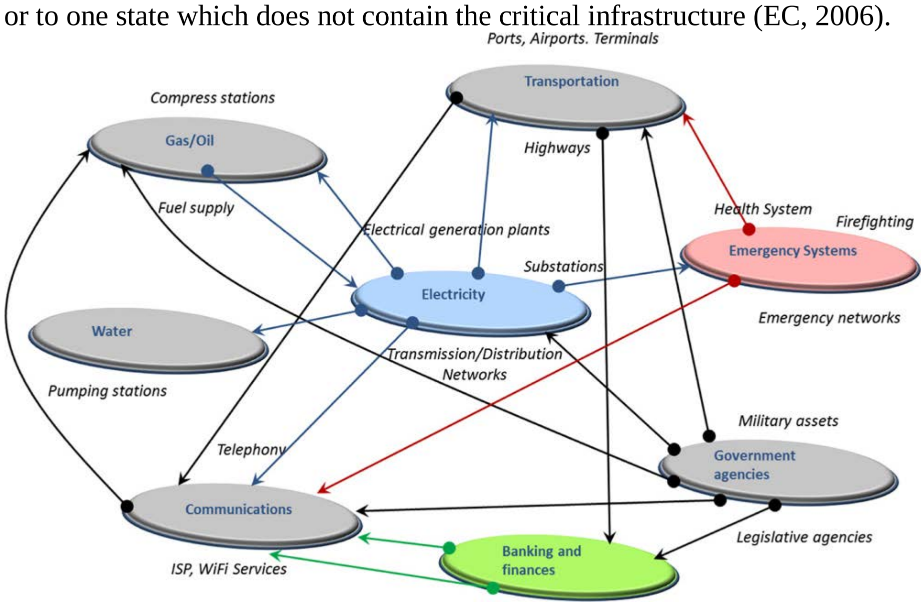
Risk and potential harmful effects derived from emergencies only arises when hazards interact with people, material assets or elements of living environment. An emergency (flood, storm, drought, landslide, terrorist attack…) striking an uninhabited (unsettled) area without any material structures or human individuals cannot be considered as causing risk (from human perspective). Basic prerequisites for such interaction are different kind of vulnerabilities:

- physical,
- social,
- economic and
- environmental vulnerabilities.

There are three core reasons that strengthen the abovementioned interaction:

- change of climatic conditions on Earth that inevitably lead to more frequent and intensive natural disasters on the one hand,
- increased human settling of the areas that have previously not contained any human settlements, so there are fewer and fewer unsettled areas, which means larger areas susceptible to disasters,
- complex political interaction between the states and social turmoil within the some states deriving the potential terrorist threat.

When defining critical infrastructure, the European Union distinguishes between national critical infrastructure and European critical infrastructure. Both terms refer to a property or a system in a Member State that is necessary to maintain key social functions, healthcare, safety, security, and economic and social well-being, the only difference being the ultimate effect. As regards national critical infrastructure, any destruction of or damage to critical infrastructure would significantly impact the Member State in which it is located, whereas in the case of European critical infrastructure, the impact refers either to two or more Member States or to one state which does not contain the critical infrastructure (EC, 2006).



Example of interdependence between energy systems and other critical infrastructure (Yusta, 2011)

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[1] For correspondence, e-mail: djnvasovic@gmail.com

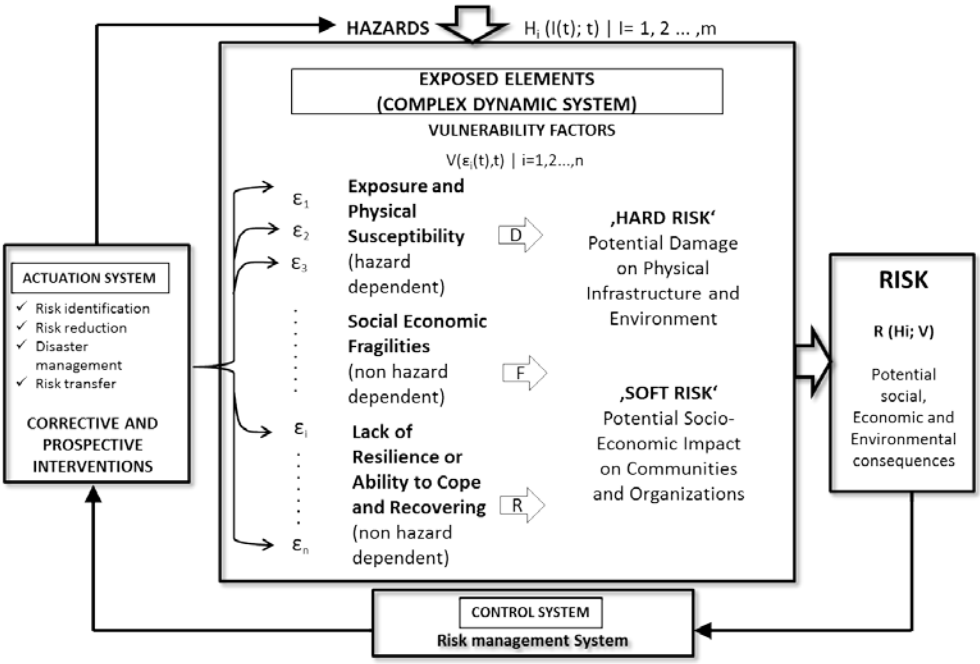
2. Risk vs. safety

One of the most comprehensive and integrative is holistic approach to risk management, which is shown on next figure. This approach integrates the deliberations regarding hazards, risks, control measures and (most important) exposed elements. Exposed elements are seen in form of complex dynamic system, as the environment and society certainly are.

Composite risk management is a process conducted through various stages, which are not discrete, but complementary:

- hazard identification;
- hazard assessment in order to determine risk level;
- preparation of control and decision-making measures;
- implementation of hazard control measures; and
- control and improvement.

Hazard identification during task study is very significant for risk management. If the hazard is not identified, it will not be taken into consideration, so the assessment of its consequences and probability of occurrence will not be conducted.



Holistic approach in disaster management (Ciurean, 2013)

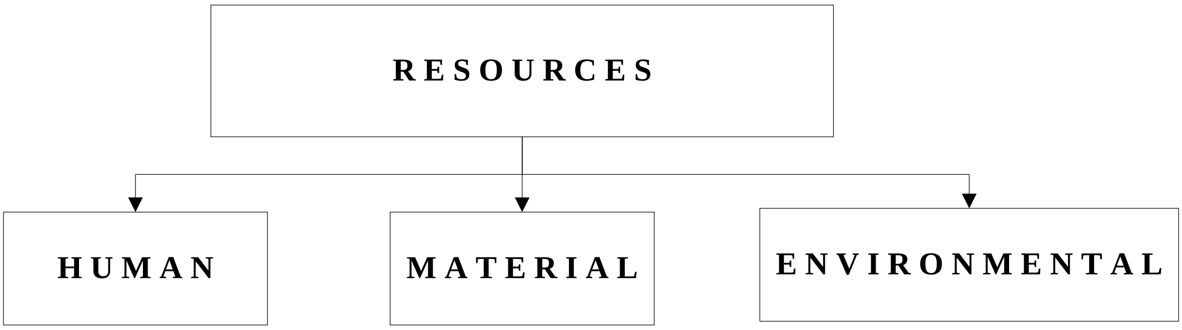
At the other hand, the concept of safety is a highly complex social phenomenon and a scientific discipline within the social sciences. Safety is also a polysemic term. In the most general sense, it refers to absence of fear, threats, and physical violence. Nevertheless, safety also includes ethical, ideological, and normative elements, which impedes a precise definition. It is a socially constructed concept, which acquires a specific meaning within a given social context. After the analysis of numerous definitions, the concept of safety can be defined in the simplest terms as a state of protected value in which there is no potential or actual threat to the value, and also as a goal that cannot be fully realized but that should be strived for.

3. Resources management

The following terms are important for the topic of this paper:

integrative model – involves a holistic approach, in this case a view of the model as a whole, which enables combining the best aspects, thus leading to the optimal solution for a given model;

resource - fr. *la ressource*, “means, source”; lat. *resurgere*, “rise again, reappear, be restored”, is a means necessary for the undertaking or completion of an action. A resource may be material or non-material. The basic division of resources is into human, natural (renewable and non-renewable), and material resources;
resource protection – utilization of resources on a scientific basis, identification of the ways to use resources rationally and complexly, and development and improvement of all forms of cooperation within scientific research;
integrative model of resource protection improvement – a learning process used to define the model and the important features of a complex resource protection model required by the state authority (in this case experience of the MoD is used), and to provide scientific knowledge about the organizational structure of the bodies in charge of implementation and realization of measures and procedures of resource protection for the MoD.



Resources – synergetic structure

Using SWOT analysis (Table 1), we listed strengths, weaknesses, opportunities, and threats to resources protection within the MoD, which allows the identification of positive and negative factors that, affect the choice and balance between internal capabilities and external possibilities.

Table 1. SWOT analysis of sustainability for resource protection in the MoD

Strengths - clear vision, mission, and goals; - operational efficiency; - favourable educational structure of employees; - existence of legal and normative acts for resource management; - planning and organization of occupational safety and health; - implementation of occupational safety and health; - control of occupational safety and health;	**Weaknesses** - insufficient number of professional personnel from the given field; - insufficient number of suitable teaching personnel; - inadequate training in the given field; - insufficient knowledge and skills in the given field; - insufficient employee interest;
Opportunities - improvement of the current state of the given field in the EU accession process; - promotion of the needs of protection implementation; - employee motivation for implementing resource protection measures; - control of training implementation and subsequent employee skills; - introduction of mandatory classes at all education levels in the MoD; - adequate training/education of current personnel; - cooperation with university faculties from the same field;	**Threats** - a drop in the economic standard; - lack of adequate material capacities; - resistance to changes; - insufficiently developed culture concerning the given field; - opposing views on the need for and scope of measures to be implemented; - failure to understand the necessity of professional personnel at all levels; - employee fluctuation;

During the MCDA process, we propose contemporary literature algorithm that is modified for the purposes of this research.

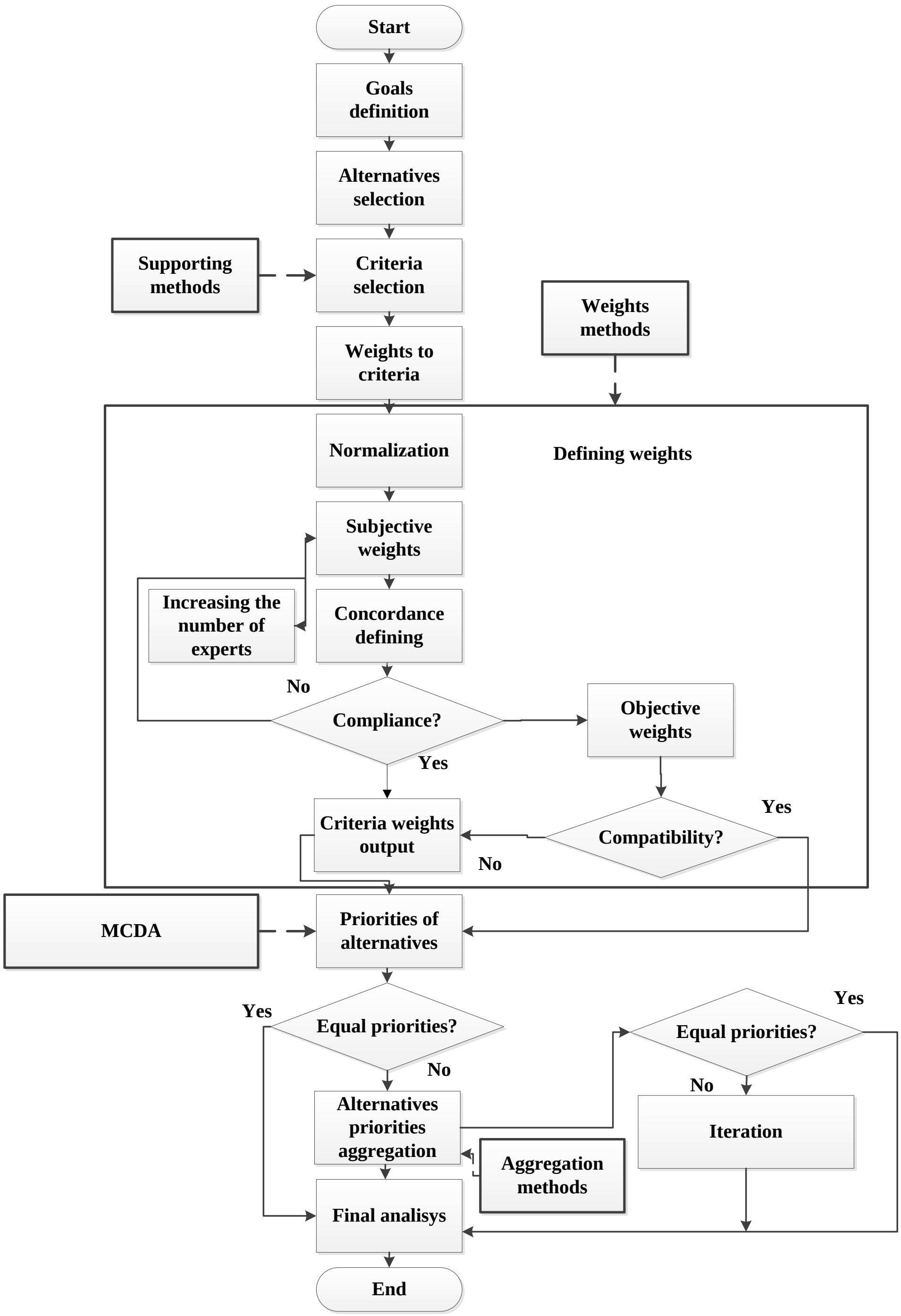


Figure 1. Proposed decision making algorithm and MCDA (Ustinovichius, 2007)

The corresponding decision making process can be described using an algorithm that includes the following four main phases:

definition of objectives and selection of criteria for alternative selection,

- determining the
- weight of criteria,
- evaluation and
- aggregation of results.

Determination of the effectiveness of the system is a problem. The development of evaluation criteria and methods to reliably measure the effectiveness and efficiency is a prerequisite that you select the best alternative, inform decision-makers about the performance of alternatives and monitor the impact of the social environment. The development and selection of alternatives is based on indicators related to reliability, convenience, safety measures and limited resources. These indicators are limited and/or affect each other.

4. Concluding remarks

An adverse impact of different kind of emergencies differs by:

- nations,
- regions,
- communities and (even)
- individuals

because of differences in their exposure to disasters (susceptibility) and vulnerability (intrinsic). Following contemporary needs and tendencies pertaining to more sustainable emergency risk reduction strategies, frameworks and practices, researchers who are engaged in this area in recent years are orientated towards viewing and reflecting on the issue of emergency risk reduction within the broader context of sustainable development concept. States that develop policy, legislative and institutional frameworks for emergency risk reduction are able to manage emergency risks and to achieve broad consensus for risk reduction measures across all sectors of society. At the other hand, there is a clear-cut consensus that the states without educated professionals and citizens (safety culture), has insufficient capacity to respond to the threats posed by emergencies.

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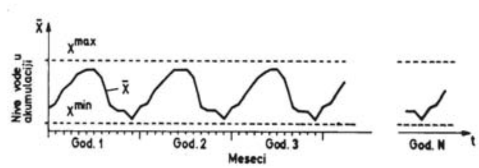
SIMULATING RESERVOIR SYSTEM OPERATION UNDER GIVEN SCENARIOS TO DETERMINE OPERATING POLICY WITH THE 'GOOD' RESILIENCE

/20-year, 30-, 40-, ... time horizon/

OPERATING POLICY = RULE CURVES FOR THE RESERVOIRS



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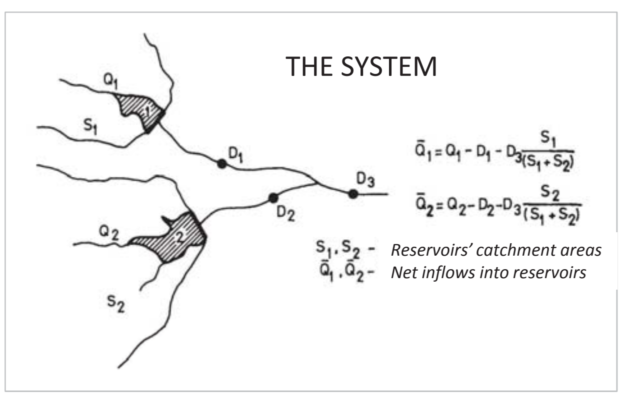
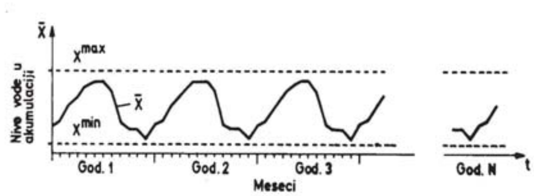
University of Novi Sad, Faculty of Agriculture
Dept. of Water Management
Novi Sad, Serbia

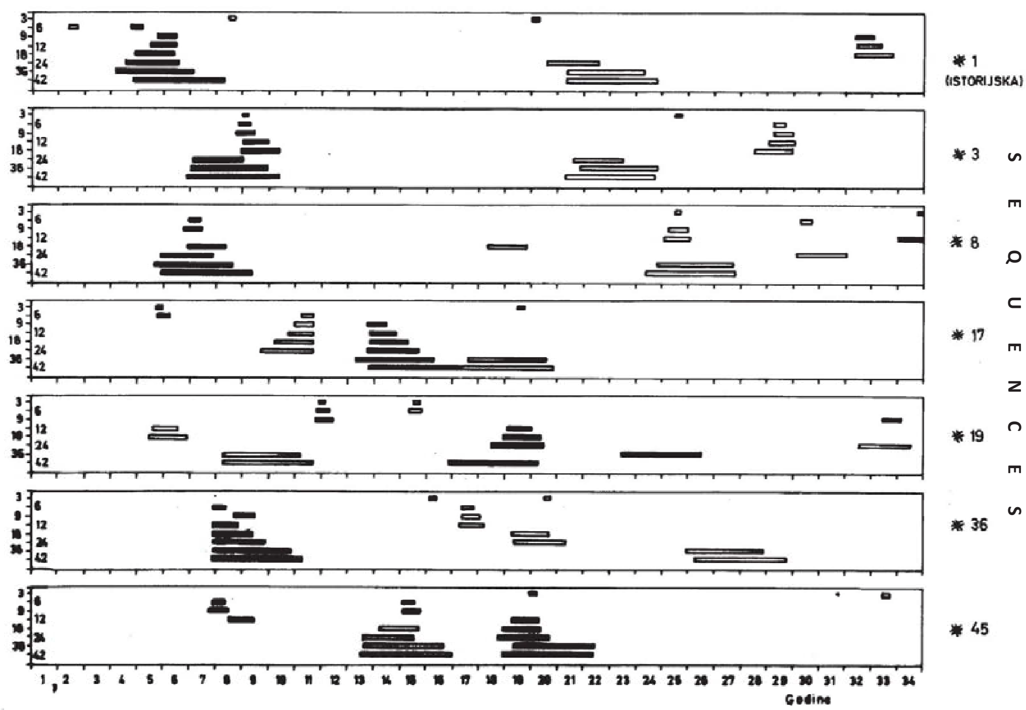
Azores, 29.06.2016. (NATO ARW CIR)



OPERATING POLICY = RULE CURVES FOR THE RESERVOIRS

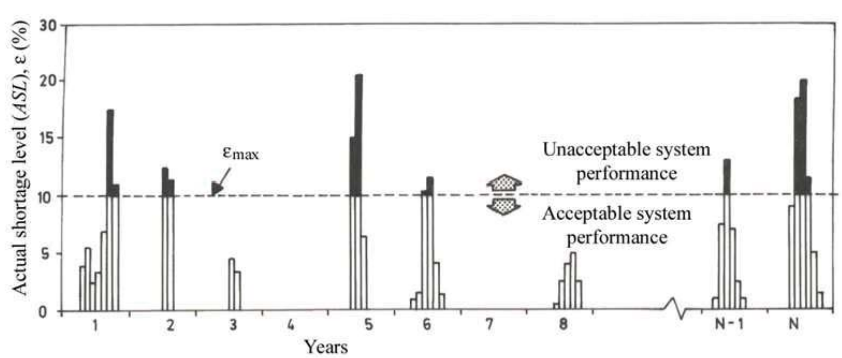


RUNNING THE MODEL WITH HISTORIC AND STOCHASTIC SEQUENCES OF INFLOWS

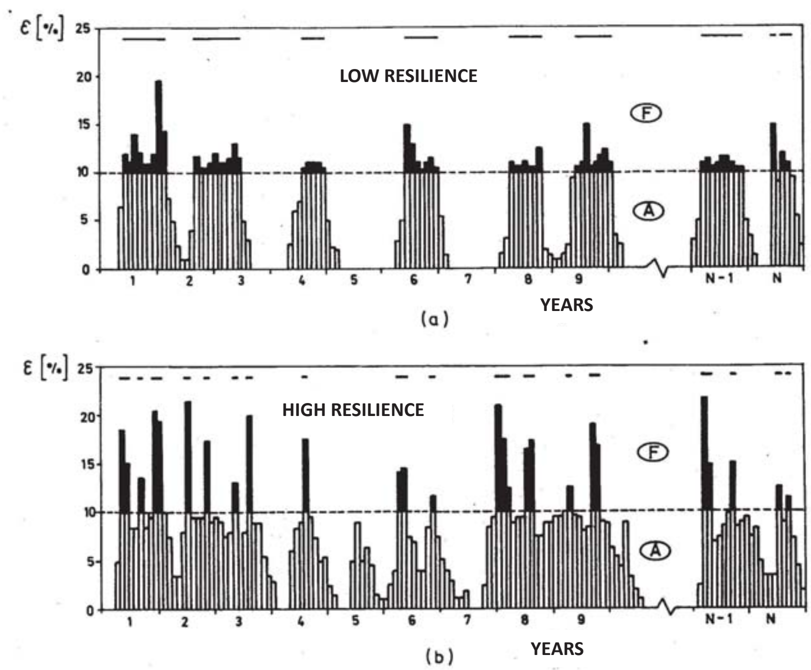


Moving min/max/ave monthly inflows into reservoirs for durations of 3, 6, 12, 18 ,24 and 36 months

Discriminating A/F system behavior



ε – Percentual deficit; A- Acceptable performance; F – Failure (Unacceptable) performance



ε – Percentual deficit; A- Acceptable performance; F – Failure (Unacceptable) performance

RELIABILITY AND RISK

$$\alpha(k) = \frac{\sum_{i=1}^{12N} Z_i(k)}{12N} \qquad r(k) = 1 - \frac{\sum_{i=1}^{12N} Z_i(k)}{12N}$$

RESILIENCE

$$\gamma(k) = \frac{\sum_{i=1}^{12N} W_i(k)}{12N - \sum_{i=1}^{12N} Z_i(k)} \cdot$$

Simulated performace and discriminated A/F status of a system /illustration/

Year	Month / Status (A,F)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	A	A	A	F	A	A	A	A	F	A	A	A
2	F	A	A	A	A	A	F	F	A	F	A	A
3	A	A	F	A	A	A	A	A	A	A	A	A
4	A	F	A	F	A	A	F	A	A	A	A	A
5	F	A	A	A	A	A	F	A	A	A	F	A
6	A	A	A	A	A	F	F	A	A	A	F	F
7	F	A	A	A	A	A	A	A	A	F	A	A
8	A	A	F	A	A	F	A	A	A	A	A	A
9	A	A	A	A	A	A	A	A	A	A	A	A
10	A	F	F	A	A	A	F	F	A	A	A	A
	(Z)											
1	1	1	1	0	1	1	1	1	0	1	1	1
2	0	1	1	1	1	1	0	0	1	0	1	1
3	1	1	0	1	1	1	1	1	1	1	1	1
4	1	0	1	0	1	1	0	1	1	1	1	1
5	0	1	1	1	1	1	0	1	1	1	0	1
6	1	1	1	1	1	0	0	1	1	1	0	0
7	0	1	1	1	1	1	1	1	1	0	1	1
8	1	1	0	1	1	0	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	0	1	1	1	0	0	1	1	1	1
Sum **Z**	7	8	7	8	10	8	5	8	9	8	8	9
	(W)											
1	0	0	1	0	0	0	0	1	0	0	0	1
2	0	0	0	0	0	1	0	0	1	0	0	0
3	0	1	0	0	0	0	0	0	0	0	0	0
4	1	0	1	0	0	1	0	0	0	0	0	1
5	0	0	0	0	0	1	0	0	0	1	0	0
6	0	0	0	0	1	0	0	0	0	1	0	0
7	0	0	0	0	0	0	0	0	1	0	0	0
8	0	1	0	0	1	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	1	0	0	0	0	1	0	0	0	0	0	0
Sum **W**	2	2	2	0	2	4	0	1	2	2	0	2

COMPUTING RELIABILITY AND RESILIENCE OF A SYSTEM

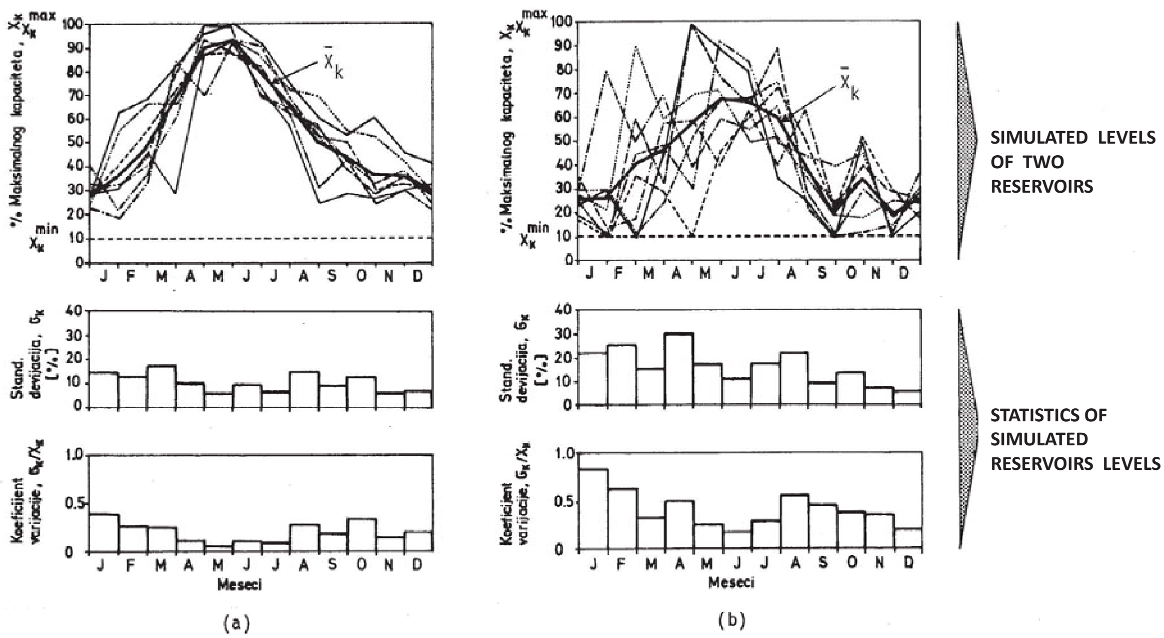
$$\sum_{i=1}^{120} Z_i = 95 \qquad \sum_{i=1}^{120} W_i = 19$$

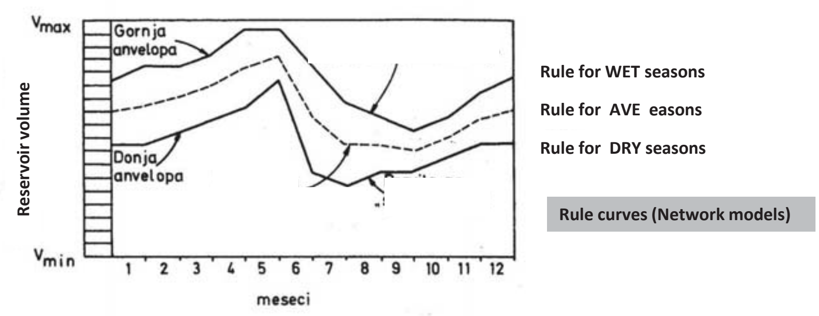
$$\alpha = \frac{\sum_{i=1}^{120} Z_i}{120} = \frac{95}{120} = 0.79$$

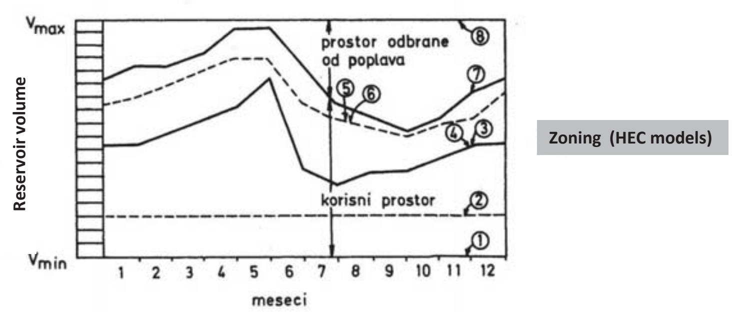
RELIABILITY

$$\gamma = \frac{\sum_{i=1}^{120} W_i}{120 - \sum_{i=1}^{120} Z_i} = \frac{19}{120-95} = 0.76$$

RESILIENCE







RULE CURVES FOR THE RESERVOIRS WITH GOOD RESILIENCE (OVER 75%)

Building Resilience

Steven L. Stockton, PE
Director of Civil Works
U.S. Army Corps of Engineers

NATO Workshop: Resilience-Based Approaches to Critical Infrastructure

Ponta Delgada, Azores, Portugal
27 June 2016

BUILDING STRONG®

From Accepting Risk to Managing Risk and Resilience

Live with floods
- Individuals and small communities adapt to nature's rhythm.

Use the floodplain
- Fertile land in floodplain is drained for food production.
- Permanent communities develop on the floodplain.

Control floods
- Large scale structural approaches are implemented through organized governance

Reduce flood damages
- A recognition that engineering alone has limitations.
- Effort to increase the resilience of communities should a flood occur.

Manage risk
- Not all problems are equal.
- Risk management is an effective and efficient means to maximize the benefit of limited investment.

Resilience
- Not all risks can be eliminated
- Systems approach & integration of communities is the key

From Sayers et al, 2012

Risk Informed View of Infrastructure Safety

Risk = f(Hazard, Performance, Consequences)

What are the hazards and how likely are they to occur?

How will the infrastructure perform in the face of these hazards?

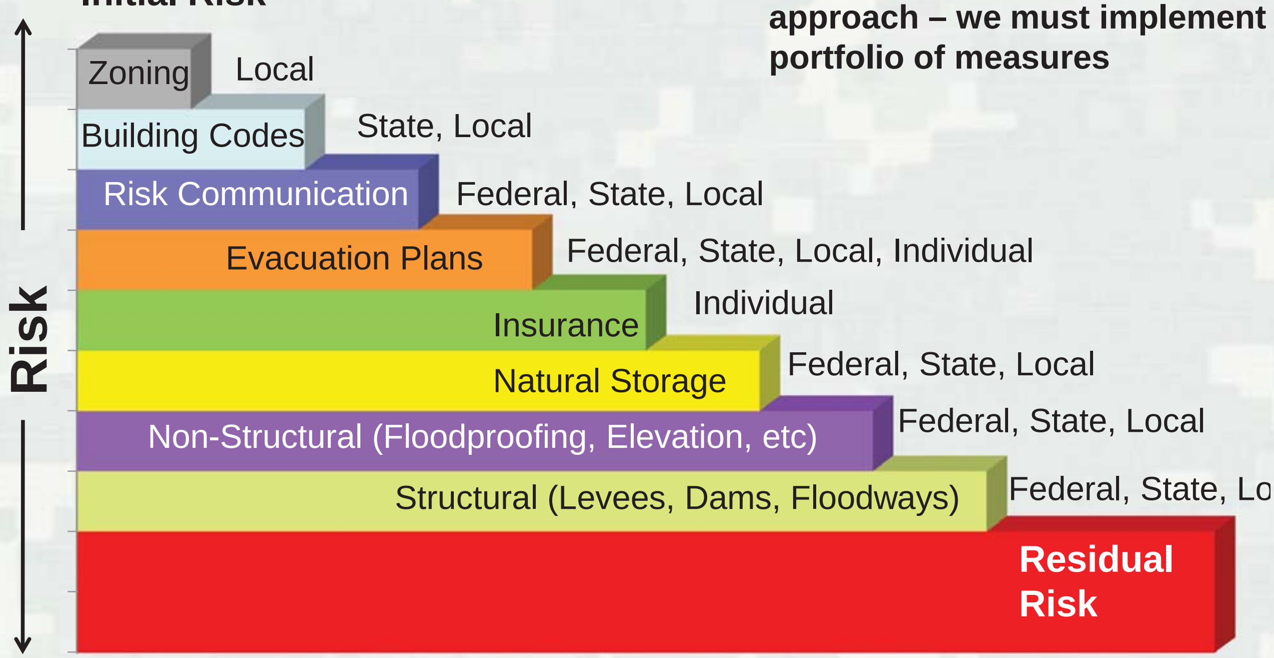
Who and what are in harm's way?
How susceptible to harm are they?
How much harm is caused?

Infrastructure Safety Program: Focused on People, Performance, and Risks

Reducing Risk

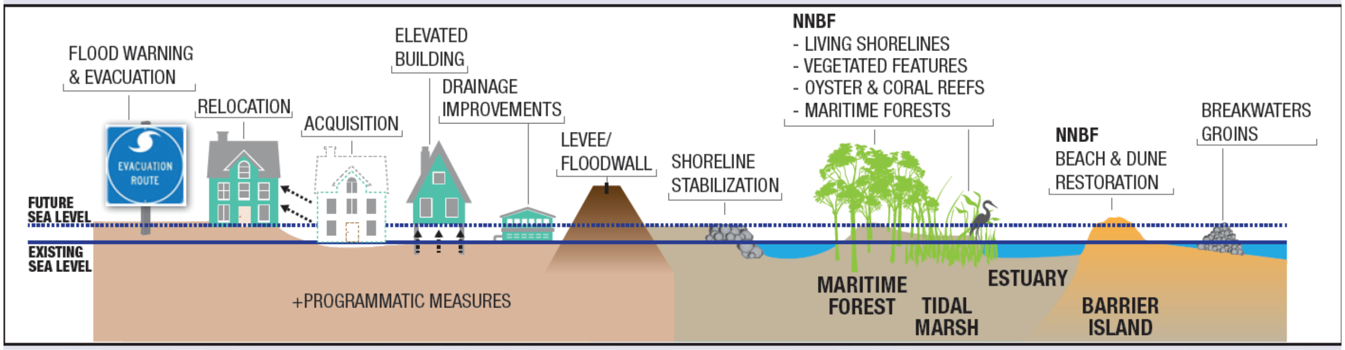
- **Absolute protection from floods is not possible – must plan for exceedance (Residual Risk)**
- **We cannot rely on single structural approach – we must implement a portfolio of measures**

Initial Risk



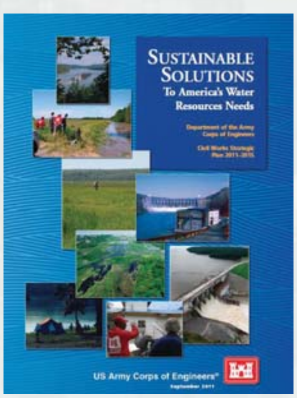
Risk reduction is a shared responsibility between all levels of government and the individual

Full Portfolio of Measures



- Multiple lines of defense and combinations of measures to improve resilience and further drive down risk
- Resilience includes adapting, which might be shifting between measures over time as conditions change

Engineering With Nature



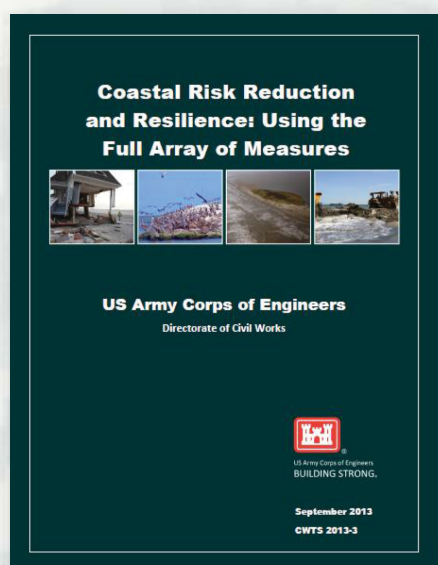
…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Expanding the benefits provided by projects
- Science-based collaboration

Principles of Resilience

A Systems Approach to Resilience

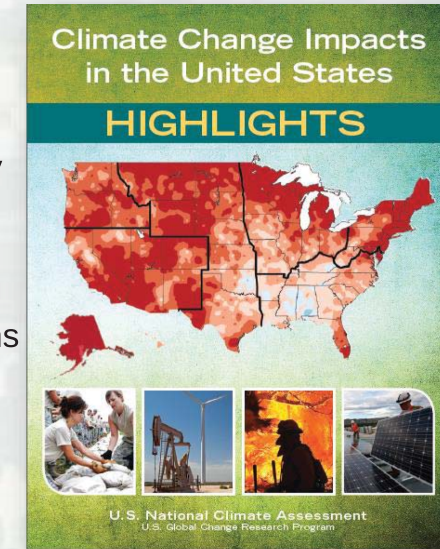
*"The USACE planning approach supports an **integrated approach** to reducing coastal risks and increasing human and ecosystem community resilience through a combination of **natural, nature-based, non-structural and structural measures**. This approach considers the engineering attributes of the component features and the dependencies and interactions among these features over both the short- and long-term. It also considers the **full range of environmental and social benefits** produced by the component features."*



http://www.corpsclimate.us/docs/USACE_Coastal_Risk_Reduction_final_CWTS_2013-3.pdf

Key Messages for Urban Systems, Infrastructure, and Vulnerability

- National economy, security, and culture all depend on the resilience of urban infrastructure systems
  - Essential infrastructure systems will increasingly be compromised
  - Disruptions of services in one infrastructure system will almost always result in disruptions in one or more other systems
- Urban climate vulnerability and adaptive capacity are influenced by pronounced social inequalities
- Preparedness and resilience requires cooperative private sector and governmental activities



Building Communities Resilient to Disruption

- Military installations must be resilient because they are critical resources where soldiers live, work, train and deploy.
- Our installations have neighborhoods, retail facilities, recreation and a complex infrastructure.
- Soldier readiness is linked to installation resilience: the ability to withstand any sort of disruption and continue with the mission.
- As the Armed Forces modernize with new units, new equipment and new technologies, facilities must be repurposed.

Net Zero Initiative

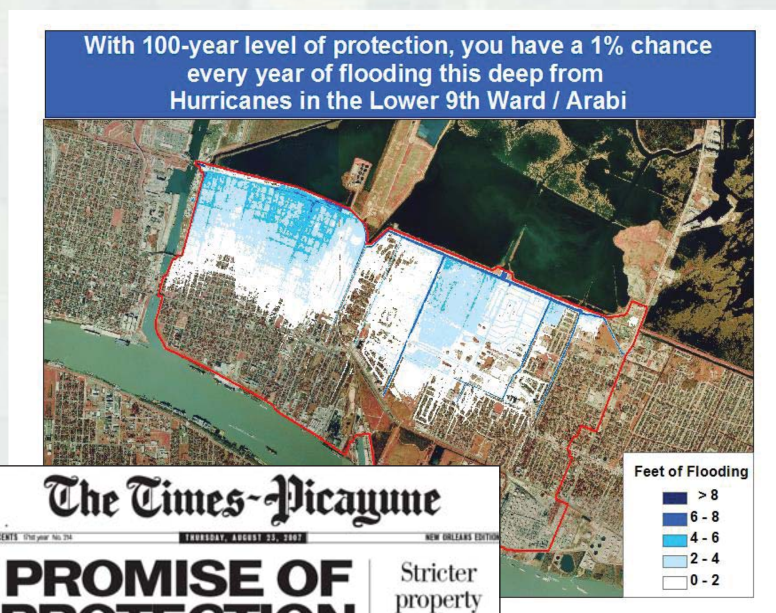
- Holistic strategy to manage energy, water and waste at Army installations by combining long-standing sustainable practices with emerging best practices.
- Enhance mission effectiveness and increase installation resiliency.
- By achieving net zero energy, water and waste, installations can more quickly recover from catastrophic events and minimize disruptions to mission operations.

Workers complete electrical connections as part of a solar microgrid project at Fort Hunter Liggett, CA

- Fifteen installations are designed to be net zero for energy, water or waste; two are designed to be net zero integrated energy-waterwaste installations.
- For energy, net zero means that an installation produces as much energy on site as it uses during a year.
- Power-generation facilities built at several installations, such as solar energy farms.

Risk Communication

- Convey what risk remains, no matter what protective measures are in place
- Educate public as to actual risk they face every day so they can take responsibility for own safety
- Work with local governments so risk can be included in urban planning decisions




Questions
BUILDING STRONG®

Resilience needs in Serbia

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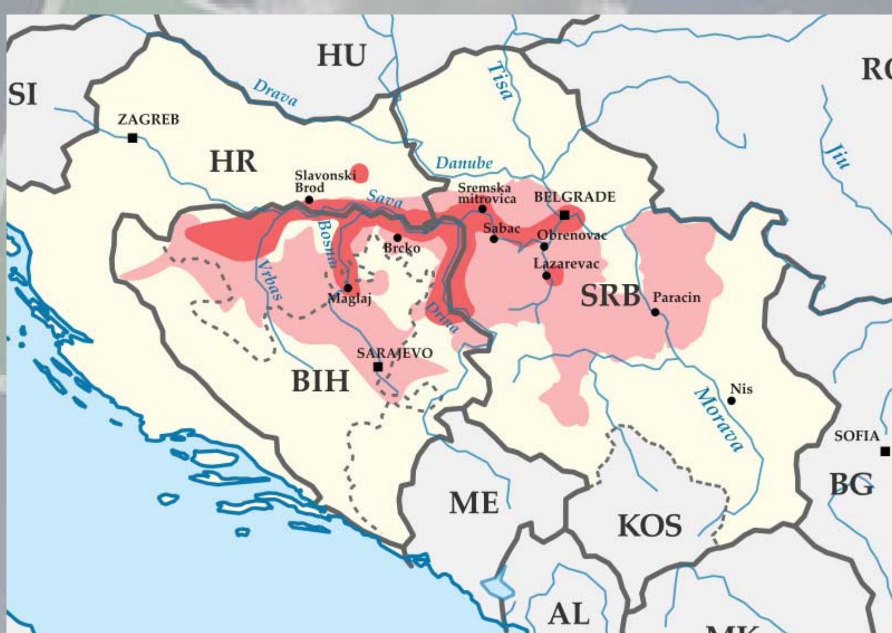
NATO Workshop

26-29 June 2016, Ponta Delgada, Azores, PORTUGAL

Southeast Europe floods 13-27 May 2014



Southeast Europe floods 13-27 May 2014

- The heaviest rain in 120 years of recorded weather measurements
- At least 62 people had died as a result of the flooding, and hundreds of thousands had been forced from their homes
- Over 1.6 million people were affected in Serbia and Bosnia, after a week of flooding
- Damage in Serbia, jointly estimated by EU, World Bank group and UN officials, stands at around 1,5 billion EUR

Southeast Europe floods 13-27 May 2014

- The city of Obrenovac was hit hardest by the floods, with an estimated 90% of the town flooded

Southeast Europe floods 13-27 May 2014

- The city of Obrenovac

Southeast Europe floods 13-27 May 2014

- The city of Obrenovac

Southeast Europe floods 13-27 May 2014

- The city of Obrenovac

Southeast Europe floods 13-27 May 2014

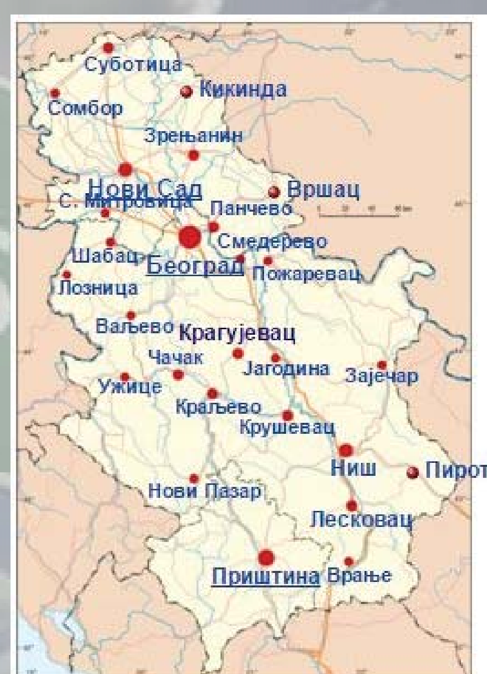
- Evacuation of people
- Cut of electric power
- Transportation in affected areas interrupted or cut
- Agricultural areas totally damaged
- 2,260 public, industrial and infrastructure facilities were flooded, and 3,500 roads were destroyed

Southeast Europe floods 13-27 May 2014

- The largest thermoelectric power plant in Serbia TPP Nikola Tesla, which supplies close to 50% of electricity in Serbia, was saved from danger.
- The thermoelectric power plant TPP Kostolac, which supplies 11% of electricity in Serbia, was threatened but the water had not breached the innermost ring of defenses.
- However, flood waters filled the largest coal field of RB Kolubara with 210 million cubic meters of water, and its pumping & rehabilitation took months.
- During the floods, the hydro plants at Iron Gates reduced their production and opened the gates in order to lower the level of the Danube

Main cities in Serbia

Beograd - 1.344.844
Novi Sad - 286.157
Niš - 202.208
Kragujevac - 150.835
Leskovac - 110.240
Subotica - 105.681



PWUC Užice

- Supplies more than 60,000 customers with potable water (15,000 household connections and 1,000 companies).
- Water supply network length of around 360 km, 29 reservoirs and 27 pressure zones.
- Due to high pressures, pipe bursts and large water losses are common occurrences.
- To reduce water losses and improve efficiency, IPA funds were used to establish the first District Metered Area (DMA) zone capable of operating under pressure control

WUC statistics for some EU countries

Country	Public/private WUC	No. of providers	Water supply responsibility
Denmark	Service provision only by public and cooperative providers	2.740 (2001)	Local governments
France	High degree of private sector participation using concession and lease contracts	12.400 (2008)	National & local (municipalities > 10.000 inhabitants)
Germany	Only 3.5% entirely privately owned	1.266 larger ones (2005)	Municipalities, regulated by the states.
Italy	Public, private or mixed	91 regional utilities; 3.161 providers	National and regional governments
Netherlands	WUC publicly owned, contracting services to the private sector	10 regional WUC	Number of institutions at different levels
Spain	Municipalities 54%, private 33% or mixed	More than 8.000 in municipalities	National & basin agencies
UK	England & Wales - private (23), Scotland- public (1) and Northern Ireland - public (1)	25	Three regulators, one each for England/Wales, Scotland and Northern Ireland

Resilience towards creeping natural hazard - *drought*

- Occurrences of drought in Serbia at 3-7 years from 1980 – today: e.g. 2003, 2007, 2011
- Within last 100 years: 17 with normal, 37 with extensive and 51 with reduced rainfall

Negative impact example:

- Agriculture (only in 2007 the damages from drought were 600 million €);
- Decreasing of energy productions (in 2007 hydro power plant produced 1,77 billion kWh less than in 2006)

рахмат
danke
謝謝
ngiyabonga
teşekkür ederim
Баярлалаа
спасибо
faafetai lava
mersi
barka
tack
dank je
misaotra
matondo
paldies
grazzi
mahalo
tapadh leat
kiitos
dankie
vinaka
blagodaram
thank you
gracias
хвала
asante
obrigada
dhanyavad
bedankt
hvala
mauruuru
enkosi
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Dynamic Functional Modelling of Vulnerability and Interdependency of Critical Infrastructure (DMCI)

POLITECNICO MILANO 1863

European Commission

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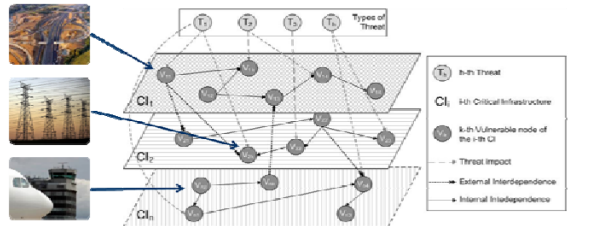
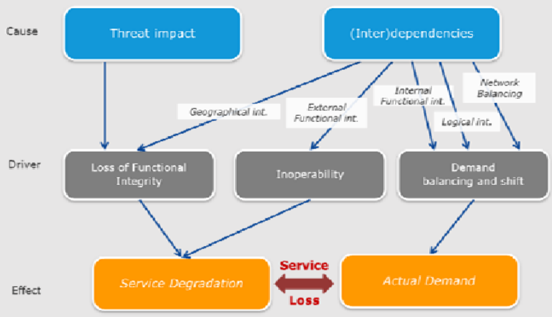
1. DMCI modelling approach

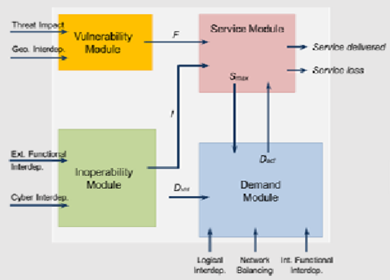
- Propagation of inoperability and demand variations throughout the nodes within and between (inter)dependent CI.
- Quantification of functional and logic (inter)dependencies based on service demand and service capacity parameters
- Continuous simulation



Assessment of service degradation and losses



Modular structure of a CI node



Functional and Cyber dependencies cause a reduction of the maximum service (Smax(k,t)) that the generic child node is able to deliver

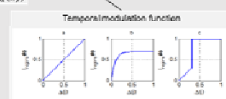
The **inoperability** of j-th (the child) node due to a disservice in the i-th (father) node is:

$$I(j,t) = \sum fI_m(i,j,t) * fI_t(i,j,t)$$

Intensity modulation function [0;1]

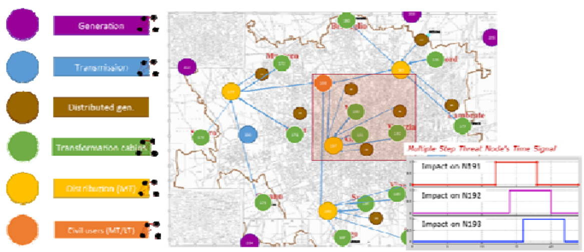
$$fI_m(i,j,t) = diss(i,t) * sensibility_{coeff} * F_{prox}(i,j)$$

Temporal modulation function

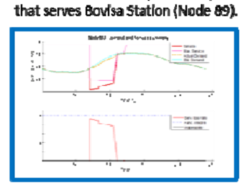


Case Example

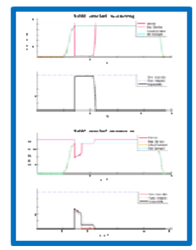
Dynamic analysis of Power Grid response and cascading effects on Transport CI



Disruption profile of the HT/MT transformation cabin (Node 183) that serves Bovisa Station (Node 89).

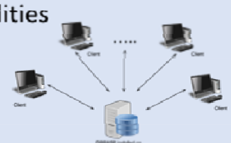


Propagation of Inoperability and service loss across train stations:
Node 85 – Central Station;
Node 89 – Bovisa Station

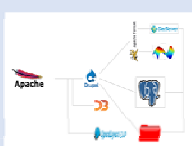


2. GRRASP - Geospatial Risk and Resilience Assessment Platform (JRC)

- A gis-based platform for model integration and advanced visualization capabilities
  - Based on Server-Client model

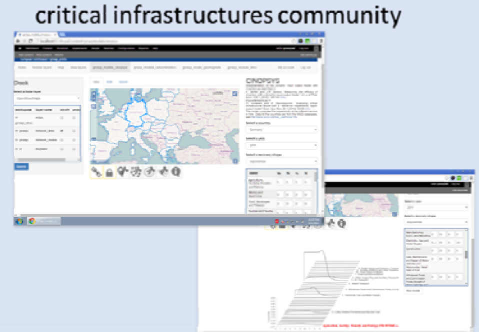


  - Exploiting open source and off-the-shelf technologies (Drupal, Geoserver, OpenLayers, D3.js) plus custom scientific modules



- Models addressing CI risk and resilience at various levels
  - Sectoral analyses
  - (Inter)dependencies analysis
  - Service and economic impact of disruptions

- Leverage the competences in the critical infrastructures community

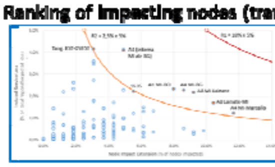


3. Support to the Public-Private Collaboration (PPC) on CI Protection and Resilience in Lombardy Region (IT)

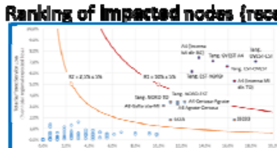
- The PPC involves 14 operators in the Energy and Transportation sectors and the Regional Civil Protection System
  - Railways
  - Metro lines
  - Airports
  - Highways
  - National and regional road networks
  - Power generation, transmission and distribution
  - Gas

- Vital Node Analysis
  - Based on territorial risk assessment

  - Ranking of impacting nodes (transmitters)

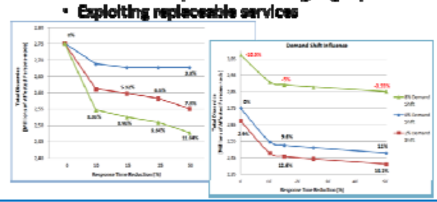


  - Ranking of impacted nodes (receivers)



- Characterisation of CI system resilience
  - Based on a real snowfall event

  - Reducing nodes' response time (10% - 50%)
    - Simultaneously in clusters of high agility nodes
    - Exploiting replaceable services



POLITECNICO MILANO 1863

Resilience-Based Approaches to Critical Infrastructure Safeguarding

NATO Workshop
26-29 June 2016, Ponta Delgada, Azores, PORTUGAL

A Dyadic view of Risk and Resilience Analysis for CIP-R programmes

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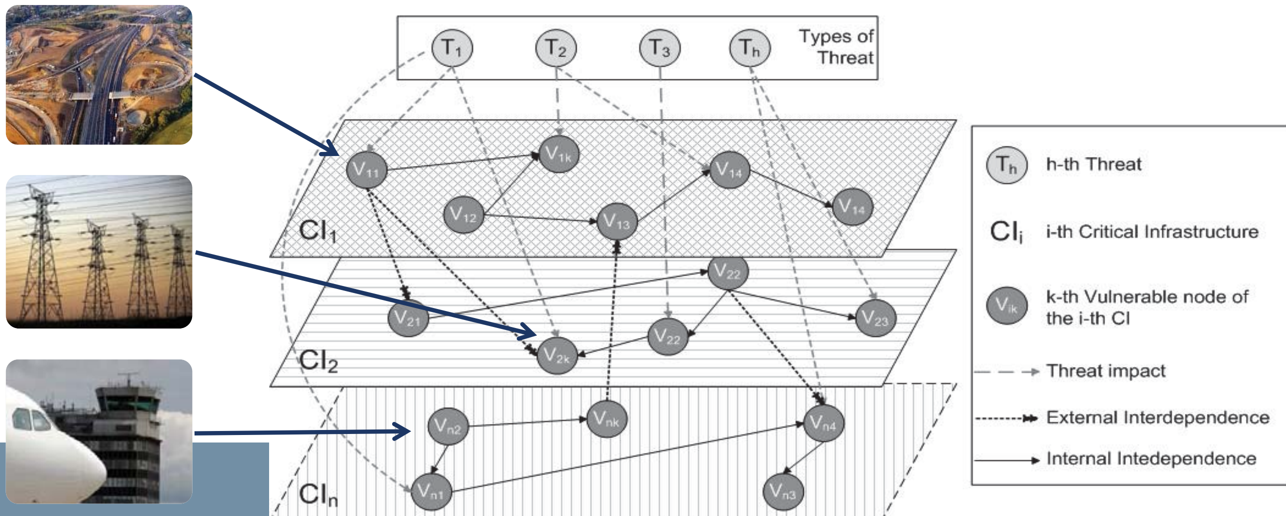
Contents

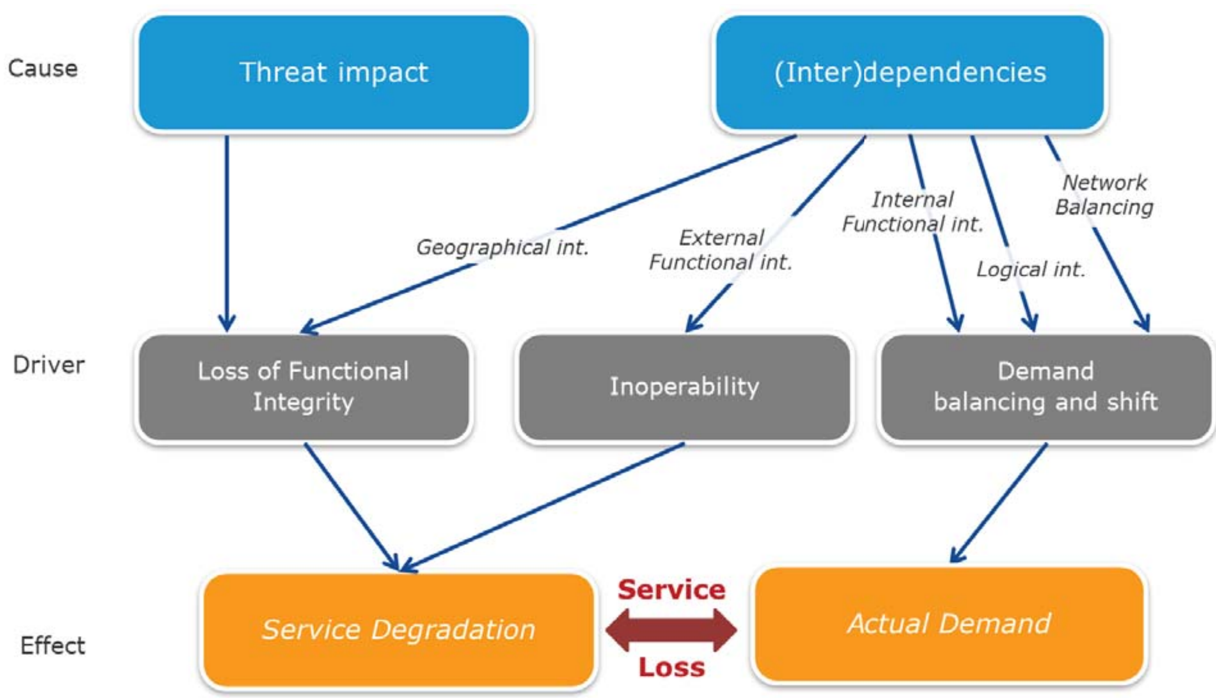
- DMCI - Characteristics of the simulation model and tool
- Vital node analysis of the regional transport system
- Impact assessment of major risks on the regional transport system
- Simulation-based characterisation of CI system's resilience

DMCI modelling approach
Key features

- **Propagation of inoperability and demand variations** throughout nodes within and between (inter)dependent CIs.
- Quantification of **functional (physical) and logical dependencies** based on service demand and service capacity parameters
- **Continuous simulation**



DMCI modelling approach
Assessment of Service disruption and loss



DMCI modelling approach
Determining the state of the node

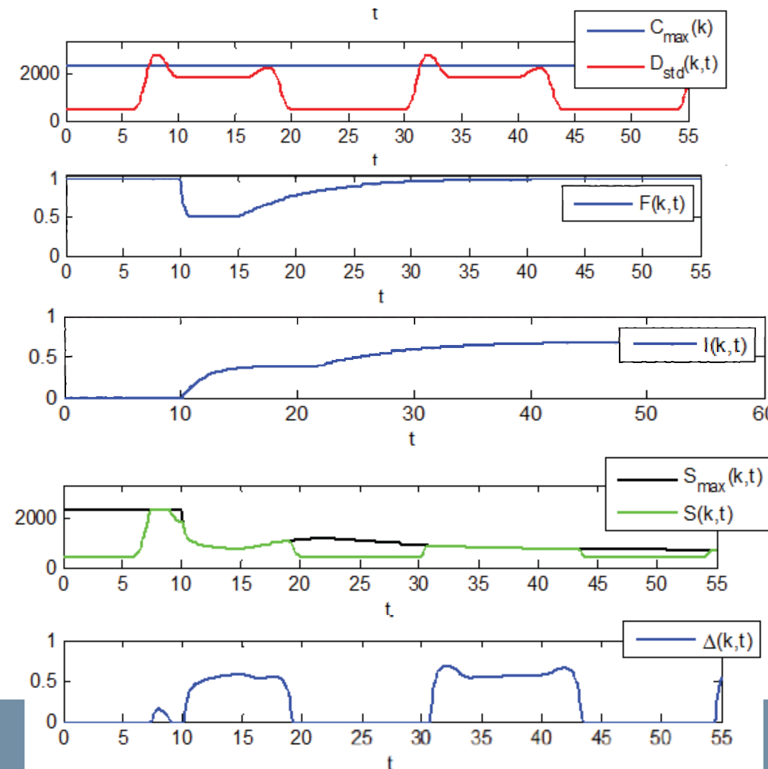
Maximum Capacity
Nominal Demand

Functional Integrity

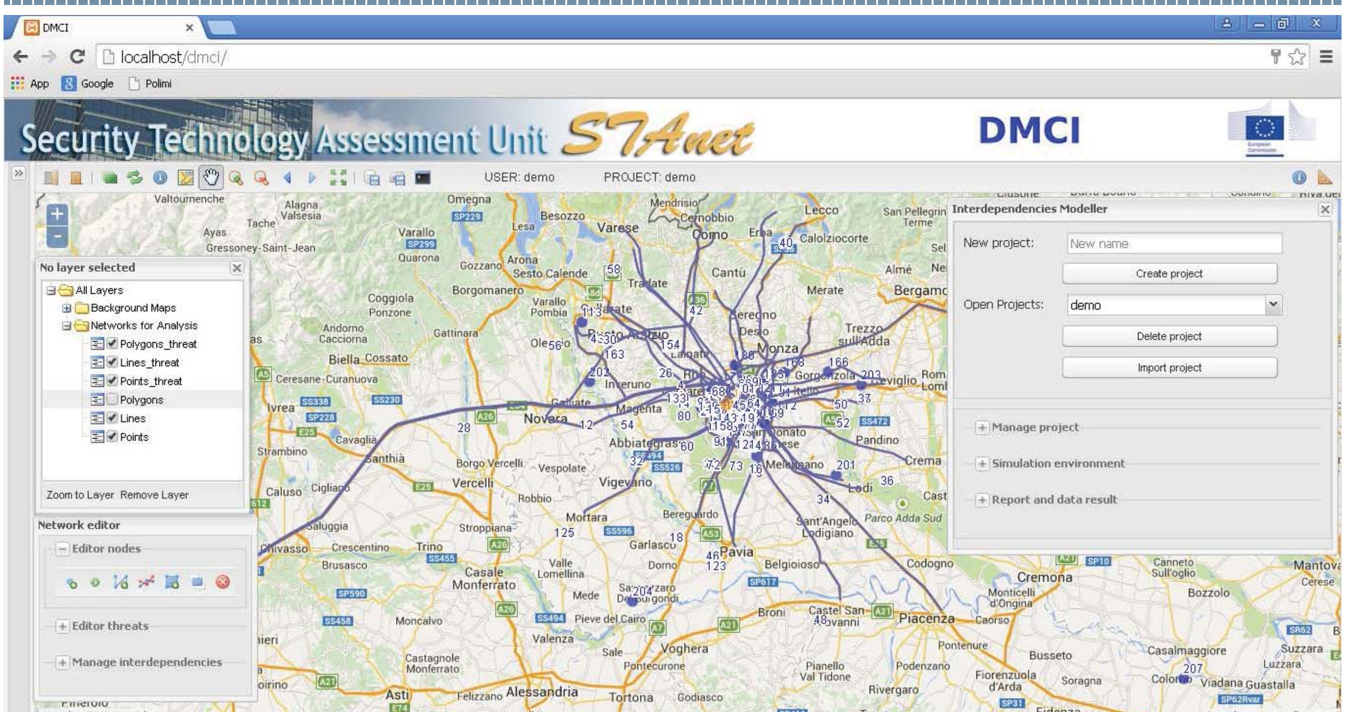
Inoperability

Maximum Service
Delivered Service

Service loss



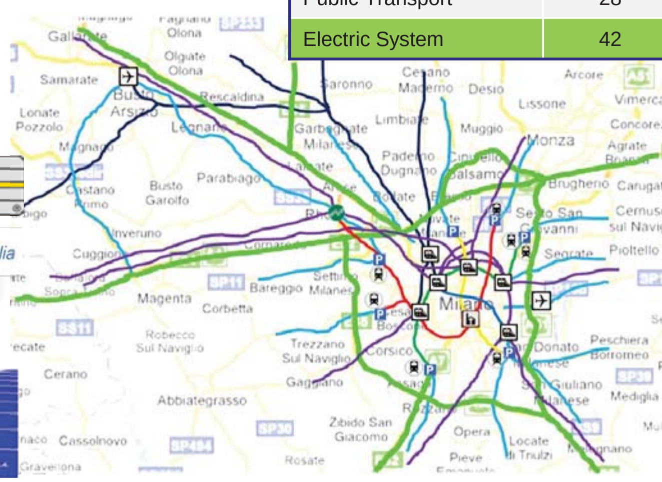
DMCI Software tool
Graphical User Interface



DMCI Application in Lombardy Region
System modelling

- Comprises 211 nodes of 5 different CI sectors
- Characterisation of vulnerable nodes by means of:
  - Regional register on Major Risks and data from operators
  - Regional data from the Civil Protection system
  - Public data and theoretical models

Infrastructure	Number of nodes
Road transportation	82
Rail transportation	57
Airports	2
Public Transport	28
Electric System	42



DMCI Application in Lombardy Region
Data Collection

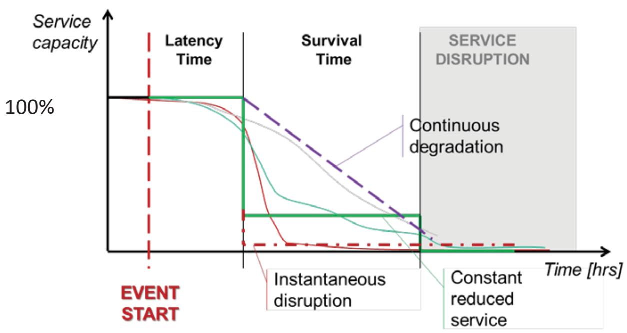
Operational failures (internal threats)	Frequency	Loss of Functional integrity (%)	Recovery Time		Direct damages	Economic loss
			mean	max		

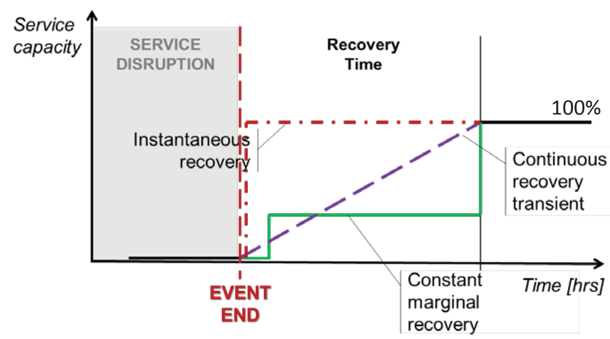
External threats	Degree of vulnerability			Loss of Functional integrity (%)	Recovery Time		Direct damages	Economic loss
	High	Average	Low		mean	max		
Floods								
Landslides/ Rockfalls								
Earthquake								
…								
Explosion								
Intentional attacks								

Dependent nodes of other CI (father)	Type of service	Inoperability rate (%)	Max Transient Time (h)	Qualitative description of the dependency

DMCI Application in Lombardy Region
Data Collection

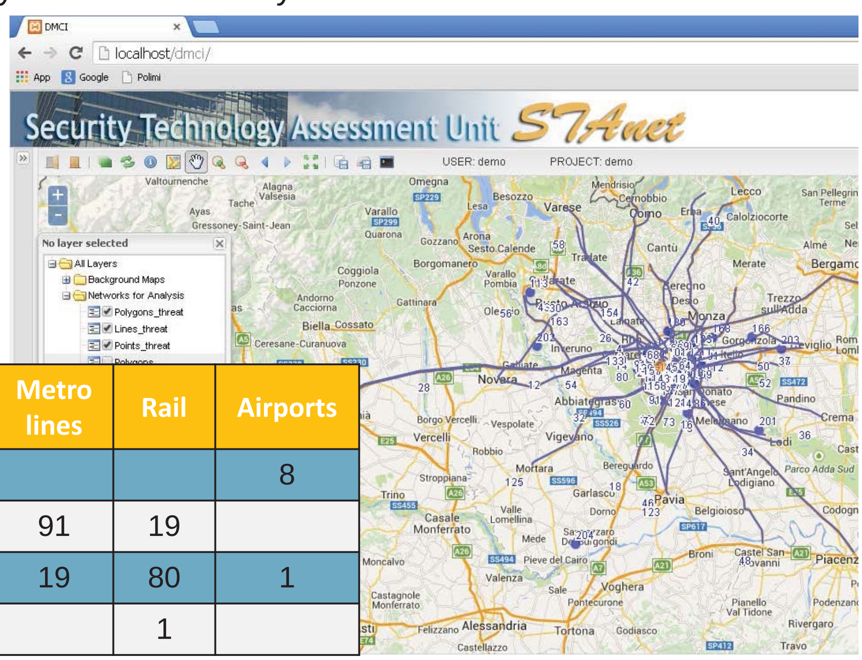
- Resilience profile of CI nodes:
  - Specific Thematic Task Forces for different scenarios
    - Heavy weather events
    - Major Electrical Blackouts
- Standard template for data collection
- Assessment of direct and indirect inoperability based on experts' judgements
- Identification and planning of mitigation and response strategies





DMCI Application in Lombardy Region
Vital Node Analysis

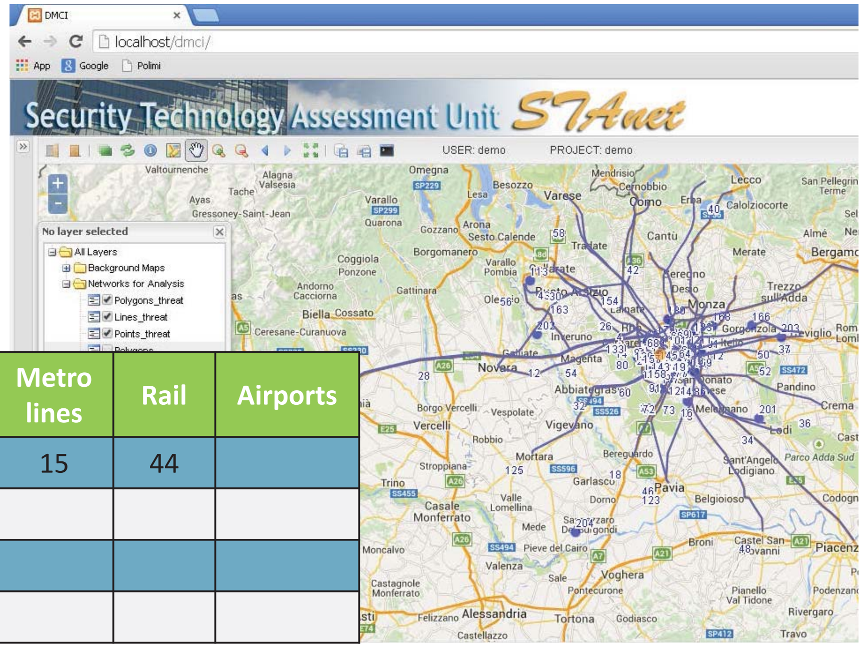
- Transport infrastructure systems modelled by **169 nodes**



Functional interdependencies	Road	Metro lines	Rail	Airports
Road	193			8
Metro lines		91	19	
Rail		19	80	1
Airports	8		1	

DMCI Application in Lombardy Region
Vital Node Analysis

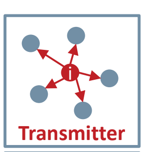
- Transport infrastructure systems modelled by **169 nodes**



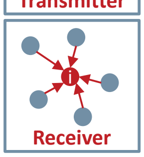
Logic interdependencies	Road	Metro lines	Rail	Airports
Road	111	15	44	
Metro lines	15			
Rail	44			
Airports				

DMCI Application in Lombardy Region
Vital Node Analysis

- Assessment of the overall impact of domino effects in the CI system (total service loss)
- Scenarios:
  - All hazard approach
  - Full functional integrity loss of a node lasting 36 hrs (max demand period)
  - 169 equiprobable scenarios



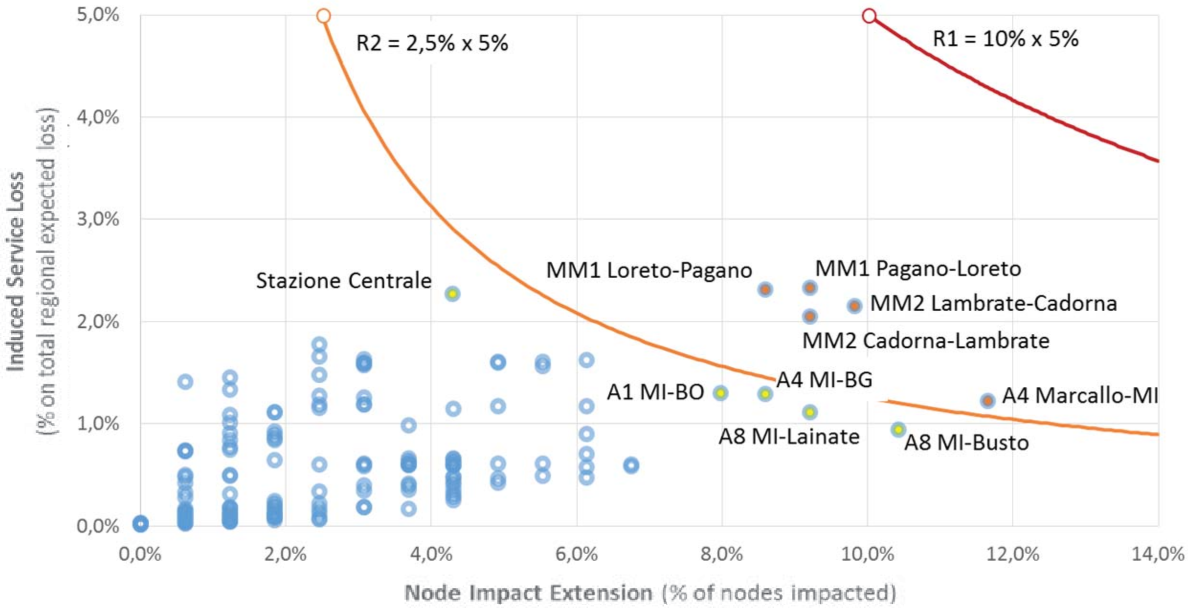
Assessment and ranking of transmitter nodes based on their potential to transfer inoperability to the entire CI system



Assessment and ranking of receiver nodes based on their susceptibility to be disrupted by the dependencies on other CI nodes

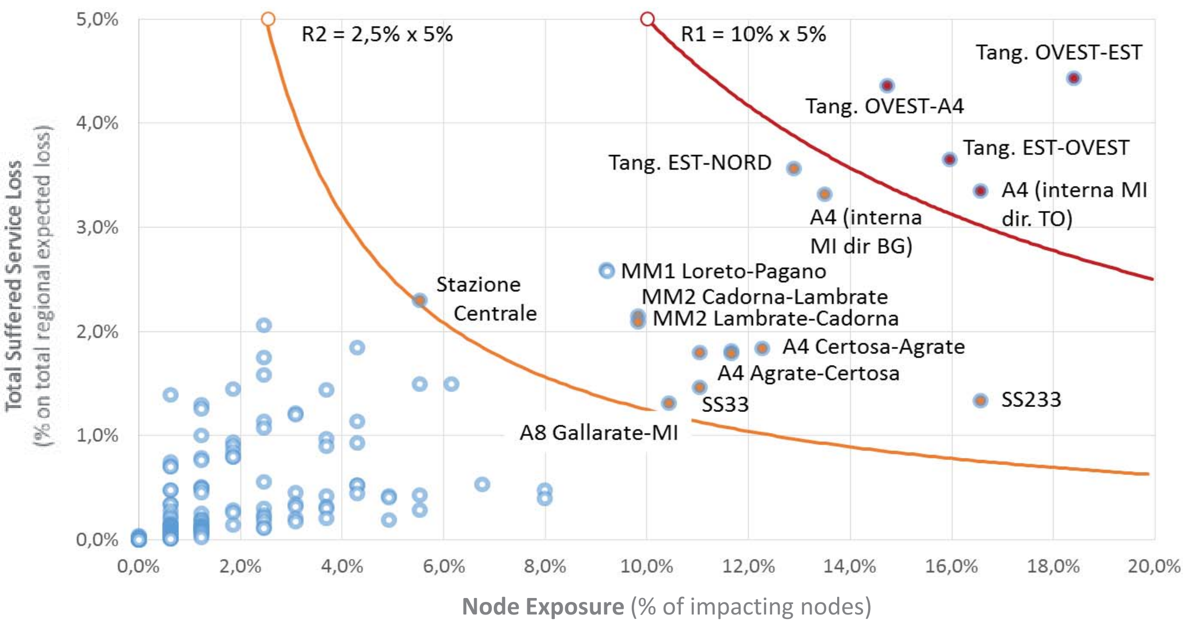
DMCI Application in Lombardy Region
Vital Node Analysis

- Ranking of **transmitter** nodes



DMCI Application in Lombardy Region
Vital Node Analysis

- Ranking of **receiver** nodes



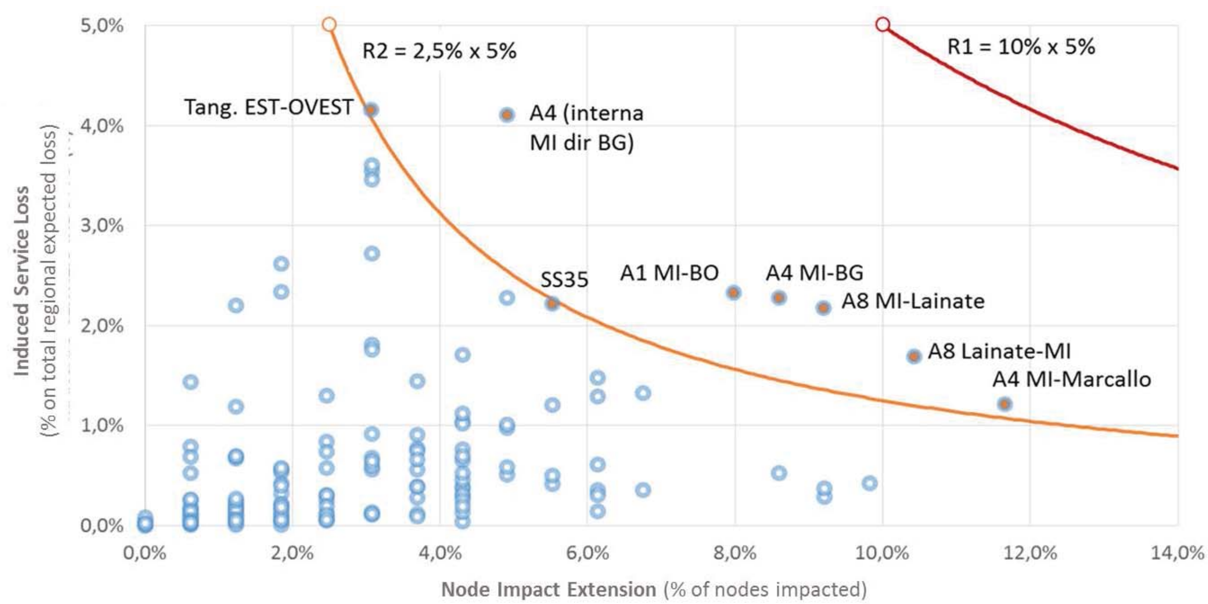
DMCI Application in Lombardy Region
Impact assessment of major risks on the CI system

- Assessment of the expected impact on the transport infrastructure and service induced by the major regional risks (PRIM profile)
- Scenarios:
  - Weighted against the risk exposure of different CI nodes to major regional risks (natural and man-made)
  - 196 scenarios lasting 36 hrs each (max demand period)

(likelihood) x (severity) x (node vulnerability)

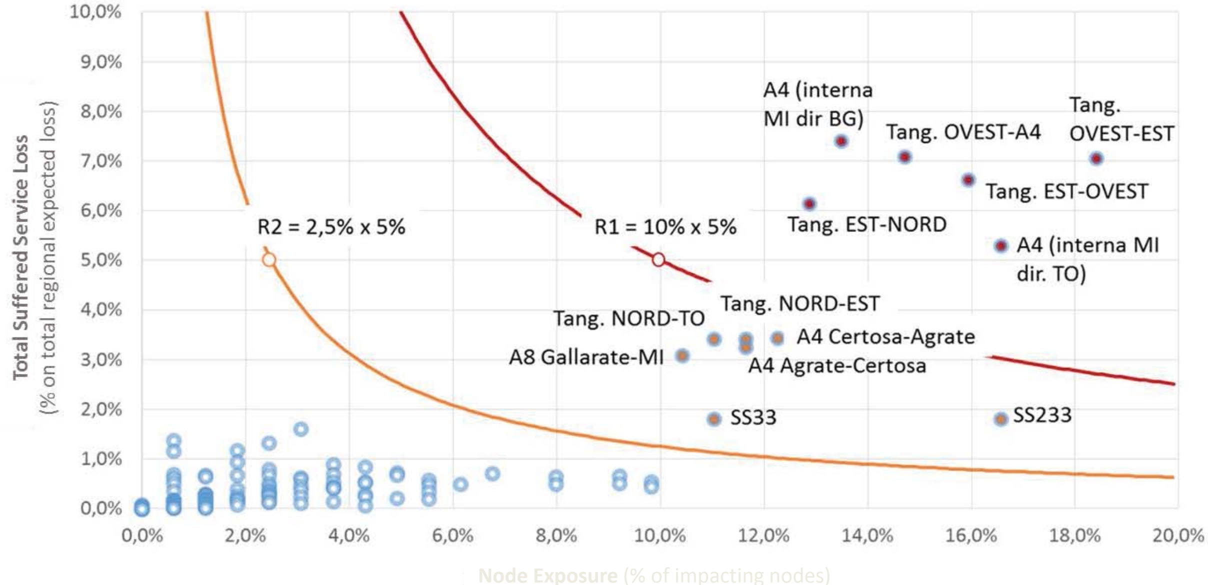
DMCI Application in Lombardy Region
Impact assessment of major risks on the CI system

- Ranking of **transmitter** nodes



DMCI Application in Lombardy Region
Impact assessment of major risks on the CI system

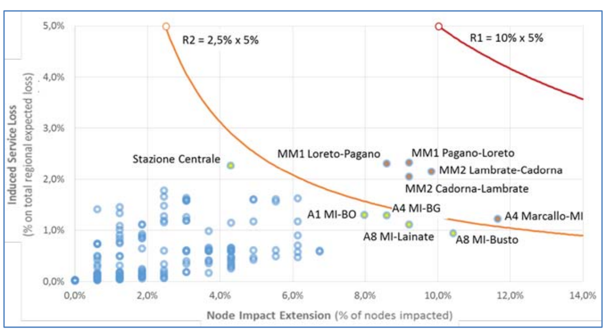
- Ranking of **receiver** nodes

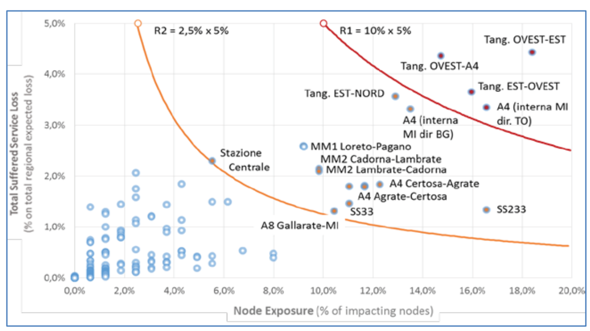


Vital Node Analysis of networked and dependent CI
Impact-based vs Risk-based analysis

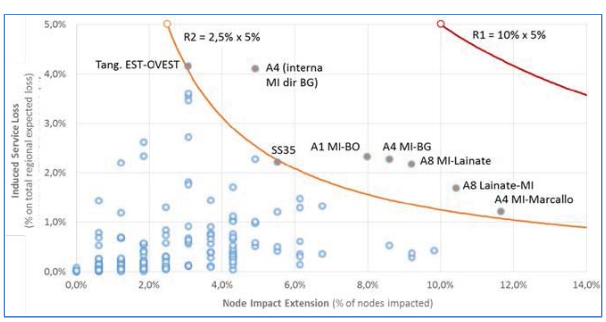
Transmitters | **Receivers**

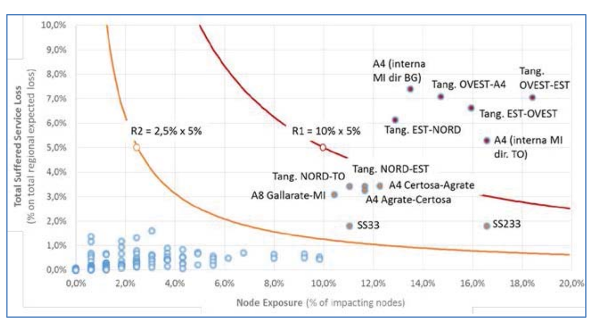
Impact-based Analysis



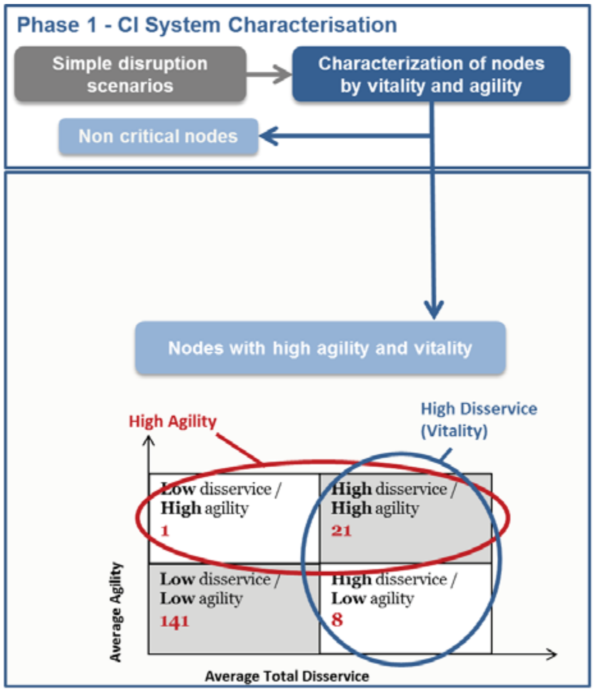


Risk-based Analysis

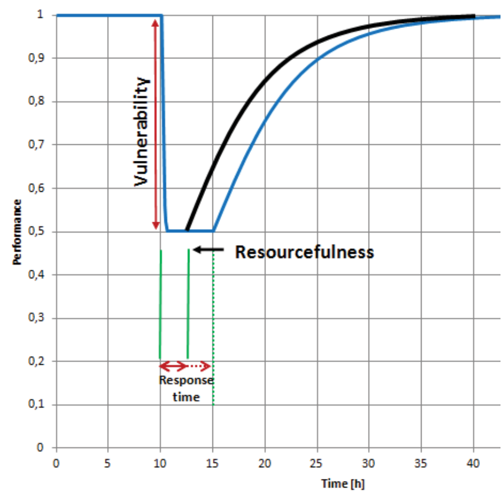




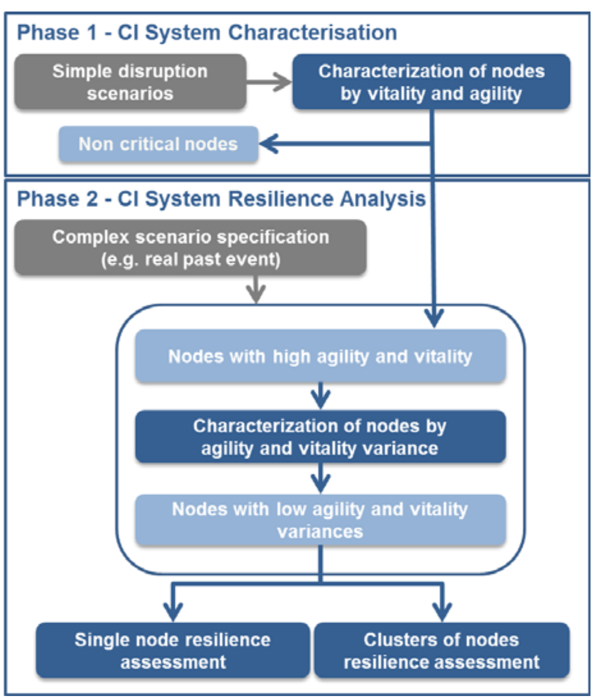
Simulation-based characterisation of CI system resilience



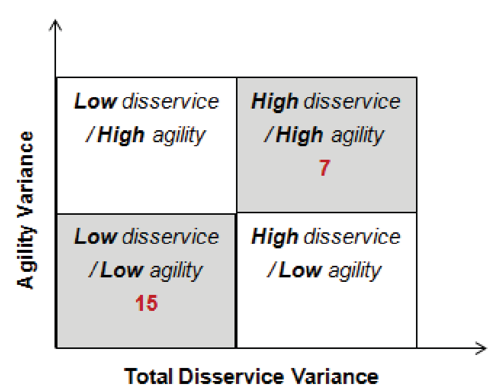
- **Node Agility**: the sensitivity of system performance (Total Service Loss) to an improved response time in the node.



Simulation-based characterisation of CI system resilience



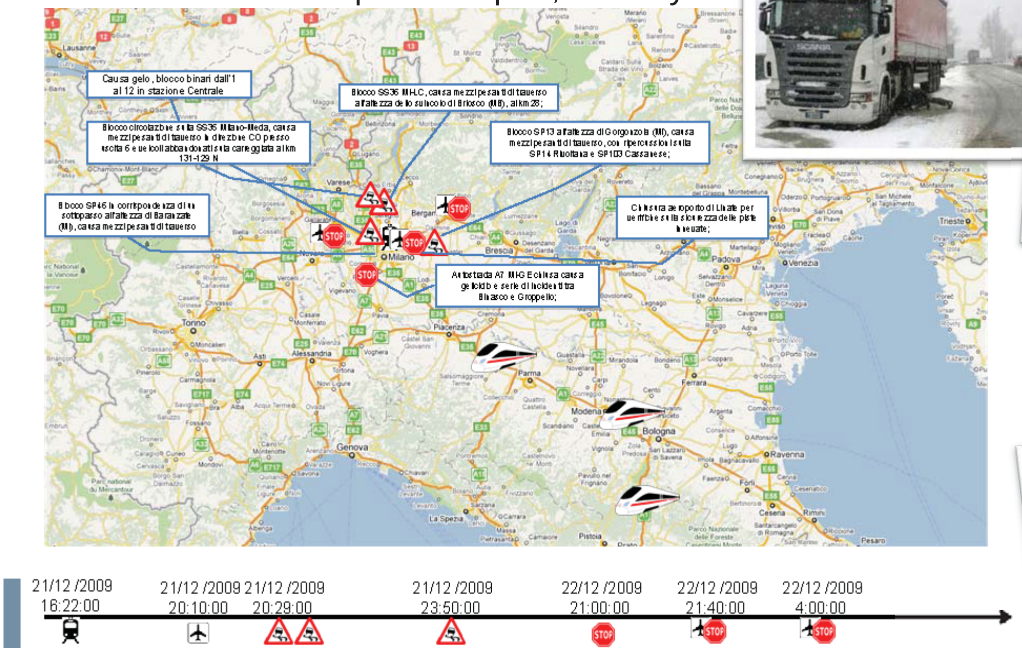
- **Node Agility**: the sensitivity of system performance (Total Service Loss) to an improved response time in the node.
- **Variance** of node vitality and agility in function of different complex scenario settings.

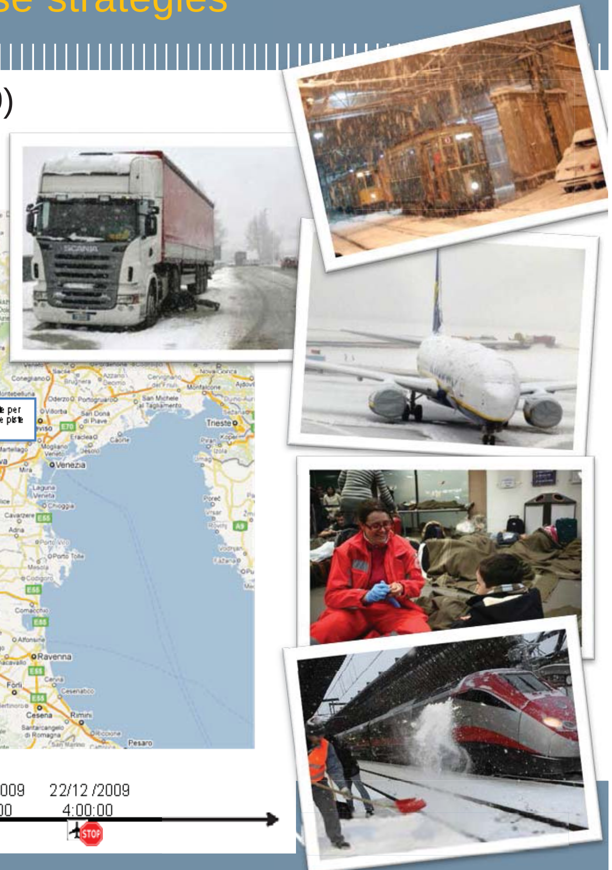


Simulation-based characterisation of CI system resilience

Assessment of collaborative response strategies

- Real large **snowfall event** (21-23 Dec 2009)
- Target nodes: Beltways; Highways;
  Malpensa Airport; Railways

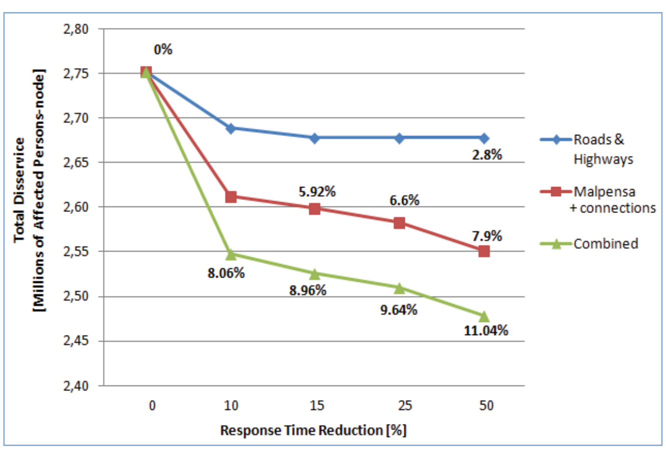


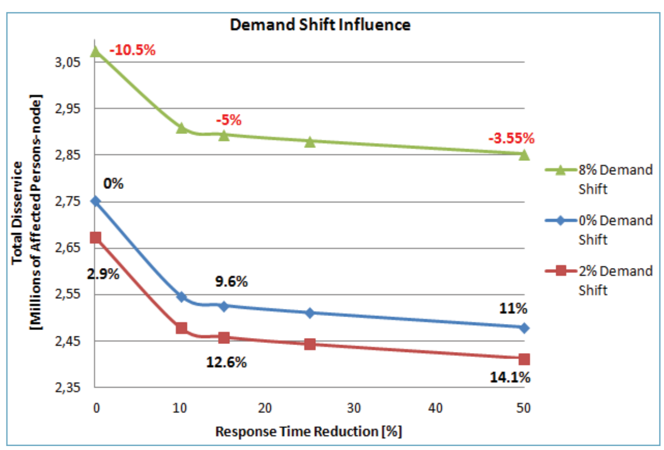


Simulation-based characterisation of CI system resilience

Assessment of collaborative response strategies

- Increasing the responsiveness of target nodes (from 10% up to 50%)
  - Simultaneously in **clusters of agile and tightly coupled nodes**
    → up to 11% impact reduction at system level, but with early saturation effect
  - Exploiting **replaceable services** (roads vs railways demand shift)
    → local reductions of service loss: 22% in roads and highways; 60% at Malpensa





Discussion
Scoping Risk and Resilience analysis for CIP-R

	Transmitter nodes	Receiver nodes
Impact-based Analysis	• Prioritise improvement objectives for **intra-org BCM** (redundancies and responsiveness)	• Characterisation of CI **system resilience** (clustering) • Expand BCM scope (cascades) • Development of **collaborative resilience capacities**
Risk-based Analysis	• Investigation of **risk exposure** and **vulnerability** of CI nodes • Prioritisation of **CIP interventions** on single nodes	• Track changes in cascading effects due to **risk mitigation** actions

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Resilience-Based Approaches to Critical Infrastructure Safeguarding

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Thanks!

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INTEGRATIVE EDUCATION MODEL FOR RESOURCES AND CRITICAL INFRASTRUCTURE PROTECTION BASED ON MCDA IN SENSE OF RISK ASSESSMENT, RESOURCES VALORIZATION AND THREAT RANKING

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THE IMPORTANCE OF CRITICAL INFRASTRUCTURE

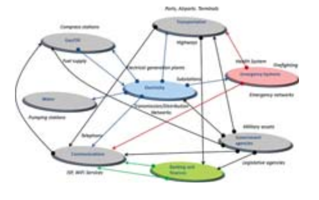
Risk and potential harmful effects derived from emergencies only arises when hazards interact with people, material assets or elements of living environment. An emergency (flood, storm, drought, landslide, terrorist attack…) striking an uninhabited (unsettled) area without any material structures or human individuals cannot be considered as causing risk (from human perspective). Basic prerequisites for such interaction are different kind of vulnerabilities:

·physical,
·social,
·economic and
·environmental vulnerabilities.

There are three core reasons that strengthen the abovementioned interaction:

·change of climatic conditions on Earth that inevitably lead to more frequent and intensive natural disasters on the one hand,
·increased human settling of the areas that have previously not contained any human settlements, so there are fewer and fewer unsettled areas, which means larger areas susceptible to disasters,
·complex political interaction between the states and social turmoil within the some states deriving the potential terrorist threat.

When defining critical infrastructure, the European Union distinguishes between national critical infrastructure and European critical infrastructure. Both terms refer to a property or a system in a Member State that is necessary to maintain key social functions, healthcare, safety, security, and economic and social well-being, the only difference being the ultimate effect. As regards national critical infrastructure, any destruction of or damage to critical infrastructure would significantly impact the Member State in which it is located, whereas in the case of European critical infrastructure, the impact refers either to two or more Member States or to one state which does not contain the critical infrastructure (EC, 2006).



Example of interdependence between energy systems and other critical infrastructure (Yusta, 2011)

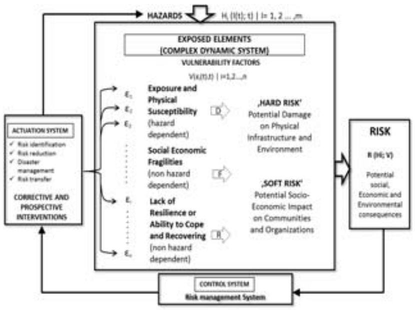
RISK VS. SAFETY

One of the most comprehensive and integrative is holistic approach to risk management, which is shown on next figure. This approach integrates the deliberations regarding hazards, risks, control measures and (most important) exposed elements. Exposed elements are seen in form of complex dynamic system, as the environment and society certainly are.

Composite risk management is a process conducted through various stages, which are not discrete, but complementary:

-hazard identification;
-hazard assessment in order to determine risk level;
-preparation of control and decision-making measures;
-implementation of hazard control measures; and
-control and improvement.

Hazard identification during task study is very significant for risk management. If the hazard is not identified, it will not be taken into consideration, so the assessment of its consequences and probability of occurrence will not be conducted.



Holistic approach in disaster management (Ciurean, 2013)

At the other hand, the concept of safety is a highly complex social phenomenon and a scientific discipline within the social sciences. Safety is also a polysemic term. In the most general sense, it refers to absence of fear, threats, and physical violence. Nevertheless, safety also includes ethical, ideological, and normative elements, which impedes a precise definition.

It is a socially constructed concept, which acquires a specific meaning within a given social context. After the analysis of numerous definitions, the concept of safety can be defined in the simplest terms as a state of protected value in which there is no potential or actual threat to the value, and also as a goal that cannot be fully realized but that should be strived for.

RESOURCES MANAGEMENT

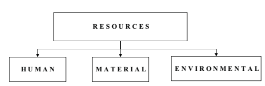
The following terms are important for the topic of this paper:

integrative model – involves a holistic approach, in this case a view of the model as a whole, which enables combining the best aspects, thus leading to the optimal solution for a given model;

resource - fr. la ressource, "means, source"; lat. resurgere, "rise again, reappear, be restored", is a means necessary for the undertaking or completion of an action. A resource may be material or non-material. The basic division of resources is into human, natural (renewable and non-renewable), and material resources;

resource protection – utilization of resources on a scientific basis, identification of the ways to use resources rationally and complexly, and development and improvement of all forms of cooperation within scientific research;

integrative model of resource protection improvement – a learning process used to define the model and the important features of a complex resource protection model required by the state authority (in this case experience of the MoD is used), and to provide scientific knowledge about the organizational structure of the bodies in charge of implementation and realization of measures and procedures of resource protection for the MoD.



Resources – synergetic structure

Using SWOT analysis, we listed strengths, weaknesses, opportunities, and threats to resources protection within the MoD, which allows the identification of positive and negative factors that, affect the choice and balance between internal capabilities and external possibilities.

SWOT analysis of sustainability for resource protection in the MoD

Strengths	Weaknesses
- clear vision, mission, and goals; - operational efficiency; - favorable educational structure of employees; - existence of legal and normative acts for resource management; - planning and organization of occupational safety and health; - implementation of occupational safety and health; - control of occupational safety and health;	- insufficient number of professional personnel from the given field; - insufficient number of suitable teaching personnel; - inadequate training in the given field; - insufficient knowledge and skills in the given field; - insufficient employee interest;
Opportunities	**Threats**
- improvement of the current state of the given field in the EU accession process; - promotion of the needs of protection implementation; - employee motivation for implementing resource protection measures; - control of training implementation and subsequent employee skills; - introduction of mandatory classes at all education levels in the MoD; - adequate training/education of current personnel; - cooperation with university faculties from the same field;	- a drop in the economic standard; - lack of adequate material capacities; - resistance to changes; - insufficiently developed culture concerning the given field; - opposing views on the need for and scope of measures to be implemented; - failure to understand the necessity of professional personnel at all levels; - employee fluctuation;

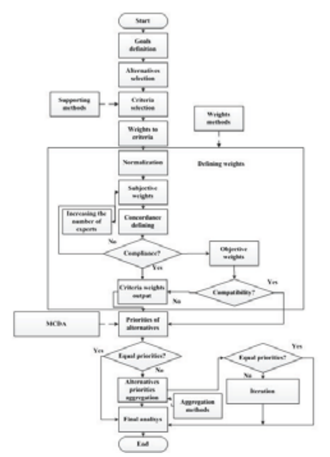
MCDA

During the MCDA process, we propose contemporary literature algorithm that is modified for the purposes of this research.

The corresponding decision making process can be described using an algorithm that includes the following four main phases: definition of objectives and selection of criteria for alternative selection, determining the weight of criteria, evaluation and aggregation of results.

Determination of the effectiveness of the system is a problem. The development of evaluation criteria and methods to reliably measure the effectiveness and efficiency is a prerequisite that you select the best alternative, inform decision-makers about the performance of alternatives and monitor the impact of the social environment.

The development and selection of alternatives is based on indicators related to reliability, convenience, safety measures and limited resources. These indicators are limited and/or affect each other. For example, a number of technical and social aspects that need to be improved is limited by economic and political interests (Ustinovichius, 2007).



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·Ustinovichius, L., Zavadskas, E.K., Podvezko, V. 2007. Application of a quantitative multiple criteria decision making (MCDM-1) approach to the analysis of investments in construction. Control and Cybernetics, 36 (1).

An adverse impact of different kind of emergencies differs by nations, regions, communities and (even) individuals, because of differences in their exposure to disasters (susceptibility) and vulnerability (intrinsic). Following contemporary needs and tendencies pertaining to more sustainable emergency risk reduction strategies, frameworks and practices, researchers who are engaged in this area in recent years are orientated towards viewing and reflecting on the issue of emergency risk reduction within the broader context of sustainable development concept. States that develop policy, legislative and institutional frameworks for emergency risk reduction are able to manage emergency risks and to achieve broad consensus for risk reduction measures across all sectors of society. At the other hand, there is a clear-cut consensus that the states without educated professionals and citizens (safety culture), has insufficient capacity to respond to the threats posed by emergencies.

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Quantifying Resilience?

NATO meeting "Resilience-Based Approaches to Critical Infrastructure Safeguarding", 26-29 June 2016, Azores, PT

Prepared/presented by: Dr Rogier Woltjer, FOI

THE PROJECT LEADING TO THIS APPLICATION HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAM UNDER GRANT AGREEMENT 653289.

Some DON'T believe in a single/simple measure of resilience

- "this paper argues that the desire for a single tool to address all of these tasks is unlikely to be satisfied because resilience is not a single 'thing'. Helping people and systems (health services, markets) to be more resilient is not a single class of activities" (Levine, 2014, p. 1; *Assessing resilience: why quantification misses the point*)

- "because resilience refers to something that the organisation *does* rather than to something that it *has*, it is not possible to represent resilience by a single or simple measurement." (Hollnagel, 2010, p. 3; *Resilience Assessment Grid*)

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Resilience definitions: *What is said to be resilient?*

Individual

Community

Infrastructure

System

Organization

Events, circumstances: *Resilient to what?*

Emergency

Catastrophy

Hazard

Disaster

Crisis

Mishap

Danger

Deformation

Perturbation

Disturbance

Disruptions

Stress

Adversity

Misfortune

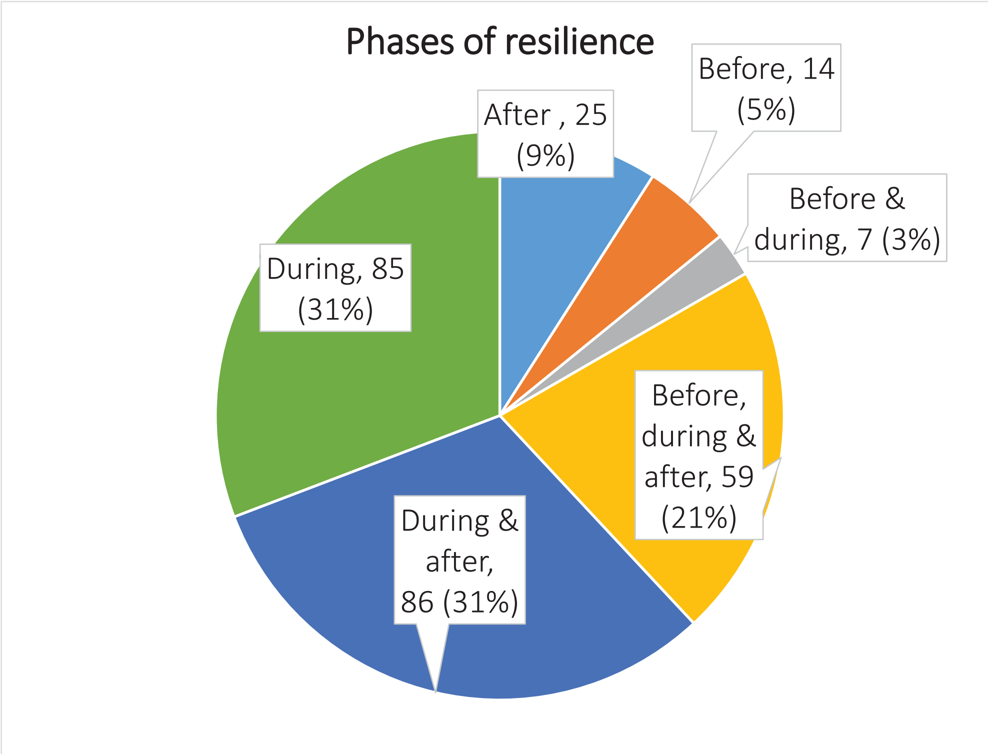
Change

Challenge

Shock

Uncertainty

Resilience definitions and the phases *before, during* and *after*



Deliverable D1.1 Survey online: http://www.h2020darwin.eu/

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Challenges to quantifying resilience

- Whether/how you (can) measure resilience depends on your definition and scope of resilience!

- Diversity in ”systems of systems” being resilient
- Diversity in when resilience ”happens”
- From specific failures/hazards (classic risk management) to ”change” to ”uncertainty” to ”unknown unknowns” to everyday performance variability

- How to develop a resilience metric that can address this diversity yet remain sensitive to the context of the system?

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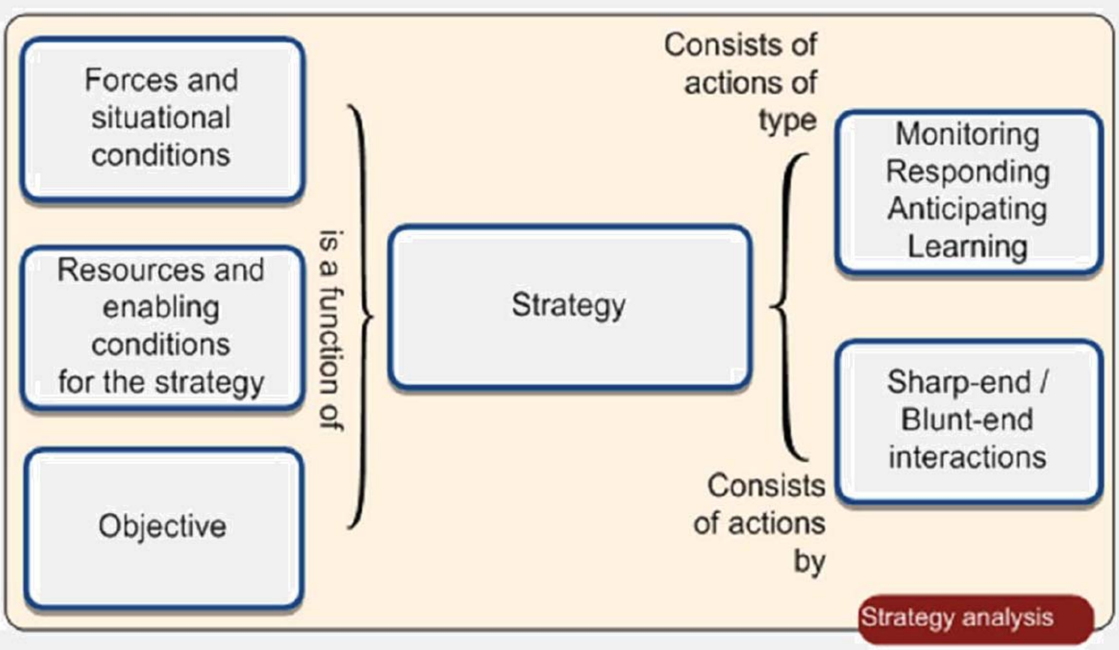
Resilience Principles for Risk Analysis

- Signals and cues (anticipation, monitoring, response)
- Work-as-done
- Varying Conditions
- Goal trade-offs
- Coupling and interactions, cascading
- Timing, synchronization, and time scales
- Under-specification, approximate adjustments
- Adaptive capacity, margins, tolerance

Woltjer, R., Pinska-Chauvin, E., Laursen, T., & Josefsson, B. (2015). Towards understanding work-as-done in air traffic management safety assessment and design. *Reliability Engineering & System Safety*, *141*, 115–130.

Resilience Strategies Framework



Rankin, A., Lundberg, J., Woltjer, R., Rollenhagen, C., & Hollnagel, E. (2014). Resilience in Everyday Operations: A Framework for Analyzing Adaptations in High-Risk Work. *Journal of Cognitive Engineering and Decision Making*, *8*(1), 78–97.

Challenges to quantifying resilience

- Resilience as an emergent dynamic property of socio-technical (human-technology-organization) system
- People as main source of adaptive capacity
- Complex system activity, diverse/competing goals and trade-offs
- Associated with multiple critical services or functions that interact in ways only partly predictable, unexpected, intractable

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Challenges to quantifying resilience

- Uncertainty and ”the unexpected”
- Embracing diversity (cf. systems, complexity theory), and ambiguity, from different stakeholder perspectives
- Adaptation is central (before, during, and after)
- Does it make sense to assess the system that adapted to the unexpected with measures defined before the adaptation to the unexpected occurred?

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EXPECT THE UNEXPECTED AND KNOW HOW TO RESPOND

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