



# **Risk & Resilience: Emerging risks and resilience – how to find right indicators**

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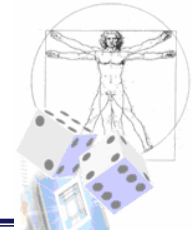
EU-VRi – European Virtual Institute for Integrated Risk Management, Stuttgart, Germany

Member of: ISO TC 262 (Risk) and TC 292 (Resilience), Convener of DIN SPEC 91299 (Em. Risks)



**What's resilience?  
(the Aspen restaurant waitress way –  
Dec. 1, 2015):**

**“Oh, it's bouncing back!”**



# Main message

1. Making the “**Risk-Resilience**” Bridge means making a bridge between two (shaky!) shores
2. **Emerging Risks** (new, unknown), and their **indicators**, can be the main challenge, but also a shared concept, for both resilience and risk

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Proposal: Establish the practical link between risk (analysis) and resilience on the issue of emerging risks and their indicators



**Resilience Indicators:** What we know about resilience, we know thanks to indicators...

**Resilience** of an infrastructure, as understood in this project, is

*“the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions”<sup>1</sup>.*

*Adapted from Linkov et al. 2014*



# Emerging risk in resilience cycle

Anticipate,  
prepare for, and  
adapt to changing  
conditions and  
withstand,  
respond to, and  
recover rapidly  
from disruptions:  
How to quantify?  
Metrics?

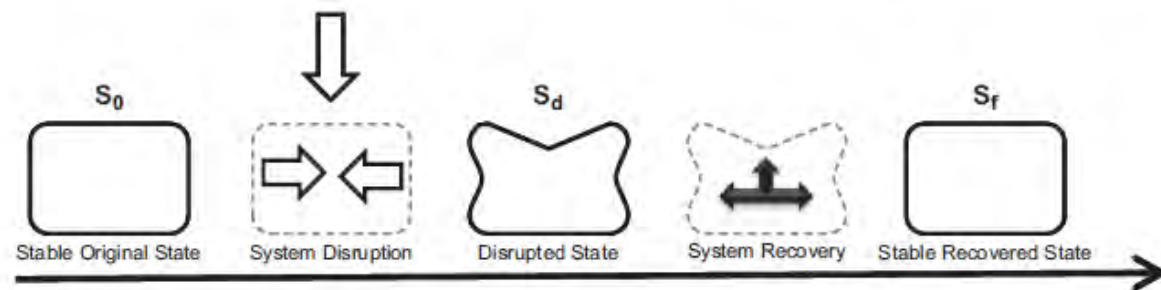
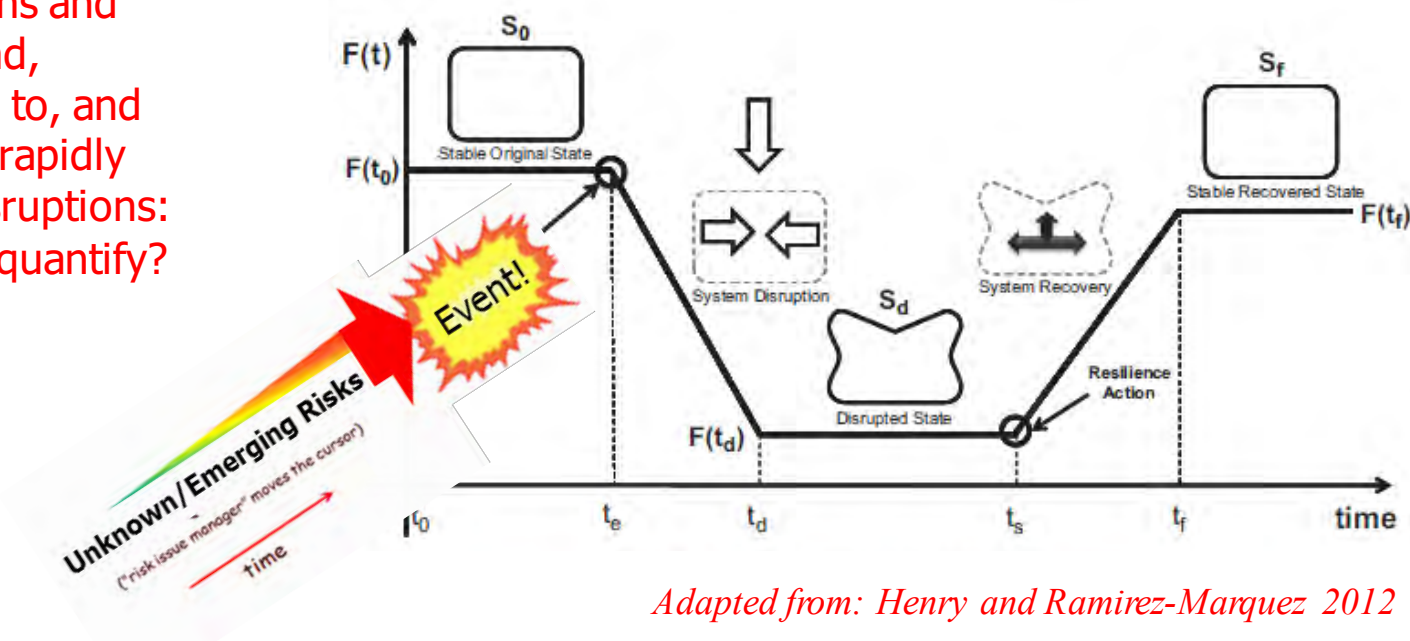


Fig. 1. System state transition in resilience.

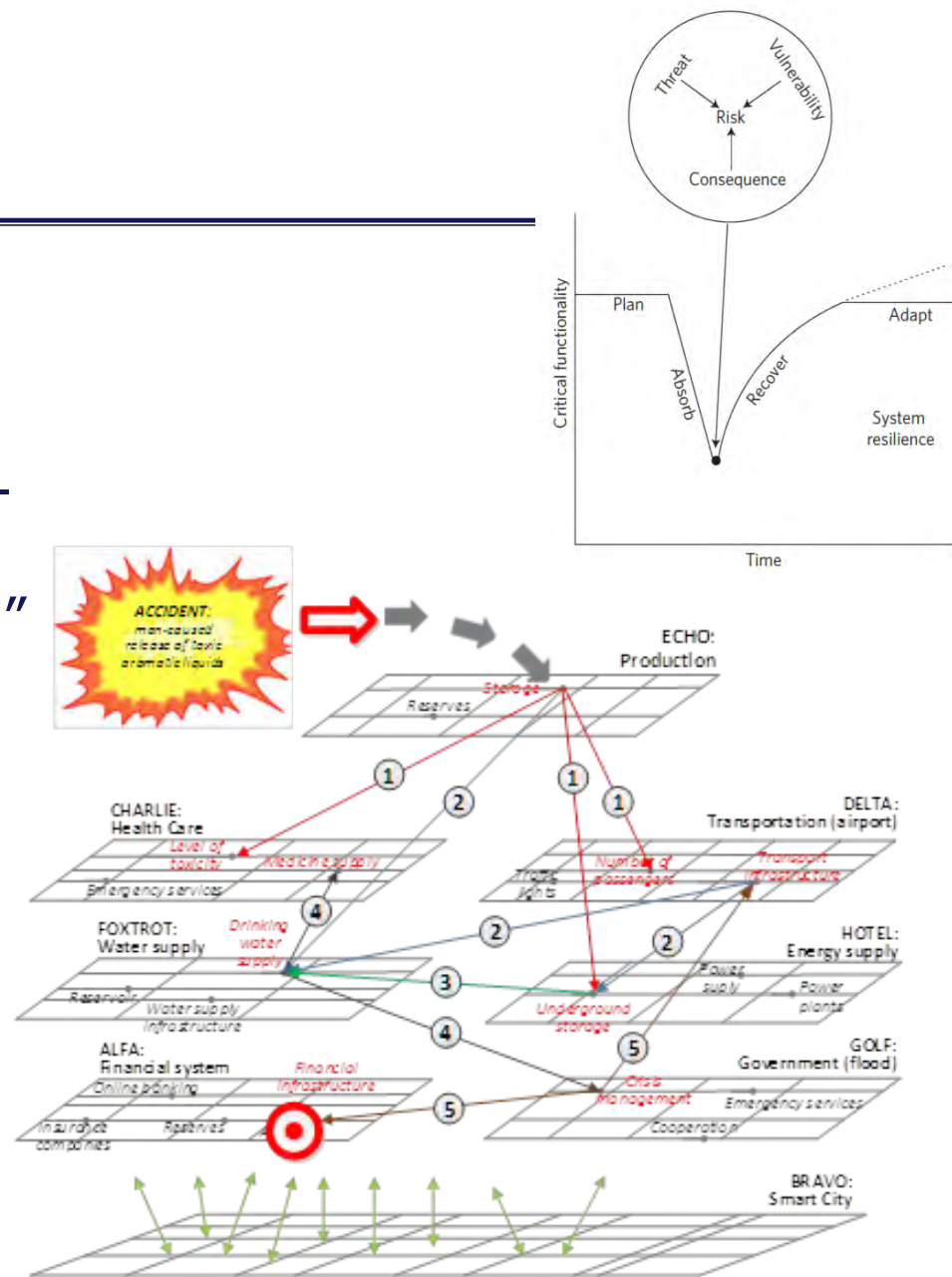


Adapted from: Henry and Ramirez-Marquez 2012

# Some thoughts...

There is an obvious need to

1. Map the landscape “risk-resilience-vulnerability-temporality-adaptation...”
2. Establish relationship (make a bridge?) between risk and resilience



*Linkov et al. 2014*

# Some thoughts...



There is an obvious need to

1. Map the landscape “risk-resilience-vulnerability-temporality-adaptation...”
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*Adapted from: O’Riordan, T, and Cox, P. 2001. Science, Risk, Uncertainty and Precaution*



# Early warnings... & emerging risks



**WARNINGS =  
WARNING ABOUT  
RISKS!**

About which risks?  
Known ones?...

Answer – the risks  
which can “catch us by  
surprise”:

NEW & “unknown”  
risks, EMERGING  
RISKS!

**Risks**

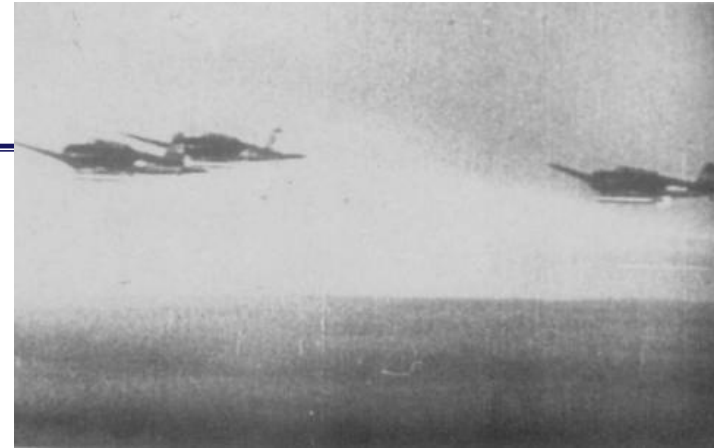


**Green jobs and  
occupational safety and health:**

**Foresight on new and emerging risks  
associated with new technologies by 2020**

# Perl Harbor Dec. 7, 1941

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✦ *"Don't worry about it."*

*Those words, which he uttered on a peaceful Sunday morning in 1941 on the Hawaiian island of Oahu, would haunt Kermit A. Tyler for the rest of his life. Tyler was the Army Air Forces' first lieutenant on temporary duty at Fort Shafter's radar information center on the morning of Dec. 7, 1941, when a radar operator on the northern tip of the island reported that he and another private were seeing an unusually large "blip" on their radar screen, indicating a large number of aircraft about 132 miles away and fast approaching.*

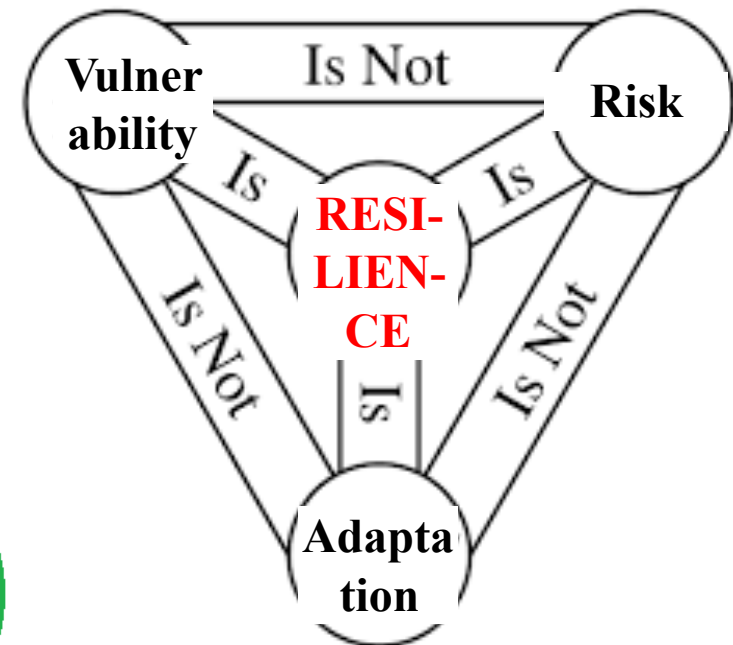
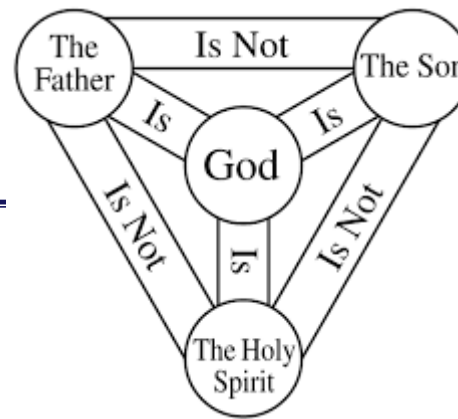
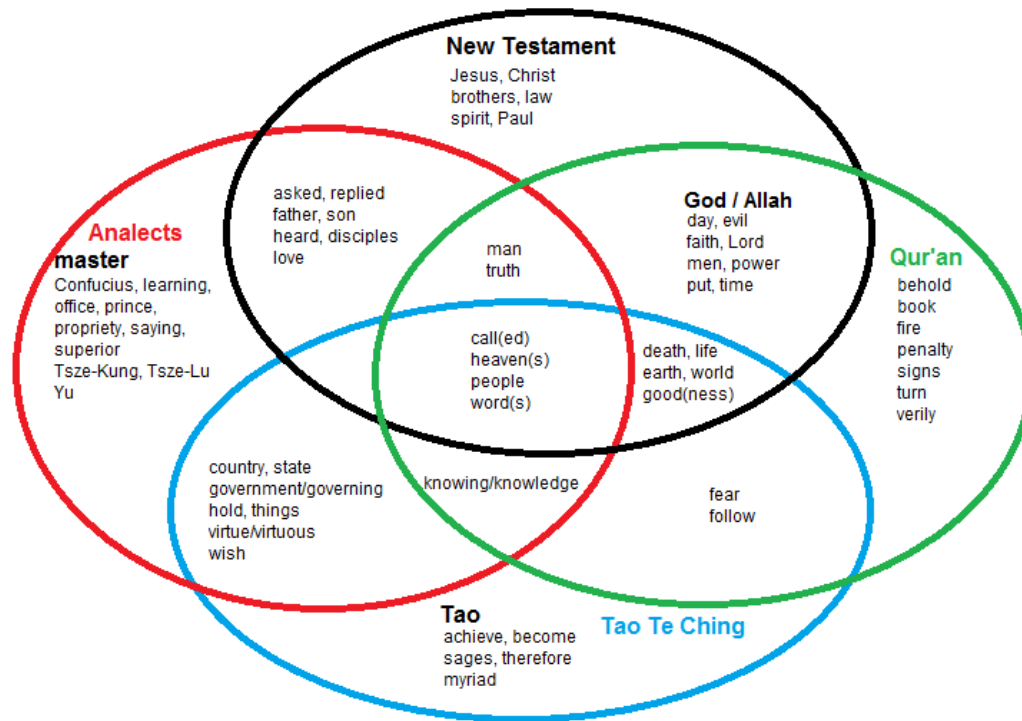
*"Don't worry about it," Tyler told the radar operator, thinking it was a flight of U.S. B-17 bombers that was due in from the mainland. Instead, **the blip on the radar screen was the first wave of more than 180 Japanese fighters, torpedo bombers, dive bombers and horizontal bombers whose surprise attack on Pearl Harbor and the island's main airfields shortly before 8 a.m. plunged the United States into World War II.***



# Some thoughts...

Avoid the pitfalls

1. Map the landscape “risk-resilience-vulnerability-temporality-adaptation...”



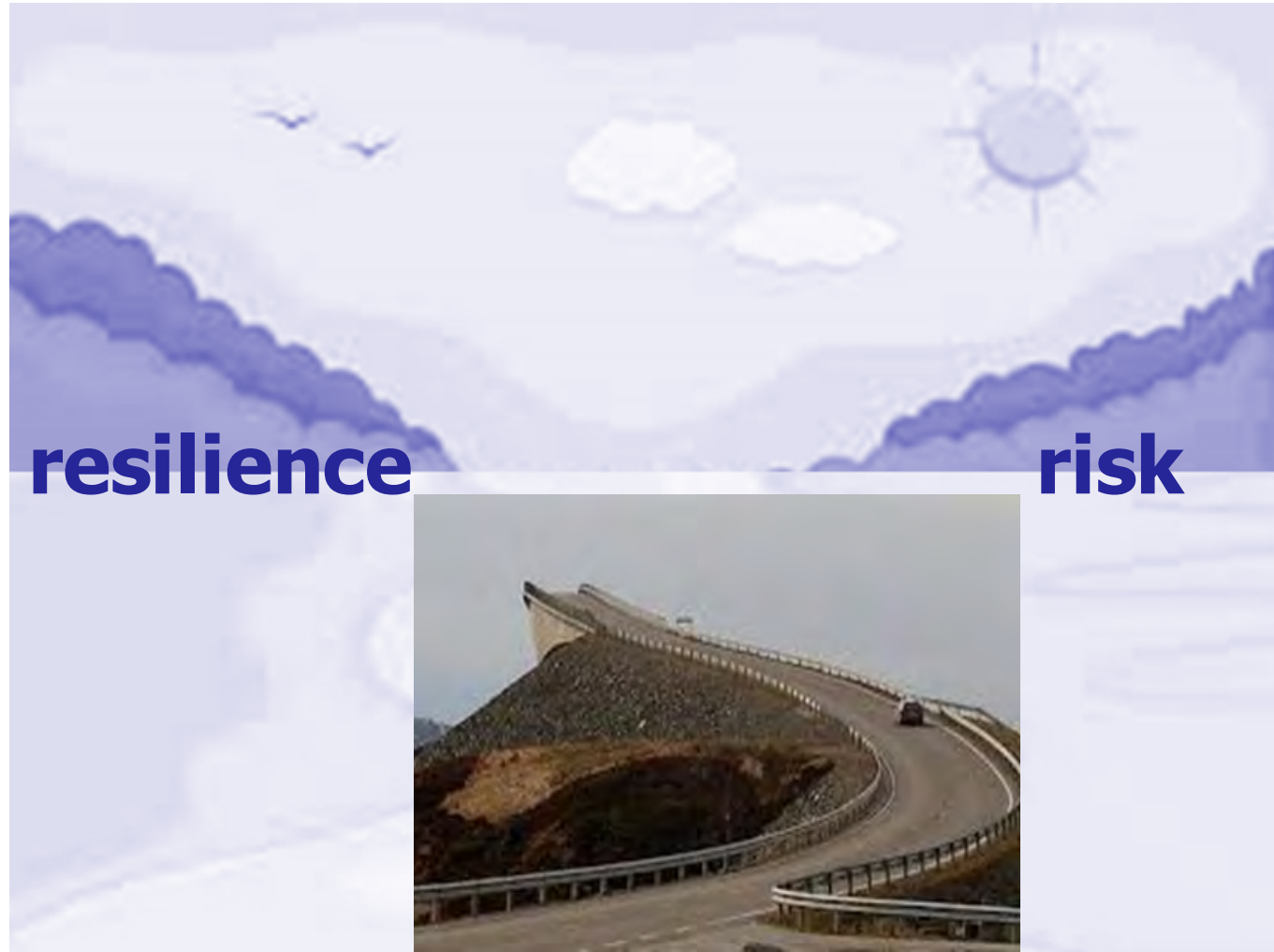
# Some thoughts...



Avoid the pitfalls

2. Establish relationship (make a bridge?) between and resilience

... some candidates for a “bridge to nowhere”



# Some thoughts...

Avoid the pitfalls

2. Establish relationship (make a bridge?) between and resilience

... can standards help? Can they hamper the process?

**Purpose of “bridging”?**  
**Decision (only)? ALARP of resilience?**  
**Benchmarking?**  
**Indicators vs. indices?**  
**Monitoring?**  
**Quantitative vs. Qualitative?**  
**Capacity to adapt vs. “alternative futures” (the “2 resiliences”)?**

**resilience**

**risk**



**BRIDGIT:**  
**Standards as the  
innovation and  
communication bridge**  
**European Conference**

*Save the date:* **30 October 2014**

**Brussels**



# ISO Standards world wide: NATIONALLY adopted; e.g. the ISO31000

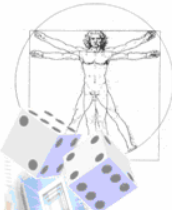


ISO 31000 standard recognized as national risk management standard, worldwide



ISO 31000 standard recognized as national risk management standard

# Meant to be a part of a larger system of standards related to risk management



Policy and Strategy of Organization  Risk & Resilience	Quality management  ISO 9001	Environmental management  ISO 14001	Environmental management (LCA)  ISO 14044	Business continuity  ISO 22301	Social responsibility  ISO 26000	IT Security management  ISO 27000	RISK management  ISO 3100	Work safety management  ISO 45001 (ex OHSAS 18000)	New standards being prepared e.g. Security management	Internal control system  Laws, Protocols, (e.g. DHS / UNISDR / Sendai) ...
ISO/IEC Guide 51:1999 Safety aspects — Guidelines for their inclusion in standards ( <i>REVISION is currently in progress</i> )										
ISO Guide 72:2001 Guidelines for the justification and development of management system standards										
ISO Guide 73:2009 Risk management — Vocabulary										

ISO 31000: Risk Management

(ISO 31004 – Guidance)

ISO 31010: Methods

***Risk & Resilience???***





# Some standards to look at...

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- ✦ ISO 22300, *Societal security — Terminology*
- ✦ ISO/PAS 22399, *Societal security — Guideline for incident preparedness and operational continuity management*
- ✦ ISO/IEC 24762, *Information technology — Security techniques — Guidelines for Information and communications technology disaster recovery services*
- ✦ ISO/IEC 31010, *Risk management — Risk assessment techniques*
- ✦ ISO/IEC Guides 51 and 73
- ✦ NFPA 1600, *Standard on disaster/emergency management and business continuity programs*, National Fire Protection Association (USA)
- ✦ ANSI/ASIS SPC.1, *Organizational Resilience: Security, Preparedness, and Continuity Managements Systems – Requirements with Guidance for Use* SS 540: 2008, *Singapore Standard for Business Continuity Management*
- ✦ New EN on RBI has Annex on resilience metrics
- ✦ New DIN SPEC INTERNATIONAL (based on New European pre-standard DIN-CWA 16648:2013 (DIN SPEC 91299) "Managing emerging technology related risks") will have an Annex on resilience of New Technologies

✦ ...

**Could "overstandardization" become a risk in itself?  
Reduce resilience?**



# Note

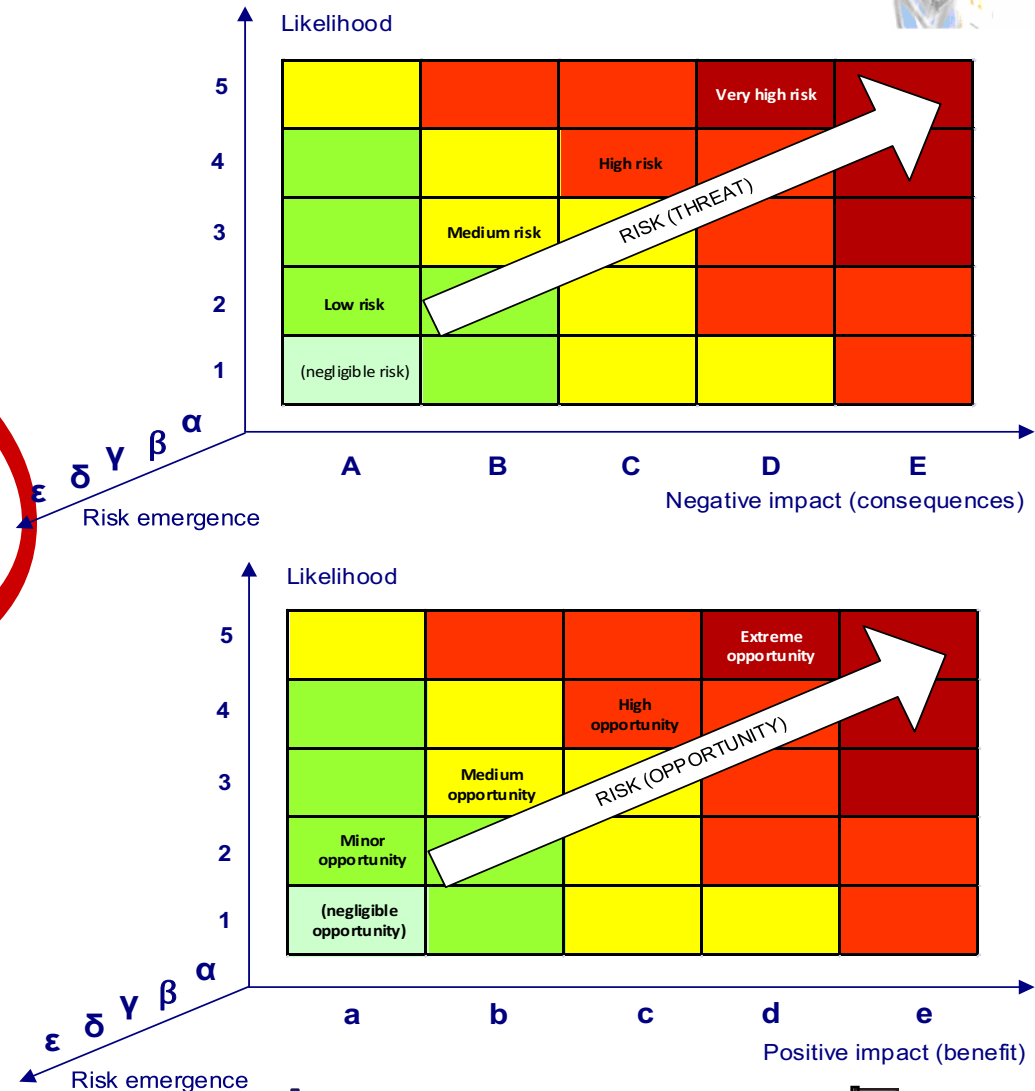


➤ **ISO Guide 73:2009,**  
Risk management -  
Vocabulary

➤ **ISO 31000:2009,** Risk  
management - Principles  
and guidelines (Risk as  
threat AND opportunity!)

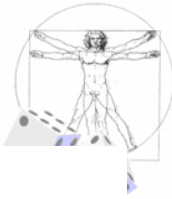
➤ **ISO/IEC 31010:2009,**  
Risk management - Risk  
assessment techniques  
(no resilience related  
techniques!... yet)

➤ ....



# ERMF - Framework for Emerging Risk Management

## ISO31000 “extended”



### I - Horizon Screening/Scanning:

1. Early warnings – notions

### II - Pre-Assessment:

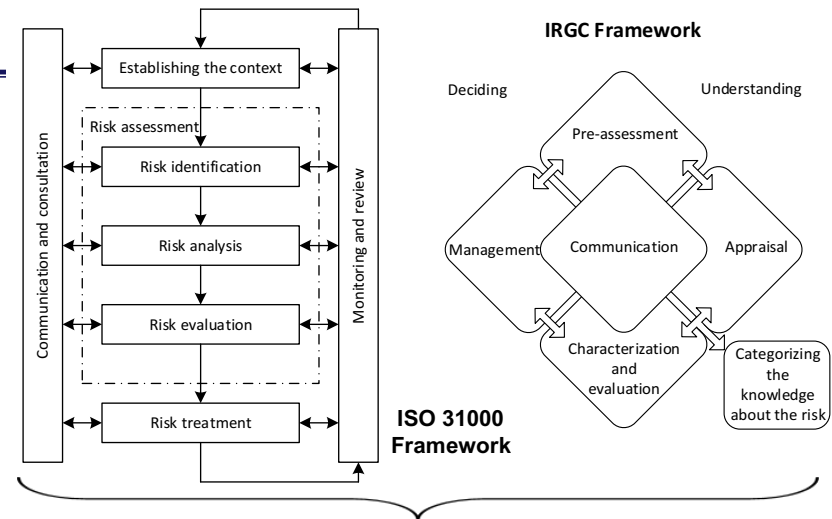
2. Context and concern
3. Identification of risk scenarios
4. Pre-assessment

### III - Appraisal/Assessment:

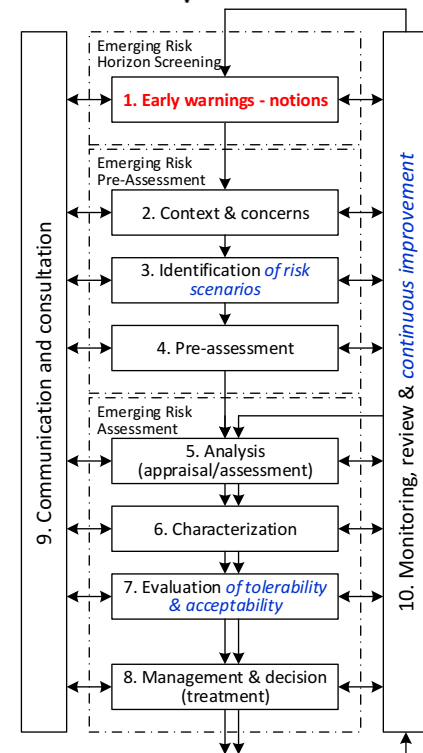
5. Analysis
6. Characterization
7. Evaluation of tolerability and acceptability
8. Management and decision (treatment)

### IV - Continuous Activities:

9. Communication and consultation
10. Monitoring, review and continuous improvement



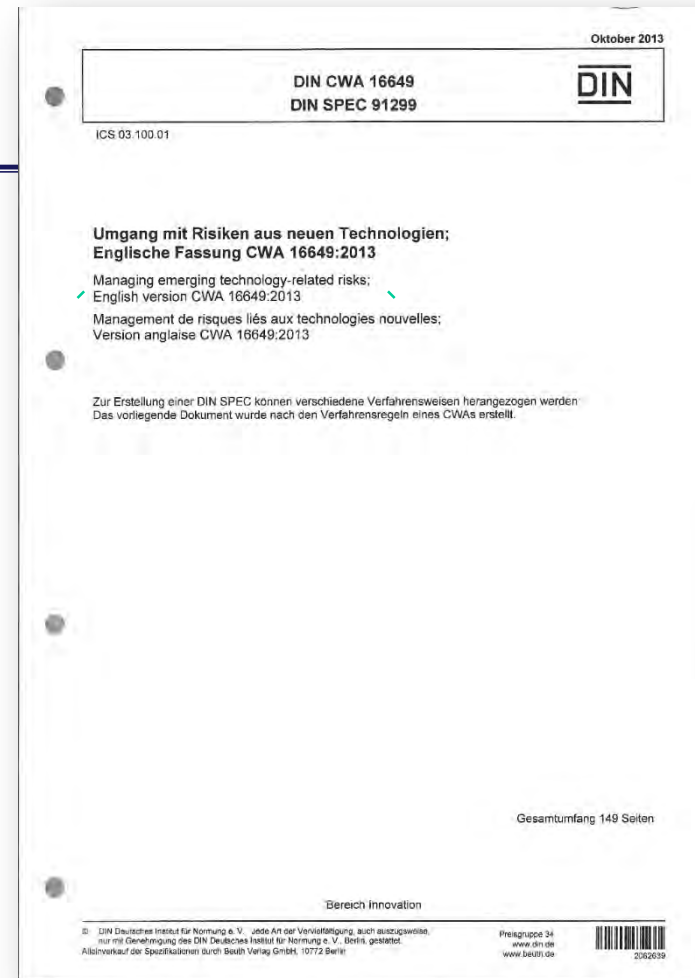
### iNTeg-Risk Framework



# Dedicated standard

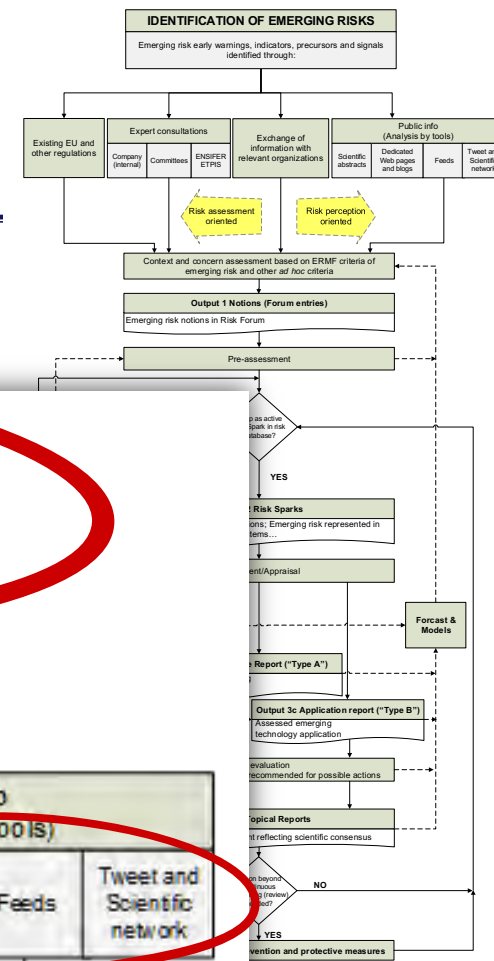
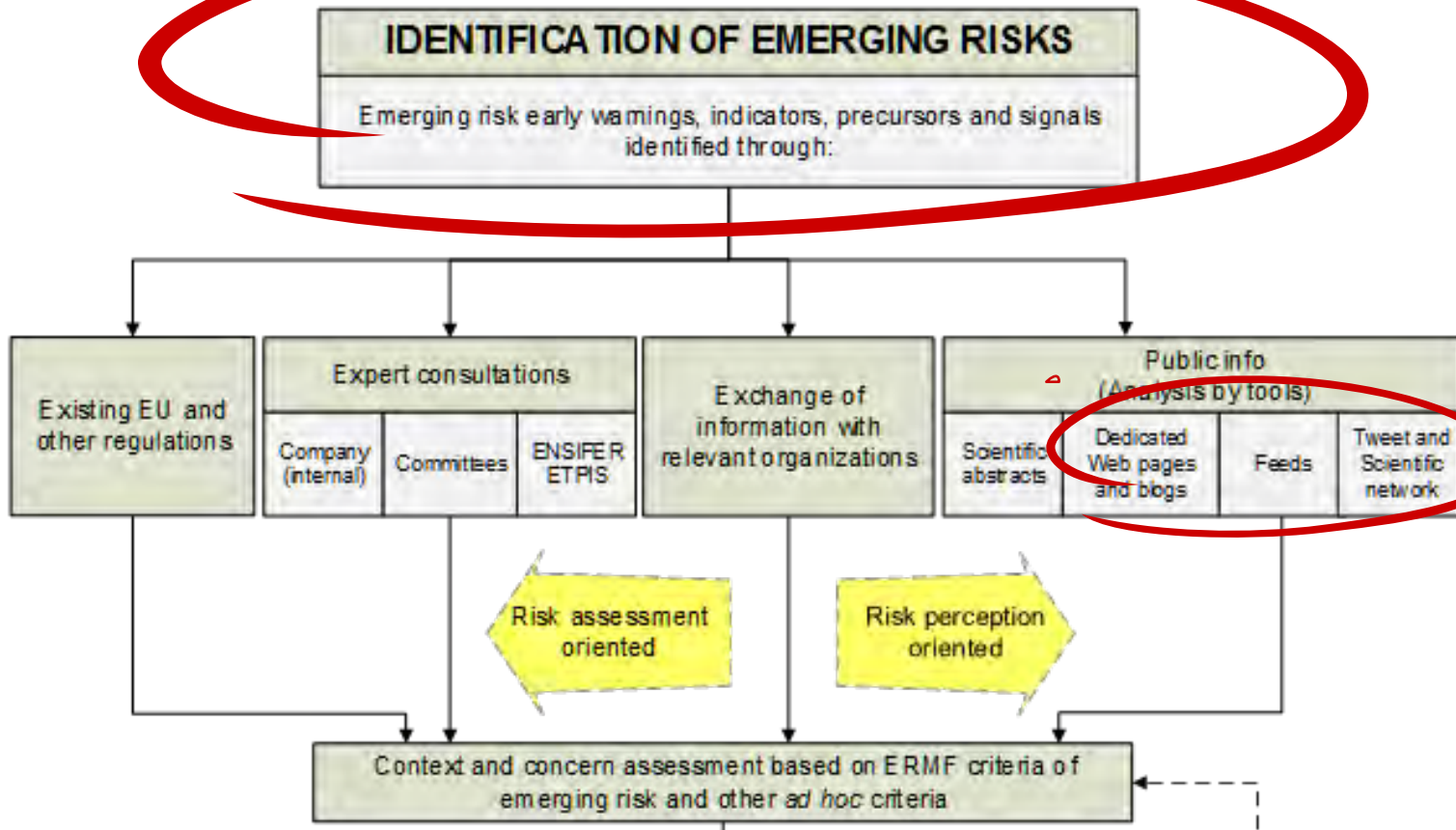
## CWA 16649:2013

- Improve for acceptance of new technologies
- Framework for managing risks related to new technologies
- Procedure for early recognition and monitoring of emerging risks (improved resilience)



Managing emerging technology related risks  
English version CWA 16649:2013

# The procedure ... Citizens' opinion, too!



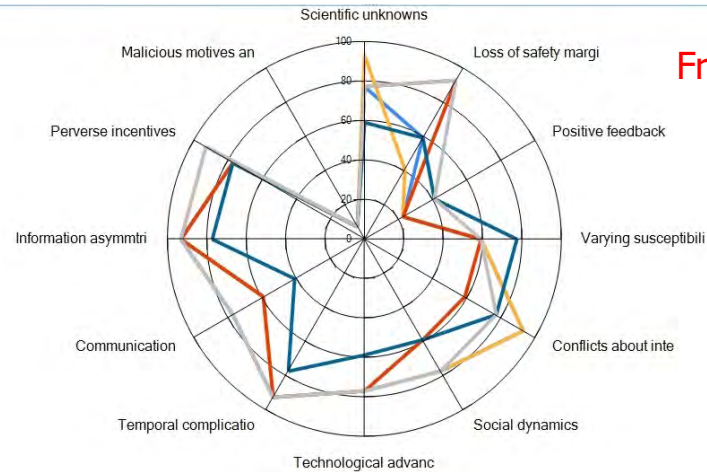
# Application cases

## ➤ In the CWA

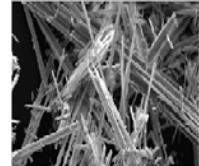
- Fracking
- New materials
- Drilling in Arctic
- Nanoregulation
- Uncertainties in measurement and characterization

## ➤ “Outside” CWA

- Biogas
- Nano @ SME
- Space
- Wind energy ...



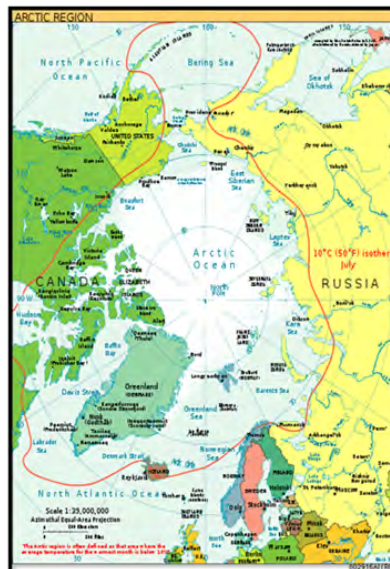
Fracking



New materials  
(nanotubes)

- How does new material distribute itself between air, water, soil etc.?
- What are the design and failure criteria for these materials including: joining, durability, life assessment, lack of standards and data bases to ensure adequate safety factors are employed in the design phase?
- What is the environmental and human health risks involved in the disposal or recycling of new materials and products, especially, the potential for small-particles of material to escape from ‘contained’ waste disposal sites as well as their *impact on sewage treatment plants*;
- What is the risk during the phases of production and use of new materials?

Drilling in Arctic



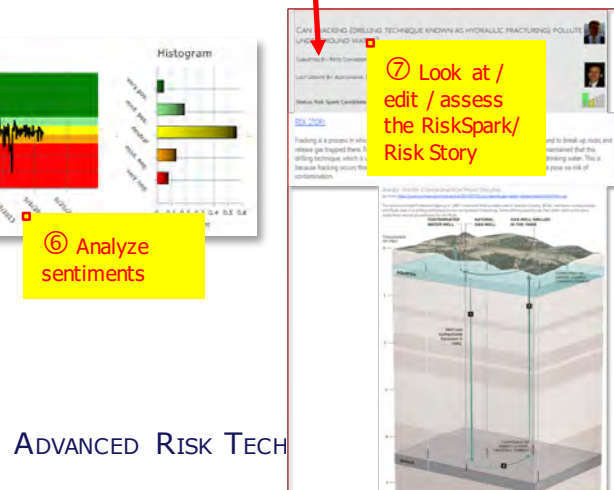
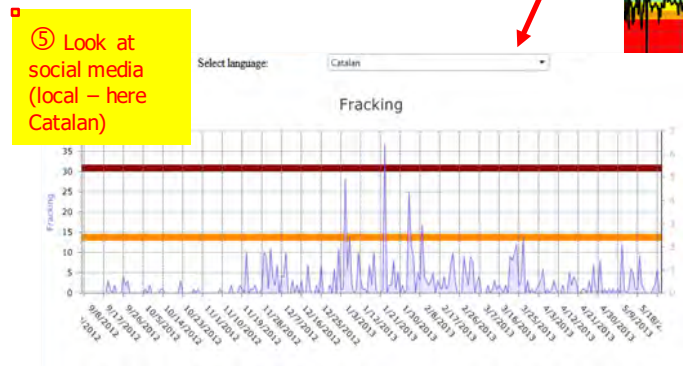
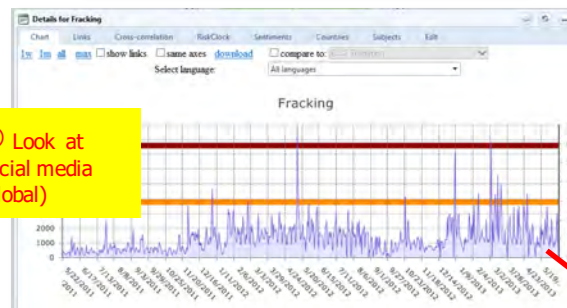
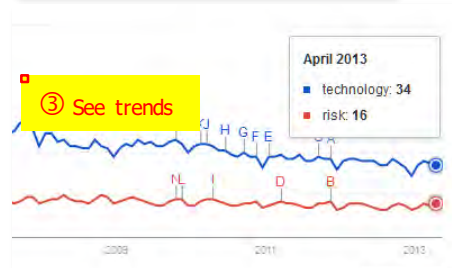


## **Example Emerging Risks and Resilience: Fracking (indications of new risks based on strong signals)**



# Use Case(s) – e.g. Insurance

1. **RiskRadar for CROF ERI initiative (industry view)**
2. Use RiskEars to generate RiskSparks exported and distributed to internal and external stakeholders
3. Use RiskEars as a Wikipedia-like reservoir of risk information for risk /safety engineers
4. Use the standards, KPI's and recommendation section for client services (expert dialogues on site and during meetings)



# ABM for New Technology Acceptance

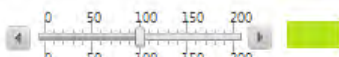


## Fracking in Germany

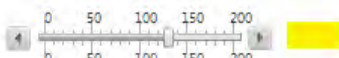
### Aspects relevant for public acceptance

apply

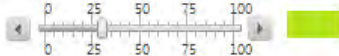
Personal benefit/benefit to people for whom one cares (in [%] compared to baseline level)



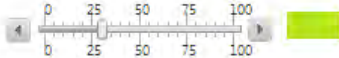
Knowledge about perceived risks/impacts (in [%] compared to baseline level)



Self-efficacy (the belief that one's actions can make a difference)



Identification with the proposed project or activity



### Simulation Control

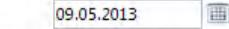
Time-steps to go



Simulation time-step equals



Select initial date



Current Simulation Time

26

Resources:

[Fracking in RiskTweet](#)

[Fracking in RiskEars](#)

[News report: Giftige Gasgewinnung: "Fracking"](#)

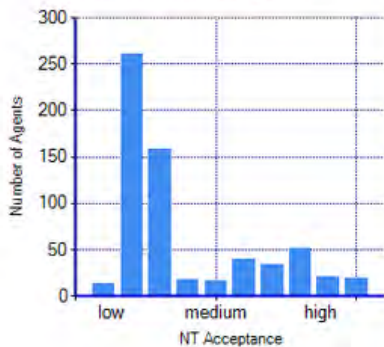
Calibrate

Reset

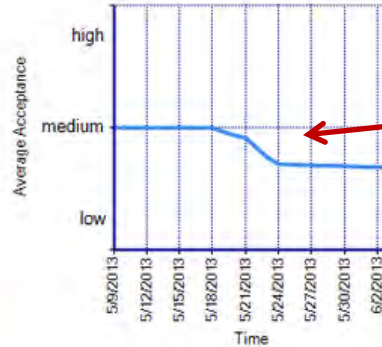
Save

Load/Delete

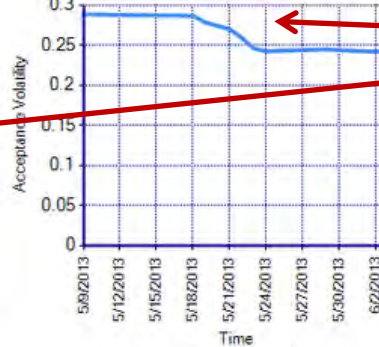
### Distribution of NT Acceptance



### Development of Average NT Acceptance



### Polarization concerning NT



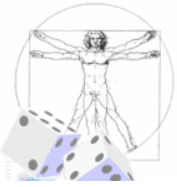
### Scenario Analysis:

How would public risk perception change, if tomorrow came a news report leading to an increase in perceived risks related to Fracking by 40%?

Model result: expected change in sentiments.



## **Example emerging risks and resilience: a national health system**



# Challenges

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Rising life expectancy together with rising number of life years spent with diseases → we spend more time being sick

Rate of productivity of developing new drugs is going down (USD 5billion per drug)

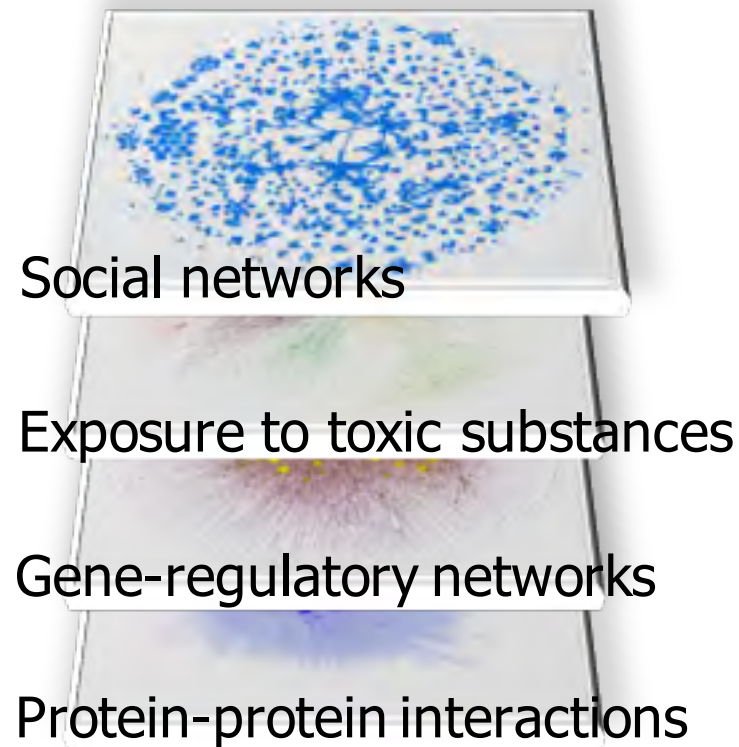
Rate of failure in clinical trials goes up (attrition rate of 95%)

Health expenditures worldwide grow faster than national incomes → unsustainable





# Multi-factorial diseases



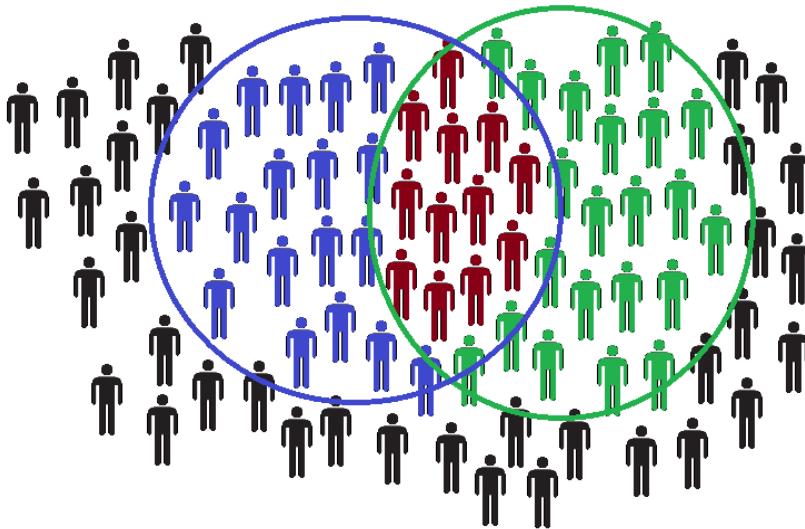
- Multi-factorial diseases = consequences of defects in various types of networks that determine health
- Multimorbidity: one defect may increase risk for various diseases
- Need to understand these networks and how they influence each other to repair them
- „**Next-generation phenotyping**“: a novel, data-driven and pathobiologically informed approach to understand human diseases and their interconnections

# Comorbidity networks



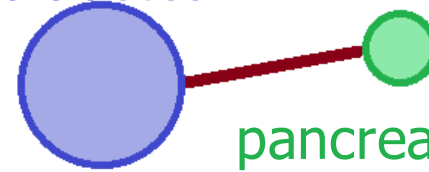
patients with diabetes

patients with pancreatic cancer



patients with diabetes *and* pancreatic cancer

diabetes

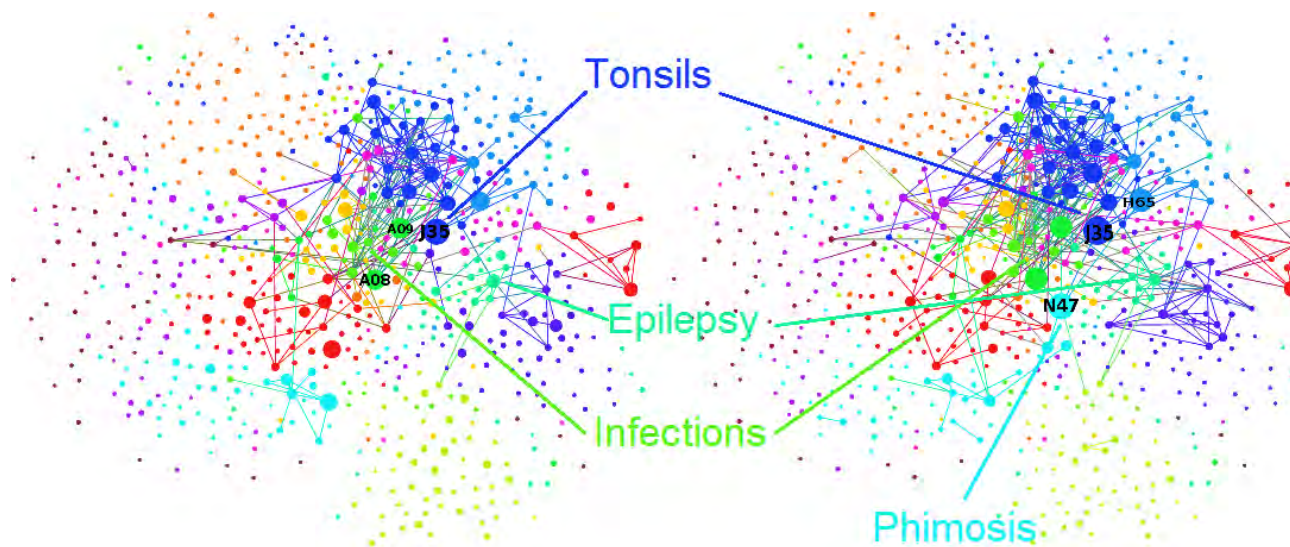


pancreatic cancer

- nodes = diseases
- links = diseases are often co-occurring
- size of nodes = disease prevalence



# Comorbidity networks



females

- A and B - Certain infectious
- C - Neoplasms
- D - Benign neoplasms and blood diseases
- E - Endocrine, nutritional and metabolic diseases

- F - Mental and behavioural disorders
- G - Diseases of the nervous system
- H - Diseases of the eye and ear

males

- I - Diseases of the circulatory system
- J - Diseases of the respiratory system
- K - Diseases of the digestive system

- L - Diseases of the skin and subcutaneous tissue
- M - Diseases of the musculoskeletal system
- N - Diseases of the genitourinary system

0-8 years



9-16 years



17-24 years



25-32 years



33-40 years



41-48 years



49-56 years

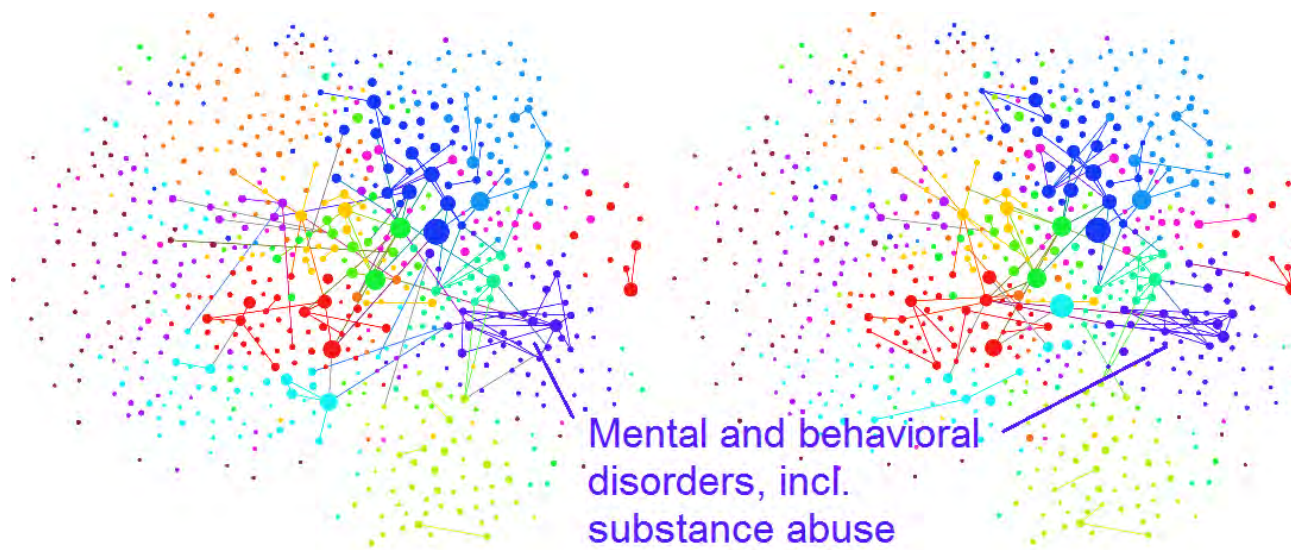
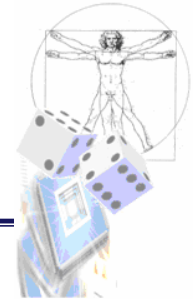


57-64 years



65-72 years

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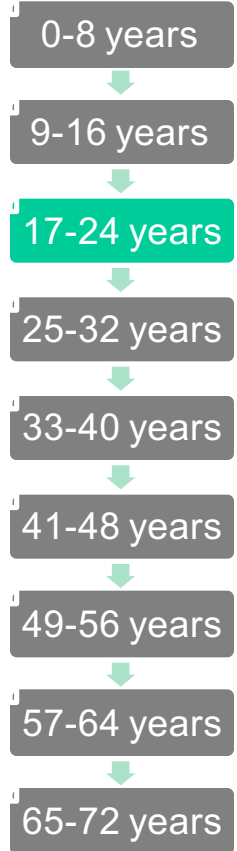
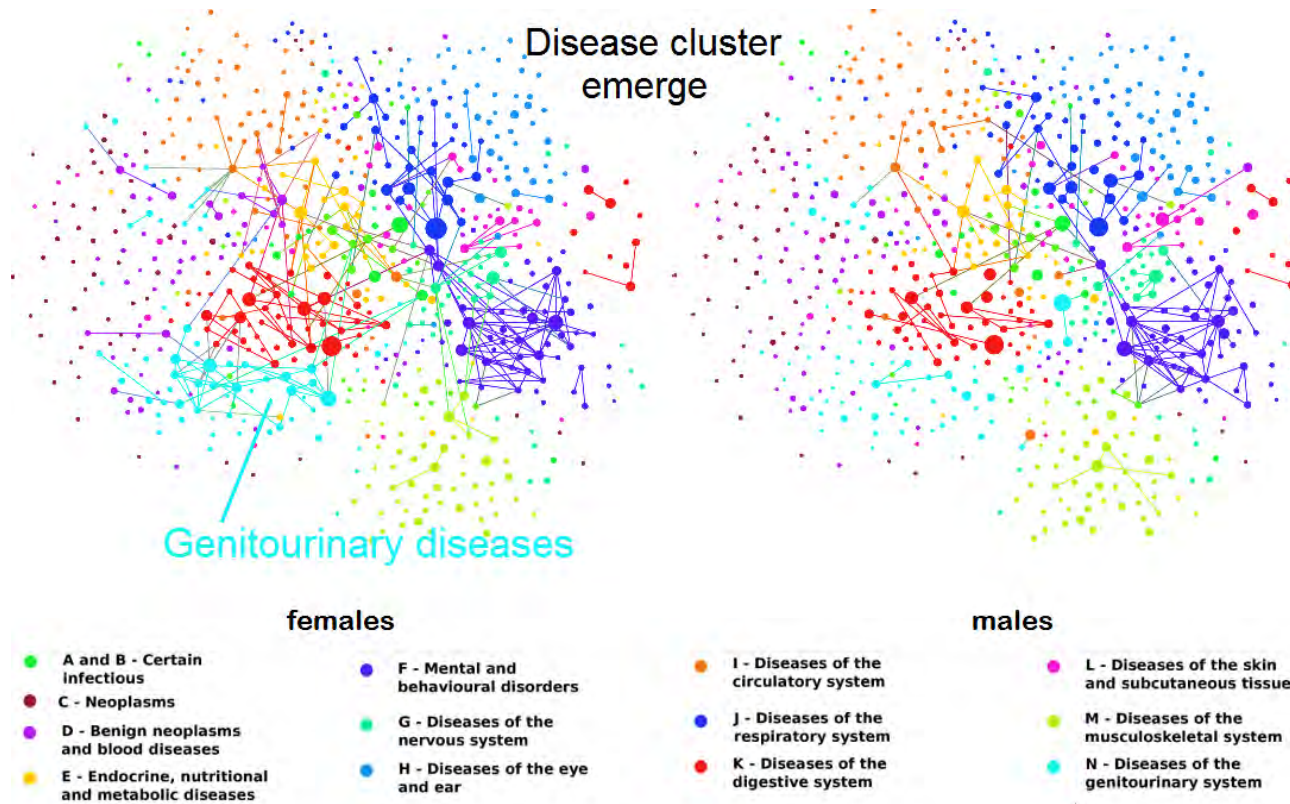


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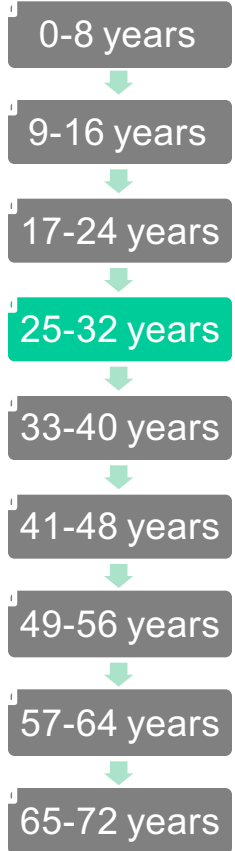
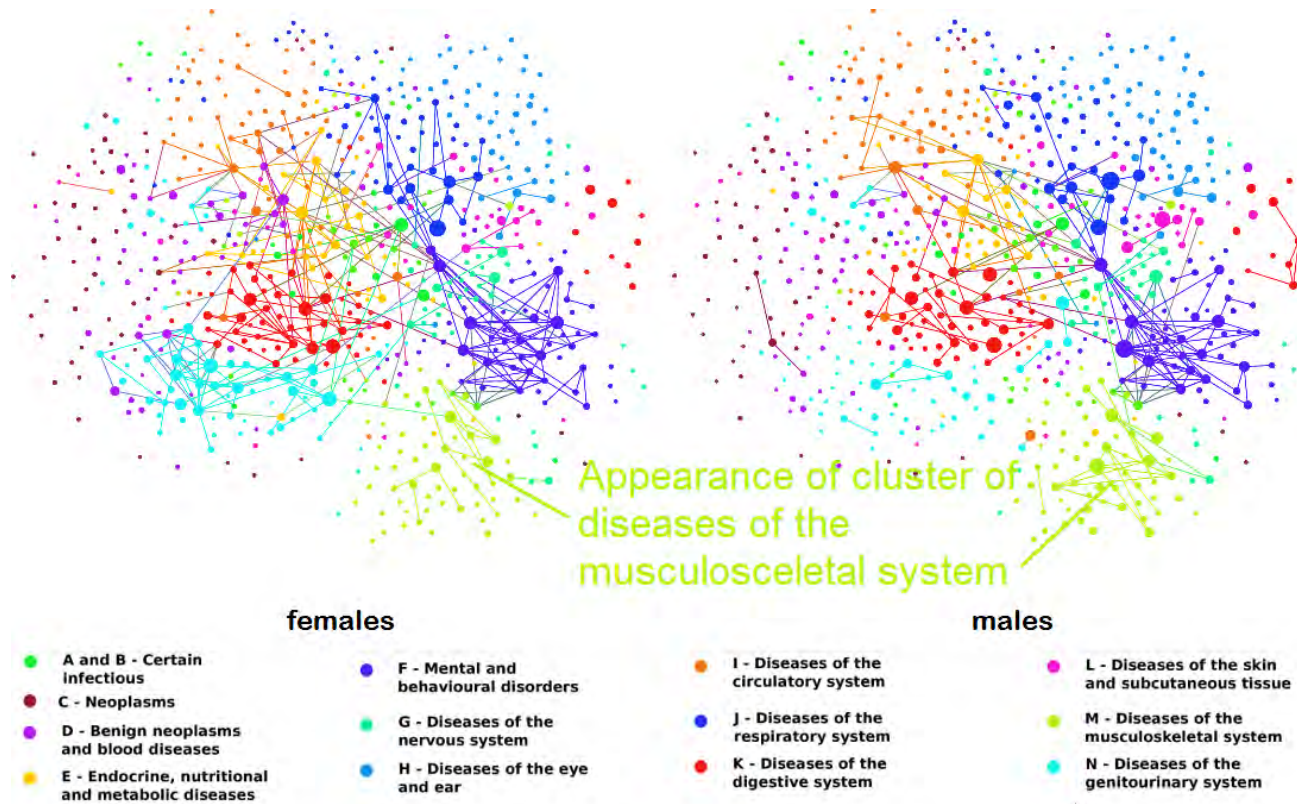
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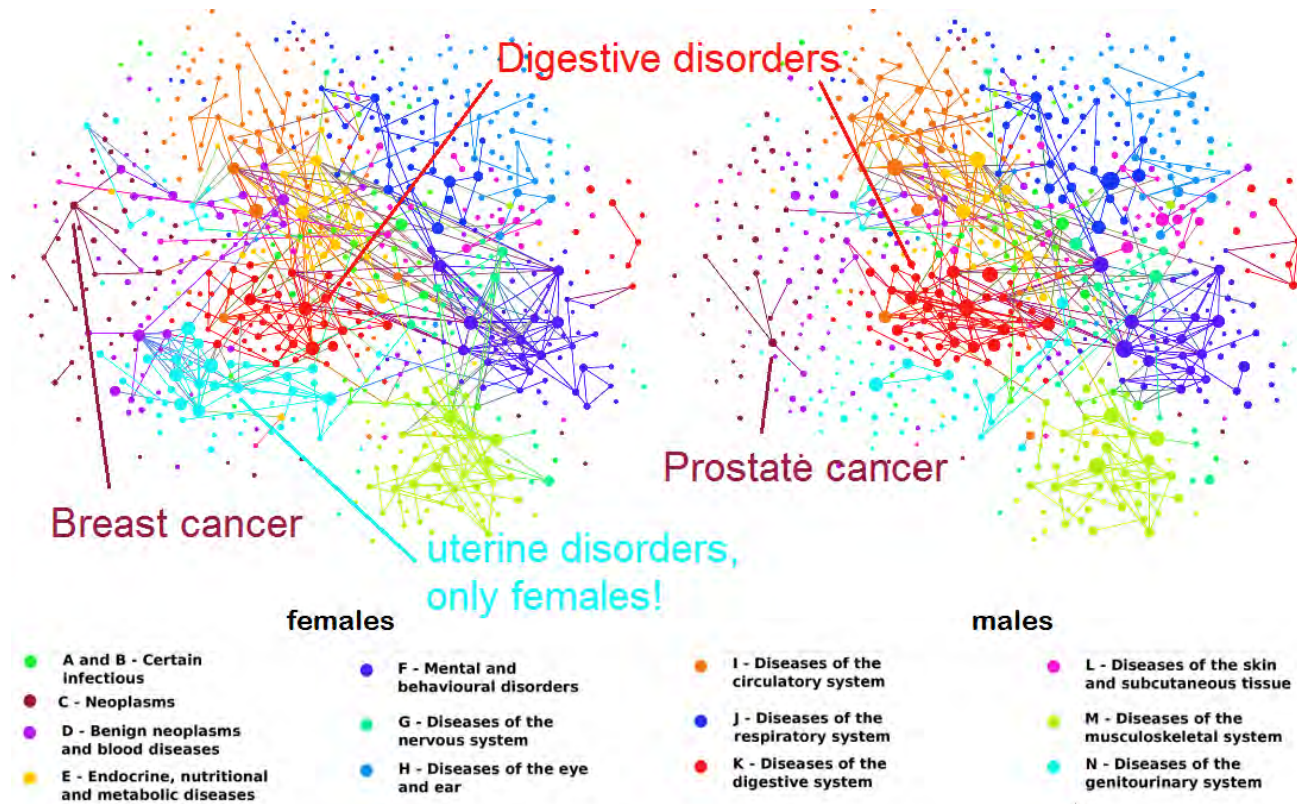




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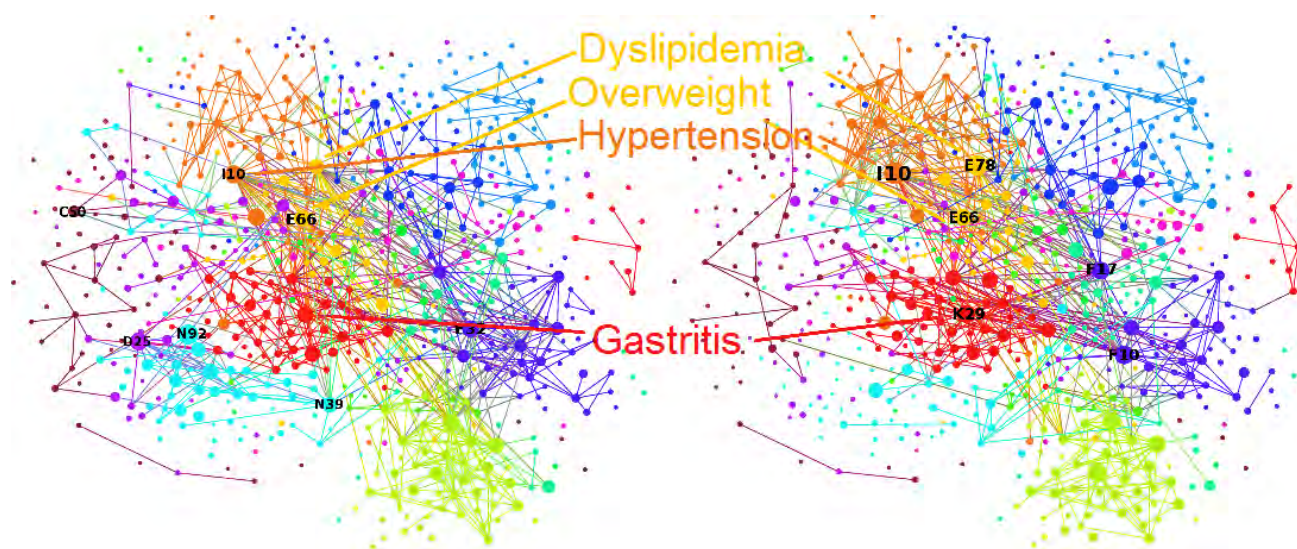
# Comorbidity networks







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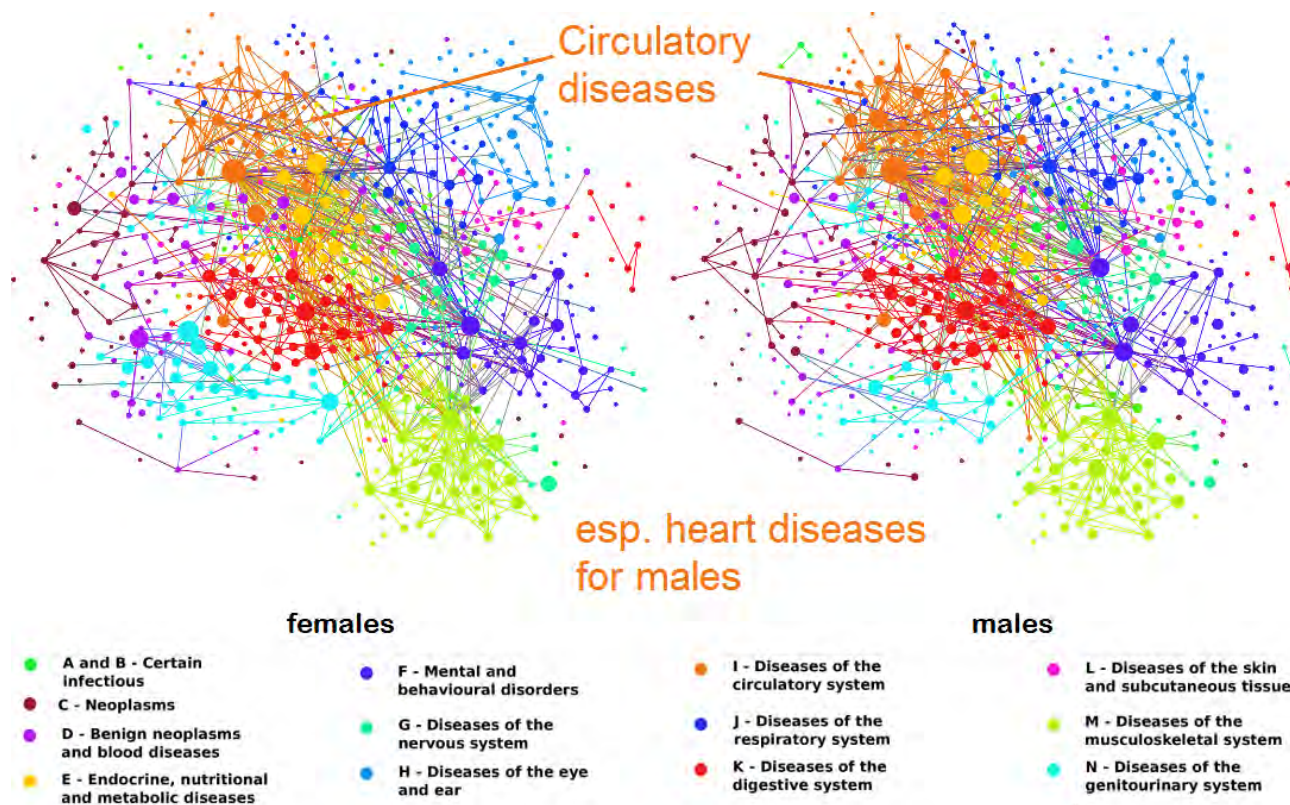
57-64 years



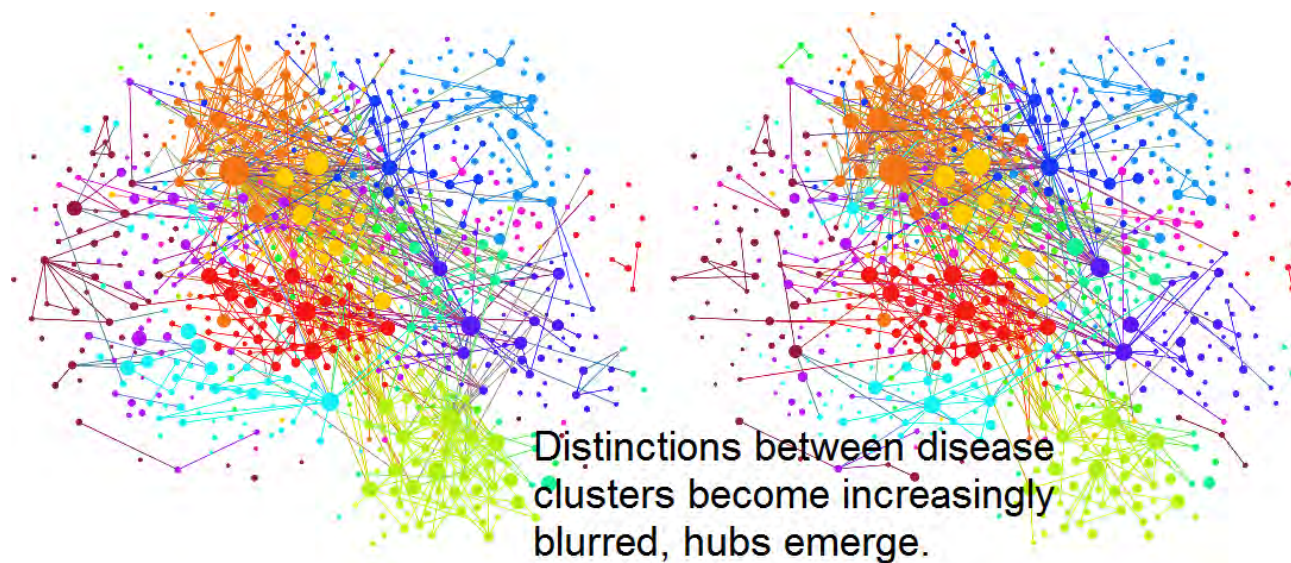
65-72 years



# Comorbidity networks



# Comorbidity networks



Distinctions between disease clusters become increasingly blurred, hubs emerge.

females

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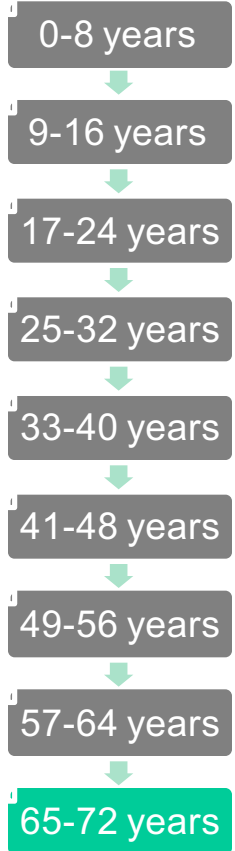
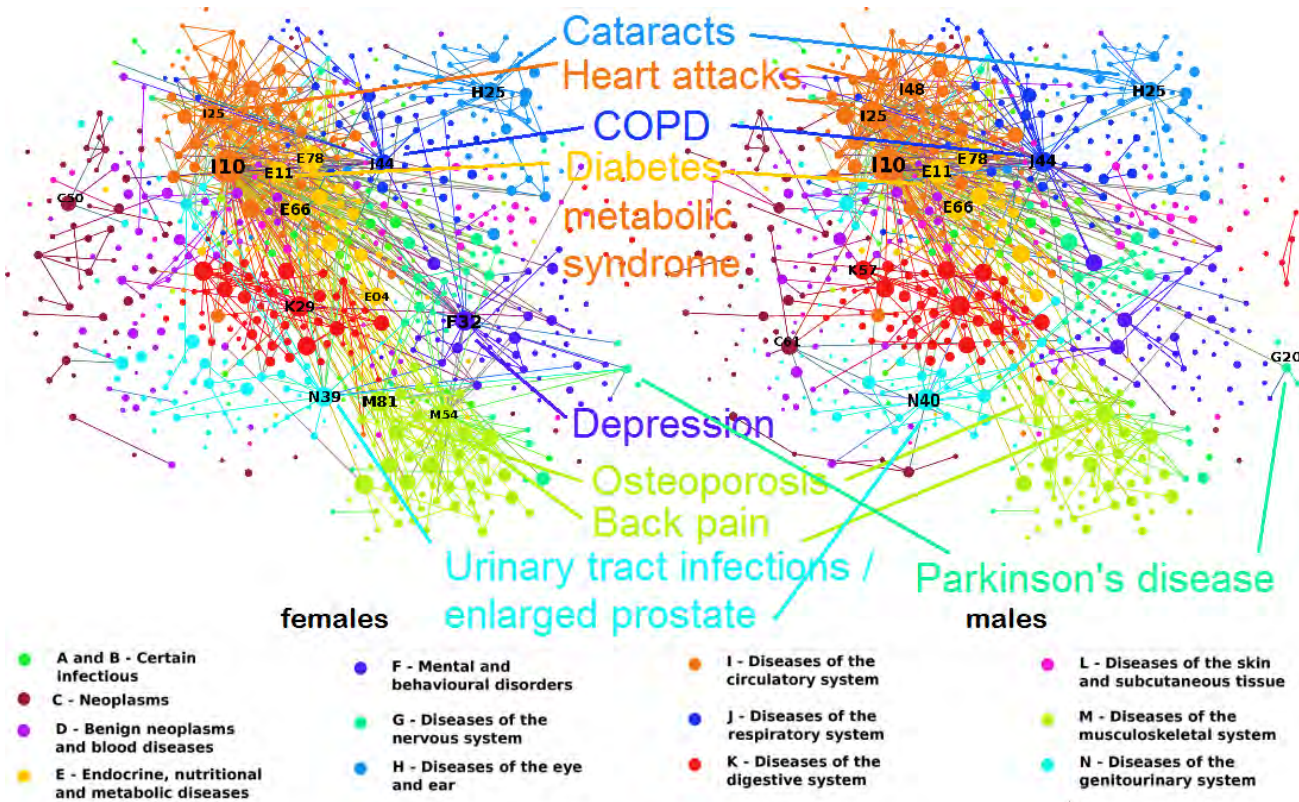
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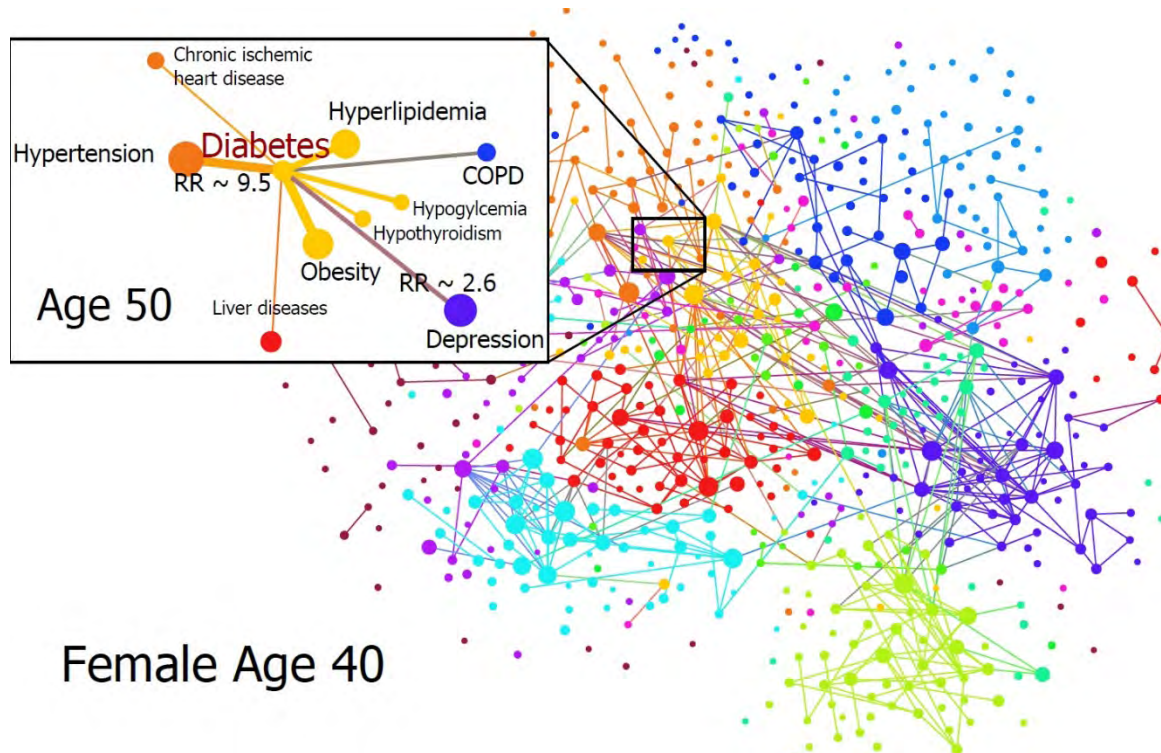
65-72 years



# Comorbidity networks



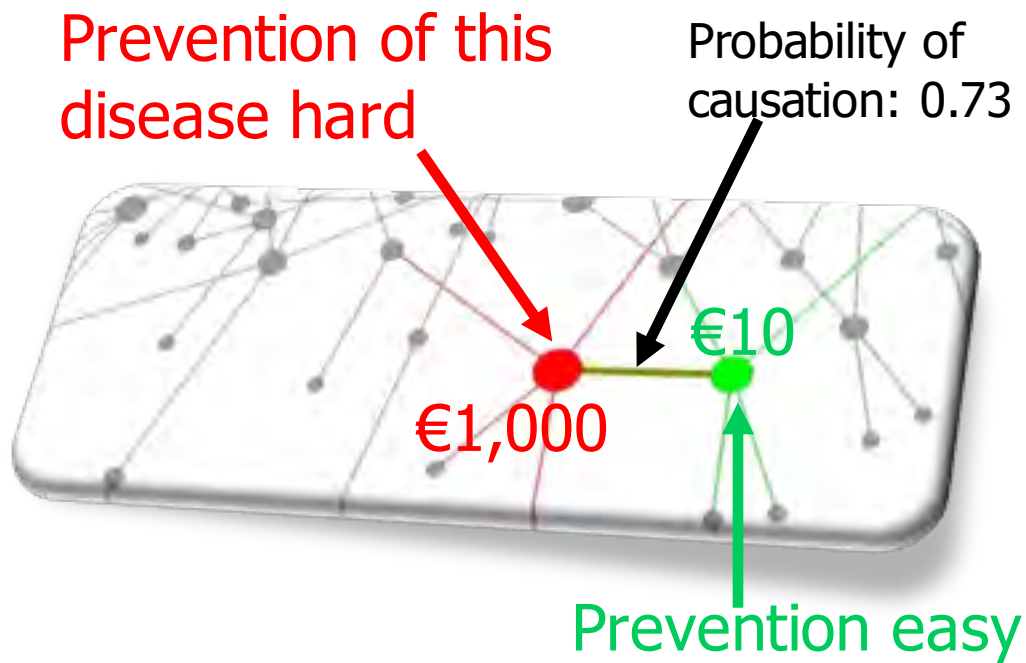
# Predict incidences using comorbidity networks



population-wide  
forecast of 85%-  
95% of all disease  
incidences within  
the next ten life  
years

Chmiel A, Klimek P, Thurner S, New J Phys 16, 115013  
(2014)

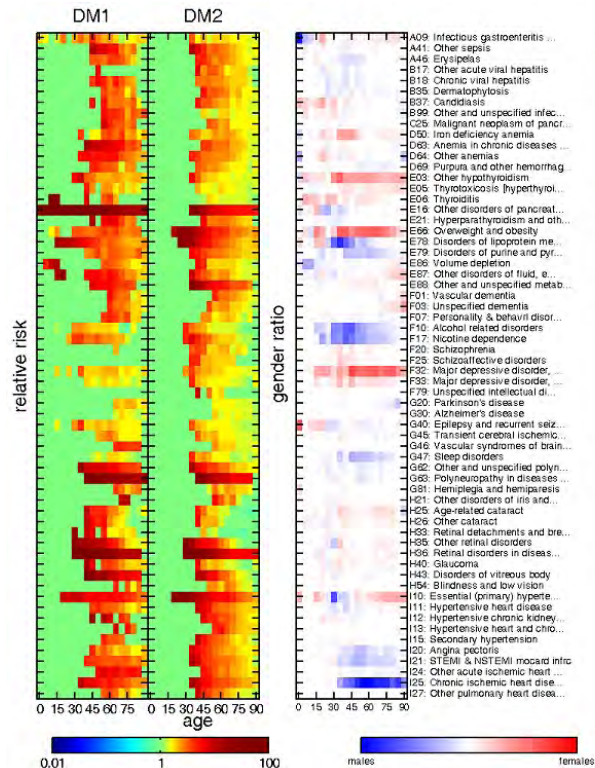
# Comorbidity networks and prevention



Identify comorbidities → Check causation → Treat causing diseases



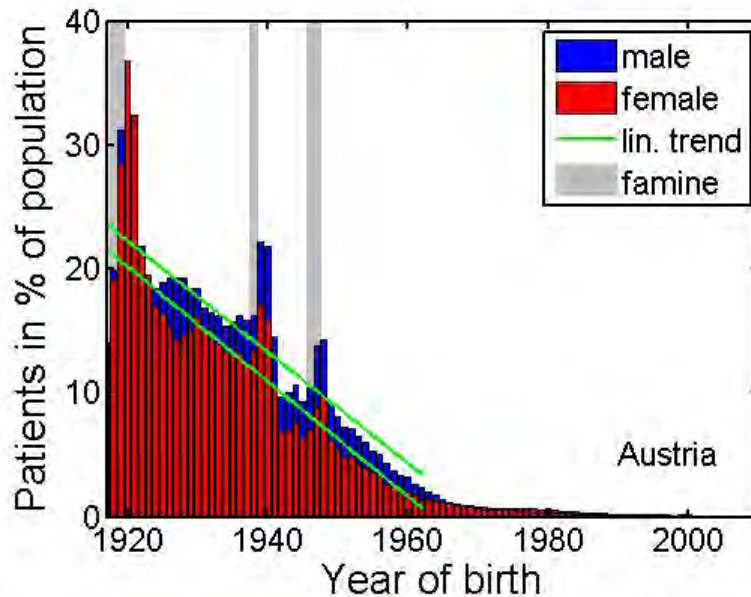
# Zoom-In on diabetes: personalized health risks



- Check diabetes for all possible known or unknown comorbidities – equivalent to 40k single epidemiological experiments → ≈100 highly significant comorbidities
- Confirmed controversial relation between diabetes and Parkinson's Disease.
- Strong gender effects: Lower risk for hypertension for females in fertile age, for example.
- Can partially check whether comorbidity relation is causative of consequential
- Type 1 diabetes typically present before onset of depressions.
- Schizo-affective disorders often lead type 2 diabetes → drug interaction?



# Telescope into the past: epigenetics of diabetes



- There exist years of birth with strongly increased diabetes risk within the Austrian population
- These years coincide with the three great famines of the 20th century
- „Fetal programming“ Perinatal malnutrition of the mother increases risk for the offspring to suffer metabolic diseases in later life
- Effects depend on regional wealth
- S. Thurner et al, PNAS 110, 4703-7 (2013).
- Similar findings for the big Chinese famine of the late 1950s and early 1960s.

# A network view on the health care system

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Nodes in the network = health care providers (HCP), for example doctors, pharmacies, hospitals, ...

Links in the network = Connect HCPs that share patients

Which flows of patients between HCPs are reasonable from a health care perspective?

Health care management = **shape this network such that it is efficient, sustainable, and resilient.**

# Big Data – a gamechanger?



Ph

Health-care data

Social, environmental,  
demographic data

Molecular / physiological  
data

**Big data without big theory is BS!**

- If you have disease A, how likely are you to have another disease B?
- Disease-disease **networks** of 141,000 classified diseases
- 1,000 known drugs
- Disease-drugs **networks**

- Population-level health care (claims) data (safeguarded by HVB)
- Dataset containing each medical treatment and its cost in Austria
- 100,000,000 doctor hospitalizations per year and health-care provider **networks**
- 12,000 health care provider

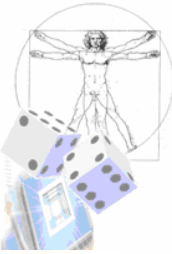
- Social **networks** and computational social science
- Geo-localized data on exposure to risk factors (e.g., fast food restaurants, ...)
- Demographic trends and population structure

- Human Genome Project (25,000 genes)
- Gene regulatory **networks** (transcription, replication, translation, ...)
- Protein-protein interaction **networks** (100,000 proteins)
- 1,000 metabolic pathways and their **networks**

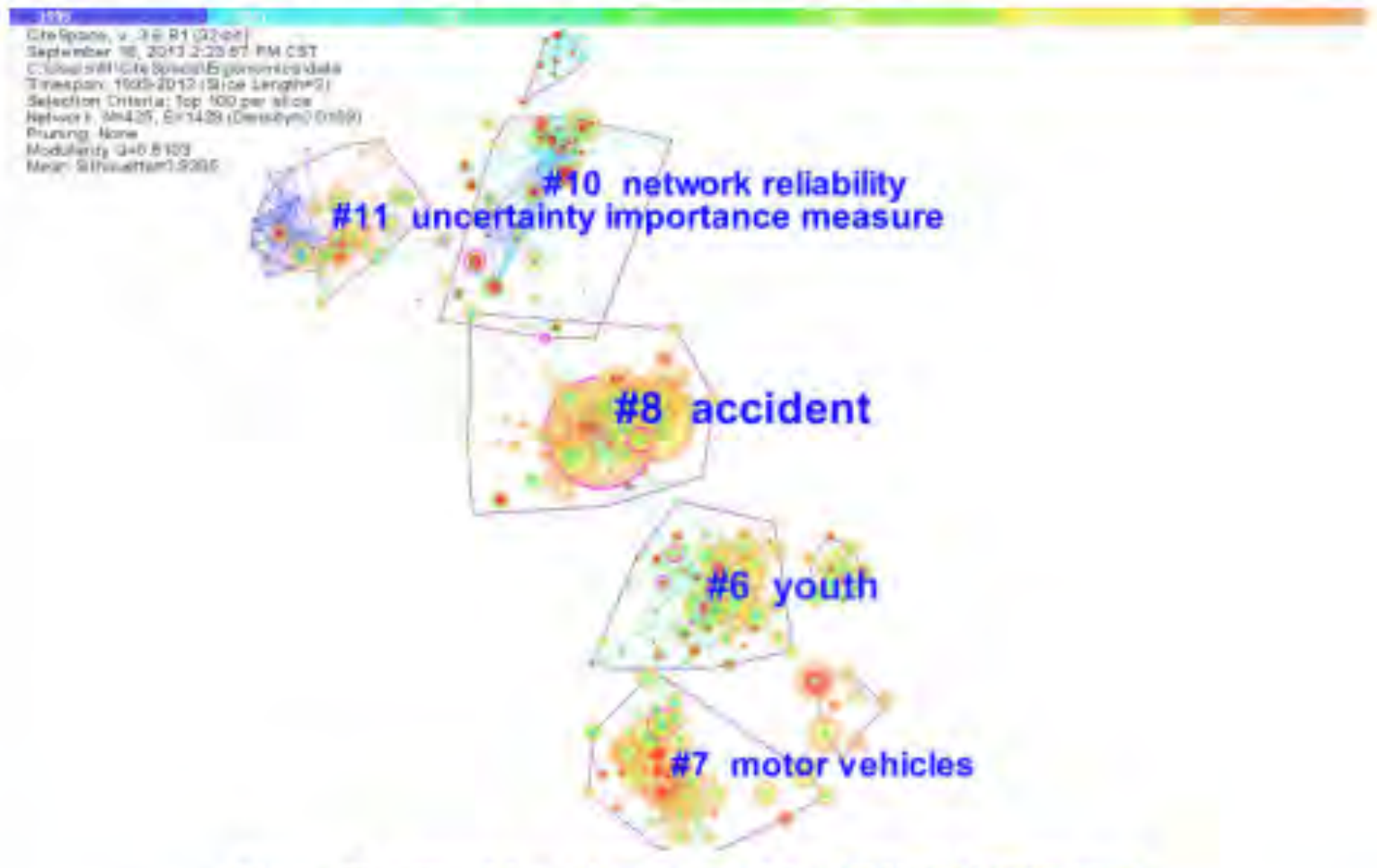


# **Example Emerging Risks and Resilience : Insurance (indications of new risks based on weak signals)**

# Analyzing social media for safety



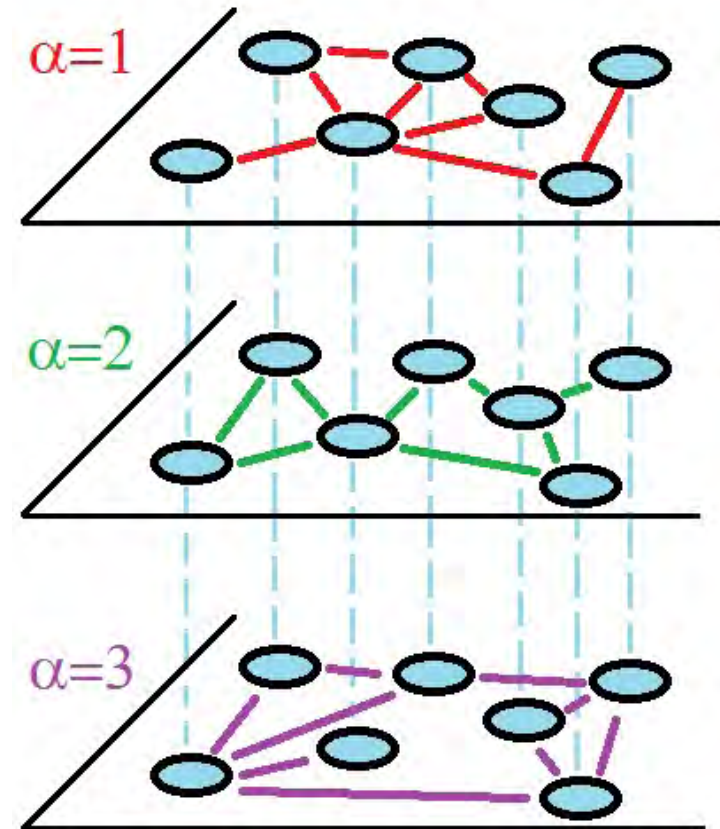
The following visualization is from [blog.sciencenet.cn](http://blog.sciencenet.cn) by Jie Li.



# Novel methodology I: Multiplex analysis

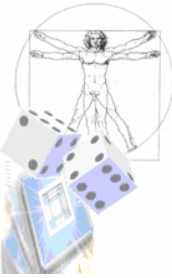


- Obtain a similarity score for each business area  $b$  separately,  $S^b(r_1, r_2)$ .
- Follow the same procedure as described above in the S-RDI Tool in each layer.
- PageRank value for a risk is then the sum over the PageRank in its individual layers,  $R = \sum_b R^b$ .
- For risks that are only relevant in a small number of business areas this number will be smaller than in the monolayer network.
- Risks that are substantially connected to other risks in multiple layers will receive higher centrality scores.



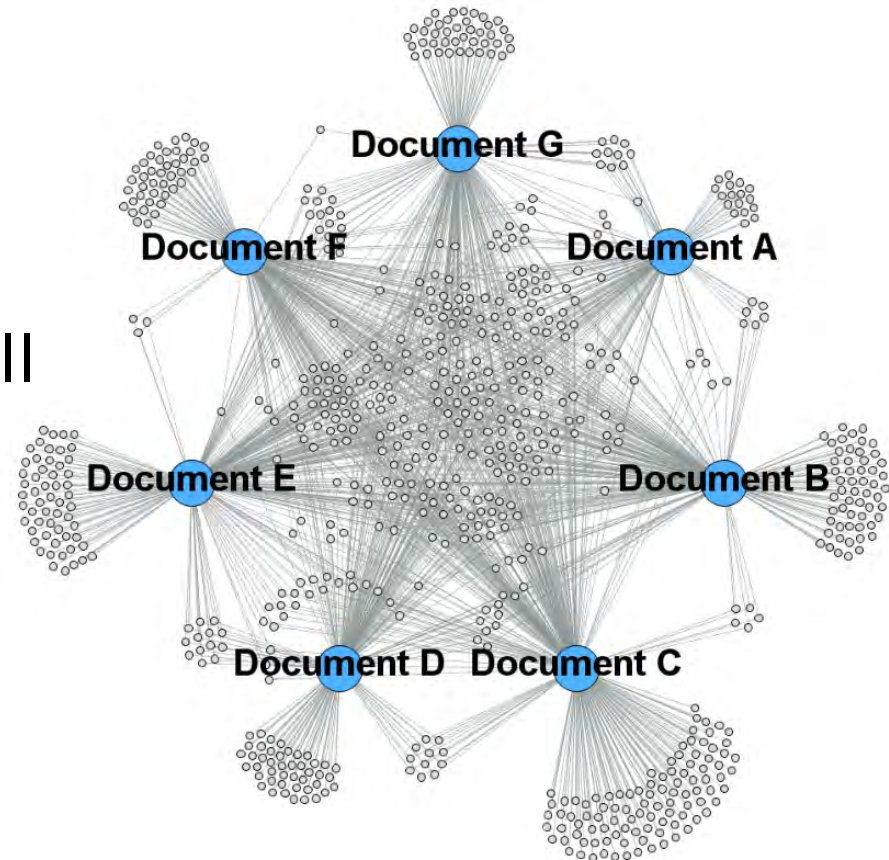


# Novel methodology II: Bipartite Networks



- Reduce documents to wordbags.
- Remove a word if it is ranked among the 5,000 most frequent words in all NYTimes issues.
- Obtain the term-document matrix (bipartite network)  $M$  as

$$M_{wi} = \begin{cases} 1 & \text{if } w \text{ appears in } d(i), \\ 0 & \text{otherwise.} \end{cases}$$

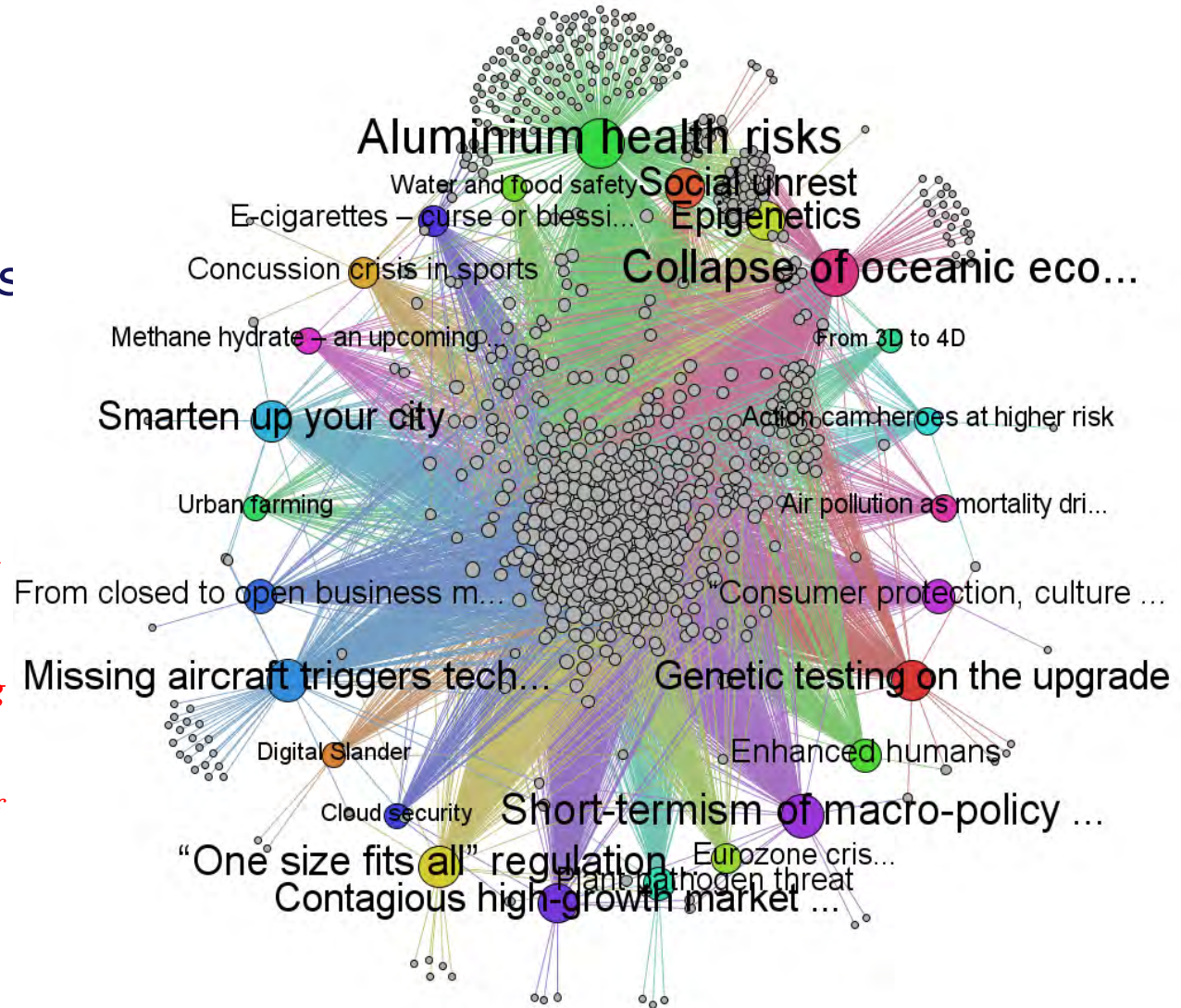


# (new!) Tools: New/emerging risk identification



- Identifying new risks in big data
  - identifying rare, but important signals (example from insurance industry)

*Bipartite network of emerging risks and their connections to their keywords. Colored nodes correspond to emerging risks, grey nodes to keywords, and the size of the labels is proportional to the number of keywords that an emerging risk is connected to (Jovanovic, Klimek, Schenider 2015)*

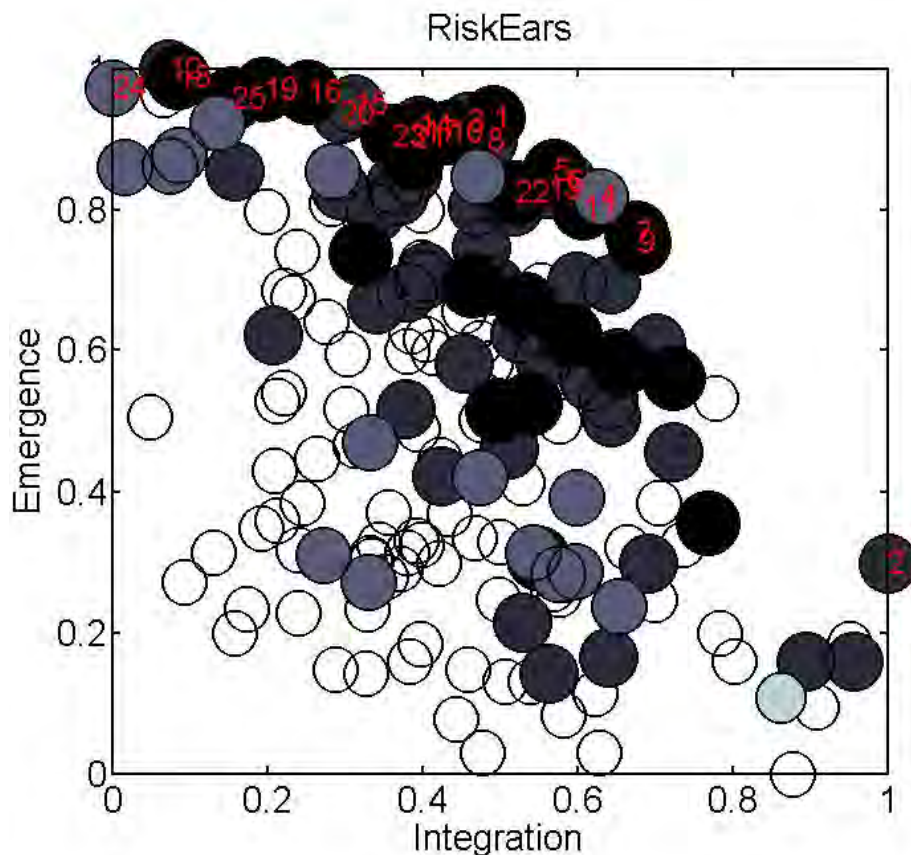




# (new!) Tools: New/emerging risk identification



- Identifying new risks in big data – identifying rare, but important signals (example from insurance industry)



- 1: Public health and medical issues related to monitoring of emerging ri...
- 2: Climate change and global warming
- 3: Nanotechnology have produced products with smaller than the usual str...
- 4: Nanotechnology and potential impacts for insurers
- 5: Integrated approach on emerging risks related to the implementation o...
- 6: Potential to change the risk landscape for re/insurers by introducing...
- 7: Insurance and re-insurance aspects of emerging risks including the se...
- 8: Critical Drone Failure and loss of control of UAVs
- 9: Emerging risks related to advanced storage technologies for hazardous...
- 10: Biogas as a booming business
- 11: Emerging risks related to development and use of advanced engineering...
- 12: Acceptance by Civil aviation authorities of operational drone flights
- 13: Objective knowledge of hazards/risks due to nano-technology
- 14: Geomagnetic storms can impose a change as high as 7 Volts per kilomet...
- 15: Automated image processing inefficiency
- 16: Safety and security of underground hubs with interconnected transport...
- 17: Emerging risks related to the industrial use of automated and un-mann...
- 18: Validation process at harbor zone of Luka Koper and adjacent industri...
- 19: Challenges to safety posed by outsourcing of critical tasks – in oil,...
- 20: Potential huge impact due to cyber vulnerability (Critical Informatio...
- 21: Automated industrial surveillance improves pipeline risk management
- 22: Emerging risks related to interaction between natural hazards and tec...
- 23: Industrial zone of Pan-evo-South involving chemical and petrochemical...
- 24: Bridges: Risk of sudden and unexpected failures (IRIS project)
- 25: Fracking- drilling technique, which is used for most natural gas well...

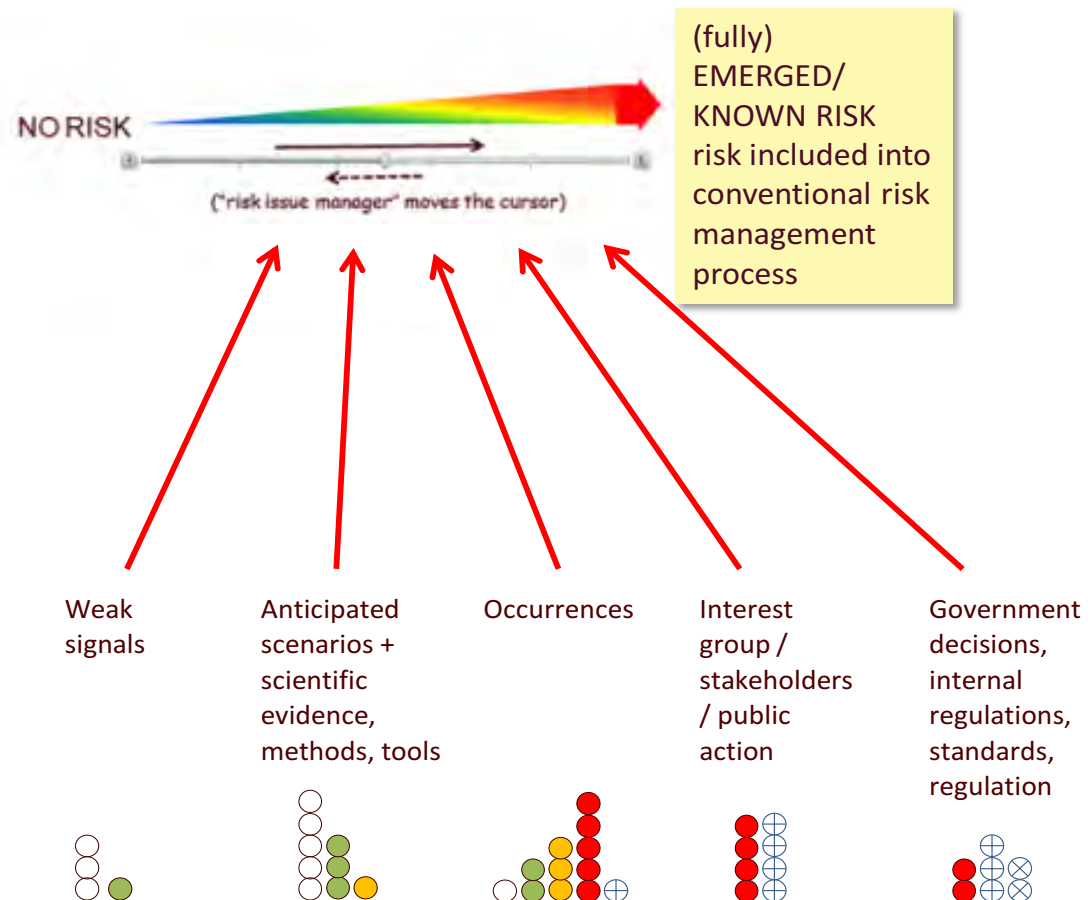


# New risks & resilience

Linkov et al.; NATURE CLIMATE CHANGE | VOL 4 |  
JUNE 2014 | [www.nature.com/natureclimatechange](http://www.nature.com/natureclimatechange)



- weak signals
- anticipated scenarios
- scientific evidence
- occurrences
- ⊕ interest group actions
- ⊗ government decision



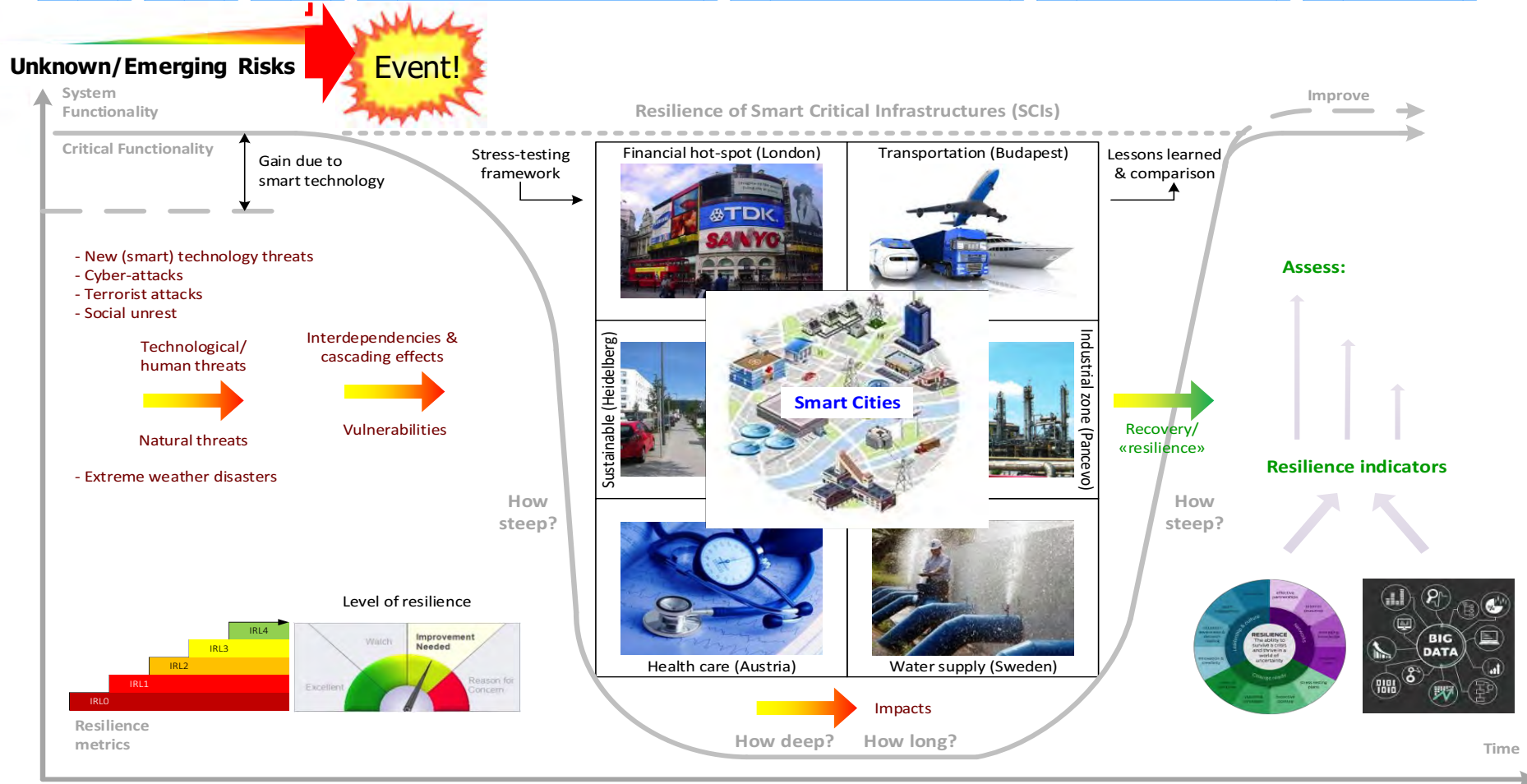
# Conclusions: Prepared for surprises (ERs)? Resilience?



**Resilience:** The ability to anticipate, prepare for, attend to, and adapt to changing conditions and withstand (absorb), respond to, and recover rapidly from disruptions.

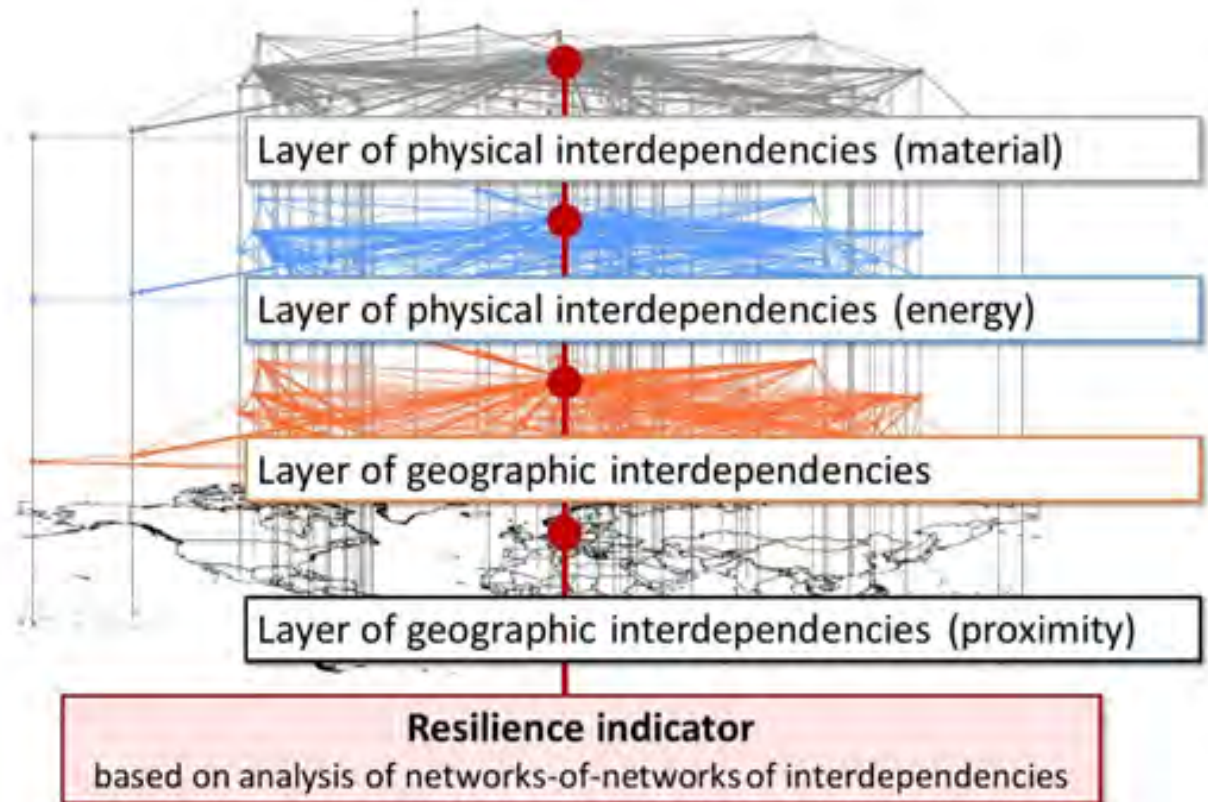
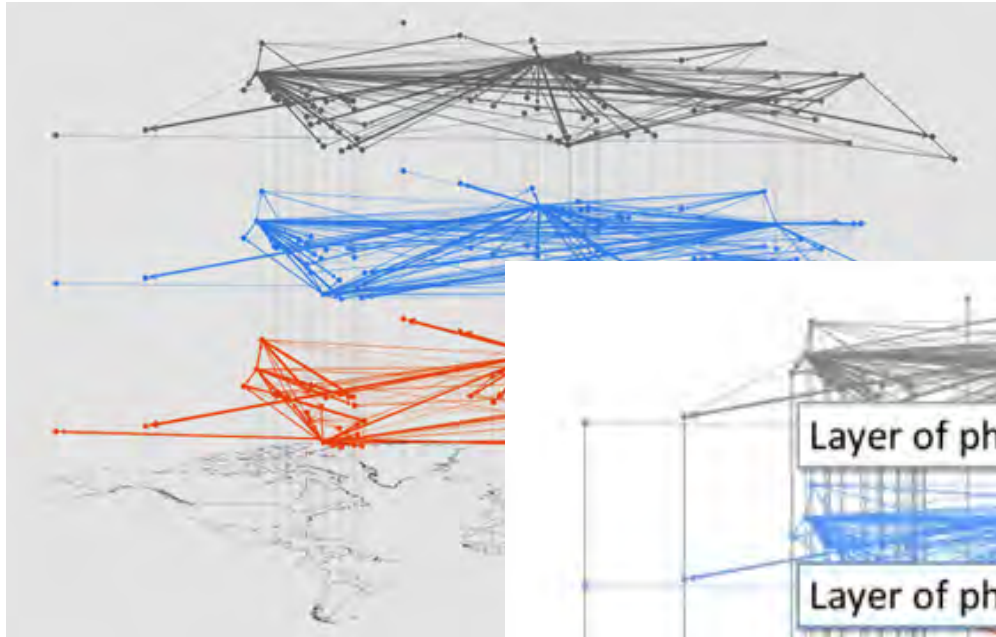
**Resilience  
Multi-Attributes**

**Holistic approach meeting the user needs of public bodies  
at all levels (local, regional, country, EU).**

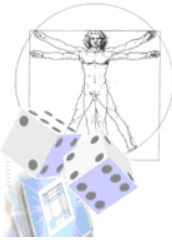




# Indicators inlayers







# Indices from Big and Open data

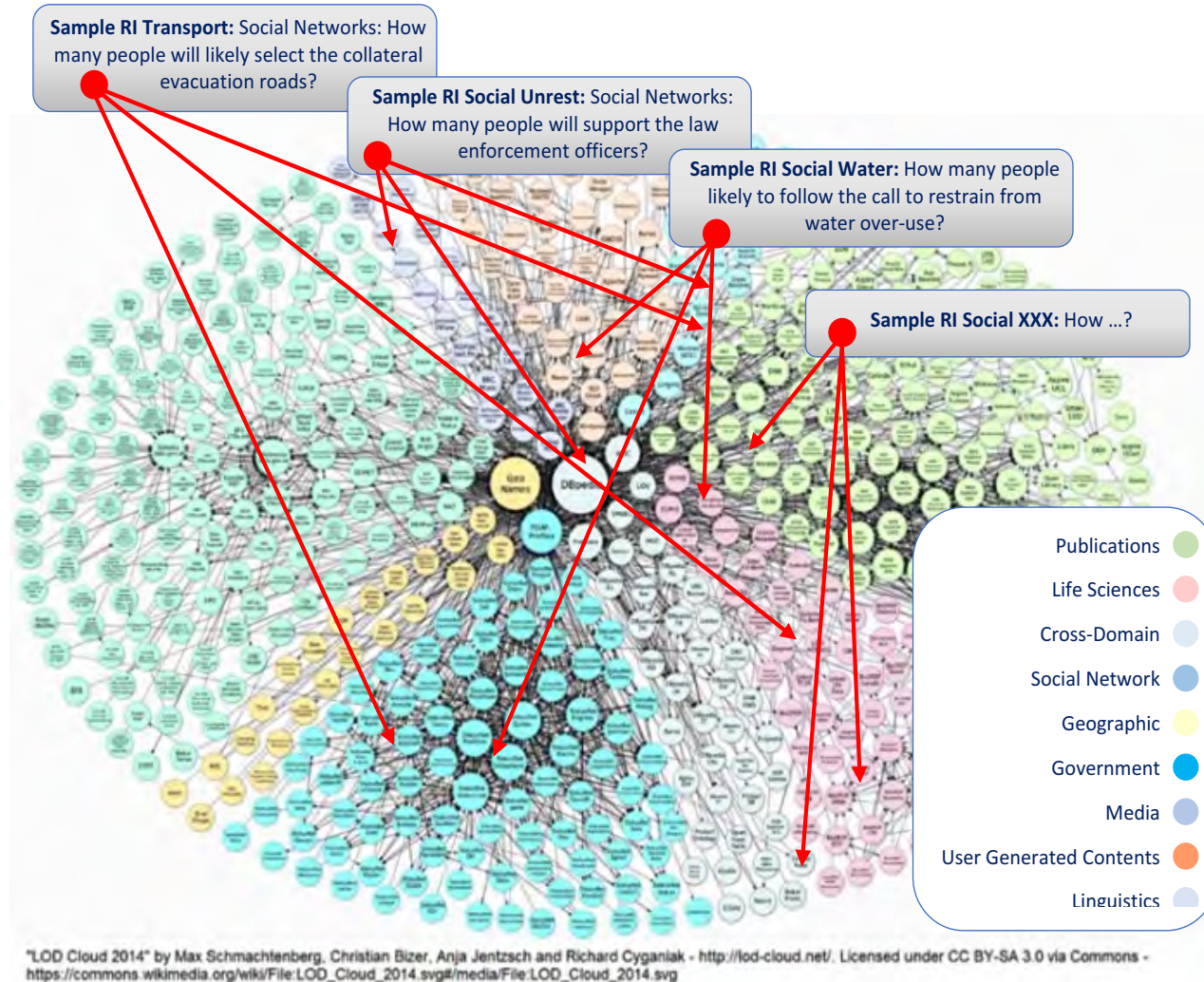


Figure 1: Overview of available linked open data sets in the Linked Open Data Cloud as of August 2014: One of the possible sources for deriving RIs (indicators) from big data



# Conclusions: Emerging risk in resilience cycle

Anticipate,  
prepare for, and  
adapt to changing  
conditions and  
withstand,  
respond to, and  
recover rapidly  
from disruptions:  
How to quantify?  
Metrics?

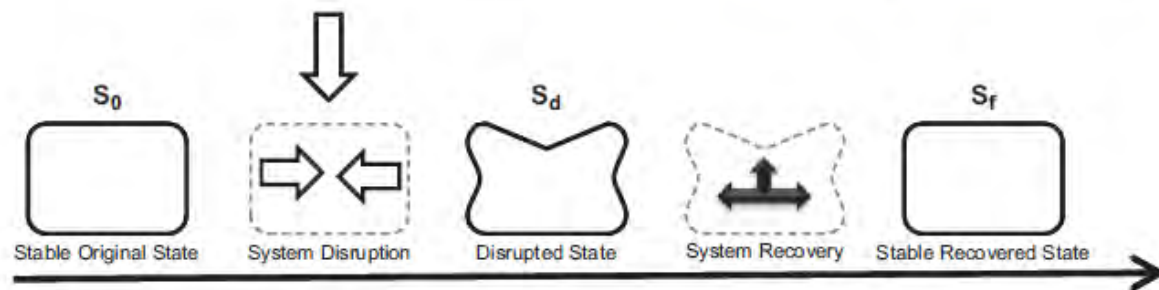
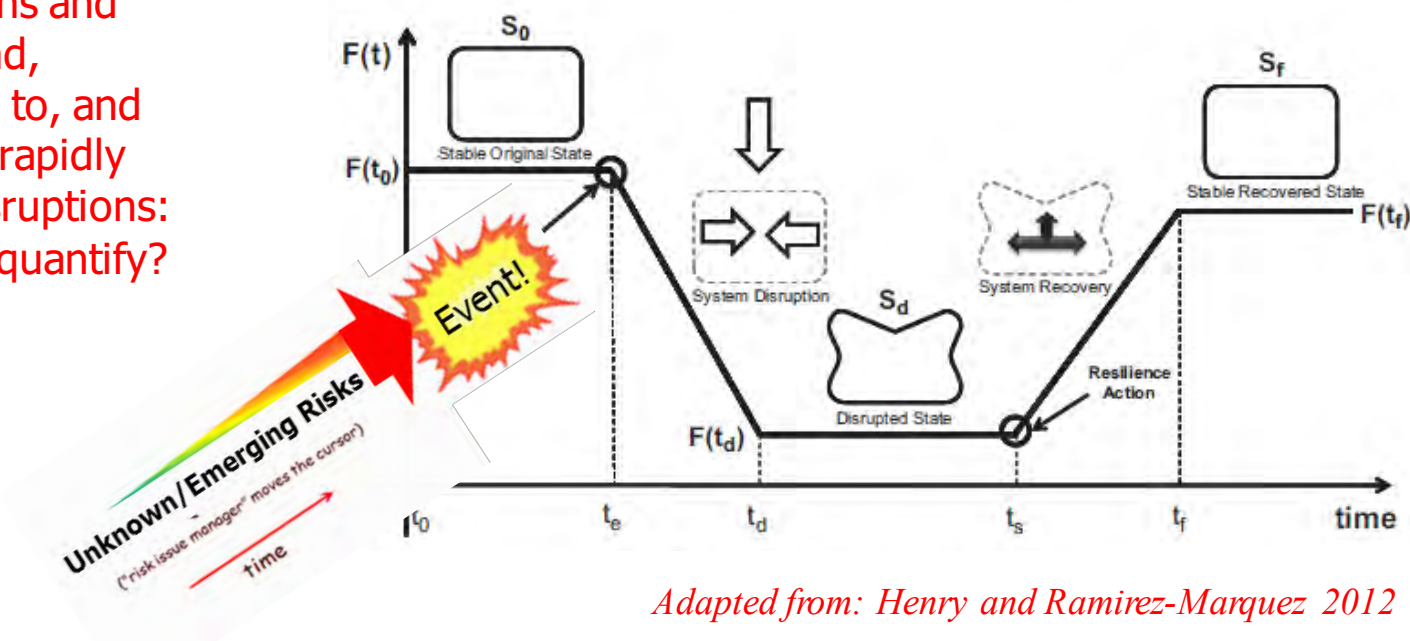
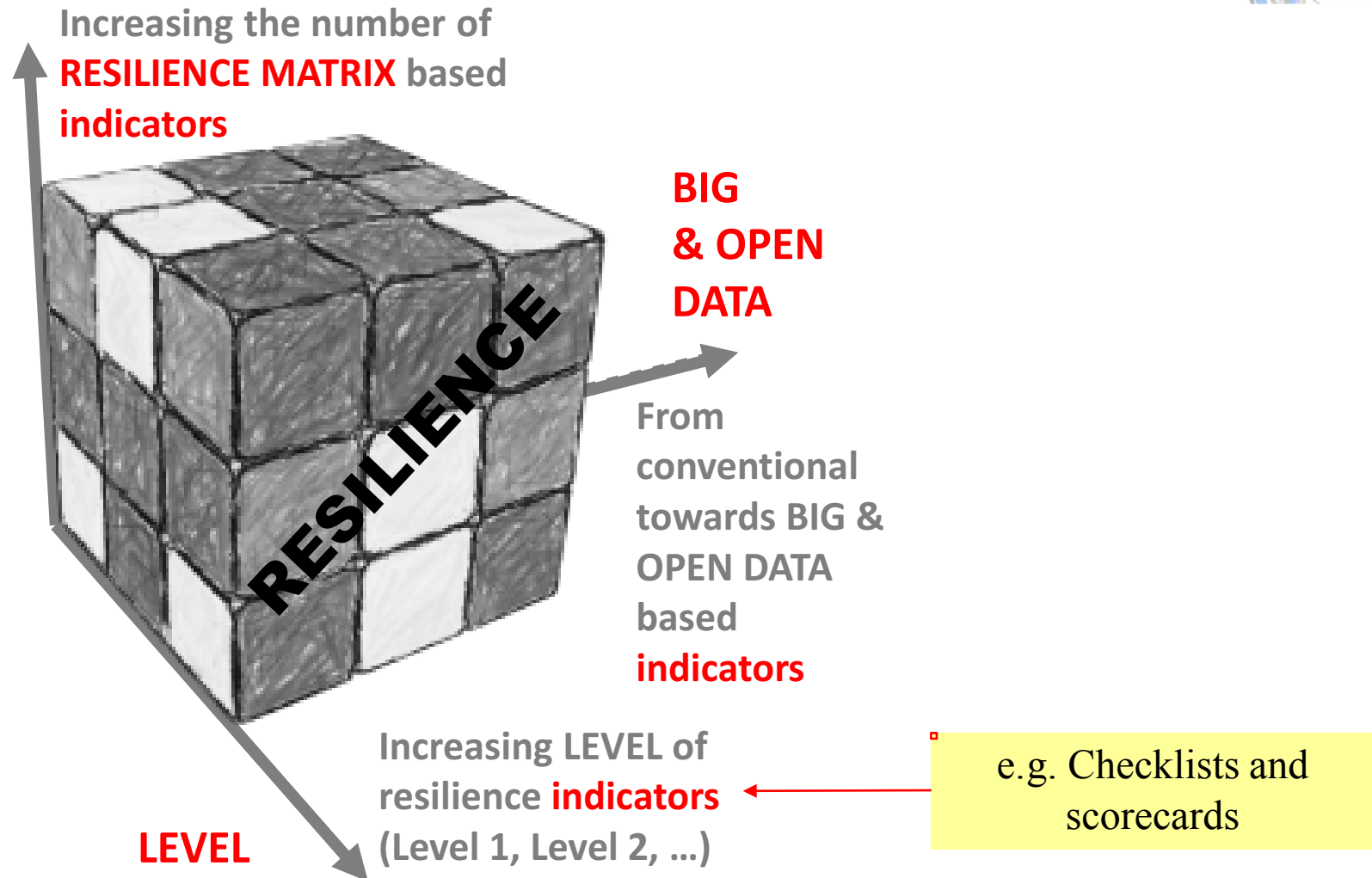


Fig. 1. System state transition in resilience.



*Adapted from: Henry and Ramirez-Marquez 2012*

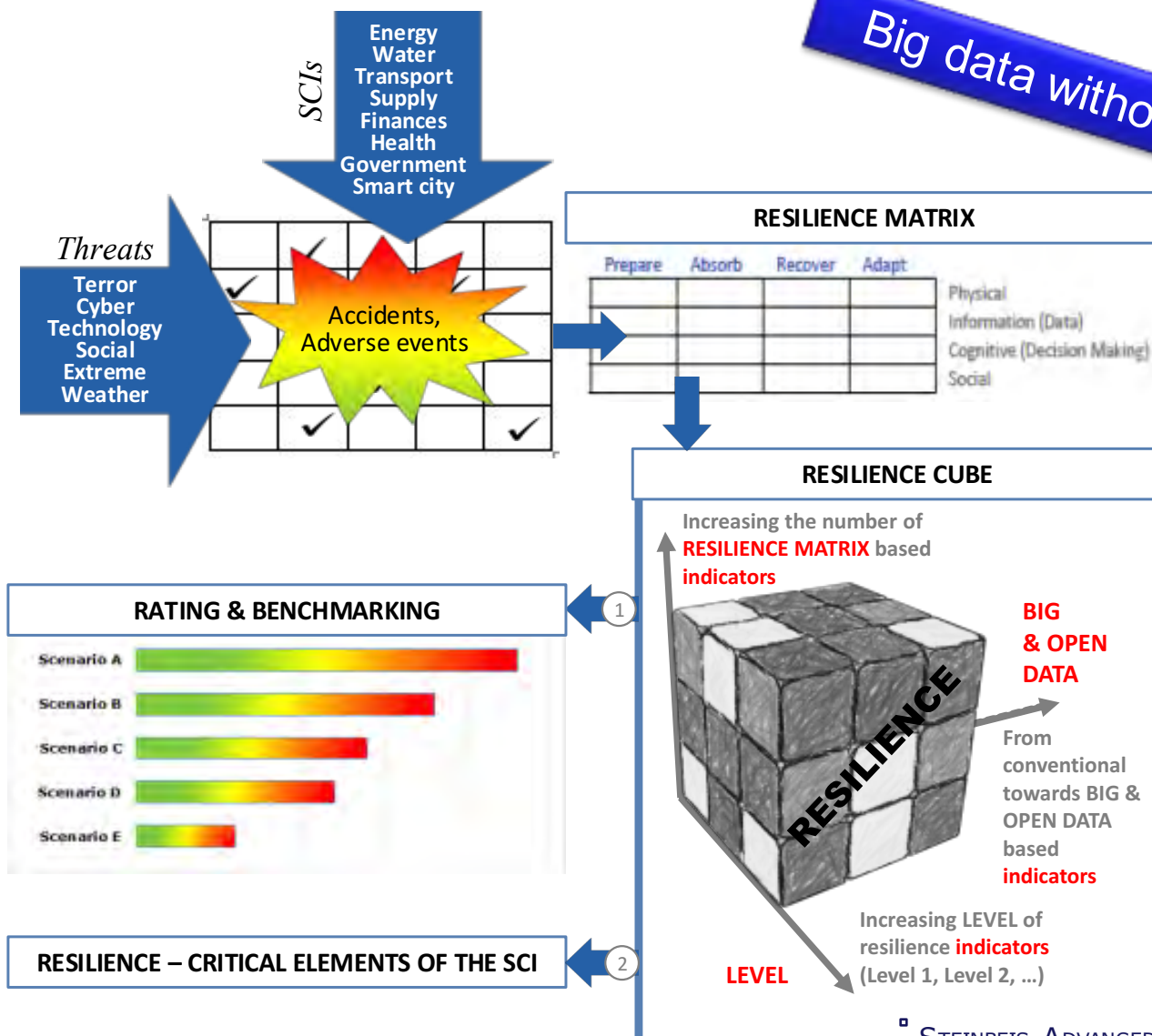
# Resilience cube





# Resilience cube in the context

Big data without big theory is BS!



# CONCLUSIONS: A chance to produce the 1<sup>st</sup> international “risk & resilience” standard?

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- ↘ European pre-standard  
DIN-CWA 16648:2013 (DIN SPEC 91299)  
“Managing emerging technology related risks”  
goes international and **will include resilience aspects**
- ↘ .. as the **DIN-SPEC INTERNATIONAL** standard
- ↘ Involvement of new countries like China, India, Brazil...
- ↘ EU involvement
- ↘ Insurance involvement
- ↘ Involvement of ISO Committees TC262 and TC292
- ↘ US? Next Aspen-Workshop? Risk-Resilience Indicators?