

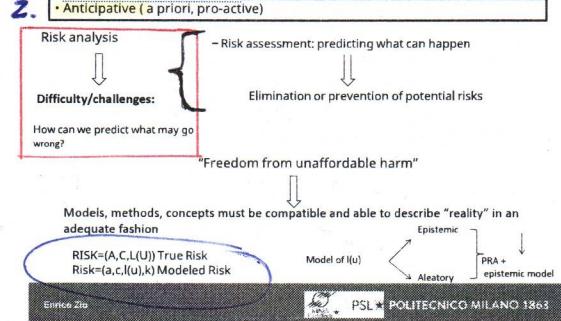
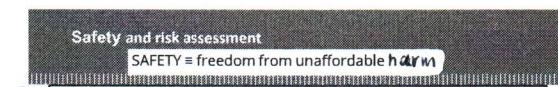
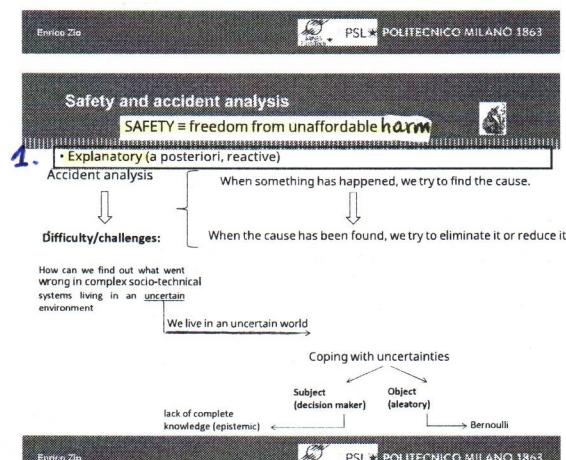
Safety



PROTECT LIVES & PROPERTY

PROTECT NATURE

Two ways of proceeding:



For all possible accidents we need to know (evaluate):

A = ACCIDENT SCENARIO

C = CONSEQUENCES
(modelling of the impact)

U = UNCERTAINTY

L(U) = LIKELIHOOD

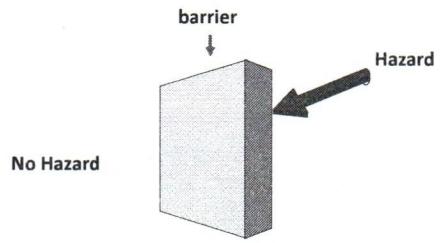
→ TRUE RISK

MODEL RISK:

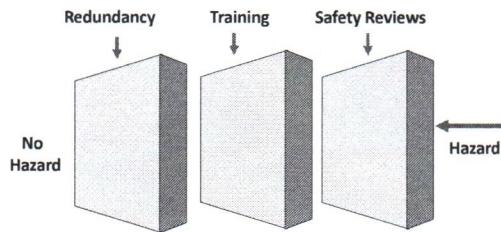
a = modelled accident
c = modelled (on a) consequences
u = modelled uncertainty
l(u) = mod. likelihood

K = knowledge on which we model

The 'parmesan cheese' model



Multiple Barriers



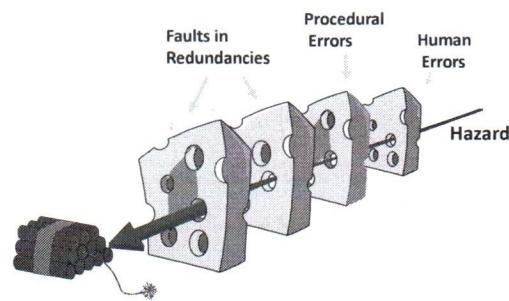
Risk

Reality: An example of a protection barrier

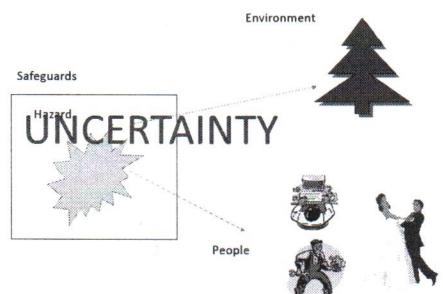
Not all risk mitigation strategies work...



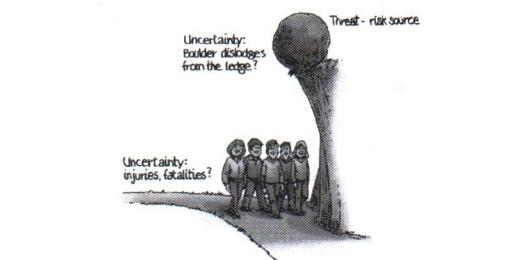
The 'swiss cheese' model



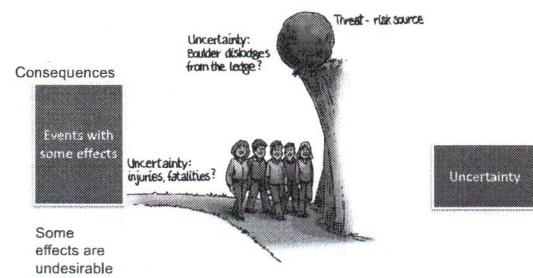
THE RISK CONCEPT:



The Risk Concept



The Risk Concept



Consequences &
Uncertainty

Risk

RISK = POTENTIAL DAMAGE + UNCERTAINTY

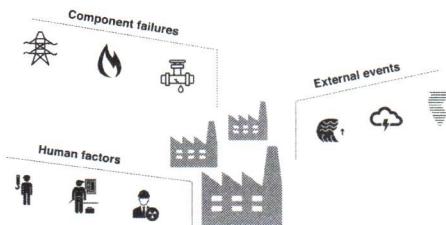
Dictionary: RISK = possibility of damage or injury to people or things

- 1) What undesired conditions may occur? → Accident Scenario, S
- 2) With what probability do they occur? → Probability, p
- 3) What damage do they cause? → Consequence, x

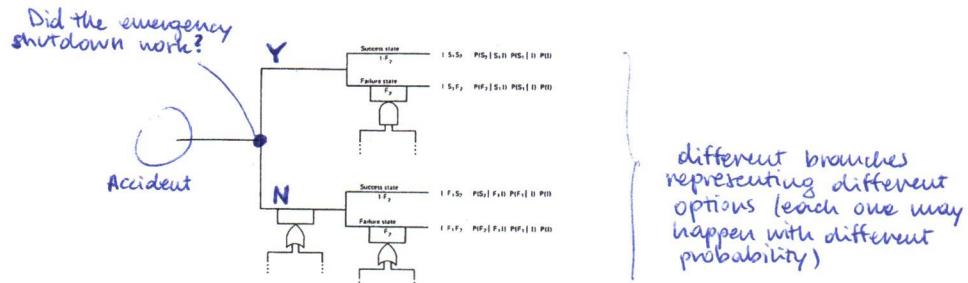
$$\text{RISK} = \{S_i, p_i, x_i\}$$

S. Kaplan, B.J. Garrick, On the quantitative definition of risk, Risk Analysis, 1981 18

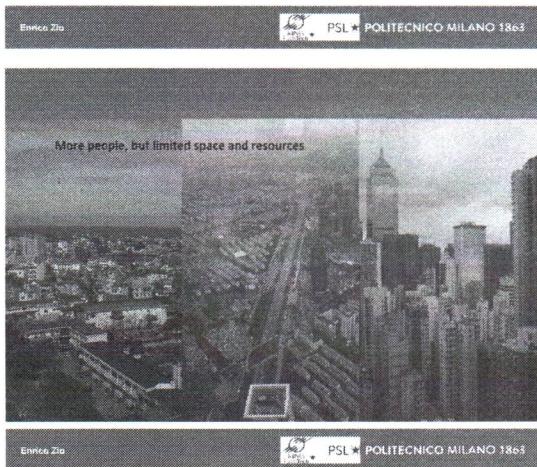
HAZARDS



Event Trees/Fault Trees



WORLD 4.0:





K. Rønning, Ecological Economics 32 (2000) 319–332.

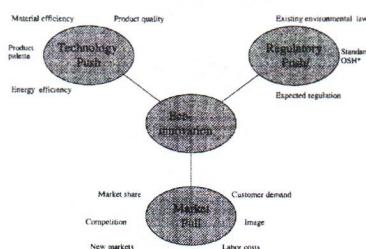
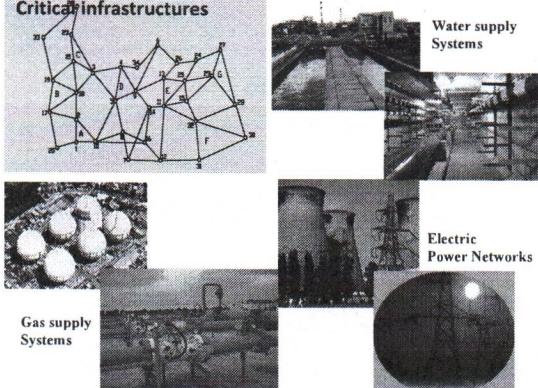
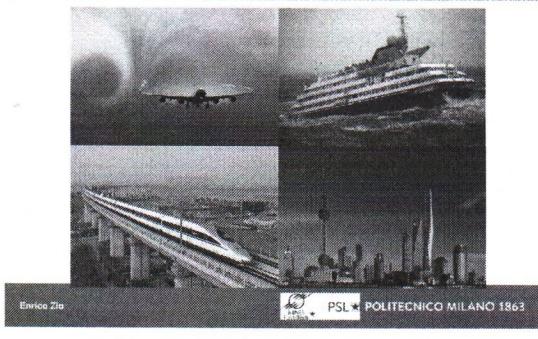


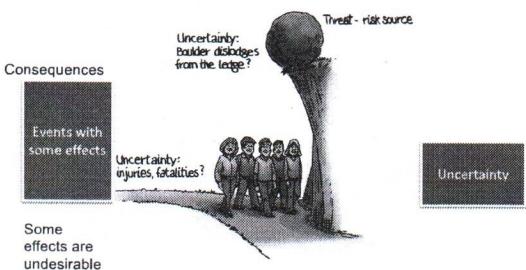
Fig. 2. Determinants of eco-innovations. *OSH = Occupational Safety and Health



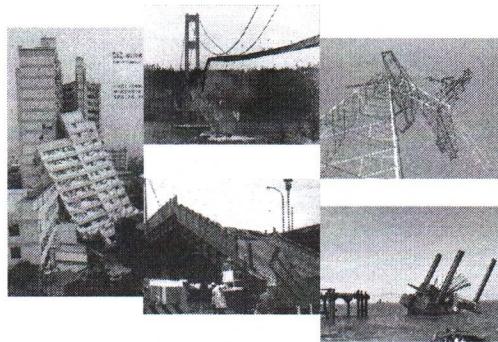
Technological systems



The Risk Concept



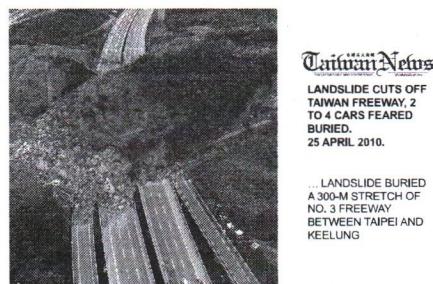
Failures



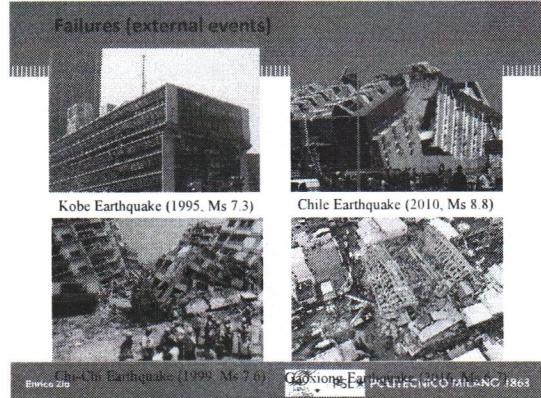
Failures



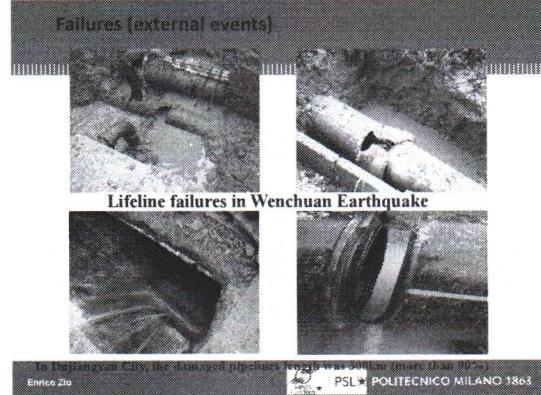
Failures (external events)



Failures (external events)



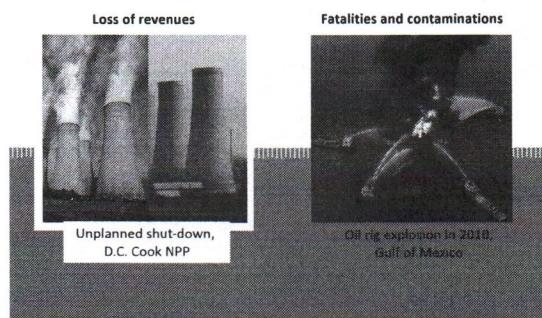
Failures (external events)



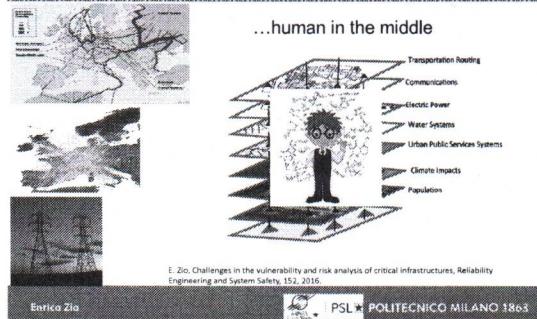
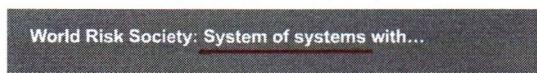
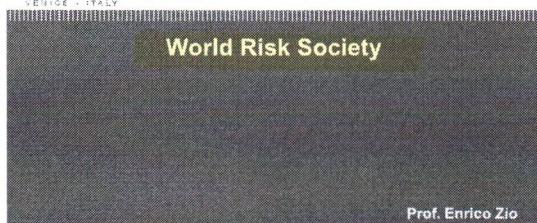
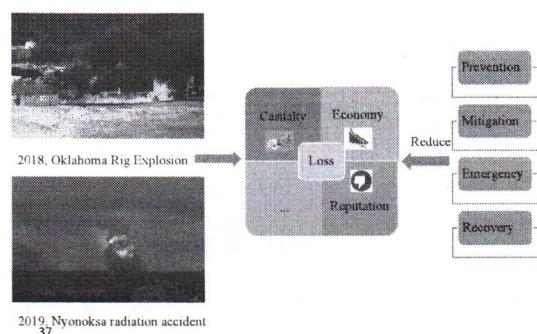
Failures (external events)



Failures and consequences



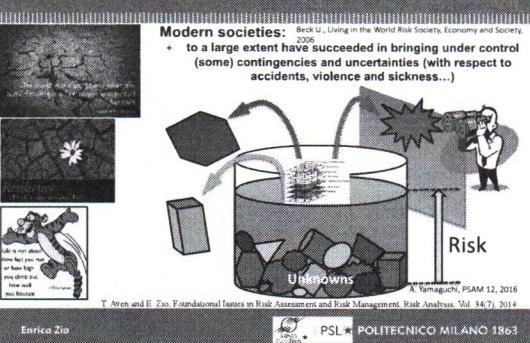
Failures and consequences: the problem and the solution



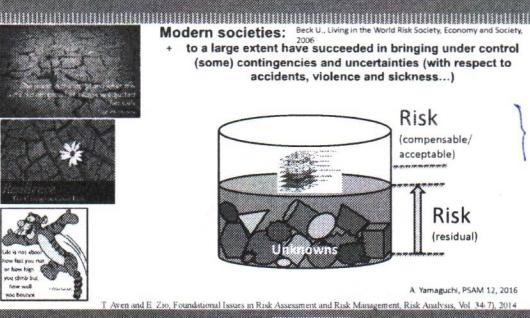
World Risk Society: multiple hazards



World Risk Society



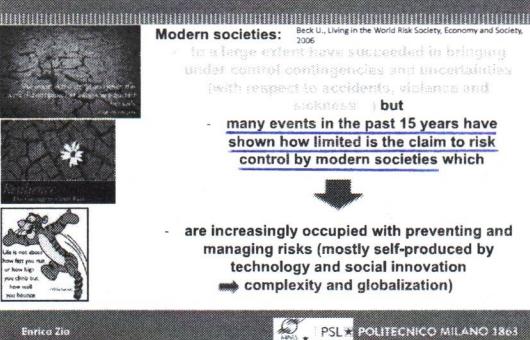
World Risk Society



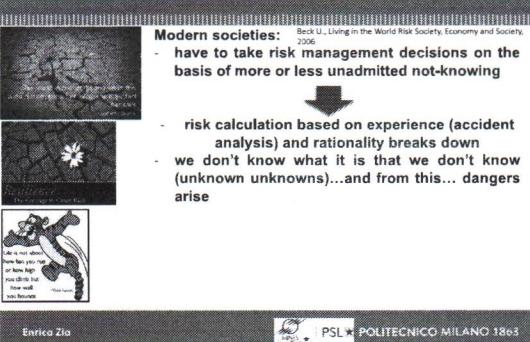
Society sets a level of acceptable risk: society sets a level below which the benefits of the service compensate the risk.

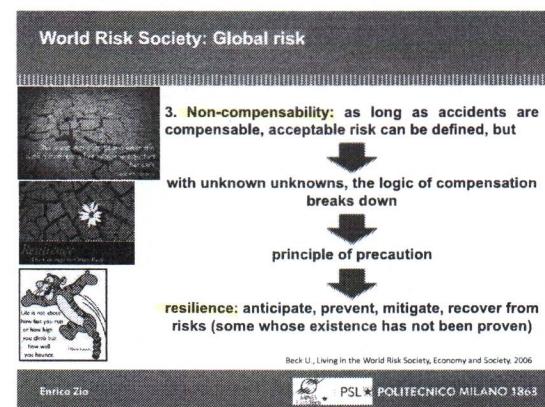
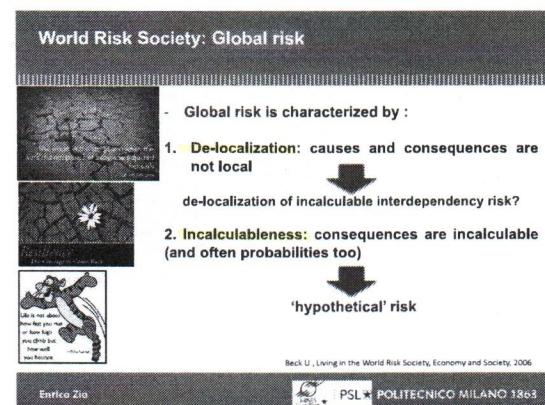
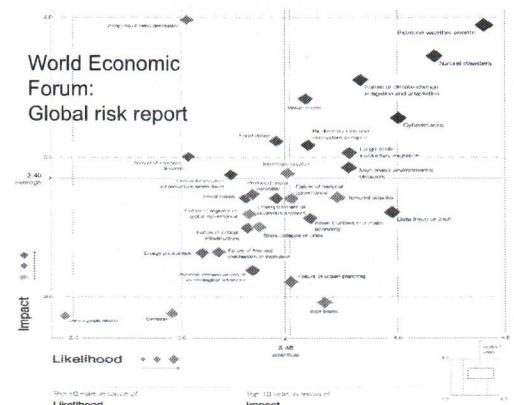
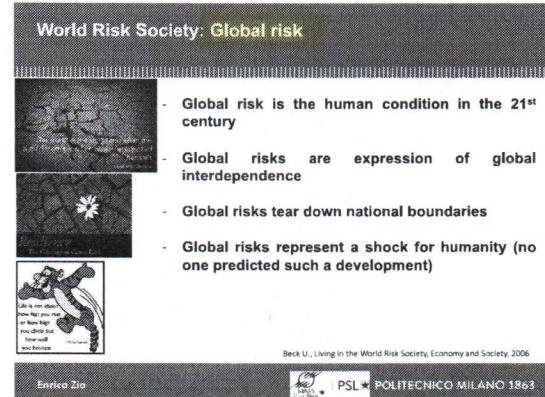
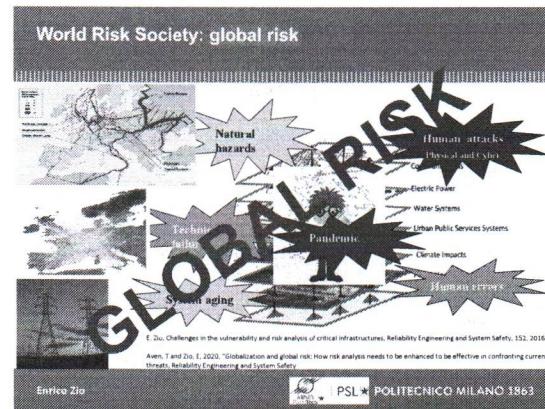
However

World Risk Society

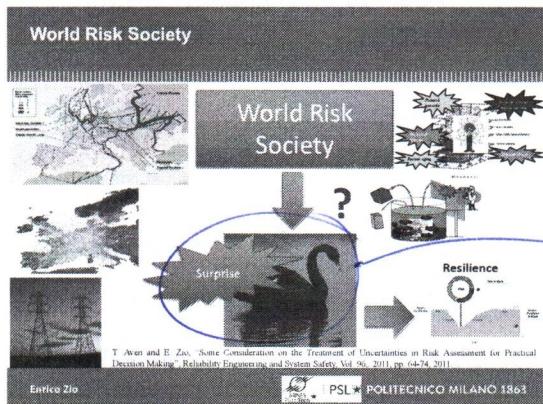


World Risk Society

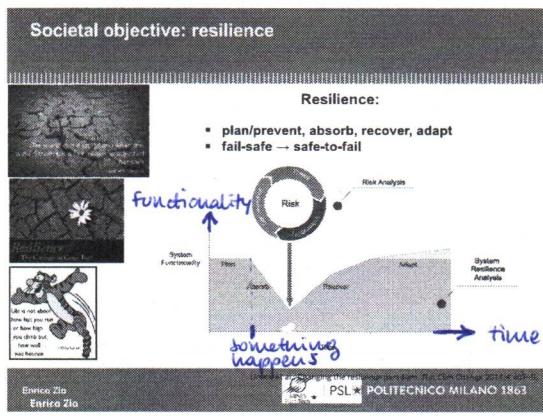




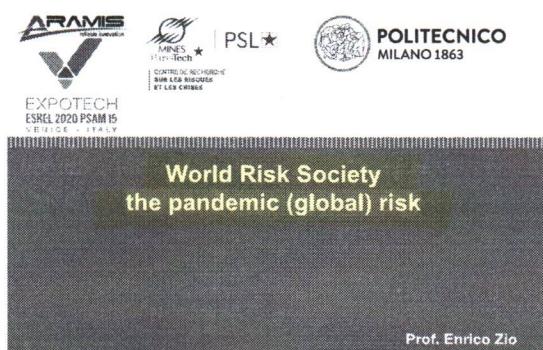
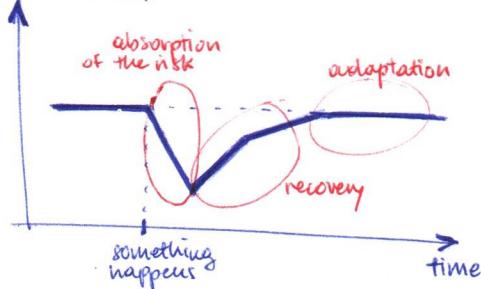
resilience is a step further:
it also takes into account the
crisis and the recovery (not only
the risk evaluation)
capacity to react, to recover quickly



BLACK SWAN
something that seems impossible to happen

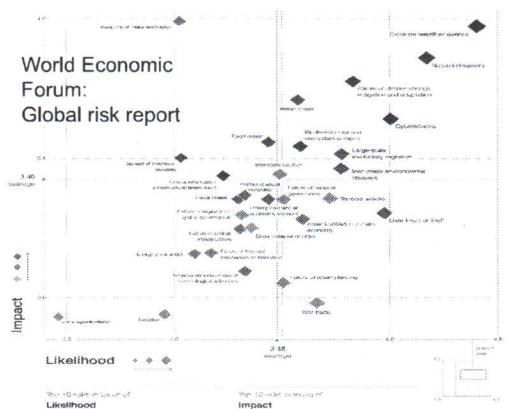
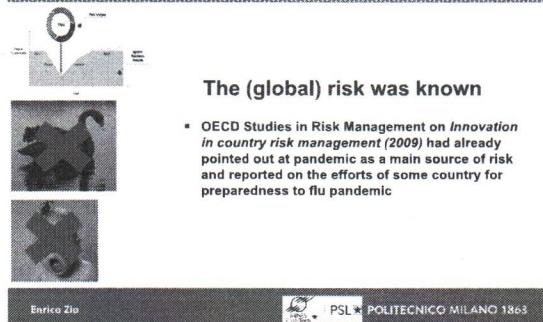


(Typical) Diagram of Resilience:
Functionality



The «before»-pandemic and risk control

Prof. Enrico Zio



The «before»-pandemic and risk control/compensability/acceptance

Risk handling includes making decisions about what is an **acceptable risk**.

- Potential consequences known, vulnerabilities accepted by Society (economical reasons-risk compensation/acceptance)
- Decrease in stockpiles of medical supplies, reduced medical staff and assets, no spare/buffer capacity. B. Ale, TU Delft, Private communication, 2020

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The «during»-pandemic and precaution/resilience

Pandemic: global, incalculable, non-compensable risk

precautionary measures

resilience of Society as a whole, of people as individuals (ethics of resilience)

Bello and Zio, 2020. Contributing to Disaster Management as an Individual Member of a collective: resilience, ethics and other of resilience. <https://doi.org/10.1111/dmfd.12147>

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The «during»-pandemic and risk attitude

- Confirmation bias:** we tend to believe what we want to be true (wishes thinking); we select the data that makes us feel good and ignore the information that might change our view
- Optimism bias:** we like to believe that we are less likely to experience a negative event

Bello and Zio, 2020. Contributing to Disaster Management as an Individual Member of a collective: resilience, ethics and other of resilience. <https://doi.org/10.1111/dmfd.12147>

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The «during»-pandemic and risk communication

10%

- Very few people are getting infected
- $10\% = 1/10$
- Probably won't affect anyone I know, though

1 out of 10

- I could be the 1 out of 10
- There has to be at least 1 in 10 of my friends

M. Bell, Freeman & Team, Graham. (2007). Efficient and effective? The 10/10 rule in the communication and perception of flood risk. Environmental Hazards, 6(1), 1-10. doi:10.1080/14777950701200001
Keller, C., Bagnoli, N. and Vassalli, V. (2020). Effect of Risk Ladder Format on Risk Perception in High- and Low-Risk-Perceiving Individuals. *Risk Analysis*, 29 (12):15-164. doi:10.1111/risan.13264

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The «during»-pandemic and the risk science (models and expertise)

- Clarity**
- Trustability (epistemic experts vs. epistemic authorities; objective science vs. scientists with moral values)**
- The relevance of knowledge but also not-knowledge (the skeptical revolution of Bertrand Russell)**

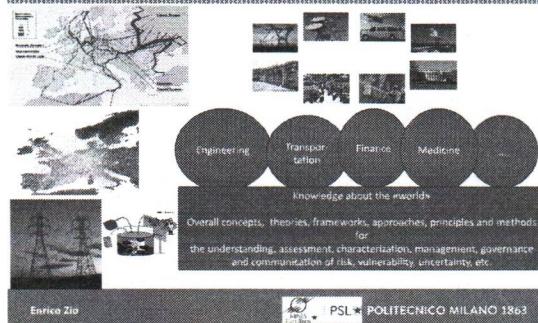
Bertrand Russell, *Sceptical Essays*, London: George Allen & Unwin, Ltd. 1928

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CONCLUSIONS

Prof. Enrico Zio

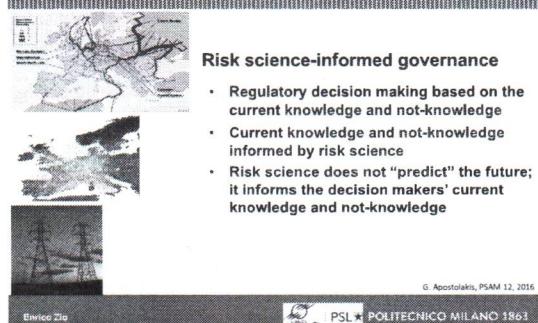
Risk science: foundations for risk assessment and management



Enrico Zio

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Conclusions: risk science-informed governance for a resilient society

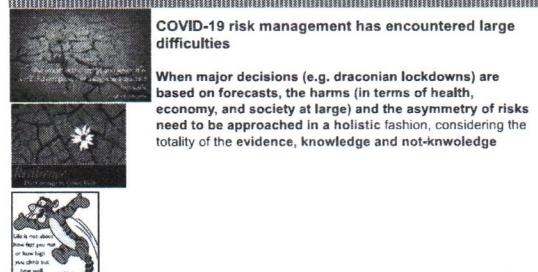


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G. Apostolakis, PSAM 12, 2016

PSL ★ POLITECNICO MILANO 1863

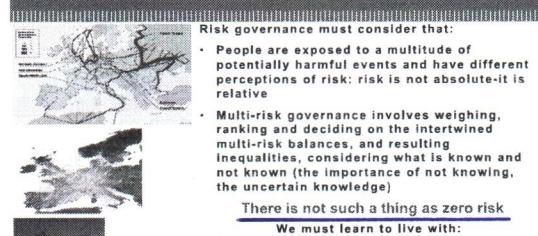
Conclusions: risk science-informed governance for a resilient society



Enrico Zio

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Conclusions: risk science-informed governance for a resilient society



There is not such a thing as zero risk.

We must learn to live with:

- global risk
- not knowing

Keynes, The Quarterly Journal of Economics, 1937
Duffy and Zio, Old lessons of risk assessment and management from the COVID-19 pandemics and individual infections dynamics, submitted to Journal of Risk and Uncertainty, 2020

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Conclusions: risk science-informed governance for a resilient society



Risk governance must also consider that:

- In the end, what really matters is what risk people are willing to take as individuals
- People refer to authority for guidance but eventually take own decisions on risk, depending on risk perception and attitude (influenced by culture, social groups etc.)
- People recognize that the overall balance guiding their decisions should be objectively evaluated (science-informed), but subjective and qualitative perception, attitude, ethics often dominate

A global world is inevitably exposed to global risks which demand global efforts

Bako and Zio, 2020, Coronabotizing to Disaster Management as an Individual Member of a collectively resilient ethics and ethic of resilience, <https://doi.org/10.31214/osf.io/46ht>
Duffey and Zio, Old lessons of risk assessment and management from the COVID-19 pandemics and individual infections dynamics, submitted to Journal of Risk and Uncertainty, 2020

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Thanks...

...for your attention



Enrico Zio

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SHOCKS. TODAY.

IPUR
COMMUNICATI INTELLIGENTI

Flight delays and railway fires: Scorching heatwave tests Europe's infrastructure

INTERVIEWED: JULY 26, 2019 • BY THE GLOOMY PAPER • JULY 30, 2019 • #30-MAR-01



"On Friday morning train commuters faced disruption after the extreme heat wreaked havoc on the rail network and airports. Widespread delays also continued at Heathrow and Gatwick, the two U.K. biggest airports, leaving passengers stranded."

"It's intense. Climate change makes this extreme heat so much more likely. This is something that virtually couldn't happen if not for climate change," Karsten Haustein, a climate scientist at the University of Oxford, told CNBC.

Engineers this week struggled to repair damaged rail lines as networks slowed down trains. High temperatures caused steel tracks to expand and buckle under stress, according to the U.K.'s Network Rail, leading to widespread delays."

<https://www.cnbc.com/2019/07/26/scorching-heatwave-causes-flight-and-railway-delays-in-europe.html>

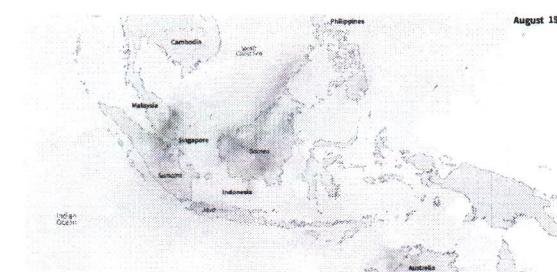
SHOCKS. TODAY.

IPUR
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Business

Malaysia Shuts 400 Schools as Haze From Indonesia's Fires Spreads

7 FEB 2018



Social media fuelling anti-vaxxer movement with Europeans the most sceptical in the world, global poll shows

Vaccination being rejected alongside gluten and hospital birth, as 'pro-nature' parents turn to Facebook and Instagram for advice, experts warn

... High-income nations in general were **more sceptical**, and the research suggests **anti-vaccine sentiments are a 'canary' for mistrust in government, doctors and other authority figures**. Experts in vaccine beliefs said that relatively high confidence in Britain could 'mask' this erosion of trust which is becoming harder to measure as social media becomes more influential in our lives.

... Social media becomes an issue when this erosion of trust in experts – or simply difficulty getting appointments with a doctor – leads concerned parents to search for their answers from peers on social media.

... 'Vaccines, for example, are one of our most powerful public health tools, and **we need people to have confidence in them if they are to be most effective**'.

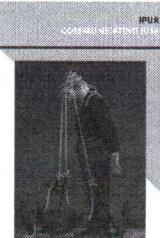
<https://www.independent.co.uk/news/health/anti-vaxxers-around-the-world-are-more-sceptical-of-vaccines-a836441.html>

WHY FACTS DON'T CHANGE OUR MINDS

In 'The Enigma of Reason' Dan Sperber and Hugo Mercier try to answer this question. The book strives to explain reason, the trait that actually makes us human and why it doesn't work the way we expect it to.

According to the book, reason was not developed so that we can draw logical conclusions, but to facilitate socialization with other individuals.

Our tendency to believe what we want to be true is called "confirmation bias". This form of thinking has often been explained as wishful thinking. Confirmation bias suggests that we are only selecting the data that makes us feel good and ignore the information that might change our view.



"Why facts don't change our minds". The New Yorker

By Elizabeth Kolbert February 19, 2017.

<https://www.newyorker.com/magazine/2017/02/19/why-facts-don-t-change-our-minds>

CONFIRMATION BIAS



The tendency to interpret new evidence as confirmation of one's existing beliefs or theories.

<https://www.persuasivelitigator.com/2017/08/right-confirmation-bias.html>

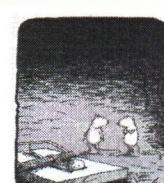
KEY ISSUES



INEFFECTIVE RISK COMMUNICATION HAS CONSEQUENCES

- Potential misguided decision-making, uninformed by sound evidence-based research.
- Resources ineffectively allocated to tackle over-perceived risks.
- Risk communication studies mainly conducted in USA, UK, Germany but under-represented in Asia.

OPTIMISM BIAS



Optimism bias is a cognitive bias that causes someone to believe that they themselves are less likely to experience a negative event. It is also known as unrealistic optimism or comparative optimism.

"Modern technology being what it is, there's a good chance it won't work anyway."

<http://giant-lt.com/why-optimism-bias-may-not-work/>

100-YEAR FLOOD

IPUR
COMMUNICATING RISK



"100-year flood"
vs.
"flood with 1% chance of happening each year"

M. Bell, Heather & Tobin, Graham. (2007). Efficient and effective? The 100-year flood in the communication and perception of flood risk. *Environmental Hazards*, 7, 302-311. 10.1016/j.envHaz.2007.08.004.

Keller, C., Siegrist, M. and Visschers, V. (2009). Effect of Risk Ladder Format on Risk Perception in High- and Low-Numerate Individuals. *Risk Analysis*, 29, 1255-1264. doi: 10.1111/j.1539-6924.2009.01261.x

100-YEAR FLOOD

IPUR
COMMUNICATING RISK

NATURAL DISASTERS

German town hit by two 'floods of the century'



...the willingness of people to live with the disadvantages of flood-prevention measures, which quickly diminishes after the flooding is over.

The catastrophe in Grimma, one of the worst-affected towns in Saxony, might not have been so bad if the flood prevention measures agreed after 2002 had been fully implemented. A citizens' initiative prevented that from happening.

The same happened in Radebeul, where residents have been arguing about a dyke for years. Stamm admits that, while the dyke would be useful, it certainly wouldn't be pretty: "Some people want the protection; the others think the next 'Flood of the Century' won't come for another hundred years."

<http://www.dw.com/en/german-flood-prevention-still-can-prevent-floods/a-18675765>

TWO MODES OF THINKING

IPUR
COMMUNICATING RISK

FAST

Experiential (System 1)

- Intuitive
- Images, associations
- Feelings (affect)
- Stories/narratives
- Often non-conscious

SLOW

Analytical (System 2)

- Deliberative
- Logical
- Reasoned
- Uses symbols, numbers
- Conscious appraisals
- Slowly constructs feelings

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

THE AFFECT HEURISTIC

IPUR
COMMUNICATING RISK

EXAMPLE #1

Probability and Relative Frequency in Risk Communication

- Are they the same or different in communicating risk?

e.g. **1% chance** vs. **1 out of 100**

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

WHICH PROBABILITY SEEMS GREATER?

IPUR
COMMUNICATING RISK

- 10%
- 1 out of 10

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

Why does 1 out of 10 seem more likely?

Frequency formats produce more vivid imagery (stronger affect) with fast thinking!

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

Patient Evaluation

10%

- Very few people are violent
- 10% = 1/10
- Probably won't hurt anyone, though

1 out of 10

- He could be the 1 out of 10
- Some guy going crazy and killing people
- The patient attacking someone
- An act of violence
- There has to be at least 1 in 10. Mr Jones could very well be that 1

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

THE AFFECT HEURISTIC

EXAMPLE #2

The Arithmetic of Compassion

- The feeling system can't count!
- Saving 1 life is extremely important
- Saving 1+1 is valued less than 2 and sometimes less than 1

And feelings don't multiply either!

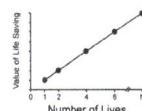
Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018



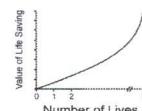
If I look at the mass, I will never act.
If I look at one, I will.

Mother Teresa

How Should We Value the Saving of Human Lives?



Normative model #1:
Every human life is of equal value



Normative model #2:
Large losses threaten the viability of the group or society

Slovic, P. (2018) "Fast and Furious Decisions", presented in NUS 9 July 2018

How Do We Value the Saving of Human Lives?



Descriptive model #1:
Diminished sensitivity as N grows
Large, all lives are not valued equally:
(psychophysical numbing)

Descriptive model #2:
Psychic numbing and the collapse of
compassion. Our capacity to feel (good or
bad) is limited. Lack of feeling (value) tends
to inaction when large losses of life occur.

Slovic, P. (2016) "Fast and Furious Decisions", presented in NUS 9 July 2016

The total amount of money needed was the same in both conditions

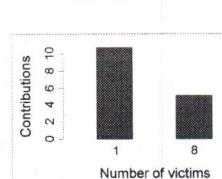
- 1 child – treatment costs \$300,000
- 8 children – treatment costs \$300,000

Will you donate?

How much?

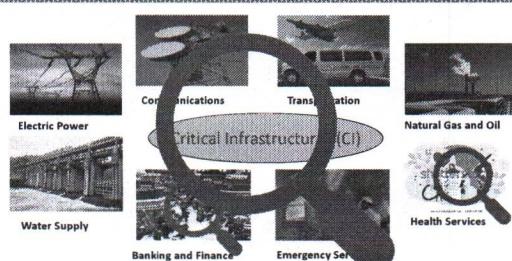
Kogut, T. & Ritov, I. (2005). "The "Identified Victim" Effect: An Identified Group, or Just a Single Individual". Journal of Behavioural Decision Making, 18, 157-167.

"The greater contribution to a single victim relative to the group stems most likely from emotions evoked by a single identified victim rather than from emotions evoked by identified victims in general"



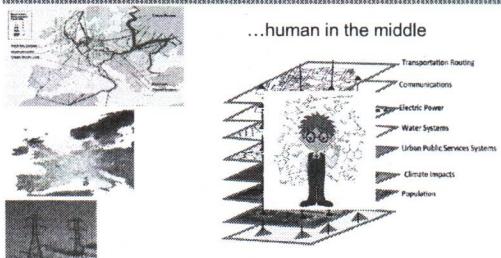
Kogut, T. & Ritov, I. (2005). "The "Identified Victim" Effect: An Identified Group, or Just a Single Individual". Journal of Behavioural Decision Making, 18, 157-167.

Grandma challenge



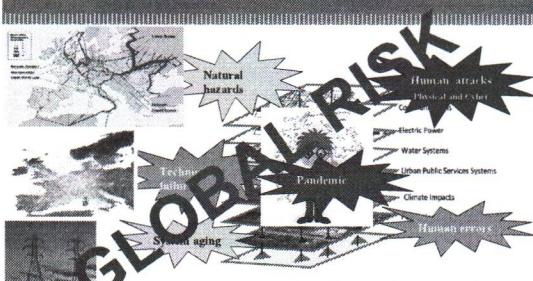
E Zio, Challenges in the vulnerability and risk analysis of critical infrastructures, Reliability Engineering and System Safety, 152, 2016

Societal context: System of systems with...



E. Zio, Challenges in the vulnerability and risk analysis of critical infrastructures, Reliability Engineering and System Safety, 152, 2016.
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Societal risk context: multiple hazards



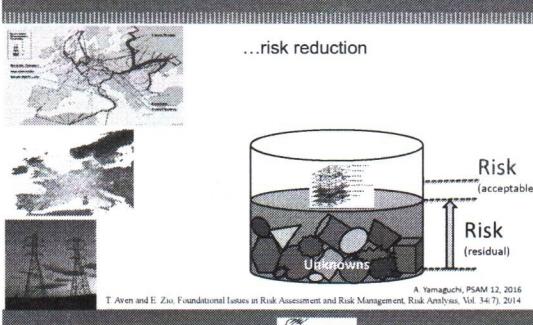
E. Zio, Challenges in the vulnerability and risk analysis of critical infrastructures, Reliability Engineering and System Safety, 152, 2016.
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Risk analysis for...



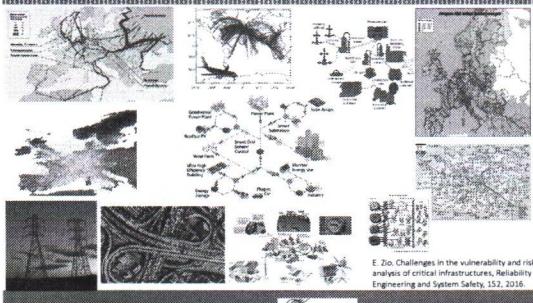
T. Aven and E. Zio, Foundational Issues in Risk Assessment and Risk Management, Risk Analysis, Vol. 34(7), 2014.
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Risk analysis for...



T. Aven and E. Zio, Foundational Issues in Risk Assessment and Risk Management, Risk Analysis, Vol. 34(7), 2014.
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Critical infrastructures (CI): complex systems (of systems)



E. Zio, Challenges in the vulnerability and risk analysis of critical infrastructures, Reliability Engineering and System Safety, 152, 2016.
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Complexity: surprises

T. Aven and E. Zio, Some Consideration on the Treatment of Uncertainties in Risk Assessment for Practical Decision Making, Reliability Engineering and System Safety, Vol. 96, 2011, pp. 64-74, 2011.

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REFLECTIONS (obvious?) – the pandemic experience
(RIFLESSIONI (ovvie?) – l'esperienza della pandemia)

Prof. Enrico Zio

Reflections: the pandemic experience and risk analysis

- The risks were known
- The national safety profile of the Netherlands (2016) ranks a pandemic as second in potential consequences after a catastrophic flood.
- Risk experts have been warning about the risks of:
 - a single source of supply for an enterprise or a country;
 - transferring production of critical goods completely to foreign nations, without retaining some production capacity at home.

B. Ale, TU Delft, Private communication, 2020

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Reflections: the pandemic experience and risk acceptance

- Risk handling includes making decisions about what is an acceptable risk.
- Potential consequences were known and, yet, vulnerabilities have been accepted by Society (by politicians and by the public at large), mostly for economical reasons.
- For economical reasons, many countries have decreased their stockpiles of medical supplies in favor of just-in-time delivery and reduced staff and assets, without any spare capacity, just as industries in various sectors.

B. Ale, TU Delft, Private communication, 2020

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Reflections: the pandemic experience and «after-the-fact» risk perception

- A risk is much less acceptable after the consequences have materialized than before.
- The decisions taken were (may be) not as one would expect from some formal risk-benefit analysis or any other decision theory.
- Risk science and science in general can support policy decision making but cannot substitute politics.

B. Ale, TU Delft, Private communication, 2020

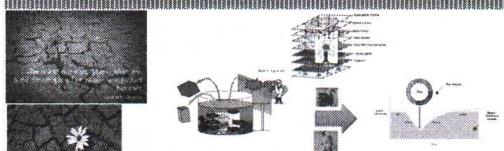
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REFLECTIONS (obvious?) –resilience

(RIFLESSIONI (ovvie?) – infrastrutture critiche e resilienza)

Prof. Enrico Zio

Reflections: resilience



Protection from very large events may be impossible (since there will always be unexpected incidents) or prohibitively costly (since the scale of incidents seems to be increasing).

There will always be unforeseen events due to the complexity of our CI systems:

- * means to adequately respond to such events when they occur (resilience)

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Reflections: resilience



Resilience approach acknowledges that there are events that cannot be planned for, encourages adaptability and flexibility to respond to unexpected events and does so at a marginal cost when compared to asset protection.



This does not mean that precautionary measures are unnecessary and that precaution can be reduced for the opportunity of saving upfront costs for events that may not happen.

L. Petersen et al., Who cares what it means? Practical reasons for using the word resilience with critical infrastructure operators, Reliab. Eng. and Sys. Safety, 2020

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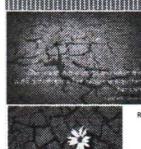
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CONCLUSIONS (also obvious?)

(CONCLUSIONI (ovvie anche queste?))

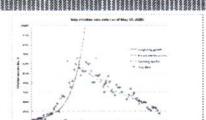
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Conclusions: science and decision-making



"In Italia, ... Il controllo del contagio potrà essere raggiunto tra i 30-40 giorni a partire dal quel picco di fine marzo." (E. Zio)

R. Bruno, Corriere della sera, 9 April 2020



"Disclaimers":

- Science can inform political decisions.
- Science cannot prescribe political decisions: these are always value judgements, which are essentially subjective.
- No matter how much we improve science, decision making remains up to politics.

B. Aït, TU Delft, Private communication, 2020

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Conclusions: risk science-informed decision making for resilience

To inform decision making:

- structured systemic (system-of-systems) risk assessment + precautionary principle

For resilience:

- defense in depth
- multiple barriers
- safety margins
- disaster preparedness
- ...

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Conclusions: risk science-informed governance for resilience

Risk science-informed governance

- regulatory, like any other, decision making is based on the current knowledge
- the current knowledge needed for regulation can be informed by (risk) science
- risk science does not "predict" the future; it identifies and evaluates future events to inform the decision makers' current knowledge.

acceptable risk, not zero risk

G. Apostolakis, PSAM 12, 2016

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Conclusions (Italy): risk science-informed decision making and governance for resilience

Risk science-informed decision making for resilience:

An internationally recognized high-level center of studies and research in risk science (assessment, management and governance) of complex systems of systems (Istituto Italiano del Rischio)

Training next generation professionals : mandatory courses on risk science (safety, risk, resilience...) in technical university

Education for safety culture at all levels

Education for ethics of resilience at all levels

Fonte e Dr. G. Zio, Considering Resilience Management as an individual Member of a collective resilience effort, and ethic of resilience, <https://doi.org/10.1111/j.1467-9594.2009.00702.x>

Culture, openness and access to trustworthy information, as prerequisite for (good) risk management

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Conclusions (World): an invitation that you cannot refuse

Expotech:

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Reliability and security for a truly sustainable world

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