Aktuelle forskningsutfordringer innenfor risikoområdet

Terje Aven

Universitetet i Stavanger

University of Stavanger

ESRA Norge seminar UiS, 8 Oktober 2012

Workshop on

Foundational issues in risk assessment and risk management

Hotel Laurin in Salò, Milano, Italy, 3-4 August 2012

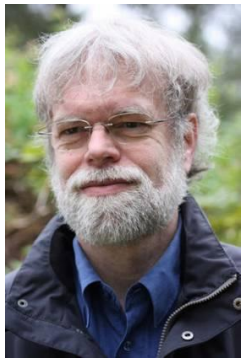
Henning Boje Andersen, Technical University of Denmark, DTU

Terje Aven, University of Stavanger, Norway

Lee B. Clarke, Rutgers University, USA

Tony Cox, Cox Associates, USA

Seth Guikema, John Hopkins University, USA



Sven Ove Hansson, The Royal Institute of Stockholm, KTH, Sweden

Elisabeth Paté-Cornell, Stanford University, USA

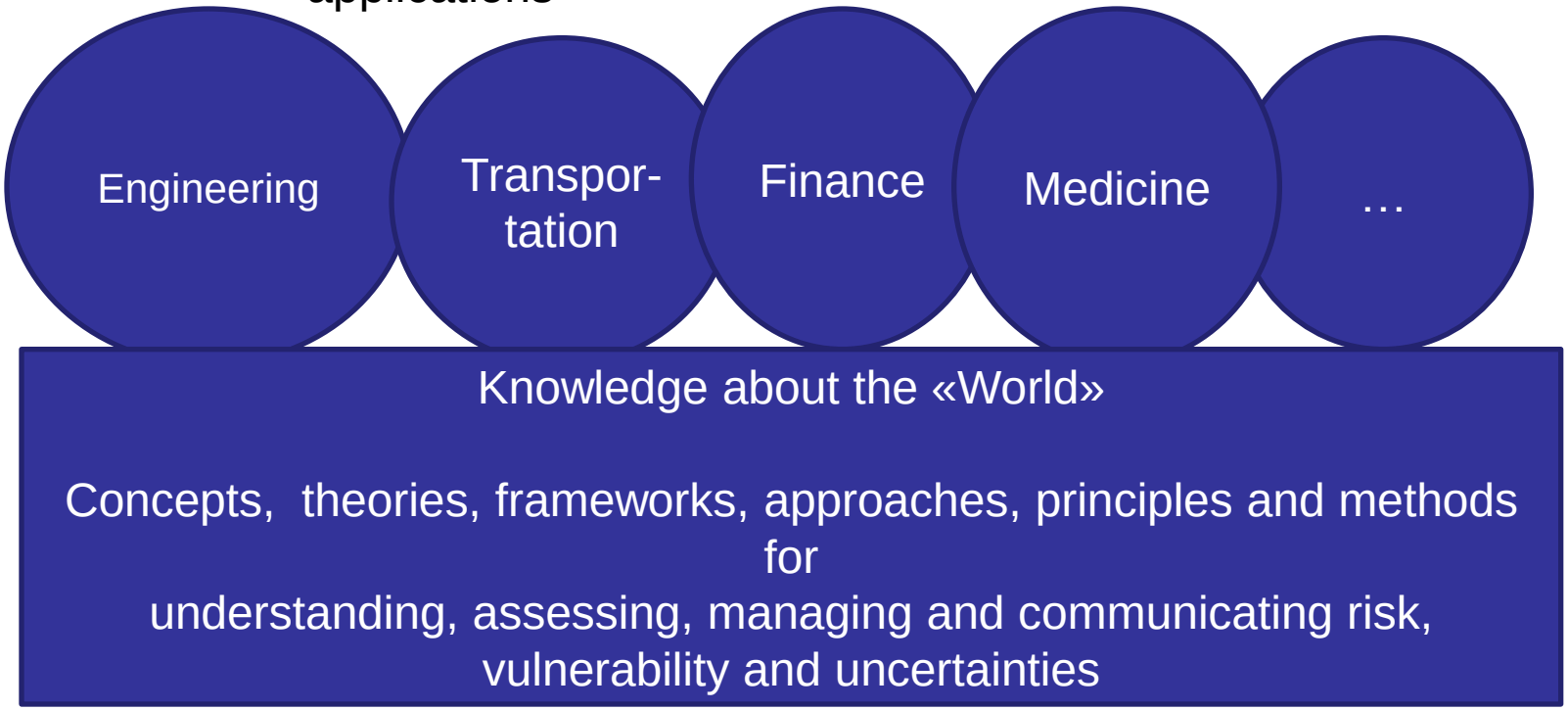
Mitchell Small, Carnegie Mellon University, USA

Enrico Zio, Politecnico di Milano, Italy, ECP, France

Roger Flage


(conceptual)
GAP 2:
(practical)
risk theory
risk
(missing foundations)
practice
Obstacle
GAP 3:
observations
learnings

Risk assessment and management in different applications



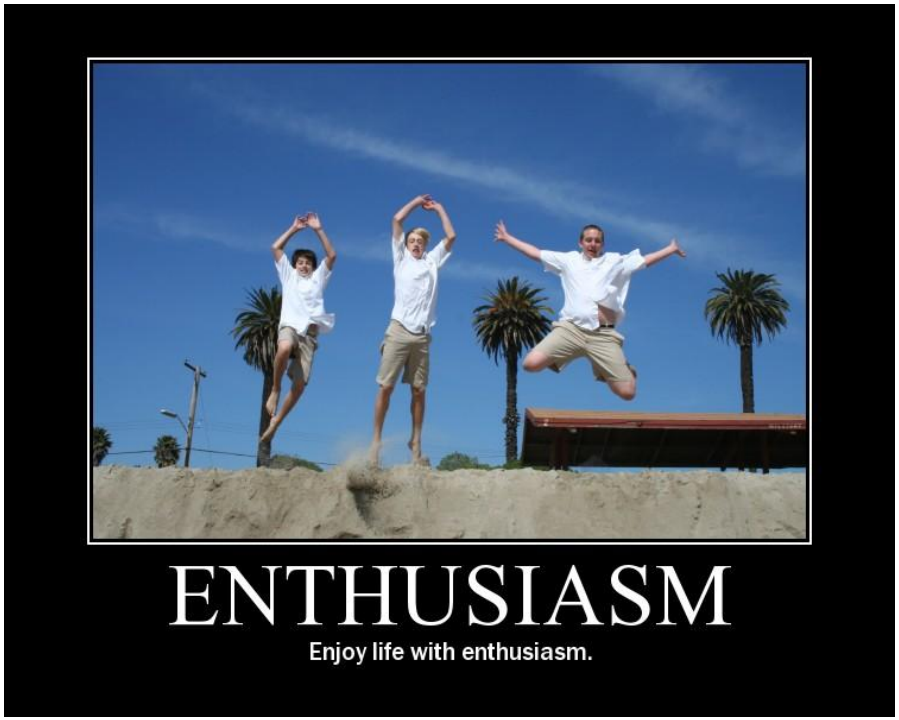
Foundational issues in risk assessment and risk management


Risk Analysi
AN INTERNATIONAL JOURNAL
RELIABILITY
ENGINEERING
& SYSTEM
SAFETY
safety
science

1980-90s

- Thompson KM, Deisler Jr. PH, Schwing RC. Interdisciplinary vision: The first 25 years of the Society for Risk Analysis (SRA), 1980–2005. Risk Analysis, 2005; 25:1333–1386.

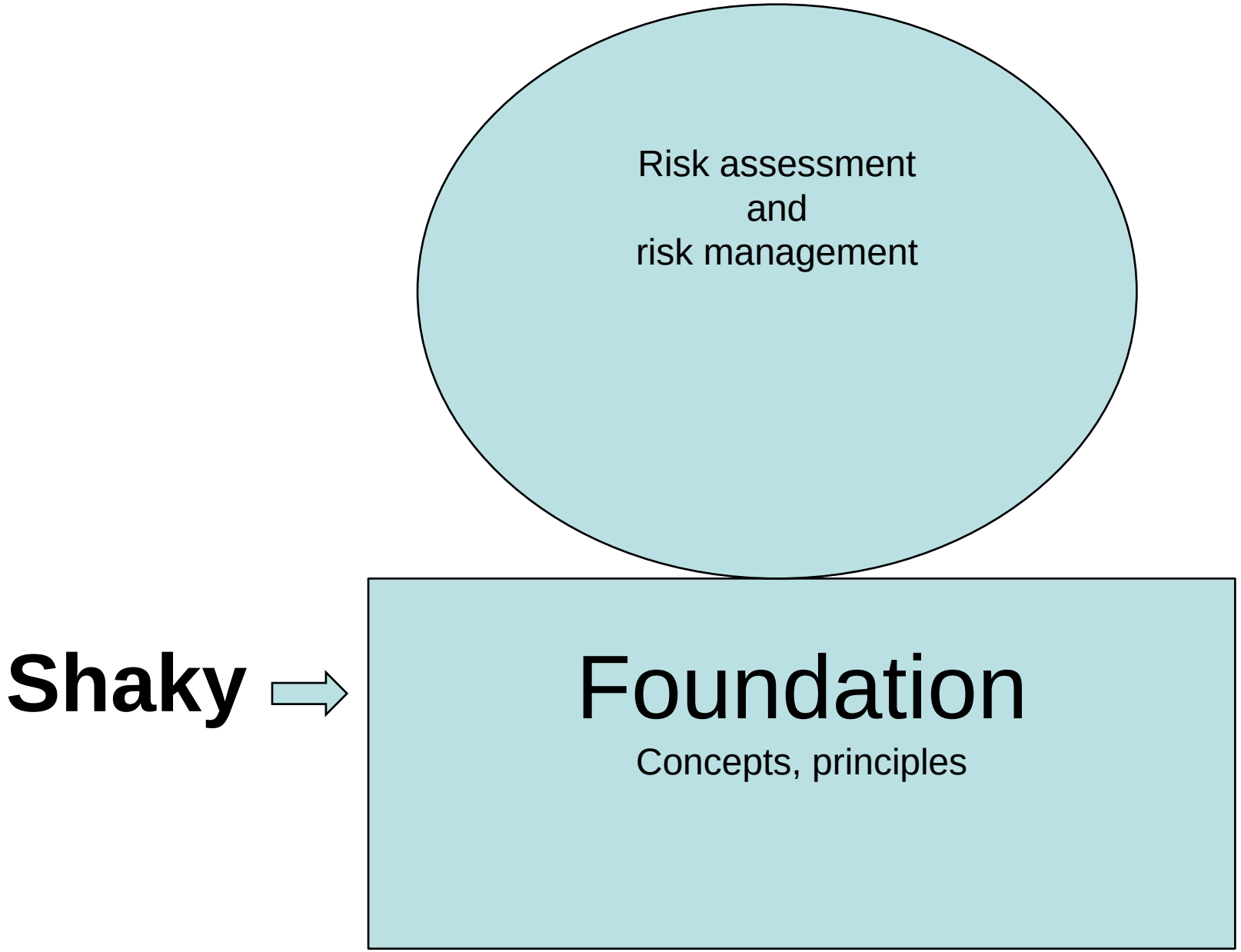
- Nuclear risk community



Where is this enthusiasm now?

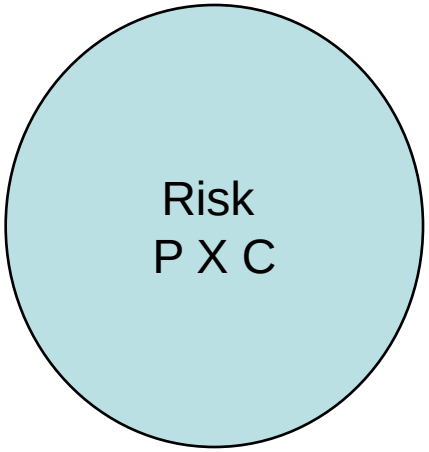
- Have we solved the fundamental problems of risk assessment and risk management ?
- Have these fields now a strong foundation?

No, No, No


Risk assessment
and
risk management
Shaky
Foundation
Concepts, principles

22. Juli-kommisjonen:

- Risk = expected loss?



Meglerhus spår en eventyrlig vekst i Norge. Tiltar vi egentlig mer nå?

22. juli-kommisjonens rapport Myndighetenes rolle

«Det kan ikke bli nok bredde og snutt i sikkerhetsarbeidet før et eget sikkerhetsdepartement er på plass,» understreker Terje Aven. Bildet er fra fakkeltoget i Stavanger 25. juli i fjor. FOTO: ANDERS MINGE

Føres den rådende risikotenkning videre i vårt samfunn, gambler vi høyt, og vi bruker våre ressurser på en lite effektiv måte.

Risikotenkningen er svært foreldet

Terje Aven
Professor ved Universitetet i Stavanger

Så har rapporten fra 22. juli kommisjonen endelig kommet. Jeg har studert den med utgangpunkt i hvordan den ser på de overordnede spørsmål knyttet til hvordan vi styrer og bør styre risiko i vårt samfunn. Vi er alle opptatt av selve hendelsen 22. juli og hvordan den ble håndtert, men med tanke på fremtiden, er det de overordnede risiko- og samfunnssikkerhetsmessige forhold som er av størst betydning.

Rapporten på dette området er skuffende lesning. Kommisjonens tanker i forhold til overordnet risikotenkning og samfunnssikkerhet

og beskrive risiko ikke evner å få frem på en god måte hva som er de største og viktigste truslene og farene. Hvorvidt en bredere og mer moderne tilnærming til risiko og usikkerhet hadde kunnet hindret 22. juli-hendelsene kan vi ikke vite, men en ting er sikkert: føres den rådende risikotenkning videre i vårt samfunn gambler vi høyt og vi bruker våre ressurser på en lite effektiv måte. Et stort antall internasjonale eksperter innen risikoanalyse har ropt et varsko i flere år men lite har skjedd. Endringsviljen har vært påfallende svak. Forhåpentligvis er

til vår kunnskap. Dette usikkerhetsaspektet er ikke lett å tallfeste, ikke desto mindre er det en viktig side ved risikoen. Den rådende tenkning svikter også her. Beslutningstakerne blir ikke informert på en god nok måte hvis ikke dette aspektet av risiko vies oppmerksomhet.

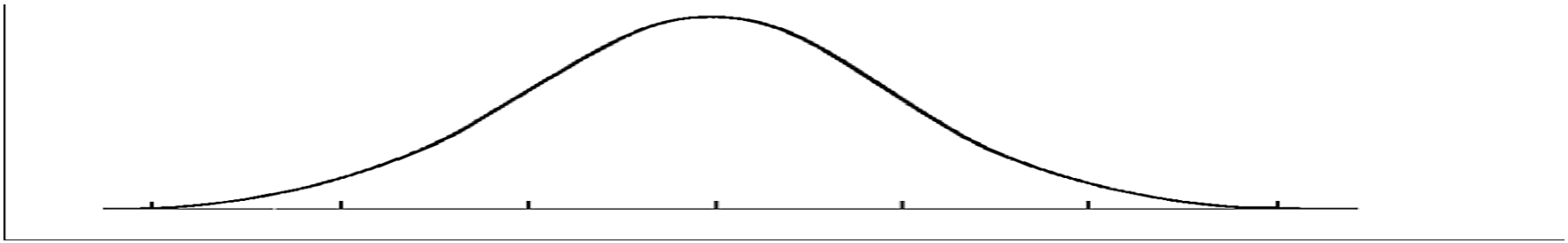
Kommisjonen omtaler usikkerhetsaspektet på side 70 i rapporten, når de skriver «Når det gjelder terrorangrep, er det knyttet stor usikkerhet til risikoen». Men problemet er ikke usikkerhet knyttet til forventningsverdien (som er måten Kommisjonen definerer risiko på),

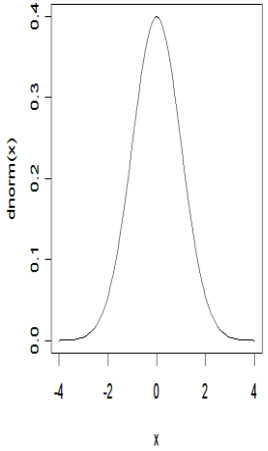
Politiets Sikkerhetstjeneste (PST) bruker ikke å tallfeste sannsynlighet i deres trusselvurderinger. Betraktninger gjøres av mulige angripers intensjon og kapasitet, men også her mangler tenkningen en skikkelig forståelse av kunnskaps- og usikkerhetsdimensjons plass i risikovurderingene.

Når vi nå skal vurdere ansvar i forhold til det som har skjedd, må vi også tenke hva myndighetene har gjort for å utvikle et hensiktsmessig tenkesett i forhold til risiko og samfunnssikkerhet. Min dom er klar. Myndighetene har sovet i

Stavanger Aftenblad 20 august

- For some experts “risk” equals expected loss of life expectancy (HM Treasury 2005, p. 33).
- Traditionally, hazmat transport risk is defined as the expected undesirable consequence of the shipment, i.e. the probability of a release incident multiplied by its consequence (Verma and Verter 2007).
- Risk is defined as the expected loss to a given element or a set of elements resulting from the occurrence of a natural phenomenon of a given magnitude (Lirer et al. 2001).
- Risk refers to the expected loss associated with an event. It is measured by combining the magnitudes and probabilities of all of the possible negative consequences of the event (Mandel 2007).
- Terrorism risk (Willis 2007): The expected consequences of an existent threat, which for a given target, attack mode, target vulnerability, and damage type, can be expressed as the probability that an attack occurs multiplied by the expected damage, given that an attack occurs.
- Flood risk is defined as expected flood damage for a given time period (Floodcite 2006).





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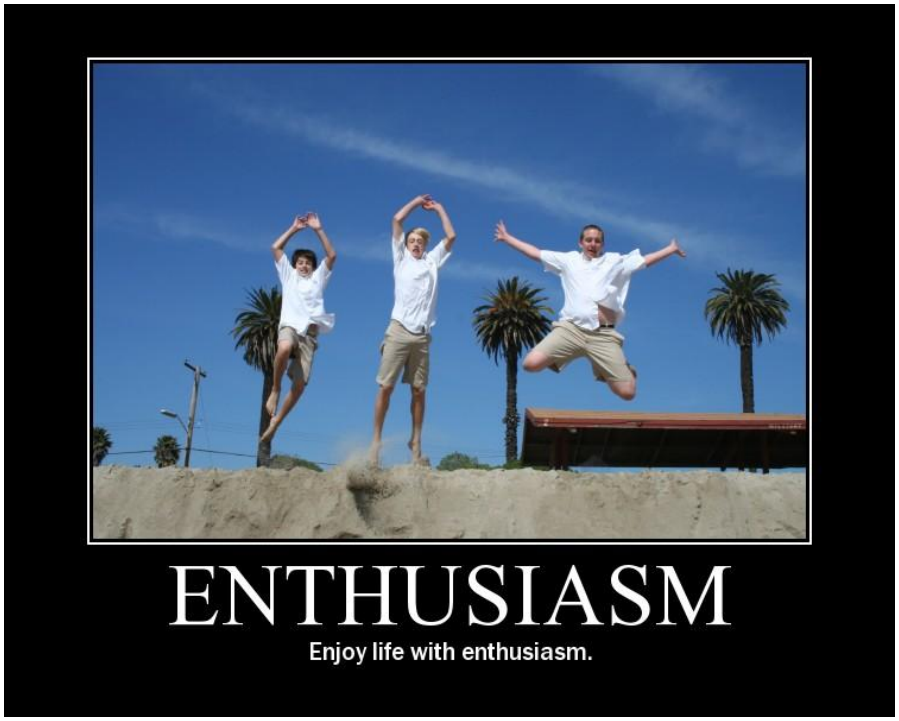
Existing frameworks, principles and concepts

Workshop



Revitalise the focus and enthusiasm for fundamental issues in the risk field

How should we proceed?

Foundational issues in risk assessment and risk management

Terje Aven, University of Stavanger, Norway

Enrico Zio, Ecole Centrale Paris and Supelec, France, Politecnico di Milano, Italy

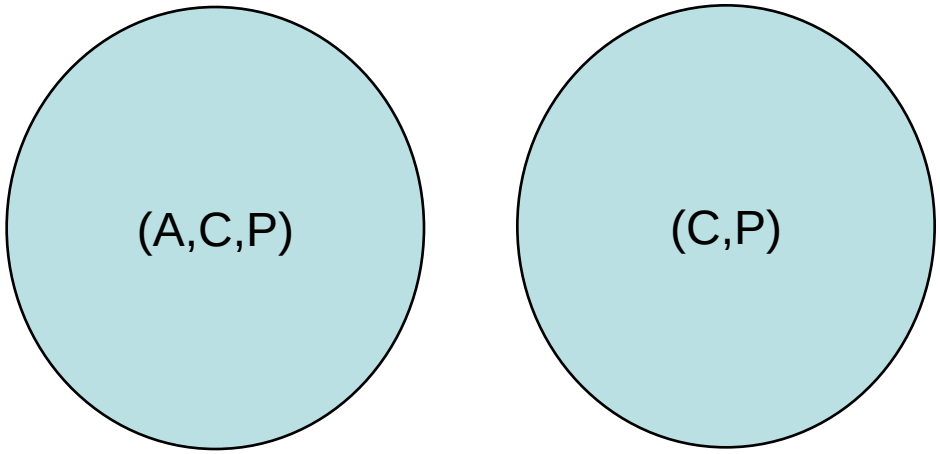
Ten scientific challenges/issues that need further research

Issue 1

- **Terminology and fundamental principles**

Issue 1

- **Terminology and fundamental principles**
  - **Risk concept**
  - **Precautionary principle**
  - **…**

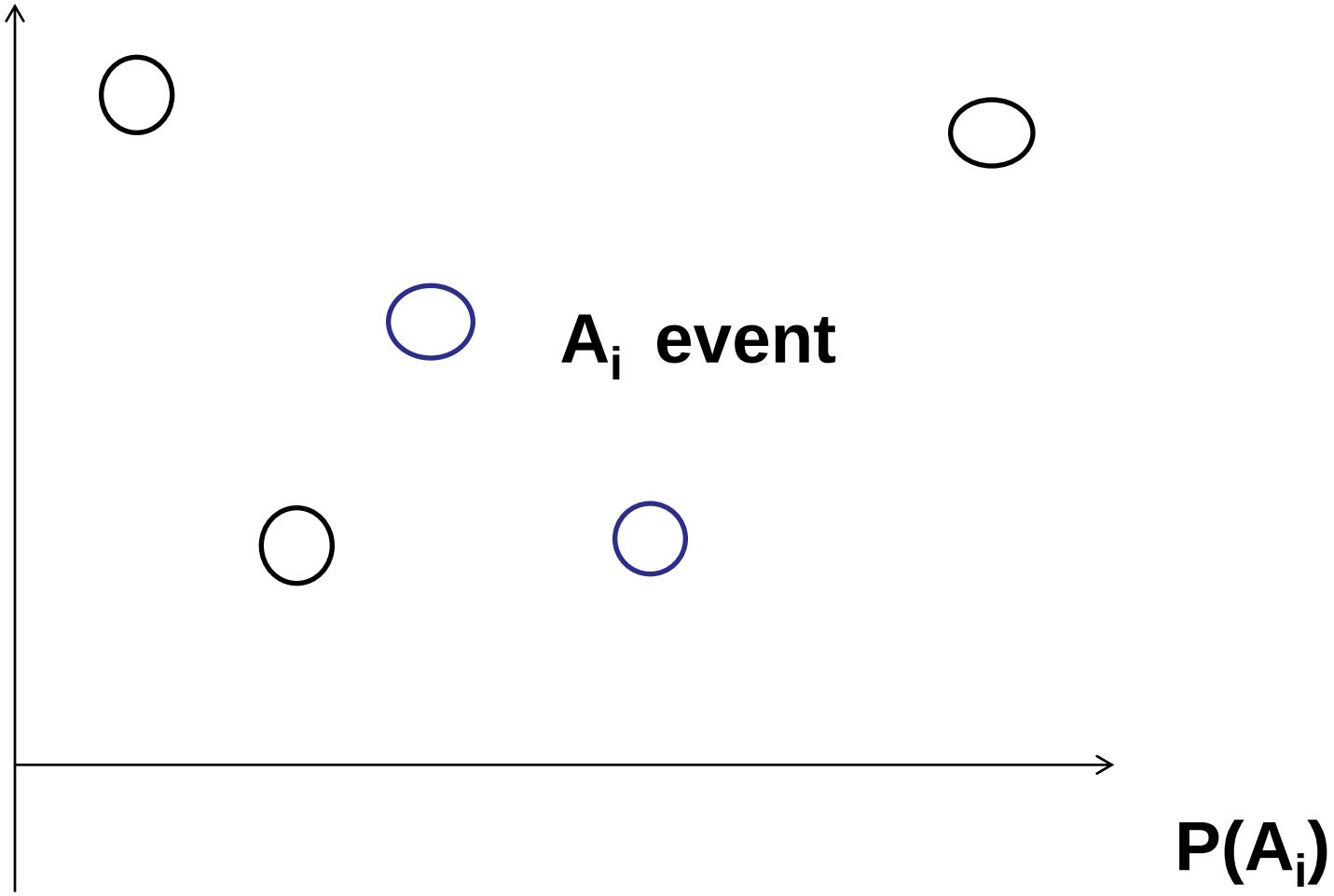


- Risk is a measure of the probability and severity of adverse effects (Lowrance 1976)
- Risk is the combination of probability and extent of consequences (SEVESO, Ale 2002).
- Risk is defined as the triplet (s,p,c), where s is the scenario, p probability and c consequence of the scenario (Kaplan and Garrick 1981)

A: Event, C: Consequences of A,

P: probability

$E[C|\ A_i\ ]$



Considerable risk aspects not measured by these two dimensions

- Strong deviation between $E[C|\ A_i\ ]$ and C given A_i
- poor understanding of the phenomena, little data, assumptions represent strong simplifications, experts disagree

Risk concept

- $P(A|K_1) = 0.2$ K_1 strong
- $P(A|K_2) = 0.2$ K_2 weak

- The background knowledge that the probabilities are based on could be completely different, but the numbers are the same

Risk concept cont.

- A quantitative risk assessment, which establish a risk description using probabilities, will always be based on a number of assumptions and these could conceal important aspects of uncertainty and risk

John offers you a game: throwing a die

- ”1,2,3,4,5”: 6
- ”6”: -24

What is your risk?

Risk

(C,P):

- 6 5/6
- -24 1/6

Is based on an important assumption – the die is fair

“Background knowledge”

Assumption 1: …
Assumption 2: …
Assumption 3: …
Assumption 4: …
…
Assumption 50: The platform jacket structure will withstand a ship collision energy of 14 MJ
Assumption 51: There will be no hot work on the platform
Assumption 52: The work permit system is adhered to
Assumption 53: The reliability of the blowdown system is p
Assumption 54: There will be N crane lifts per year
…
Assumption 100: …
…

Model: A very crude gas dispersion model is applied

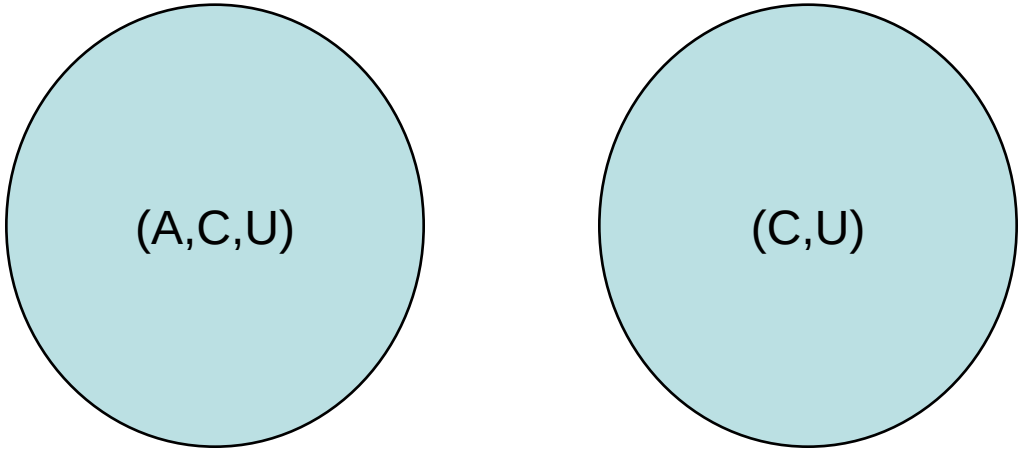
Risk concept cont.

- There is a need for seeing beyond the probabilities – must better cover the knowlede and lack of knowledge dimension

- We need a broader risk concept

- How should we reflect the uncertainties not adequately reflected by the probabilities ?

New Risk definition



A: Event, C: Consequences of A,

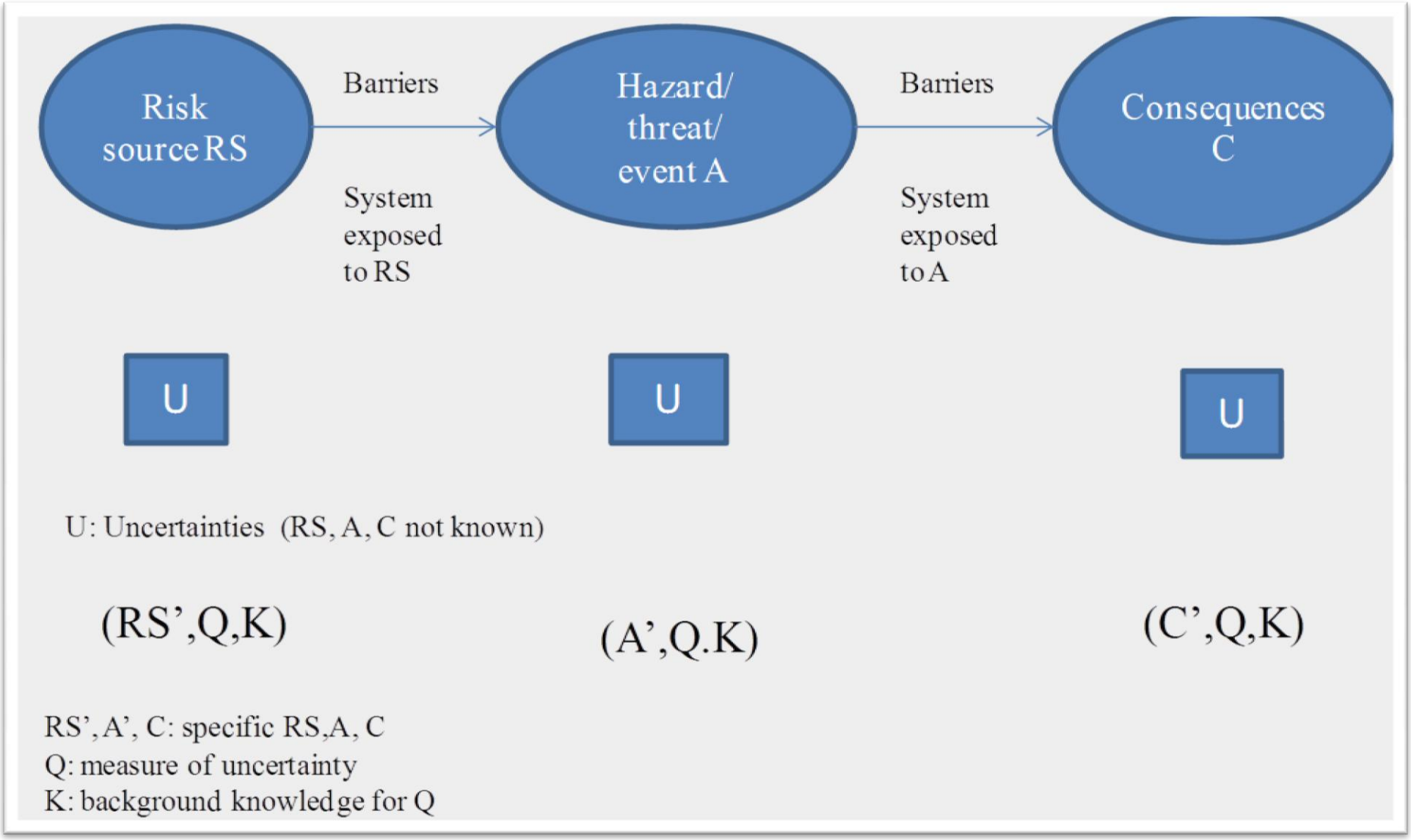
U: uncertainty

A broader risk concept

- Risk description (C', Q, K)

- C' = representations of C, for example the number of fatalities
- Q= measure of uncertainty, for example probability ….
- K= Background knowledge that Q is based on

More detailed model covering risk sources, hazards/threats and exposure



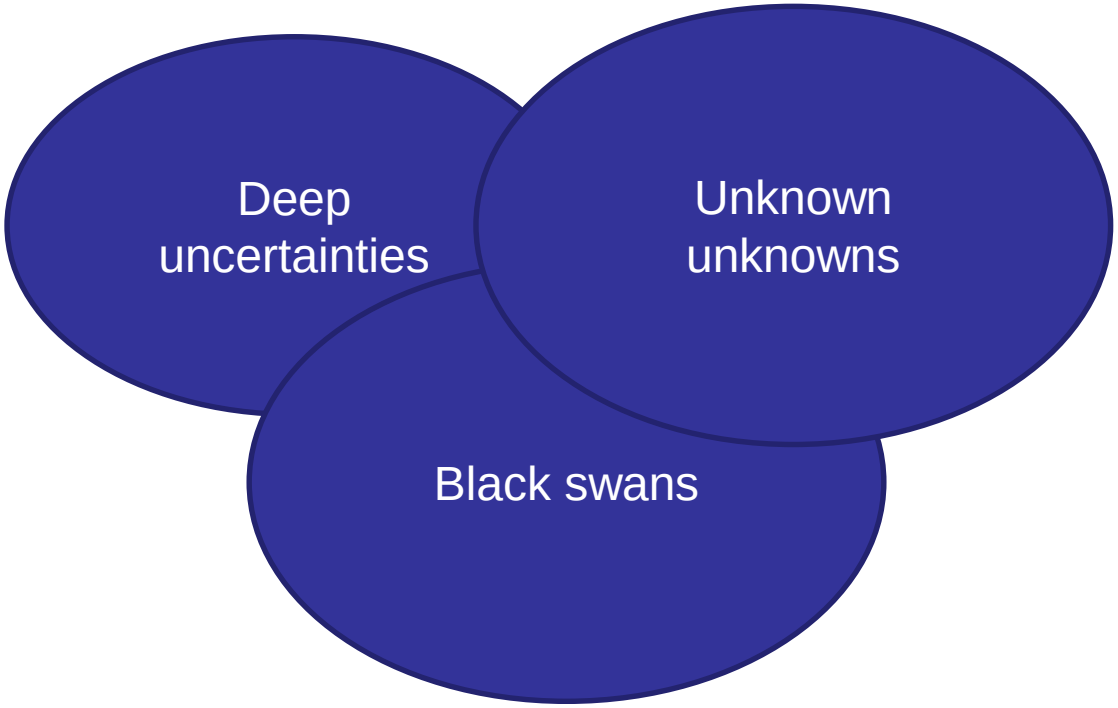
Issue 2

- The appropriate representation, characterization, and interpretation of uncertainty in a risk assessment context

- Q= P is problematic as discussed above
- Alternative approaches for Q – a research topic
- Quantitative methods (imprecision intervals, possibility theory, evidence theory)
- Qualitative methods

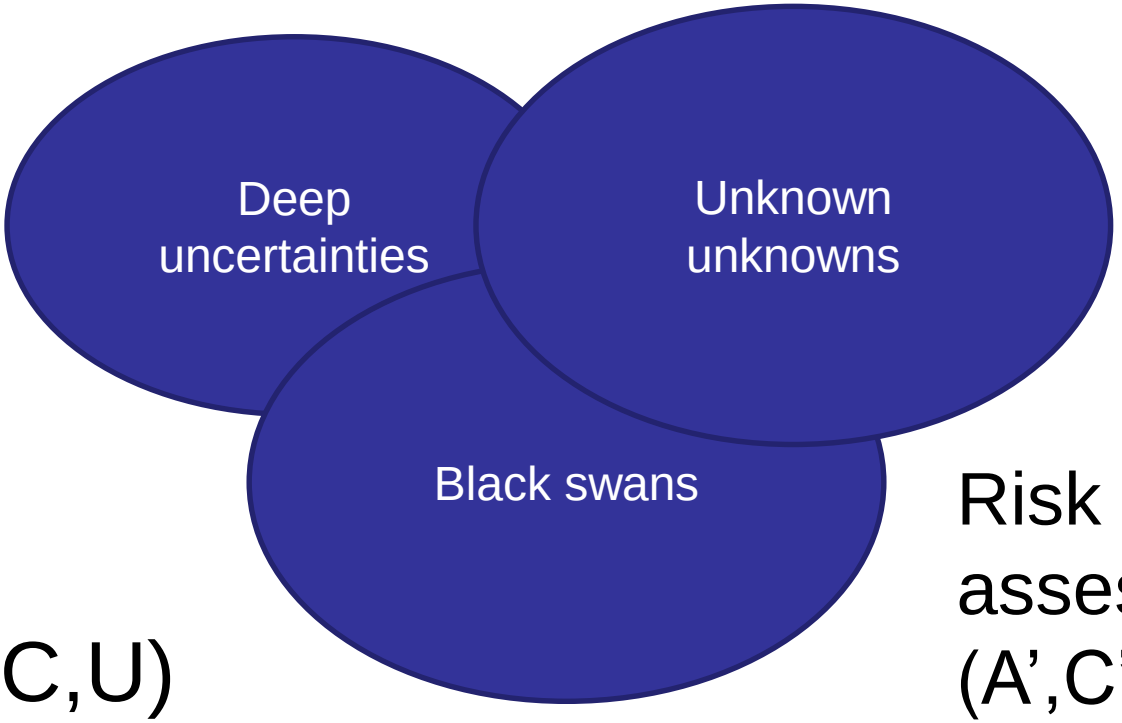
Issue 3

- **Risk management policies suitable for situations with deep uncertainties**



Issue 3

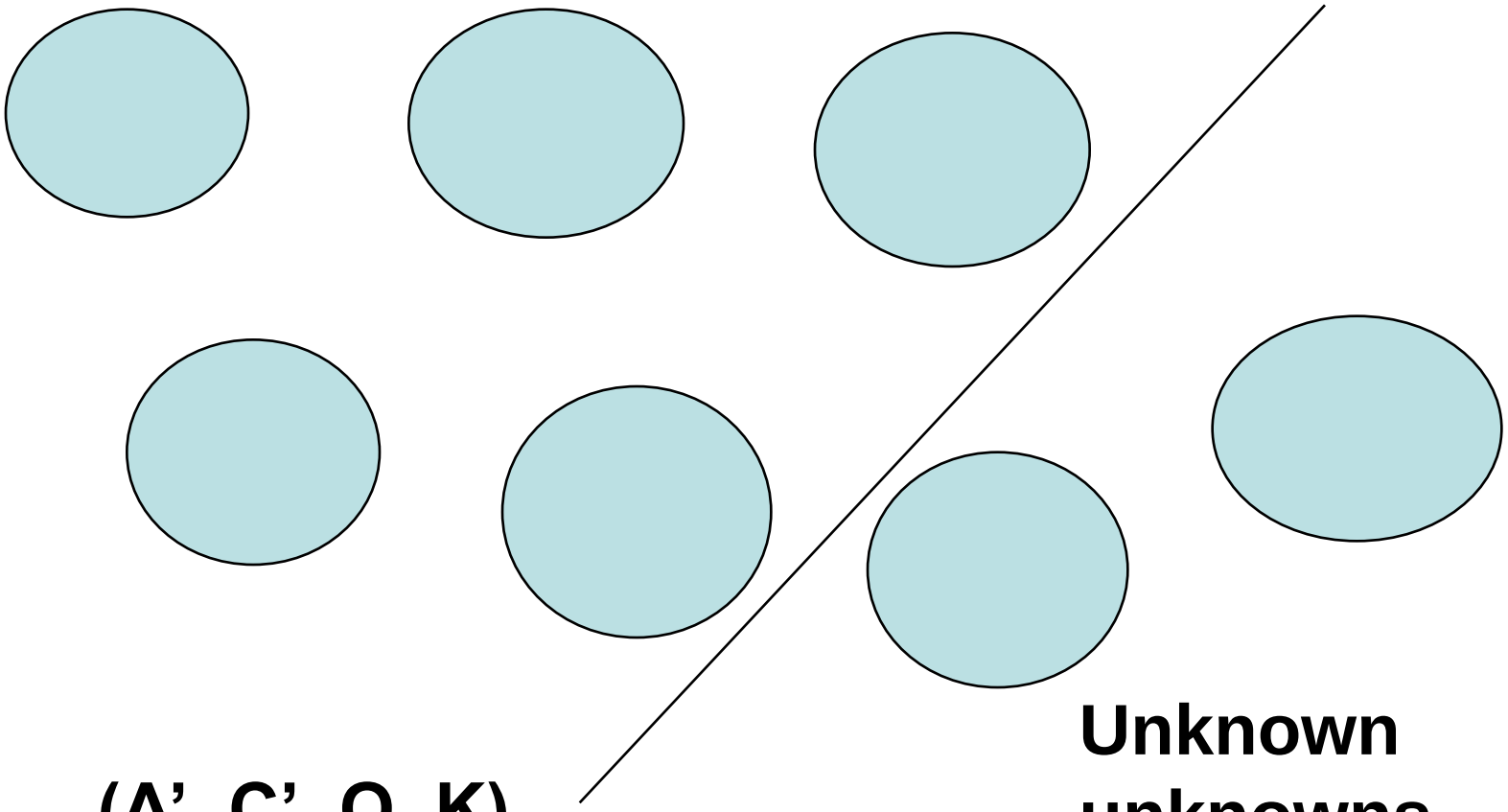
- **Risk management policies suitable for situations with deep uncertainties**



Risk (A,C,U)

Risk assessment (A',C', Q, K)

Threats



(A’, C’, Q, K)

Unknown unknowns (”black swans”)

Issue 4

- **Critical infrastructures, complex systems and systems of systems**

Issue 5

- **Probability and risk assessment in security applications**

PST

- Low: The likelihood of a terrorist attack is low. One or more parties may have the intention of, but are not thought to have the capacity to strike at specific interests.
- Moderate: The likelihood of a terrorist attack is moderate. One or more parties may have the intention of and capacity to strike at specific interests.
- High: The likelihood of a terrorist attack is significant. One or more parties have the intention and capacity to strike at specific interests. There is an unspecified threat.
- Extreme: The likelihood of a terrorist strike is extremely high. One or more parties have the intention to strike at specific interests. There is a specific threat. No further warnings are to be expected before a strike is carried out.

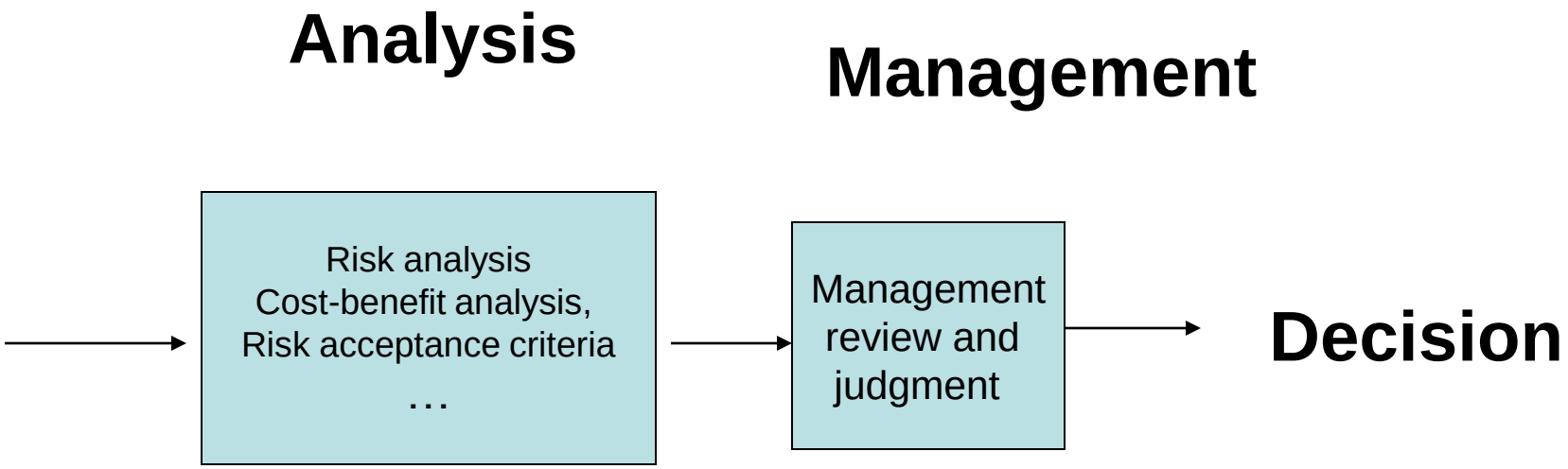
One or more parties may have the intention of and capacity to strike at specific interests.
Concerns about unknown unknowns. Strong knowledge.

Issue 6

- **Causality and risk analysis**

Issue 7

- **The separation between science and value judgments**



Risk-informed decision making

Issue 8

- **How and when to pay attention to some risk events and situations and not to others**

Issue 9

- **Societal risk decision-making**

Issue 10

- **The science of risk assessment**

Other issues

- How do domain science (psychology, technology, medicine, etc.) and risk analysis interact and integrate − what is the interface and why is it that way?
- How are risks treated in the political processes and discourses? What are the boundaries of the decision-making and the political processes?
- In intergenerational decision-making situations, what are the available frameworks and perspectives to be taken? What are other options? When are different frameworks more appropriate than others? How do we capture the key knowledge issues and uncertainties of the present and future? What duty of care do we owe to future generations?
- How can we clearly and unambiguously separate risk analysis (including uncertainty judgments) and decision analysis (including value judgments)?
- How can we extend decision theory to address practical risk management problems characterized by group decision-making?
- How can we develop an integrative framework for bridging analytical and cognitive approaches to risk science?
- In the understanding and developing of the theory of safety science, why do we have the safety principles we have, and how do these principles relate to probabilistic risk assessment methods?
- How can the cultural aspect of risk perception and risk management (not limited to safety culture) be accounted for, in relation to nations, politics, and incentives?
- How can we say how well we know risk? How can we define which is the proper level of risk analysis, depending on the (qualitative and quantitative) knowledge available (possibly including signals, precursors, near misses, warnings etc.)?
- How can we describe and represent the results of risk assessment in a way useful to decision makers, which clearly presents the assumptions made and their justification with respect to the knowledge which the assessment is based upon?

Other issues cont.

- How can we display risk information without misrepresenting what we know and do not know?
- How can we accurately represent and account for uncertainties in a way to properly justify confidence in the risk results?
- How can we state how good are expert judgments and how can we improve them?
- Can we structure methods/metrics (qualitative or quantitative) to effectively characterize detectability/foreseeability/controllability of hazards?
- How can we decide when one risk is larger than another?
- How can we help communities better manage risks? How can we determine which information would be most valuable for helping communities manage their risks?
- How can we better account for and include heterogeneities of values in the definition of the acceptability of risk?
- Under which conditions can risk analysis enable a consensus to be reached on risk and, thus on protective actions?
- How do different risk management and governance structures in different countries affect the use, role and controversy associated with science?
- How do fairness considerations in the distribution of risks and benefits across society (nations, groups, individuals) enter the picture?
- In the analysis of near-misses, how should we structure the multi-dimensional space of causal proximity among different scenarios in order to measure “how near is a miss to an actual accident”?

Some recent papers

- Aven, T. (2011) On the interpretations of alternative uncertainty representations in a reliability and risk analysis context. Reliability Engineering and System Safety. *3*, *353-360.**
- Aven, T. (2011) Selective critique of risk assessments with recommendations for improving methodology and practice. Reliability Engineering and System Safety. 96, *509-514.* *
- Aven, T. (2011) On the new ISO guide on risk management terminology. Reliability Engineering and System Safety, 96, 719-726. *
- Aven, E. and Aven, T. (2011) On how to understand and express enterprise risk. International Journal of Business Continuity and Risk Management, 2(2), 20-34.
- Aven, T. (2011) On different types of uncertainties in the context of the precautionary principle. Risk analysis. 31(10), 1515-1525. With discussion 1538-1542. *
- Jones-Lee, M. and Aven, T. (2011) ALARP—What Does it Really Mean? Reliability Engineering and System Safety..96, 877-882. *
- Aven, T. (2011) On risk governance deficits. Safety Science. 49(6), 912-919. *
- Selvik, J.T., Scarf, P. and Aven, T. (2011) An extended methodology for risk based inspection planning. Reliability & Risk Analysis: Theory & Applications, 2 (1), 115-126.

Recent papers cont.

- Aven, T. Renn, O. and Rosa, E. (2011) On the ontological status of the concept of risk. Safety Science. 49, 1074–1079. *
- Aven, T. and Hiriart, Y. (2011) The use of a basic safety investment model in a practical risk management context. Reliability Engineering and System Safety, 96, 1421–1425.
- Abrahamsen, E. and Aven, T. (2012) Why risk acceptance criteria need to be defined by the authorities and not the industry. Reliability Engineering and System Safety. *
- Aven, T. (2012) The risk concept. Historical and recent development trends. Reliability Engineering and System Safety. *
- Aven, T. (2012) On the critique of Beck's view on risk and risk analysis. Safety Science. *
- Aven, T. and Renn, O. (2012) On the risk management and risk governance for petroleum operations in the Barents Sea area. Risk Analysis*
- Flage, R., Aven,T., Baraldi, P. and Zio, E. (2012) Probability and possibility based representations of uncertainty in fault tree analysis. Risk Analysis.*
- Aven, T. (2012) On the link between risk and exposure, Reliability Engineering and System Safety.*
- Aven, T. (2012) How to define and interpret a probability in a risk and safety setting. Safety Science. *
- Aven, T. (2012) On the meaning and use of the risk appetite concept . Risk Analysis. *
- Veland, H. Aven, T. (2012) Risk communication in the view of different risk perspectives . Reliability Engineering and System Safety.

Topics addressed the coming year

- Integrated risk management, enterprise risk management (helhetlig risikostyring)
- Different aspects of foundations of risk assessment and risk management:
  - Risk assessment and science
  - Black swans, deep uncertainties
  - Alternative representations of uncertainties than probability
  - Climate change assessments and treatment of uncertainties