

Risk, uncertainty and decision support

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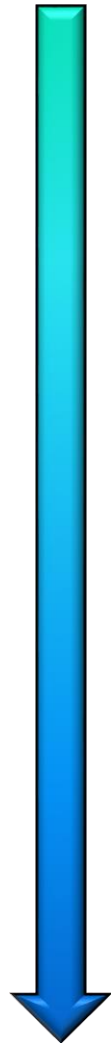


STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Governance of radiological risk after nuclear accidents poses several challenges

- Scientific and societal uncertainties
- Differing perceptions of risk
- Disagreement between experts
- Asymmetrically perceived risks and benefits
- Societal distrust
- Stigma associated to affected areas

Risk communication: from information provision to engagement




- All we have to do is **get the numbers right**
- All we have to do is **tell** them the numbers
- All we have to do is **explain** what we mean by the numbers
- All we have to do is show them that they've accepted **similar risks**
- All we have to do is show them that it's a **good deal** for them
- All we have to do is **treat them nice**
- All we have to do is make them **partners**
- **All of the above**

- Uncertainty?
- What numbers?
- Effects for whom?
- Justification of exposure?
- **Social values**
- **Ethical considerations**
- **Engagement (response and preparedness)**

Dealing with uncertainty

- Behaviour is driven mostly by perception, rather than facts or what is understood as facts by risk analysts and scientists (Renn 2008)
 - Common sense reasoning
 - Personal experience
 - Social communication
 - Cultural traditions
- People's sense making of and behaviours in relation to events or actions with uncertain consequences are influenced by their "expectations, ideas, hopes, fears and emotions" (Renn 2008)

Kim Clijsters geeft Jada jodium tegen radioactieve wolk

23/03/2011 om 08:17 door ikerremans  Print



Kim Clijsters geeft Jada jodium tegen radioactieve wolk

Foto:



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shares

Kim Clijsters wil dochter Jada beschermen tegen de radioactieve wolk uit Japan. Ze mengt nu zelfs jodium in de yoghurt van Jada en past ook voor de tornooien van Peking en Tokio.

Dealing with uncertainty

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- "Relatively consistent patterns of creating images of risks and evaluating them" (Renn 2008)

COping with **uN**certainties **For** **I**mproved modelling and **DE**cision making in **N**uclear emergen**CI**Es

- Social, ethical and communication aspects of uncertainty management
 - Stakeholders' response to uncertainty in past incidents and accidents;
 - Implications of different types of uncertainty and relationships to ethical issues;
 - Behavioural intentions and information needs in relation to protective actions in emergency situations;
 - Differences in mental models of uncertainty management for lay citizens and emergency actors in various national contexts.
- Robust decision making
 - Uncertainty handling and "robust" decision making using MCDA (multi-criteria decision analysis)

Outline of the remainder of this presentation

- Rationales for communicating risk, uncertainty and variability to decision-makers and lay publics
 - rationales
 - challenges
 - implications on subsequent decision-making processes
- Vulnerability analysis as a point of convergence between
 - safety science
 - science and technology studies
 - and multi-criteria decision aid

What is risk?

- “Risk is risk perception” → Beck (1992), Jassanoff (1999) question the separation of scientific assessment from perception

Average expected damage vs. perception, voluntary consent, control over risk, risk distribution, potential for disaster (worst possible scenario, independent of probability)



higher weight in perceiving/evaluating risk
(Renn, 2008)

- Studying risk perception can contribute to improving risk policies (Fischhoff, 1985)
 - Reveals people's concerns and values
 - Provides indicators for preferences
 - Helps design risk communication
 - Highlights personal experiences

What is risk?

- Different risk estimates needed, depending on values attributed to the outcomes at stake (Pidgeon and Fishhoff 2011) → *not only health consequences*, but also
 - Vulnerable groups: health consequences for whom?
 - Impact on economy: who bears the costs?
 - Impact on environment: who bears the risks?
 - Impact on culture
 - Psychological characteristics of risk (voluntary, controllable, ... etc).
- Societal priorities for risk mitigation actions may not align with those identified by expert groups.



- Communication about risk should include information about wider social values (Frewer 2004)
- Simply communicating about the impact on human health would probably be unacceptable to the public (Frewer, 1999)

Why is communication of uncertainty necessary?

- Scientists must provide the information that is necessary for informed choices (Pidgeon and Fischhoff 2011)

L'Aquila quake: Italian judge explains why he jailed scientists over disaster

Experts sentenced to six years for manslaughter after giving 'generic and ineffective' risk assessment, says judge

Lizzy Davies in Rome

guardian.co.uk, Friday 18 January 2013 17.27 GMT



Why is communication of uncertainty necessary?

- Scientists must provide the information that is necessary for informed choices (Pidgeon and Fischhoff 2011)
- Lay people can understand risk related information, but use a **broader range of dimensions** to make judgments about those risks
 - Johnson and Slovic (1995) investigated lay understanding of technical risk estimates → although unfamiliar with the notion of uncertainty in risk assessment, only 20% of their respondents had difficulties with uncertainty per se.
 - Acknowledgement of uncertainties facilitates decision-making, if results are framed as **relative risks of action and inaction**



- Communication contents should be targeted and specific enough to aid informed decision making

Why is communication of uncertainty necessary?

- “If trust is lacking no form or process of communication will be satisfactory” (Slovic 1993)
- Acknowledgement and communication of uncertainty **increases public confidence** in regulatory processes (Frewer et al., 2002)
 - → *but possibly lowers perceived competence?*



- Communication about risks should include and respond to associated uncertainties (including the nature and extent of disagreements between different experts)

How to communicate uncertainty?

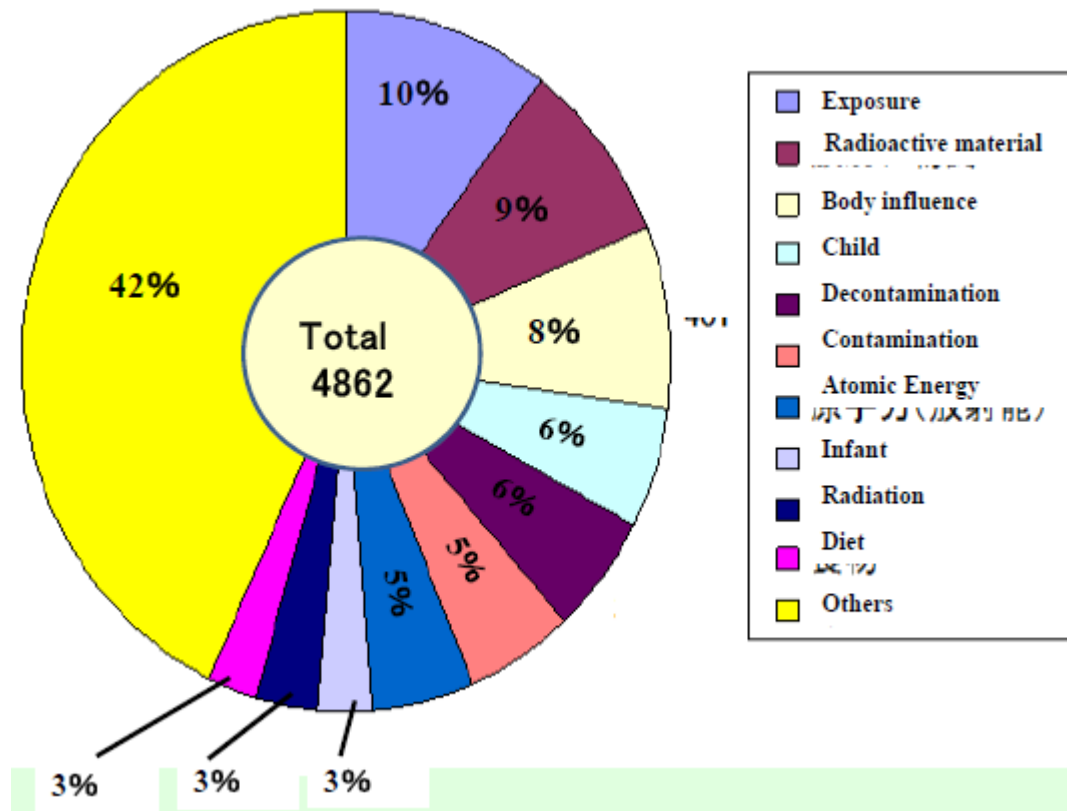
- The **type of uncertainty** should be specified (Brown and Ulvill 1987), e.g.
 - Outcome uncertainty ("what might actually happen and with what probability")
 - Assessment uncertainty ("to what extent are the results of the analysis likely to change with additional information")
- **Ambiguity of a target event** should be differentiated from its **underlying uncertainty** (Budescu et al 2009)
 - E.g.: "it is **unlikely** that a **large accident** will occur" → too ambiguous
 - Define target events as precise as possible
- **Sources of uncertainty** may need clarification, e.g.
 - Incomplete understanding of a process,
 - Imperfect information about its parameters,
 - Unreliability of measurements,
 - Insufficient data,
 - ... other.

How to communicate uncertainty?

- Highlight the **impact of uncertainty on protective actions**
 - The public has little need for technical detail; what is needed is the information on how to cope with the hazard (Renn 2008)

Results* from a Q&A website in Japan (Kono et al 2012)

Main topics: **pathways**, **radiation and radioactive material**, effects on **health**, effects on **children**, **decontamination**, **diet**, other



*Questions asked via dedicated website, active between March 2011 till February 2012, but inactive from May 26 to June 5, and from July 2 till August 21 due to overload

How to communicate uncertainty?

- Lay people can often extract needed information from clear numeric expressions of uncertainty, but have difficulties with ambiguous verbal quantifiers (e.g. 'unlikely', 'probable') (Budescu et al 2009)
- Graphical presentation of uncertainty produces higher comprehension (Johnson and Slovic 1995) (but somewhat lower trustworthiness?)
- The absolute magnitude of risk estimates influences people's confidence in its accuracy (Johnson and Slovic 1995, 1998)
 - Low estimates deemed more "preliminary"
 - Zero lower bounds may cause concerns that risk is probably higher, and people may worry more often than if small positive lower bounds are used.



- Use various, combined modes of presenting uncertainties (e.g. both verbal terms and numerical values)
- Attention to lower risk bounds

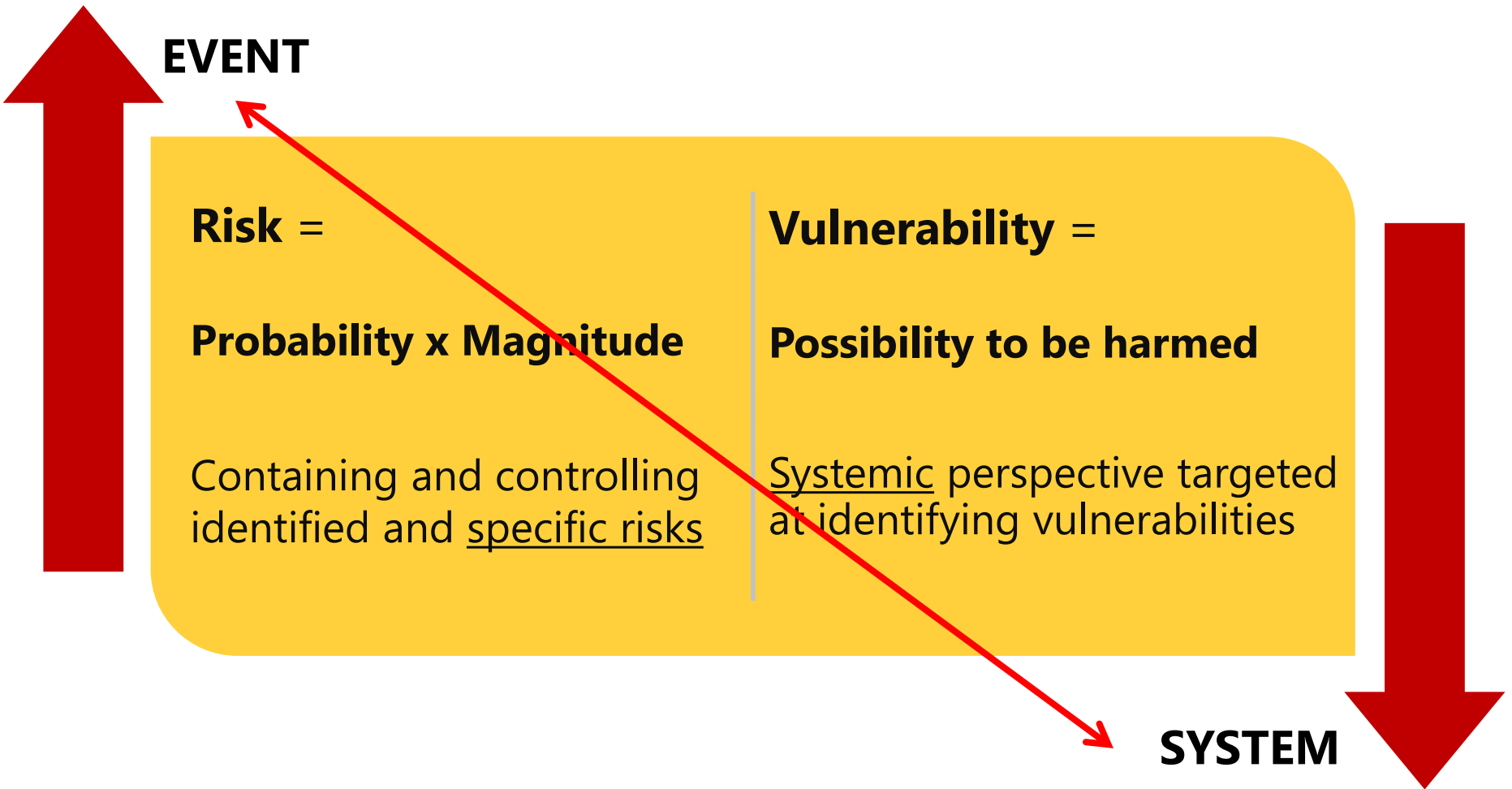
Uncertainty vs. variability

- “Uncertainty forces DM’s to judge how probable it is that risks will be overestimated or underestimated **for every member** of the exposed population” (NRC, in Thompson 2002)
- “Variability forces DM’s to cope with the certainty that **different individuals** will be subjected to risks both above and below any reference point one chooses”
 - Identification of sub-populations “at risk” → Implications for allocation of resources



- Communicate to decision-makers both uncertainty and variability (distributions instead of average estimates, Thompson 2002)
- Targeted communication to at risk individuals

Vulnerability and risk



Multi-Criteria Decision-Aid

- Decision-support tool originating from operation research
 - Decision **aiding** instead of decision-**making**
 - Supports the search for a **compromise solution**
- Accepts **multiple dimensions** (radiological, environmental, social...)
 - Evaluation criteria expressed in natural units (vs. conversion to monetary costs as in Cost Benefit Analysis)
 - Qualitative and quantitative evaluations
- Includes **stakeholders' values and preferences**
 - Supports best practice in stakeholder involvement

Problem formulation → Analysis of options → Decision

Decision Problem

MCDA

CBA

Establish decision context

Identify objectives, key concerns

Identify decision options

Set of
evaluation criteria

Identify impacts

Determine which impacts are
economically relevant

Physical quantification of
relevant impacts

Monetary Valuation of
Relevant Effects

Discounting of cost and
benefit flows

Evaluate or compare
options against criteria

Aggregate preferences
(e.g. by weighting criteria)

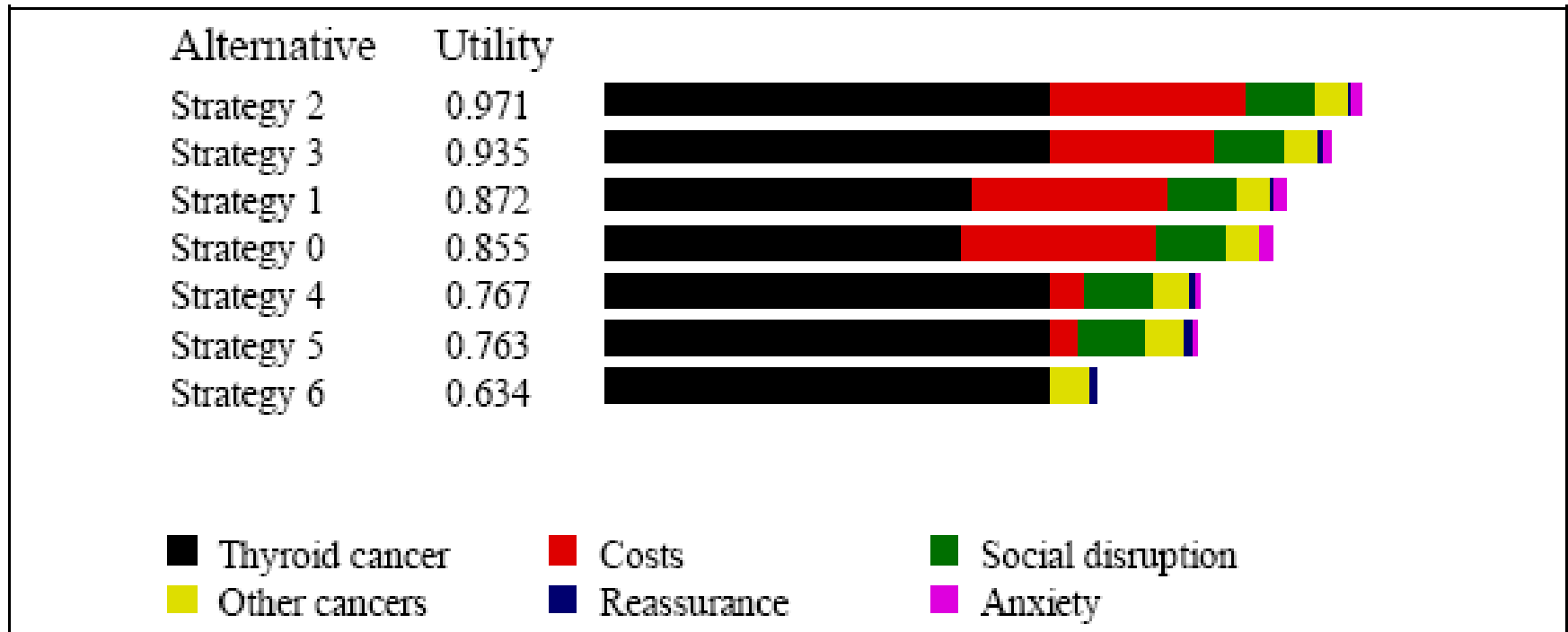
Examine results

Conduct sensitivity /robustness analysis

Adapted from
Gamper et al,
2006)

MCDA example-

Application of MAVT to derive overall value/utility scores



Weights: $w(\text{Health})=0.53$, $w(\text{Socio-psycho})=0.10$, $w(\text{Cost})=0.37$

The higher the utility, the better is considered an alternative

Source: Hämäläinen, R.P., Sinkko, K., Lindstedt, M.R.K., Amman, M. and Salo, A., 2000. Decision analysis interviews on protective actions in Finland supported by the RODOS system. STUK-A 173 Report, STUK - Radiation and Nuclear Safety Authority, Helsinki, Finland. ISBN 951-712-361-2.

- Different interpretations (Dias, 2006; Hites *et al* 2006)
- Robustness of a decision is a measure of flexibility:
 - → the potential of a decision taken at a given moment to allow for achieving near-optimal states in the future, in conditions of uncertainty (Rosenhead *et al* 1972)
 - → one that is always near, or does not contradict solutions corresponding to other admissible (model) parameter instances (Vincke 1999)
- Robustness analysis is the process of elaborating recommendations founded on robust conclusions.
 - → can be extended to address vulnerability analysis issues.

Robustness Analysis ex-ante: embedded in a model to be optimised

- Kouvelis and Yu (1997) defined several measures of robustness.
 - Absolute robust solution (best performance in worst case scenario):

$$X_r^{abs} = \arg \max_C \min_s V(C,s), \text{ where}$$

C denotes countermeasure strategies, s scenarios and

$V(C, s)$ is the *value* of strategy C under scenario s (V is to be maximised).

- Deviation robust solution (smallest deviation from scenario best):

$$X_r^{dev} = \arg \min_C \max_s d(V(C,s) - V(C_s^*,s)), \text{ where}$$

C_s^* is the optimal strategy for scenario s , d is a distance measure

Substituting or complementing sensitivity analysis

Dias and Clímaco (1999) classified **robust conclusions** (valid for all admissible instances of a decision aid model parameters, *or scenarios*) in:

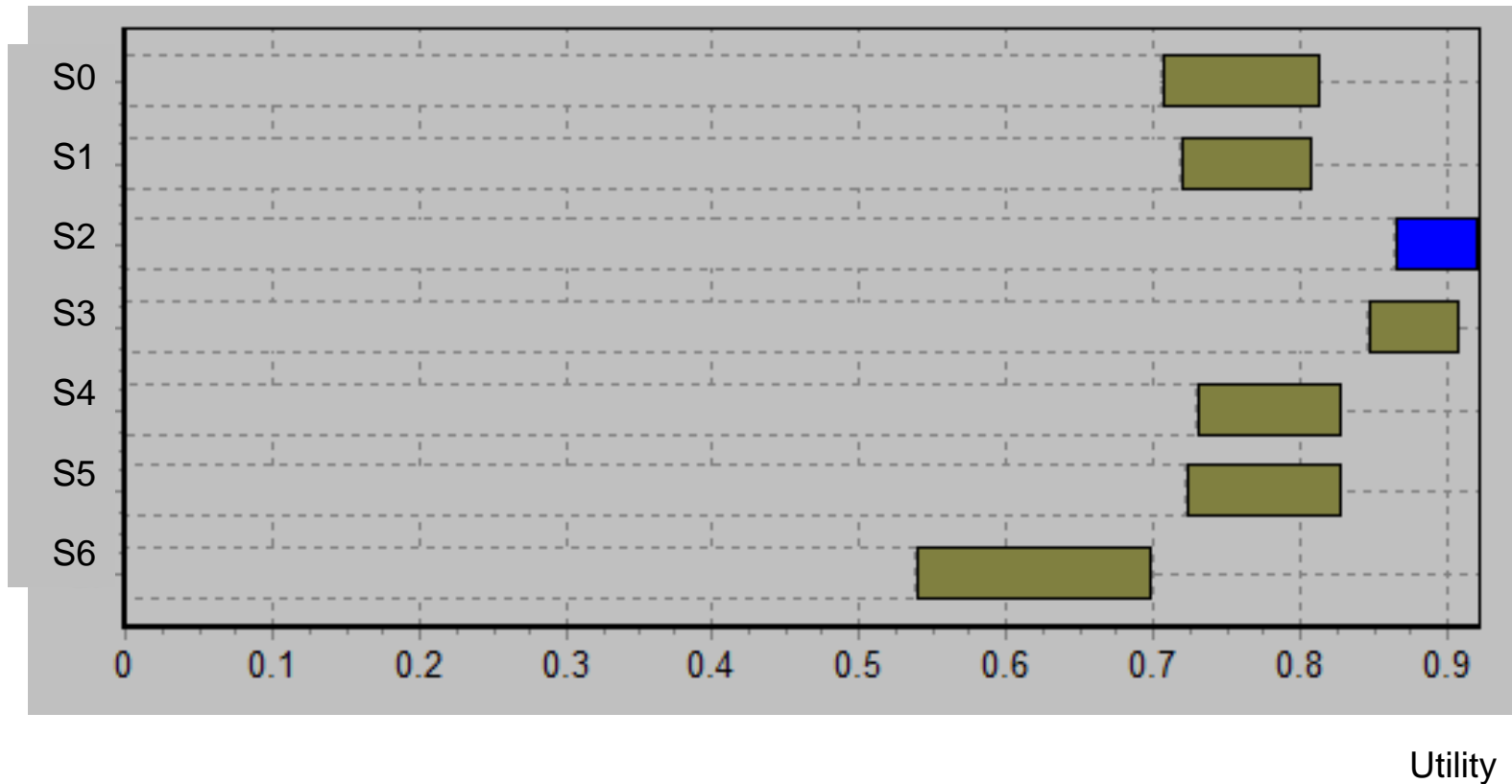
- **Absolute robust**

- → referring to one alternative only, independently of the others
- E.g. "utility $u(a) > 0.5$ "

- **Relative robust**

- → referring to one alternative in relation to others or to a pair of alternatives
- E.g. "alternative a has a better rank than b " or "alternative a has the best rank".

MCDA example- Application of robustness analysis w.r.t. criteria weights



Dias, L. C. & J. N. Clímaco (2000) "Additive Aggregation with Variable Interdependent Parameters: the VIP Analysis Software", JORS 51(9): 1070-1082.

Vulnerability and emergency preparedness

- The Science and Technology Studies approach to vulnerability
 - Vulnerability is socially-constructed, and emergent
 - Positive aspects of vulnerability
 - Technological cultures

Exposure

Sensitivity

Adaptive capacities



Preparedness

→ **Participatory vulnerability analysis**

Vulnerability and emergency preparedness

- Emergency plan as a socio-technical object (Rossignol et al, 2014)
- Focus group study in 2010-2011 on three cases
 - Area around SEVESO plant (general emergency plan)
 - Participants: citizens
 - School near Tihange NPP (nuclear scenario)
 - Participants: teachers, educators, staff
 - City of Liège (chemical scenario)
 - Participants: first responders, medical emergency personnel, municipal authorities



- Identify socio-technical factors that can
 - **Hinder emergency planning**
 - **Stimulate people's adaptive capacity.**

Vulnerability and emergency preparedness

- Reality check for emergency plans

- 'Where should we gather the 1000 students?';
- 'How can we provide food?';
- 'How do we know that they are all in school?';
- 'How should we react if parents want to take their child home while a sheltering measure is on?';
- 'What if half of the teachers run away, letting the others take care of the pupils?'

+

- Gain awareness of & enhance capacity to adapt to new situations
- Initiate mutual learning process among the participants
- Question the relations between decision-makers, experts and citizens

- There are normative, substantive and instrumental reasons for communicating uncertainty and variability to decision-makers and lay publics
- Communicating is not just about providing knowledge – but also about tackling ethical issues, lay beliefs and concerns
- The classical risk analysis paradigm can be enriched with vulnerability analysis
- More research is needed... → EC CONFIDENCE project
- 10 Lessons from Fukushima:
 - “When creating these [legal] systems [of protection], it is absolutely essential that the **affected communities and individuals themselves** can be **at the center of the process**” (Fukushima Committee Booklet)

“Radiation Protection is informed by science, but driven by personal and social values”



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