Meaning of Different Types of Uncertainty in Supporting Decision Making

Simon French (University of Warwick, UK)

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

Uncertainties and emergencies

- Emergency management must face many uncertainties
- The list on the right comes from *D 9.28 Report on observational study of emergency exercises: List of uncertainties*
  - It is on your memory stick.

Terminology

We are necessarily taking a *very* multi-disciplinary approach on this course. So beware

- Some words are used differently in different disciplines
  - Different words are used for the same concept
  - the same word for different concepts

- What is the origin of the first information?
- Is the information exchange sufficient?
- Which tools of information exchange are reliable?
- How to deal with time pressure?
- Which factors impact information exchange?
- How is information understood by different stakeholders?
- Is information consistent?
- Are all emergency actors informed timely?
- How to communicate negligible impacts?
- Is Information Communication Technology reliable?
- Which information is public and which information should be restricted to the emergency management?
- How public communication/information needs will be addressed effectively?
- Which areas will be affected?
- How serious is the accident?
- How to decide on protective actions?
- Which protective actions to apply?
- How to implement protective action?
- Will people follow the instructions or recommendations given?
- How to deal with long-term consequences?
- When is the time of the beginning of the release?
- How to deal with technical aspects (e.g. source term) during the early phase of the emergency?
- Is radiological assessment consistent?
- How to interpret dispersion models maps?
- How to coordinate cross-border aspects?
- How coordination and collaboration among emergency response actors will be achieved?
- Is there a gap between legislation (including plans) and reality ?
- Are the preconditions of the functioning systems taken into account?
- Are all emergency response actors familiar with their roles, procedures and plans?
- Are the available resources adequate?
- Are the emergency actors familiar and trained to use equipment?
- Are social and ethical considerations taken into account?
- What comes first: Safety or security?

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Different types of uncertainty

- Uncertainty can take many forms
- There have been many categorisations
  - Some emphasising one characteristic of uncertainty; some another
  - None truly exhaustive

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Uncertainties

- Stochastic or Aleatory (physical randomness)
- Actor (behaviour of others)
- Epistemological (lack of knowledge)

- Judgemental (what to include in models and analyses)
- Computational (inaccurate calculations – and mistakes)
- Modelling error (imperfect fit of the real world)

- Ambiguities (ill-defined meaning, e.g. choice of attributes)
- Value, Social and Ethical (partially formed preferences)
- Depth of Modelling (Is the analysis requisite for its purpose)

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These are only some types of uncertainties!

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Knowledge of External World

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Modelling and Analysis Errors

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Internal Uncertainties about Ourselves

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Uncertainties

Scientific Uncertainty

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Knowledge of External World

Usually ignored

- Judgeme de in models and analyses)
- Computatio te calculations – and mistakes)
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Modelling and Analysis Errors

Needs to be resolved by deliberation

- e.g. choice of attributes)
- ally formed preferences)
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Probability Modelling

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Probability Modelling
Adversarial Risk Analysis

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Bayesian Probability Modelling (Classical Statistics)

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Modelling and Analysis Errors

Expertise & Experience
Sensitivity & Robustness Analysis

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Numerical Analysis
Emulation Studies

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Very Difficult.
Expertise and Judgement

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Deliberation

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Judgement:
Emergencies ⇒ decision must be made

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Deep or Knightian Uncertainty

- Knight (1921) distinguished:
  - **Risk**: probabilities known and available
  - **Strict Uncertainty** , now often called **deep uncertainty**: probabilities unknown or unavailable and no relevant data available (within time constraints)
- What happens when some uncertainties are *so deep* that while an expert might express uncertainties as probabilities, the range of these probabilities over a group of experts is effective 0-1?
- Sensitivity analysis will give almost anything as possible.
- Some uncertainties are ***too great*** to build a ***'useful'*** model or analysis.

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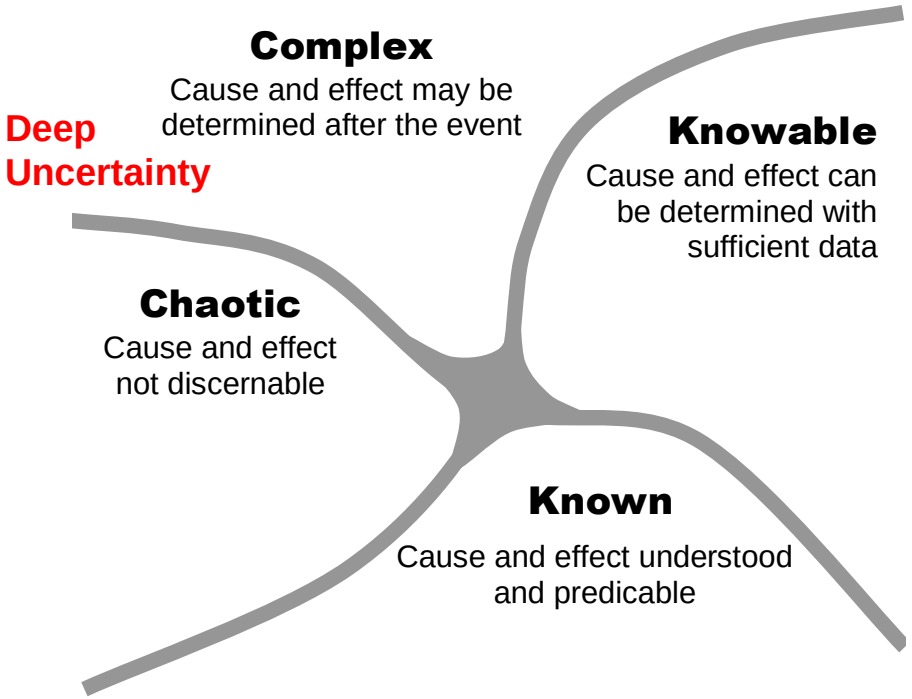
Uncertainty versus Knowledge

- Uncertainty is the opposite of knowledge
  - Uncertainty ⟷ Knowledge
- The Cynefin categorisation of contexts:
  - Relates to decision-making
  - Knowledge of cause and effect
- Typically in an emergency
  - We begin in the Complex or even Chaotic domain
  - As we understand the causes of the event we move into the Knowable domain and eventually into the Known domain.
- We learn both about *what is happening* and *our values* applied to the emergency



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Dealing with External Uncertainties

Uncertainty	Examples	Approaches to modelling and analysing
Stochastic or Aleatory (physical randomness)	• Occurrence and patterns of precipitation • Actual numbers and locations of the local population at the time of the release • Long term radiation related health effects	• Probability modelling and statistical analysis
Implementation and compliance (effectiveness of strategies)	• Compliance of population with advice on protective measures (e.g. sheltering vs. spontaneous evacuation) • Radiation protection behaviour (e.g. consumer behaviour towards products with residual radioactivity)	• Psychological study of real and expected behaviour • Identification of vulnerable groups • Probability modelling drawing on expert judgement
Epistemological (lack of scientific knowledge)	• Source term characteristics: time profiles of radionuclide mix, energy, etc. • Course and shape of plume and deposition	• Normal uncertainty Probability modelling and statistical analysis
		• Deep uncertainty Exploration of several scenarios
Judgemental (e.g. setting of parameter values in codes)	• Parameters within models and computer codes • Compliance of population with advice on protective measures	• Sensitivity analysis • Monte Carlo analyses
Computational (inaccuracy in calculation)	• Accuracy of approximations used in atmospheric dispersion and deposition models	• Bounds from numerical analysis • Probability modelling of error distributions if stochastic approximations or statistical emulation used
Modelling (i.e. however good the model is, it will not fit the real world perfectly)	• Discrepancy between model and reality if model based on accurate parameters and data and calculations performed perfectly	• Highlight modelling limitations • Experience, including model-model intercomparisons

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Dealing with Internal Uncertainties

Uncertainty	Examples	Approaches to modelling and analysing
Ambiguity, lack of clarity and values (ill-defined meaning)	• How should Endpoints be described, what matters • Importance of different criteria in evaluating endpoints	• Stakeholder engagement processes
Social and ethical (i.e. how expert recommendations are formulated and implemented in society, and what their ethical implications are)	• Values and principles underlying expert recommendations (e.g. consent, equity, fairness). • Trade-offs between groups and values	• Naturalistic observation of decision processes • Multi and transdisciplinary dialogue, • Assessment against recognised ethical principles.
Depth of modelling	• Is the analysis requisite?	• Judgement, experience and pragmatism

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Thank You

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