Risk Assessment in CCS

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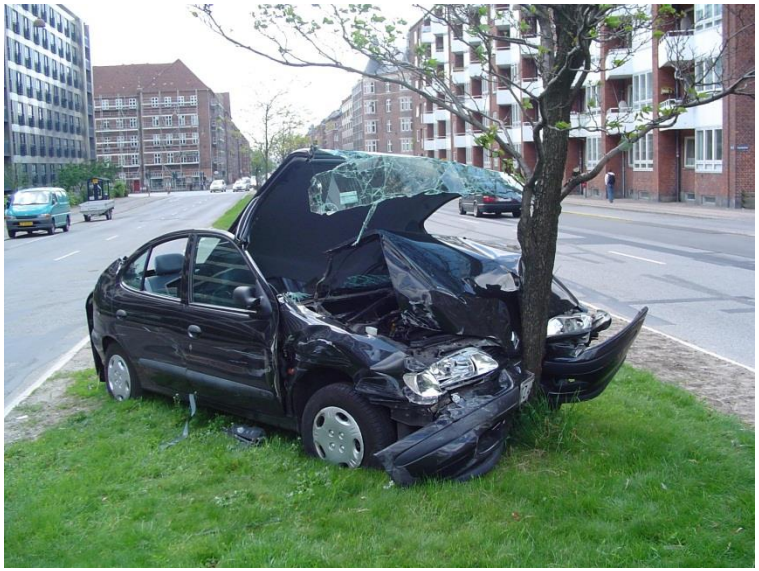
Outline

- What is risk and risk assessment?
- Key CCS risks
- What are the stakeholder needs?
- Risk assessment requirements
- Types & tools of risk assessment
- Expert elicitation & uncertainty
- Key challenges
- Concluding remarks

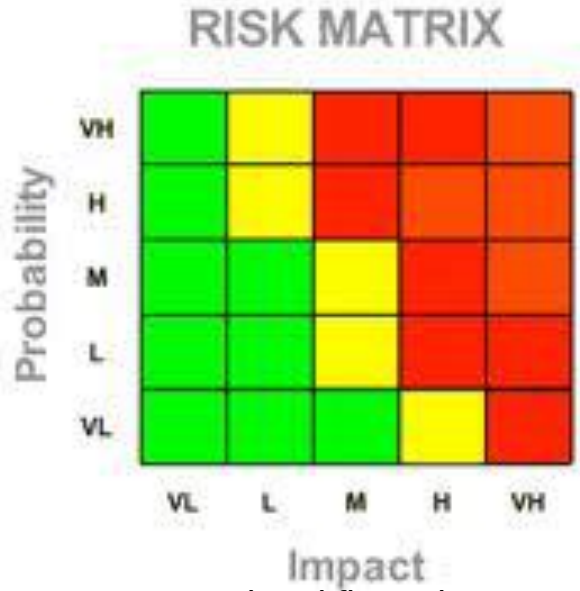


http://upload.wikimedia.org/wikipedia/commons/e/e1/Car_crash_1.jpg

What is Risk?

Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss (an undesirable outcome)(http://en.wikipedia.org/wiki/Risk).

Risk = probability x consequence

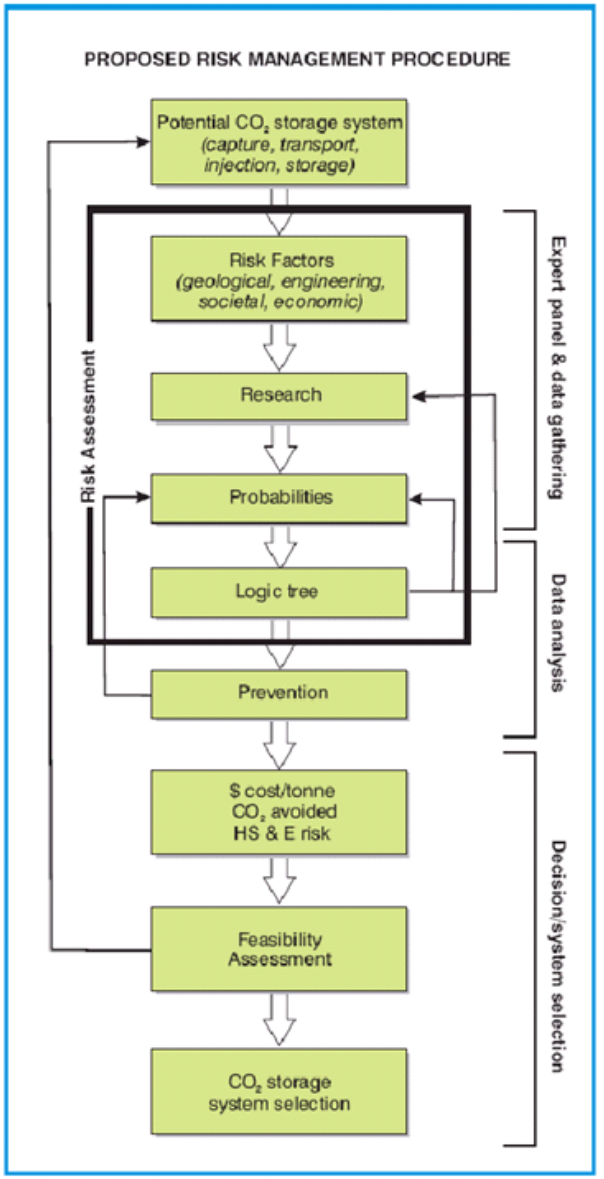


International.fhwa.dot.gov

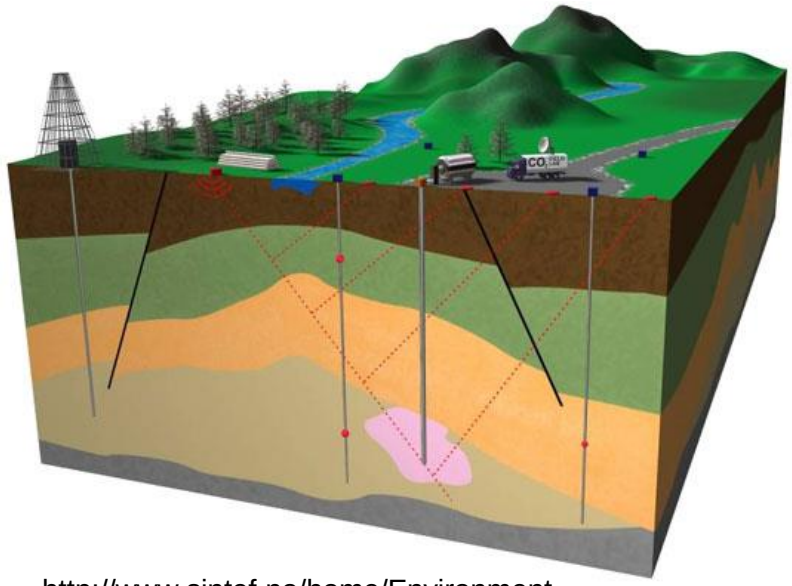
http://www.bizjournals.com/columbus/print-edition/2011/09/16/cfo-of-the-year-balancing-risks.html?page=all

What is Risk Assessment?

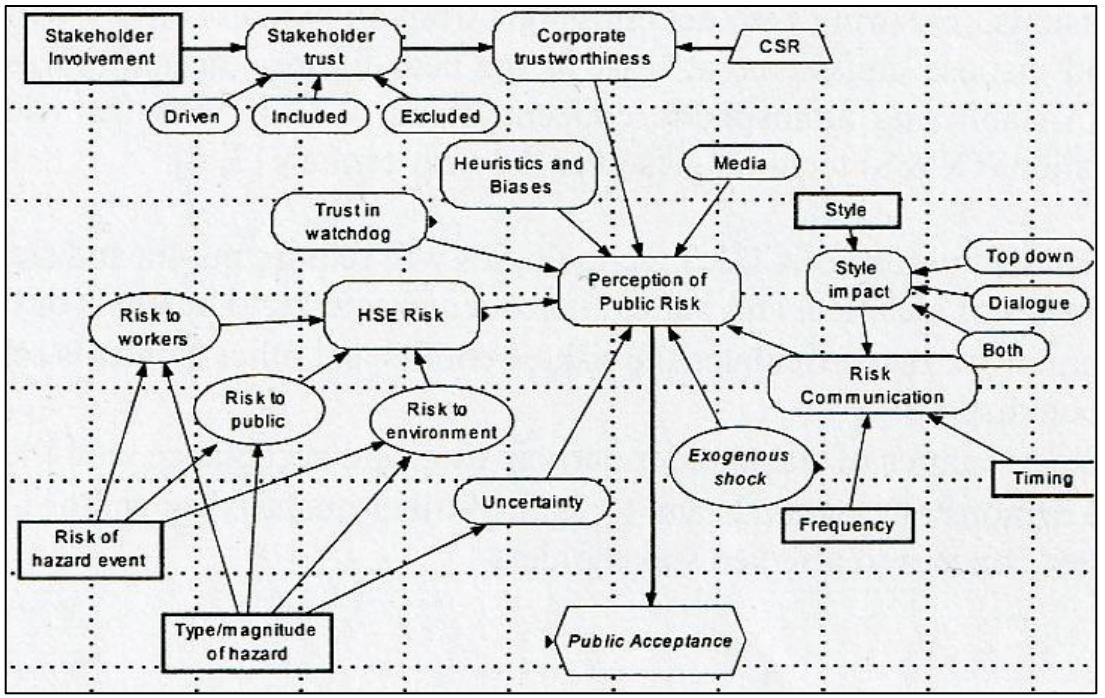
- **Risk Analysis**: systematic procedure to understand the nature of and to deduce the levels of risk. Three components: Risk Assessment; Risk Management; Risk Communication
- **Risk Assessment:** a process to calculate the risk to a given target organism, system or population including the indentification of uncertainties
- **Risk Management:** decision making process involving considerations of political, social, economicc and technical factors with relevant risk assessment information - to implement appropriate response
- **Risk Communication:** interactive exchange of information about risks among risk assessors, managers, media, interested groups & the general public



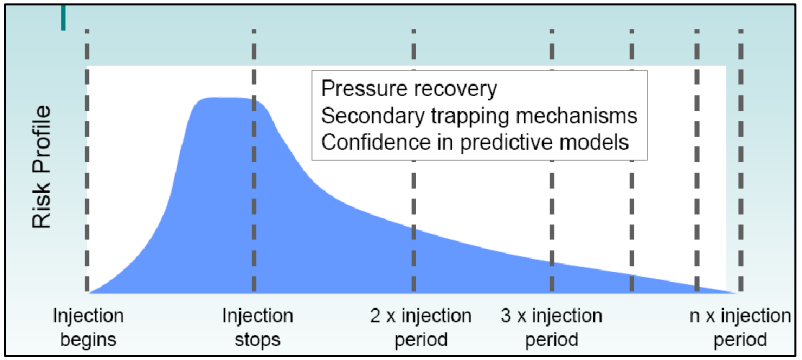
CCS - complex system of risks



http://www.sintef.no/home/Environment/CO2-fangst-og-handtering/CO2-storage/



- Many potential risks.
- Risks are not independent
- Dependencies should be accounted for



What are the risks?

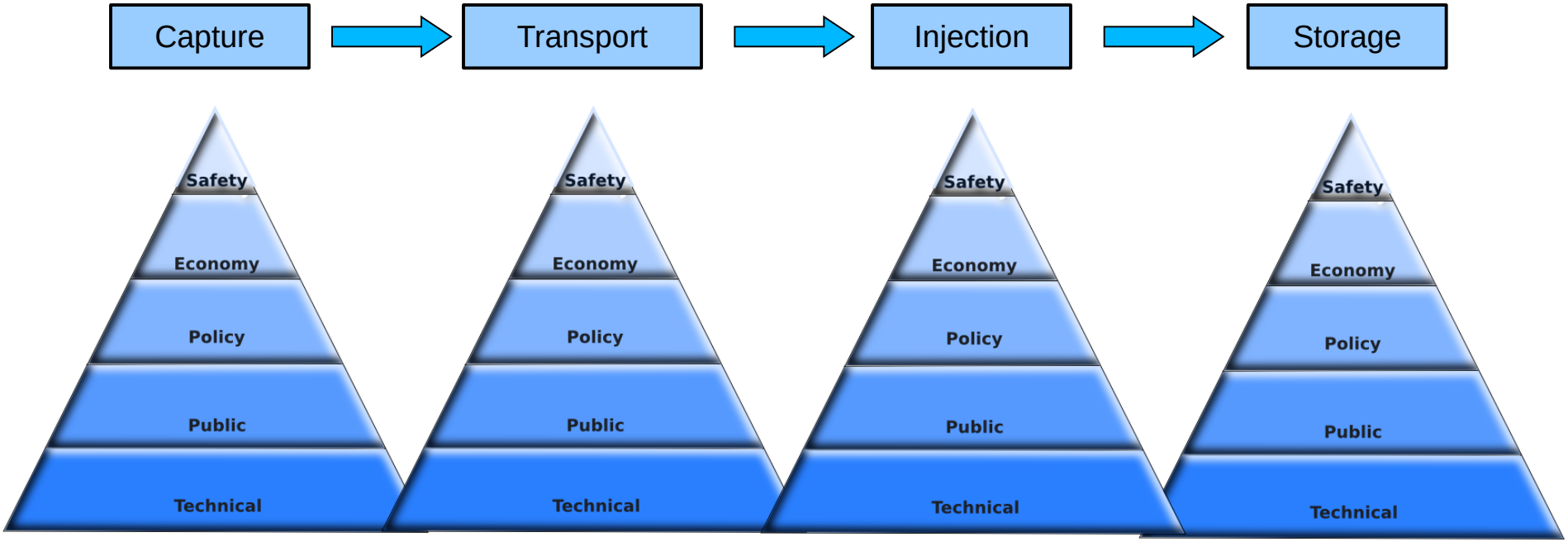
- Most CCS Risk assessments tend to focus on HS&E: Health, Safety and Environment related to long-term storage. This may or may not be the greatest risk

Other important risks:

- Project financial risk
- Long-term liability
- Regulatory risk
- Public opinion risk
- Insufficient reduction of GHG

CO2 FEP Database (http://www.quintessa.org/co2fepdb/PHP/frames.php)

System Risk Assessment



Project Risk = Capture + Transport + Injection + Storage

CCS Risks may come from anywhere in the system and are not independent

An integrated system assessment will highlight the greatest risks

Components of successful risk assessment

- Definition of context and risk assessment goals
- The use of appropriate tools
- Selection of experts to provide input
- Expert elicitation
- Communication of results

Who is risk analysis for and why is it being done?

Everybody has different interests and questions

- Stakeholders must be clearly identified: Public, regulators, project managers, scientists, etc…
- What part of the system? (can the system be separated)? capture-transport-storage
- What time scales? Project planning? During injection? Post-closure within 50 years or 1,000 years?
- What aspects? Technical, public, regulatory, economic, HS&E?
- What metrics? $$, $/tonne CO2 lost? CO2?

Stakeholders	CCS System	Time scales	Risk Aspects	Metrics
Public Regulators Project managers Scientists	Capture Transport Storage	Project planning Operation Post closure 1000 years	Technical Public Regulatory Economic HS&E	$$ $/tonne CO_2 lost

Tools for Risk Assessment

- Informational
- Organisational
- Qualitative – Probabilistic?
- Quantitative – Probabilistic!

theaccidentalsuccessfulcio.com (2011)

Different tools are appropriate and useful for different tasks

Tools: Qualitative vs. Quantitative

- Qualitative Risk Assessment: the likelihood and magnitude of the consequences are not quantified. For example: The estimated risk is low
- Quantitative Risk Assessment: all inputs and outputs are fully quantified.
- Quantitative assessment would usually be desired, but is rarely possible.
- Both have appropriate uses and most assessments are qualitative or a mix of both.

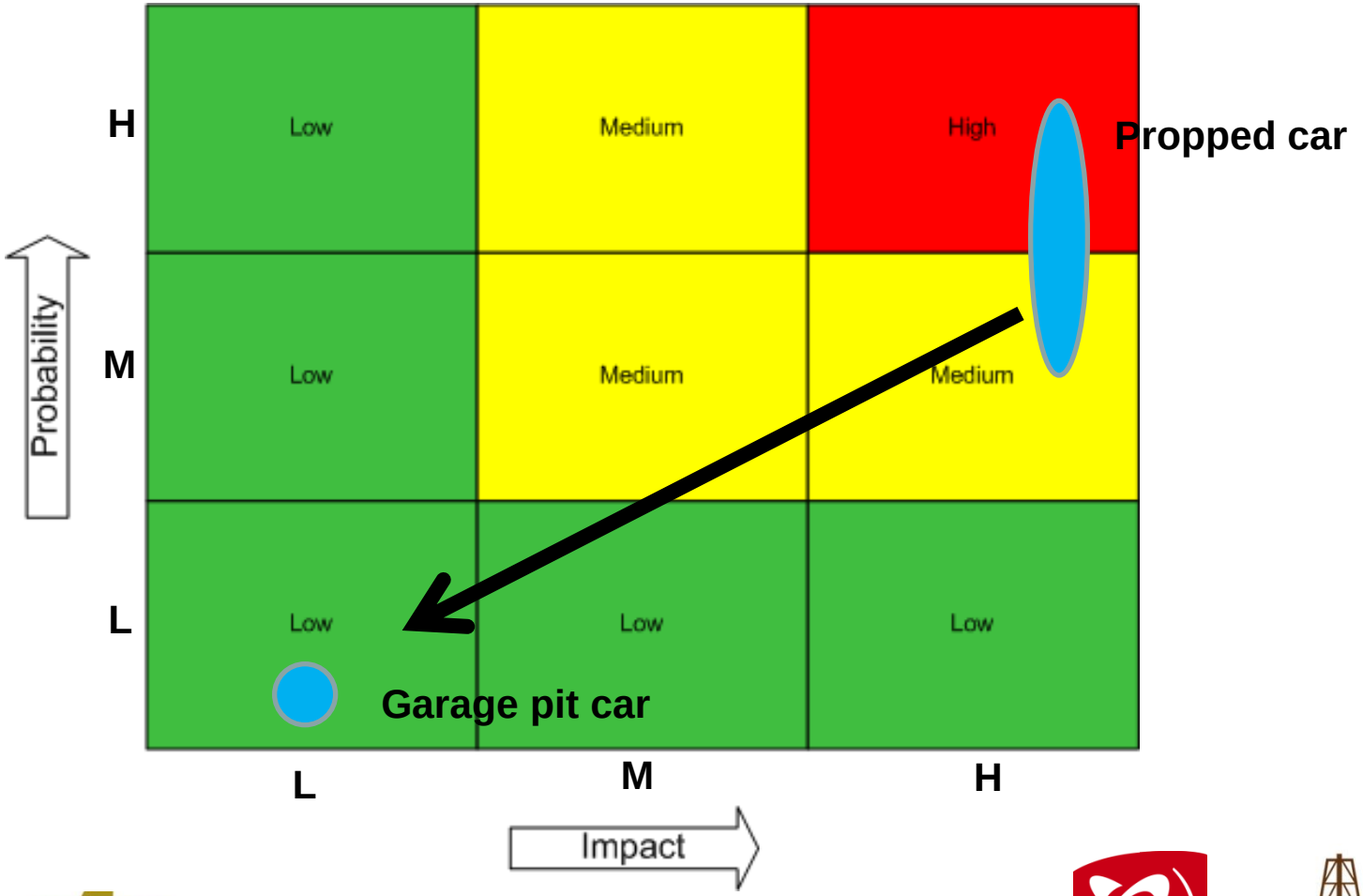
Tools: Risk Register (Informational)

Event	Cause	Mitigation
Lack of Public Support	• Insufficient consultation and education • Misinformation • Lack of trust of government and CCS operating companies • Cultural Sensitivities to sequestration • Low tolerance to risk	• Educate about CCS process and risks • Consultation • Transparent government decision making process • Robust risk assessment and Monitoring and verification programmes
Not Economically Viable	• Price of carbon too low • Cost of capture, transport and CO_2 sequestration too high • Cost of sequestration higher than alternative mitigation measure	• Increase price of carbon via taxation • Decrease the cost of CCS • Introduce incentives for sequestration • Government funding (if considered of vital importance)?
Lack of operational Framework	• CCS legislation incomplete • Long term liability unresolved • Uncertainty of economic model for CCS • Insurance/reinsurance not available	• Government regulates CCS and accepts long term liability • Robust risk modelling

FEPs – Features Events & Processes

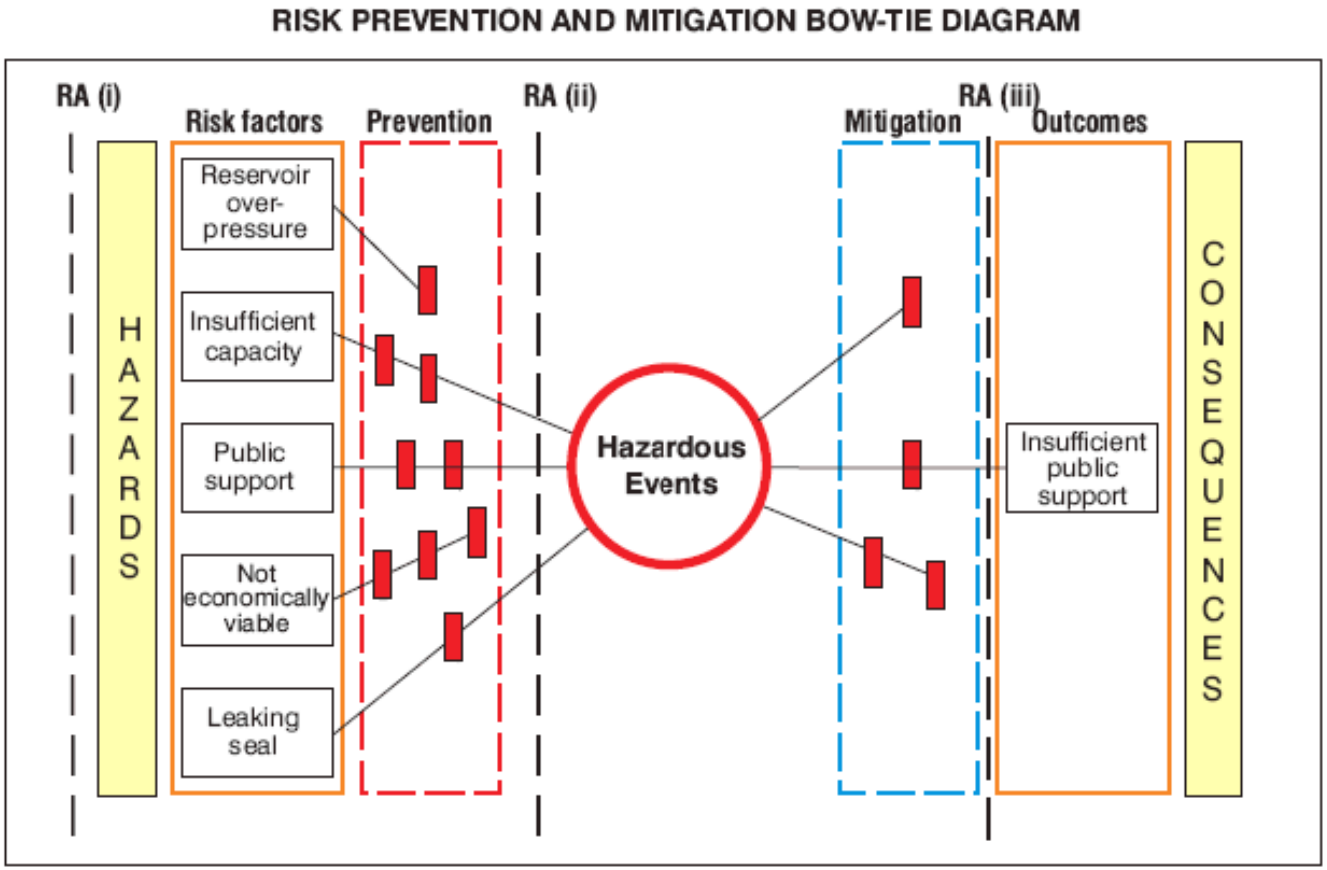
CO2 FEP Database (http://www.quintessa.org/co2fepdb/PHP/frames.php)

Tools: Risk Matrix (Informational and Qualitative)



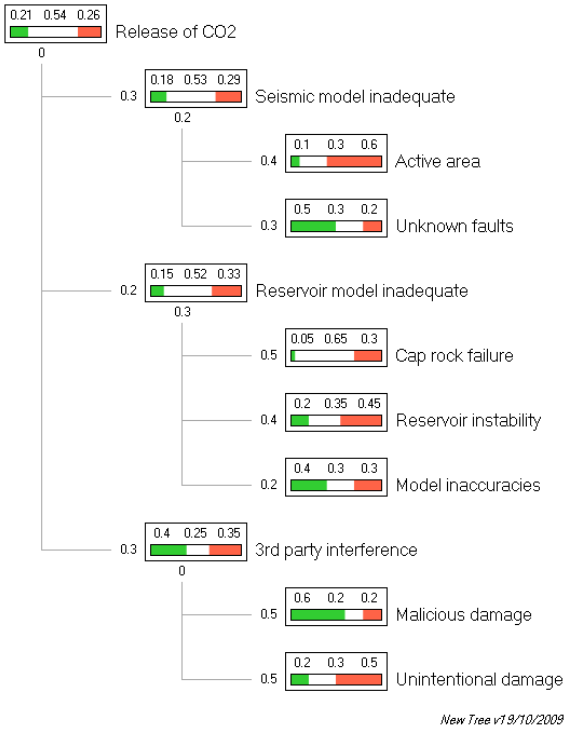
Tools:Bow-Tie (Organisational)

- Risk management
- Mitigation
- Presentation



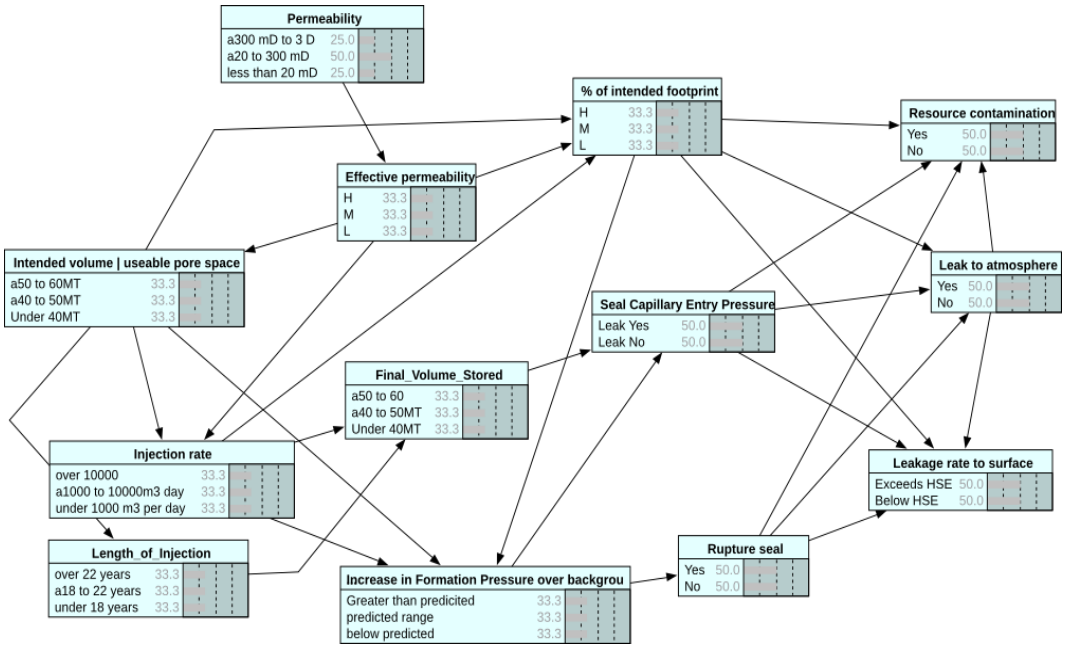
Tools: Integrated & Quantitative

Logic tree



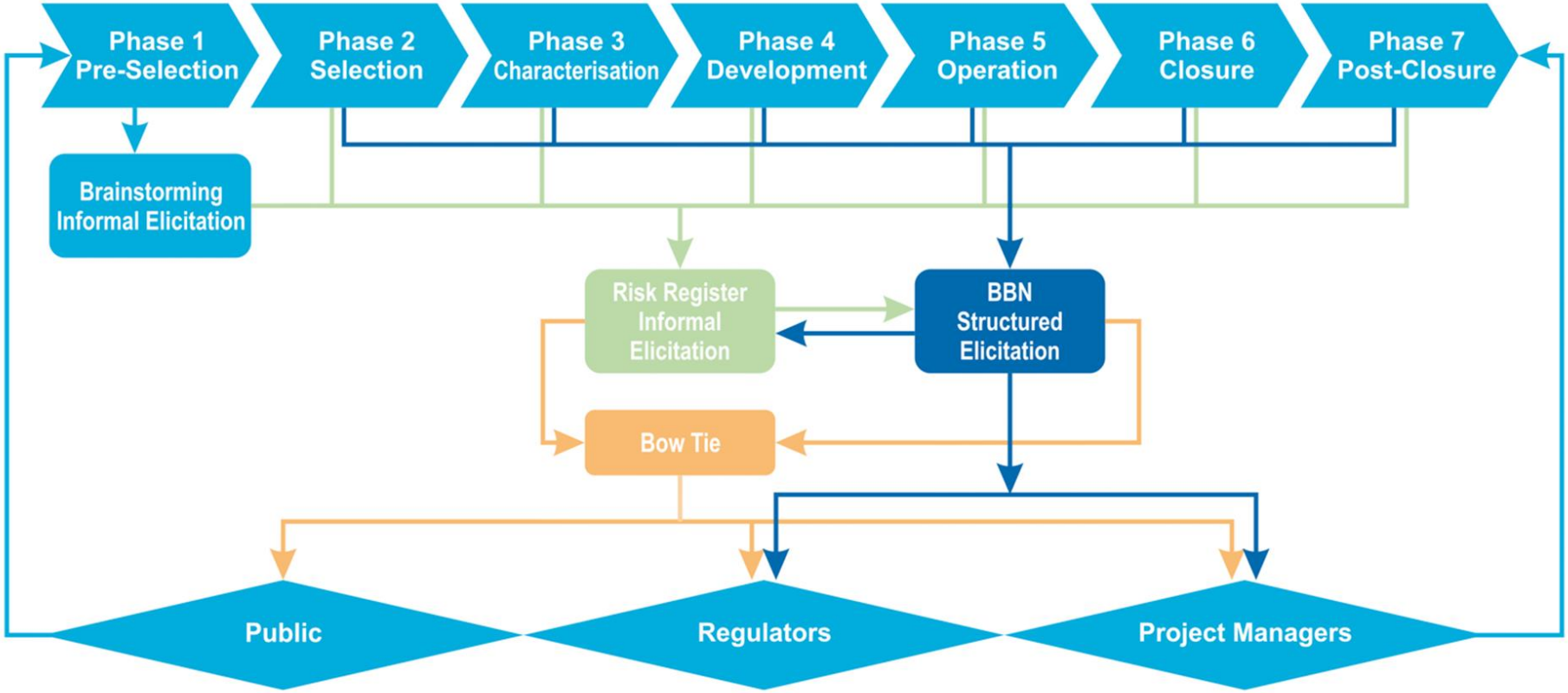
Tesla

Bayesian Belief Network

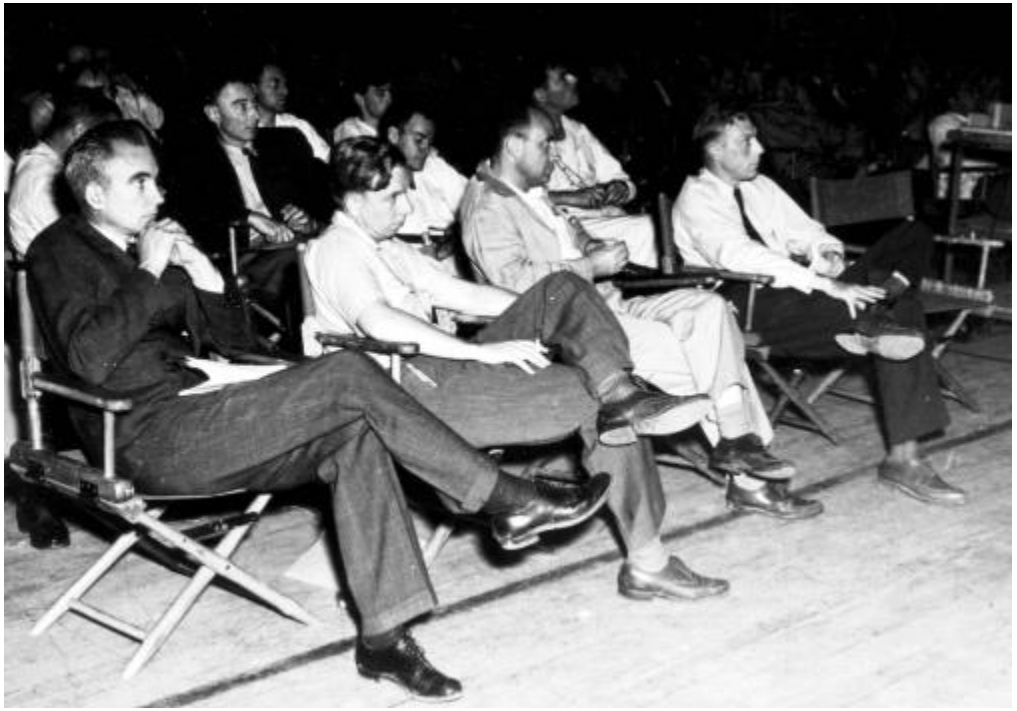


Gerstenberger et al. CO2CRC

Integration of Multiple Tools

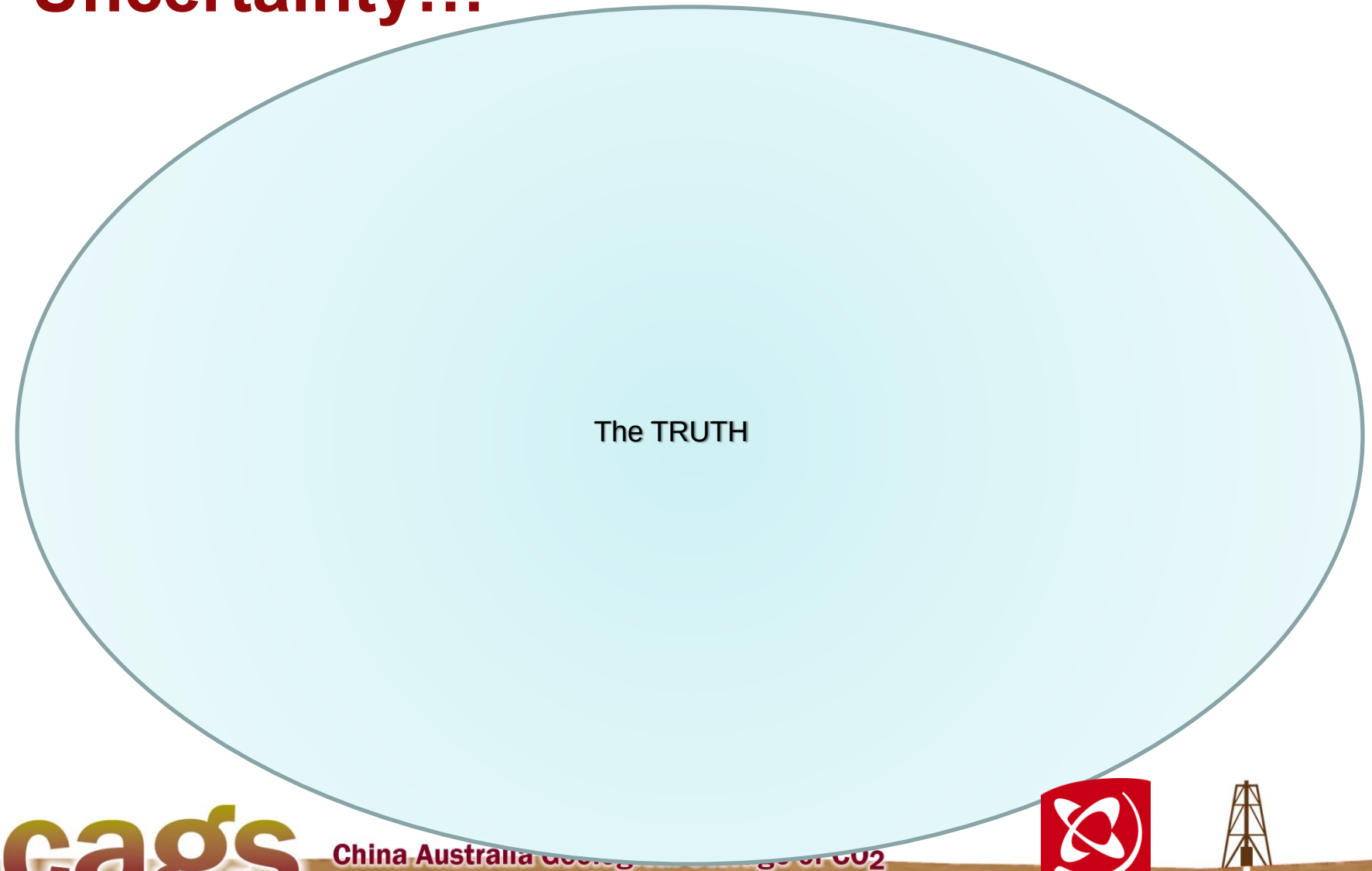


Expert Elicitation: What do we know and how well do we know it?

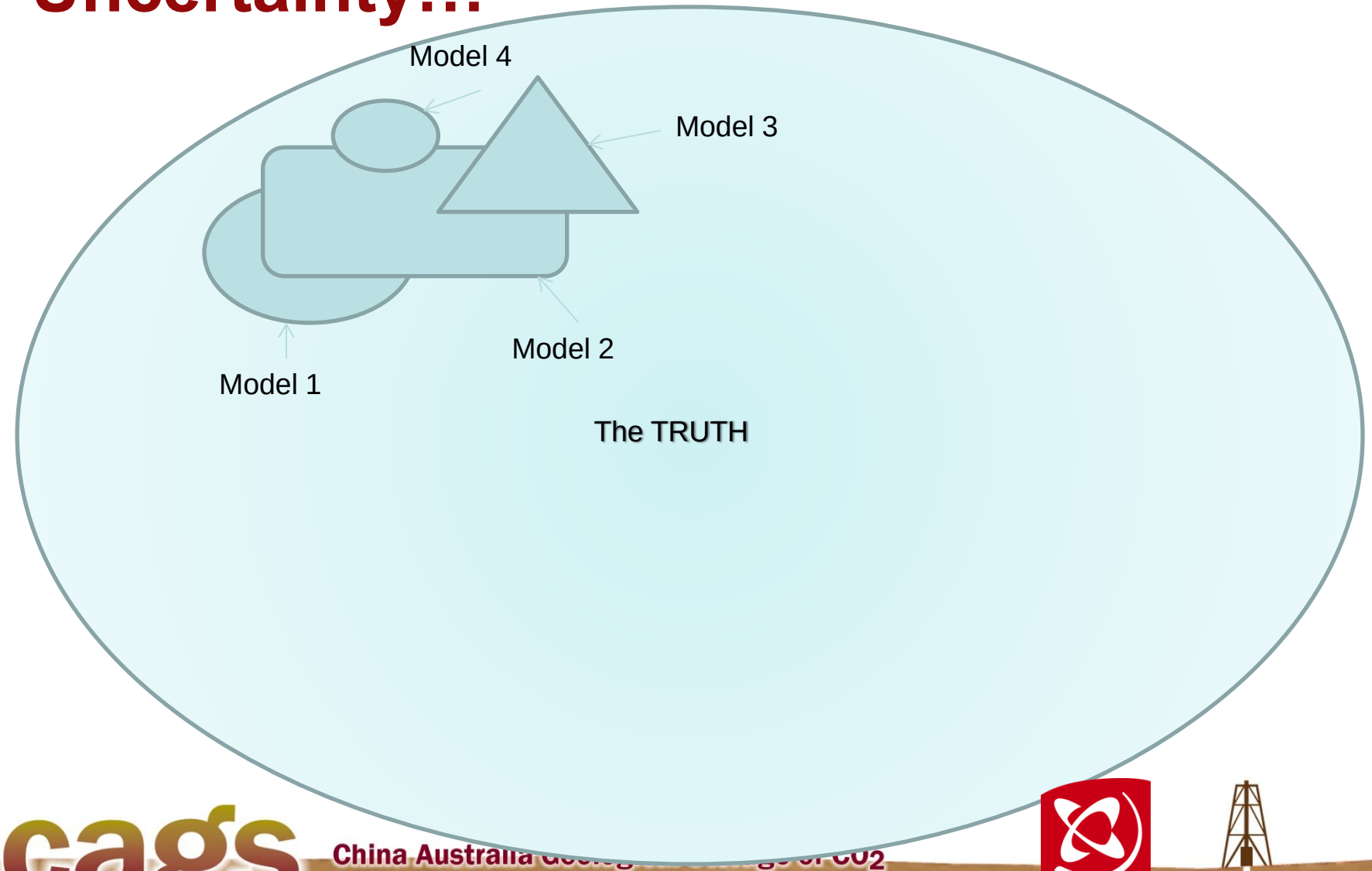


Modelling knowledge is insufficient for risk assessment: Expert judgement will almost always be required, especially for a better understanding of uncertainties

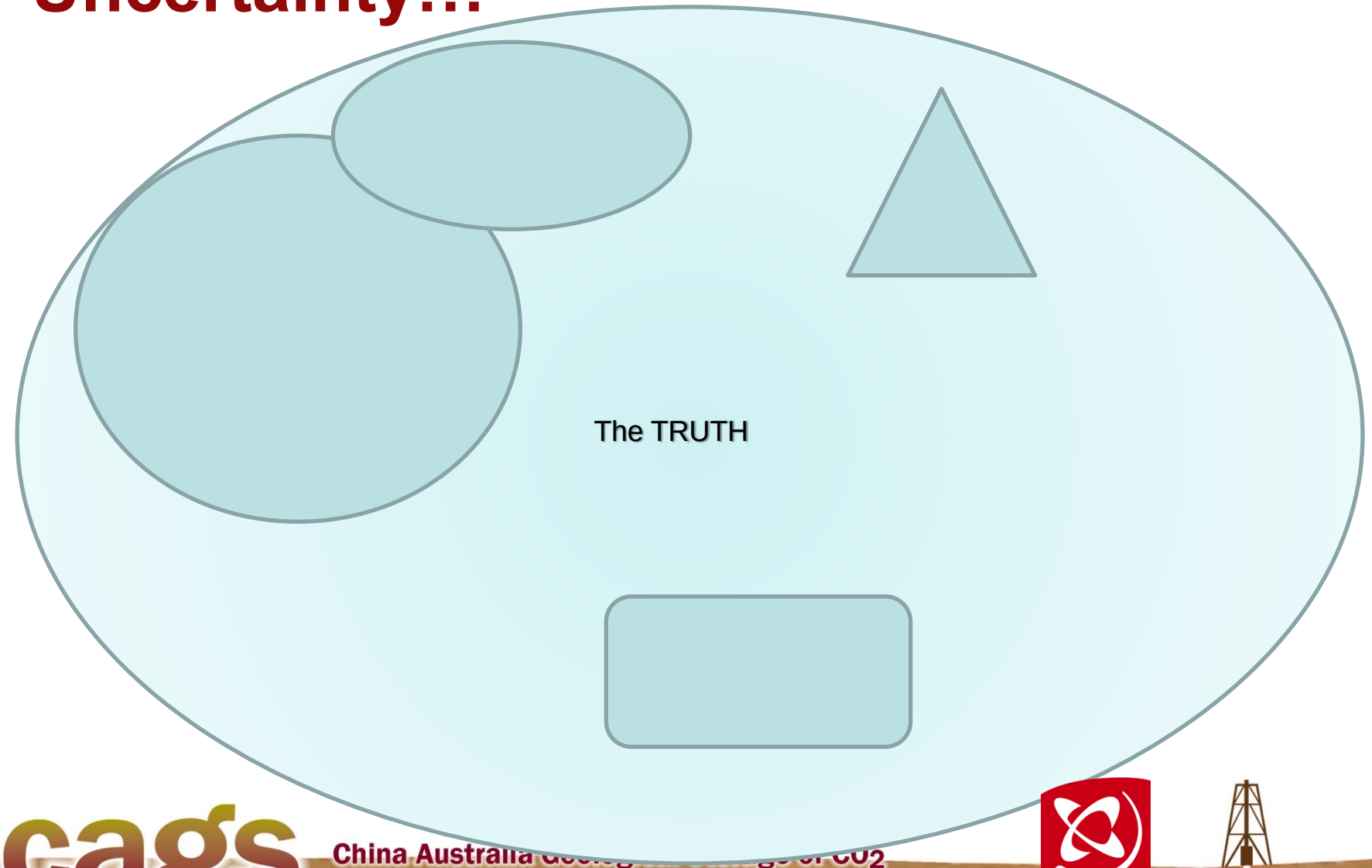
Uncertainty…



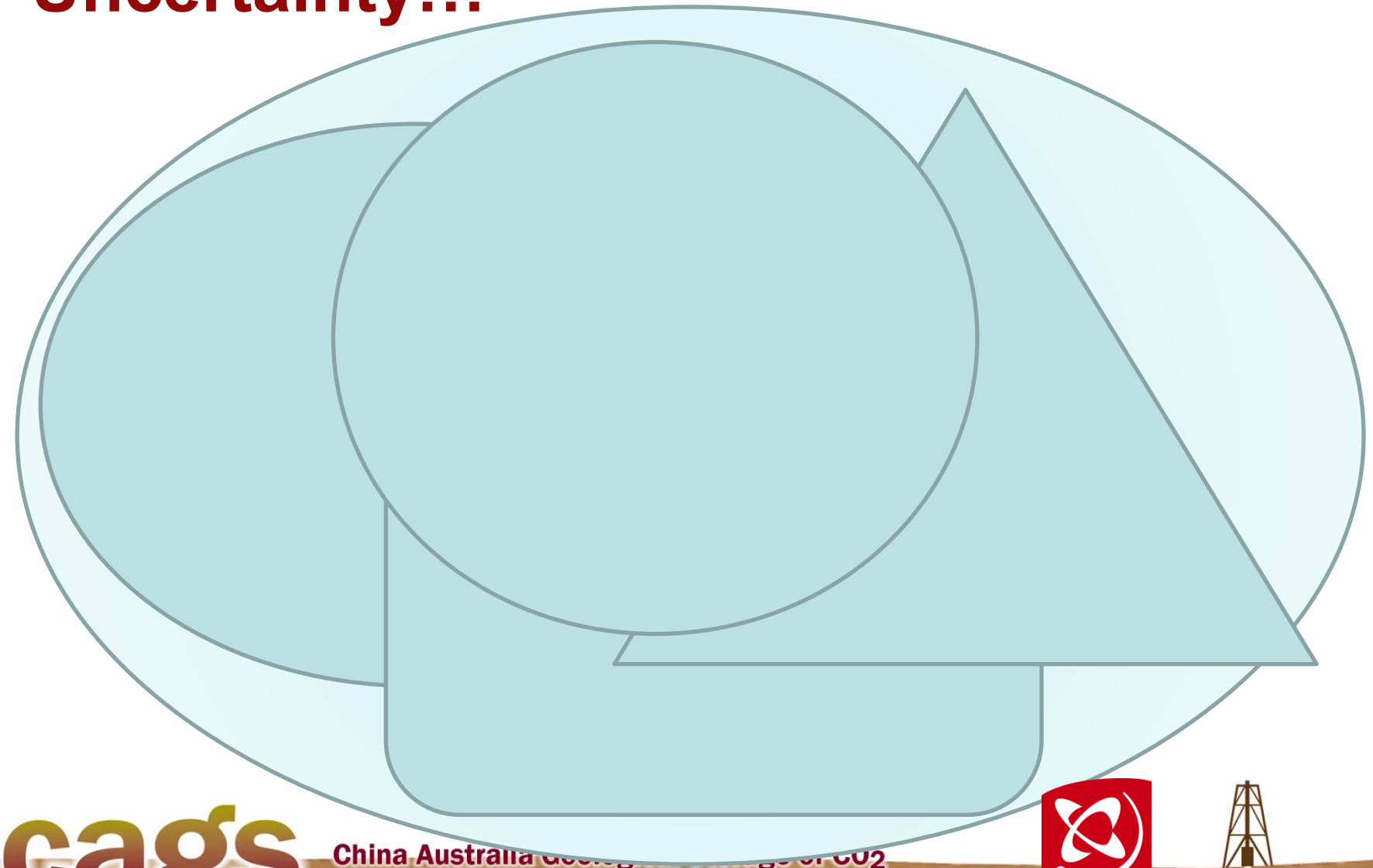
Uncertainty…



Uncertainty…

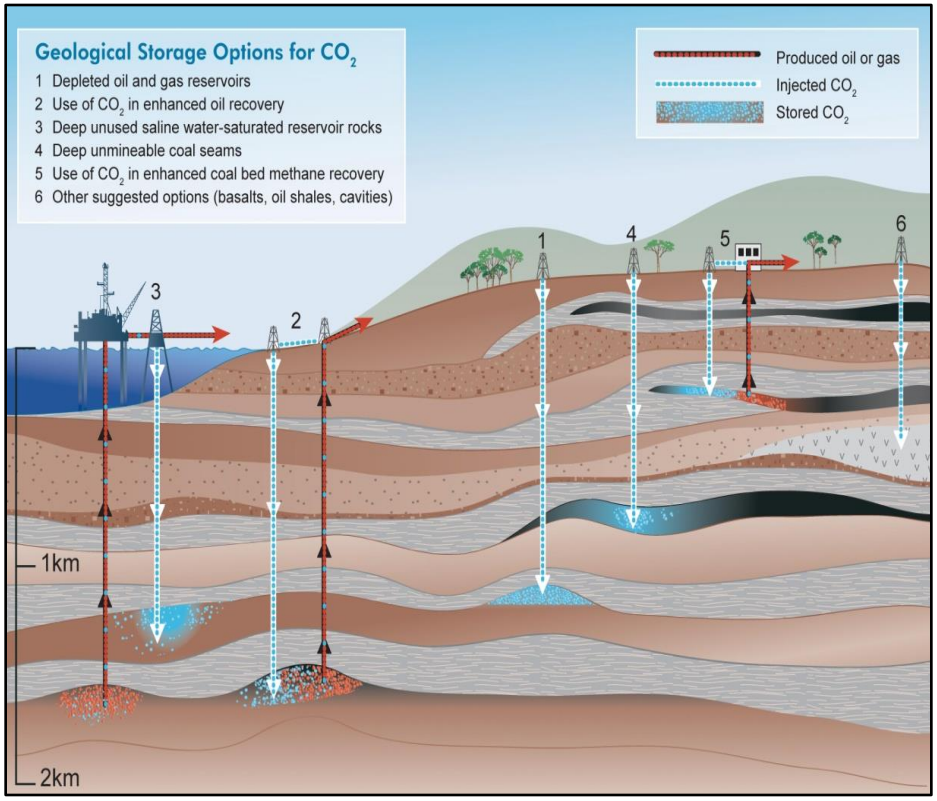


Uncertainty…



Expert Elicitation: why is it needed?

- Limited Knowledge
  - (informed) Quantitative answers often difficult to provide
  - Models/analogues not available for everything
  - Sometimes overly simplistic
- Extreme Probabilities
  - Probabilities of events generally very small – tricky to conceptualise!



Expert Elicitation: what is it?

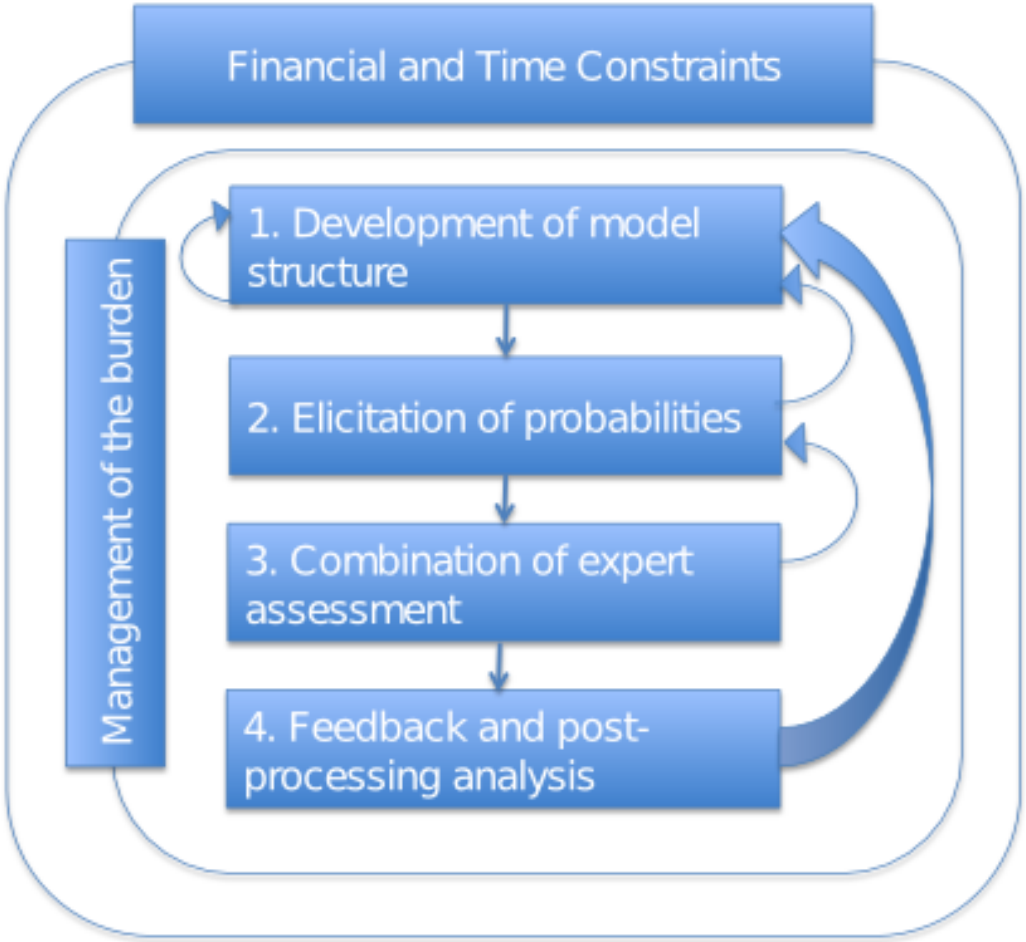
- Group of 6-15 CCS experts
- Range of relevant expertise
- Risks discussed by group
- Opinions of individual experts contribute to risk estimates
- Each expert opinion weighted using series of seed questions
- Elicitation process iterative

Expert Elicitation: Managing the Burden

Various guidelines available with varying degrees of specificity

- EU Guidelines
- SSHAC
- Australian Centre for Excellence of Risk Analysis (ACERA)
- ISO 31000 Risk Management
- Cooke methodology
- Delphi

Expert Elicitation: structure



Key Challenges to Risk Assessment

- Relatively limited knowledge of system
- Usually working with extreme probabilities
- Expert elicitation
- Identification of stakeholders
- Communication with (multiple) stakeholders
- Appropriate resourcing

Info.cytrap.eu

Key Challenges to Risk Assessment

- Plan and begin risk assessment in early stages
- Allow for appropriate resourcing and engage experts throughout the entire process
- ***Key:*** Continually work with and engage stakeholders: answer the questions they are asking
  - Ensure risk outputs are in a format easily understood by the stakeholders

Concluding Comments

- Communication!
- Risk Assessment must be designed and executed in a risk management context
- Stakeholders must be identified early
- Continual engagement with stakeholders and clear communication is key (public is largest risk?)
- Appropriate resourcing is necessary
- In most regions regulations are still undecided; this will impact risk assessment
- Good & useful expert elicitation is not easy
- Risk assessment will improve as more data are collected