ONDRAF/NIRAS

IGD-TP Exchange Forum 5

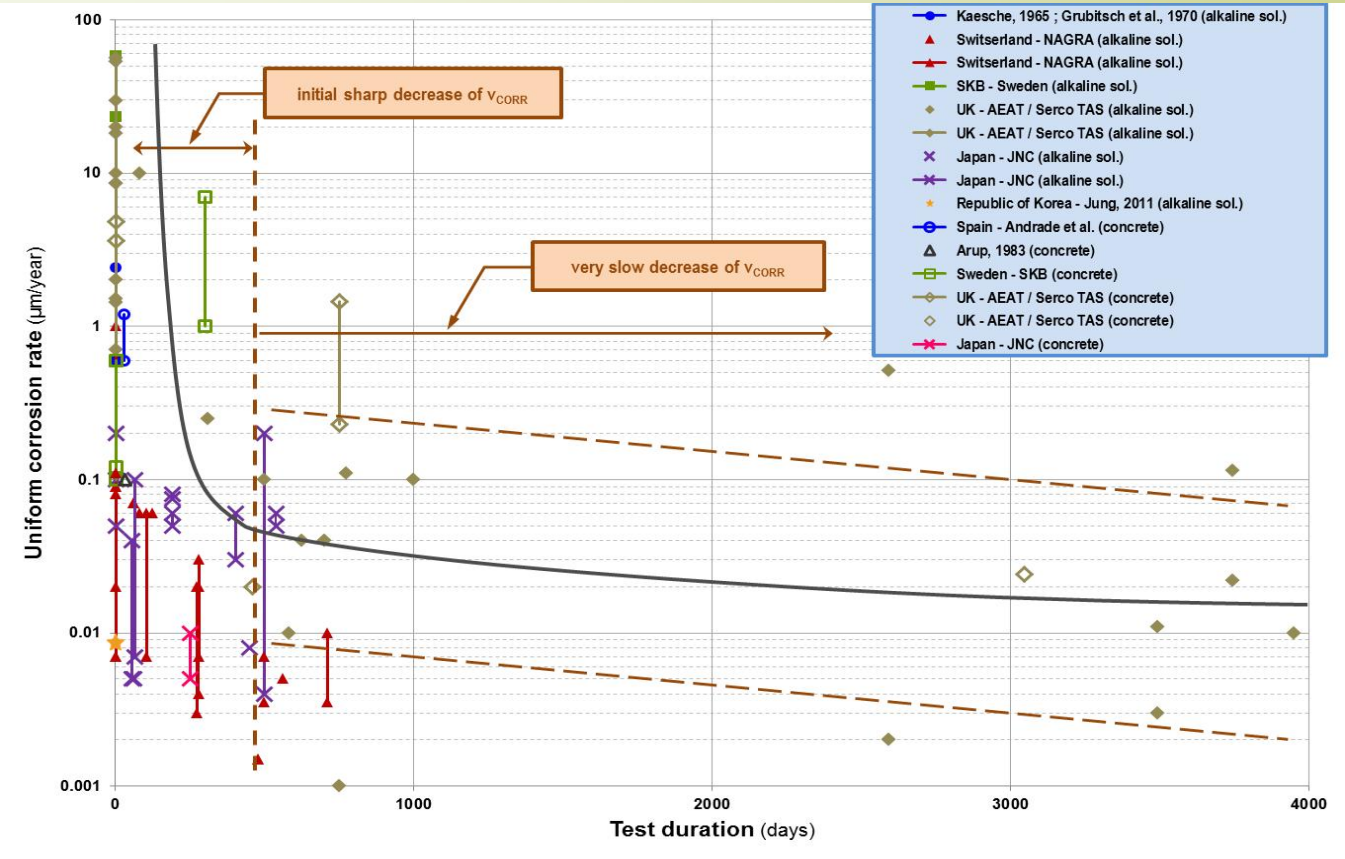
Managing uncertainties in the safety case

Quantifying uncertainty: Challenges for ONDRAF/NIRAS

Manuel Capouet

Kalmar, Sweden
28 October 2014

Belgian Agency for Radioactive Waste and Enriched Fissile Materials



- **Corrosion rates of carbon steel in alkaline (cementitious) conditions measured by different teams, using various experimental set-ups [Kursten et al., 2013].**
- **Good support for a sound model parameterization and its associated uncertainties.**

ONDRAF/NIRAS

Rich toolbox explored and developed in PAMINA to play with these models and their parameters:

- **Sensitivity analysis:**
  - Focus on probabilistic (Global) methods:
    - Investigate combined effects of uncertainties, find out unfavorable combinations of parameters, “rank” sensitive parameters.
    - Graphic methods, Monte Carlo based methods, Variance based methods.
    - Use of test cases to compare methods.

- **Guidance on the treatment of model &scenario uncertainty and,**

- **Test cases, including modeling at different levels of details.**

ONDRAF/NIRAS

What about…

- Perturbations of expected processes in the long-term (evolving conditions).
- Rare or non-periodic events for which there is insufficient information available to quantitatively estimate the probability.
- Global events (climate evolution).
- Programs at initial stages with limited or no site-specific data.

ONDRAF/NIRAS

Let's check PAMINA : Bolado et al., 2009

- **Expert judgment protocols:**
  - Stanford Research Institute (SRI) protocol (1988).
  - SNL/NUREG-1150 protocol (1990).
  - JRC's KEEJAM protocol (2000).

- **Combination of expert judgment:**
  - Group combination.
  - Total interaction group.
  - The Delphi method.
  - The nominal group.
  - Nirex/NDA protocol (1991/2006).

- **Mathematical aggregation:**
  - The linear pool.
  - Bayesian combination of expert judgment.

ONDRAF/NIRAS

Feedback of the application of expert judgment processes in Safety Cases ?

NEA MeSA project (quoted) :

- ***Expert judgment is ubiquitous, but not always visible in the treatment of uncertainties.***

- ***Expert judgment must be documented in a traceable and transparent way, and the proponent must apply appropriate quality standards.***

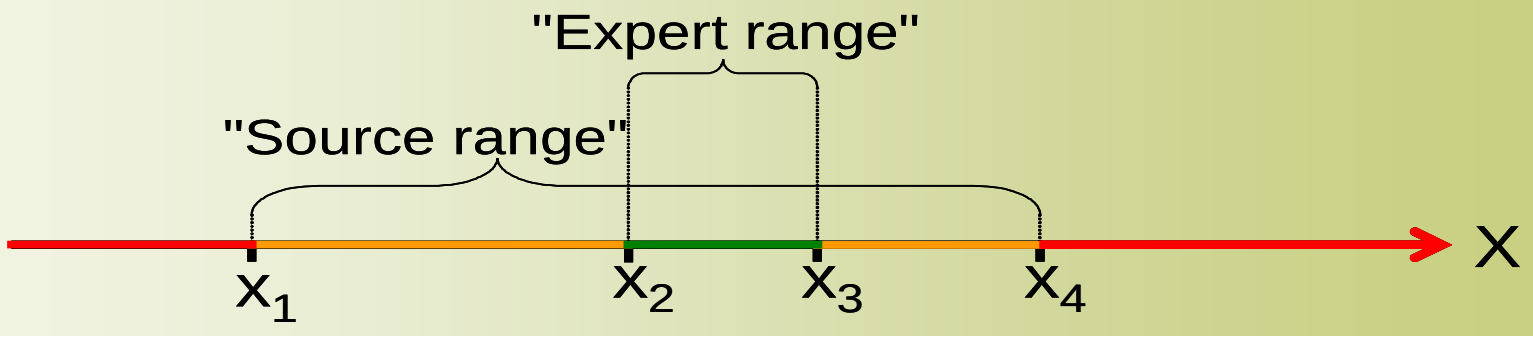
- ***Undoubtedly, expert judgment plays a central role when describing the system and deriving scenarios. In the future, it could also be interesting to examine guidelines for expert involvement further, and also to determine whether a more formal approach to expert judgment is warranted for safety assessment and in particular for system description and scenario derivation.***

ONDRAF/NIRAS

O/N methodology to quantify parameter value uncertainty (1/3)

The experts are requested to estimate two ranges:

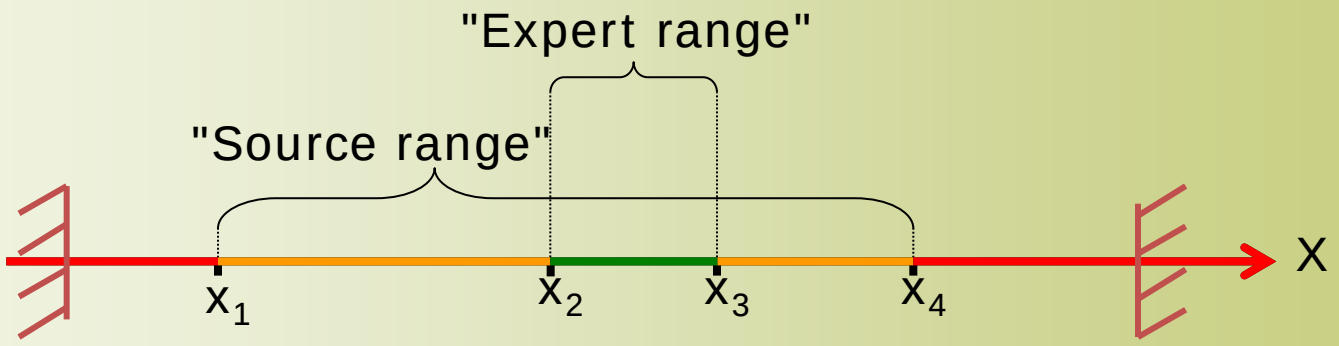
- **The expert range** - the range within which experts expect the parameter value to lie considering current knowledge
- **The source range** - the range outside of which experts do not expect the parameter value to lie considering current knowledge



Legend:
[x2,x3] = range within which the value of X should lie, according to experts i.e. "(fully)realistic values"
\ ]x1,x4[= range of values that should be ruled out for X, according to experts i.e. "unrealistic" values;
[x1,x2[U]x3,x4] = range of values that experts cannot entirely rule out for X, but which would be somewhat surprising, i.e. somewhat less "realistic"

ONDRAF/NIRAS

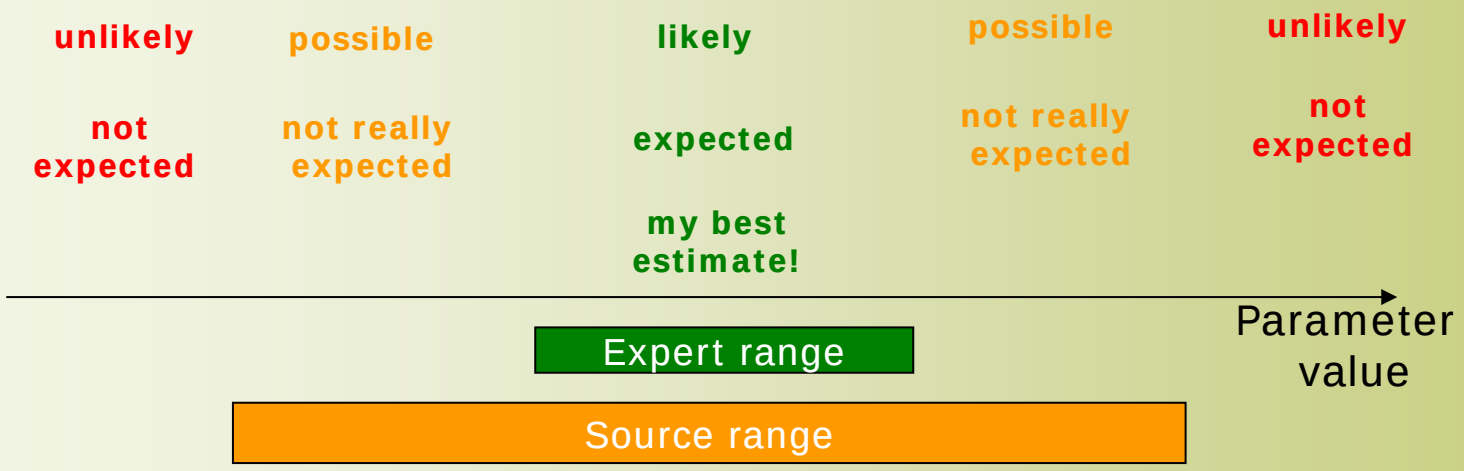
O/N methodology to quantify parameter value uncertainty (2/3)



- **The uncertainty of a parameter value is captured by 4 values (x_1..x_4).**
- **The values outside of the expert range *are not immediately excluded* or considered as unrealistic, but are seen as *somewhat less representative* considering current knowledge.**
- **R&D is on-going and knowledge constantly increases**
  - **the expert range will inevitably change (usually narrowing, but sometimes widening)**
- **"Expert judgment" is not playing darts - the ranges and, in particular, the expert range, are supported by *multiple lines of evidence***

ONDRAF/NIRAS

O/N methodology to quantify parameter value uncertainty (3/3)



- The tool can guide discussions with experts when information is too scarce to derive a pdf.
- The tool can be used to characterize qualitatively FEPs inherently difficult to predict (e.g. occurrence of a geological event).

ONDRAF/NIRAS

POSIVA methodology

Example: Knowledge Quality Assessment (1) for process understanding

Score	Theoretical understanding *	Empirical quality *	Proxy (parameteris-ation) *	Robustness against time scales and external conditions	Colleague consensus **
4	Well-established theory.	Controlled experiments, large sample of direct measurements.	An exact description of the desired process in great mechanistic detail.	The process is extremely robust. Exceptionally unlikely that it will be significantly altered over time or due to changes in the external conditions.	All but cranks.
3	Accepted theory with partial nature (in view of the phenomenon it describes).	Historical or field data, less controlled experiments, small sample of direct measurements.	Good description of the desired process with acceptable mechanistic detail.	The process is robust. Unlikely that it will be significantly altered over time or due to changes in the external conditions.	All but rebels.
2	Accepted theory with partial nature and limited consensus on reliability.	Modelled data, indirect measurements, handbook estimates.	Fairly good but simplified representation of the process.	The process is fairly robust with medium likelihood that it will be significantly altered over time or due to changes in the external conditions.	Competing schools.
1	Preliminary theory.	Educated guesses, very indirect approximations, thumb rules.	Very simplified representation of the process, considering only basic properties.	The process cannot be considered robust. It will likely be significantly altered over time or due to changes in the external conditions.	Embryonic field.
0	Crude speculation.	Pure guesses.	Poor representation of the process.	The process is not robust. It is virtually certain that it will be significantly altered over time or/and by changes in external conditions.	No opinion.

* applied from (Jeroen *et al.* 2002)
** applied from (Refsgaard *et al.* 2006)

Increasing support of observations

Increasing need for expert judgement to quantify uncertainty

Increasing use of conservatism in safety assessment

ONDRAF/NIRAS

Possible areas for further international collaborations for Ondraf/Niras:

- **Follow-up from PAMINA:**
  - Return of experience of the application of expert judgment processes & of analysis tools in recent safety cases.

- **Need for more work on expert judgment protocols, in particular:**

  Do we need a consensus about the understanding and the uncertainties of FEPs which have a global impact (climatic & geologic events) ? (NEA IGSC topical session on extreme events, 2014)
  - Making scenarios is an implementer choice constrained by national boundary conditions.
  - However, the scientific understanding supporting these scenarios should be the same.

ONDRAF/NIRAS