Potential IGD-TP – IGSC Collaboration

3 November 2015

Presented by Lucy Bailey, IGSC Chair

Radioactive Waste Management

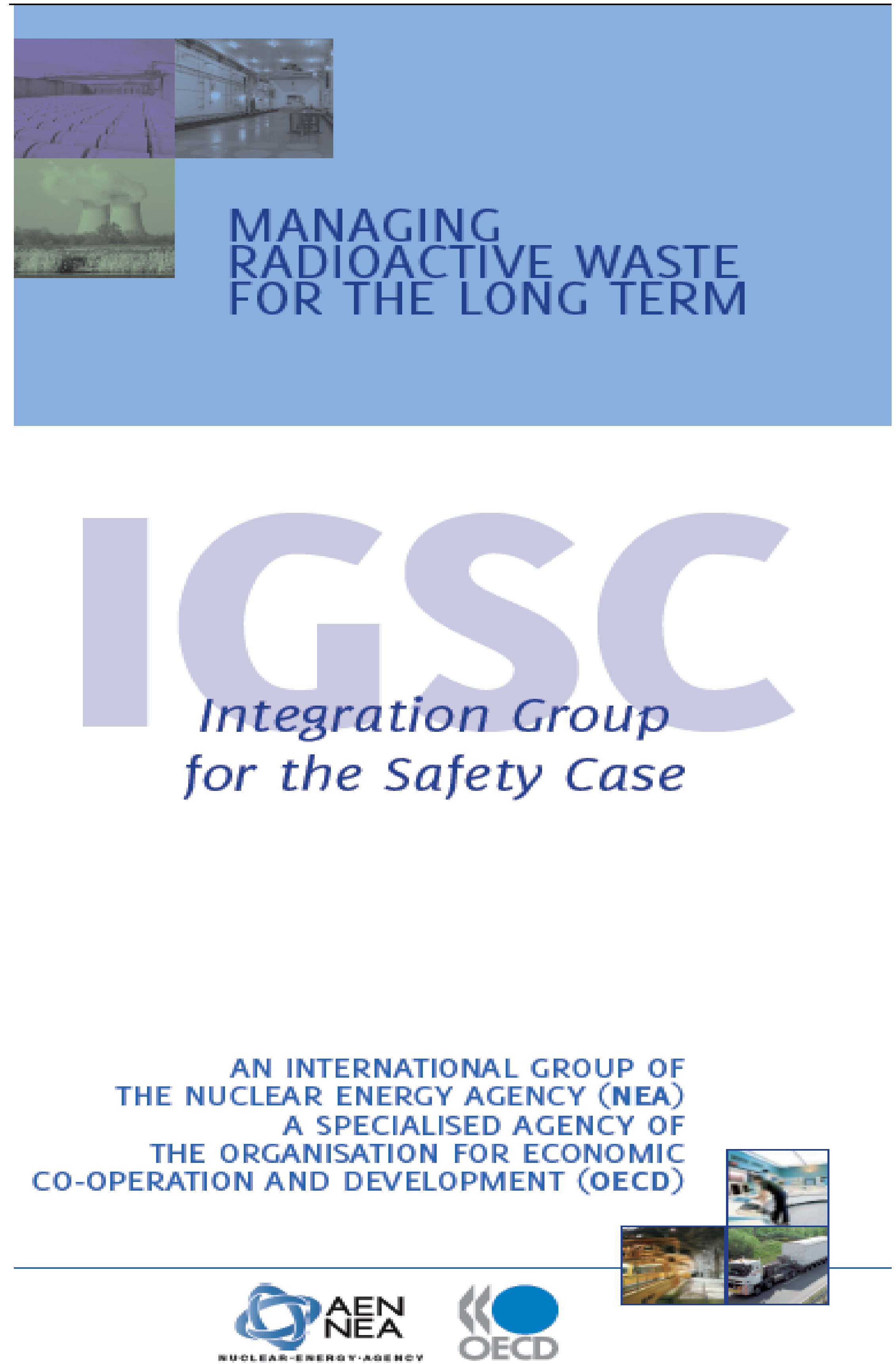
OECD-NEA Integration Group for the Safety Case (IGSC)

Mission

The IGSC builds and documents the technical and scientific basis for developing and reviewing safety cases as a platform for dialogue amongst technical experts and as a tool for decision making.

Membership

Senior technical specialists and managers from national waste management programmes, regulatory agencies and research and technical support institutions



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IGSC methods of working

- Annual **plenary meetings** with in-depth discussion of emerging issues and trends
- **Technical workshops** to explore key topics in detail
- **Studies**, joint projects
- National programme safety case **peer reviews**

All backed by expertise of participating organisations, using external expertise from the scientific and academic communities as needed

Report on IGD-TP / IGSC

Workshop on Handling Uncertainties in Safety Assessments

Hosted by RWM at Harwell, UK

23rd and 24th September 2015

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Background to workshop

- Various interactions under IGD-TP task JA.8
- Known interest in topic amongst IGSC members
- But, previously no clear agreed way forward
- So, RWM volunteered to host one-off workshop on the subject:
  - to share current experiences
  - identify if further collaboration on this topic would be beneficial
  - IGSC colleagues invited

Workshop attendees

- 16 attendees
- 8 countries represented

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Aims of workshop: 3 technical sessions

1. **The quantification of uncertainty in uncertain parameters for modelling**. The goal was to review existing approaches, demonstrate how bias may affect uncertainty quantification and consider practical tools to aid uncertainty quantification. (Led by RWM)

2. **Modelling aspects in the context of handling uncertainties** including a review of the use of the outcomes of the EC PAMINA project and what has been developed since. (Led by Nagra)

3. **Sensitivity analysis** – recent developments and applications of sensitivity analysis methods to repository performance assessment models. (Led by GRS)

Session 1: Uncertainty calibration

Weather questionnaire

The questions relate to quantities which are unknowable at the time the questionnaire is completed, but quickly become known definitively – and it can be used repeatedly without being re-designed.

It's not really about the weather/climate – it's about how well you are able to quantify uncertainty, how well you know what you don't know!

Its value is that it is a way of giving feedback on this to highlight any biases.

Uncertainty Calibration Questionnaire

Name

Date

All 15 questions below relate to the weather page in the (London) Times on the day of the workshop (23 September). The page will contain weather statistics for the previous day (22 September) and forecast data for 23 September onwards.

In the questions that follow: 'Tuesday' refers to 22 September, 'Wednesday' refers to 23 September, the 'Atlantic pressure chart' refers to a chart showing isobars and weather fronts for Europe and the Atlantic, the 'UK map' is a map with weather symbols covering the UK and Ireland.

The purpose of this questionnaire is not to test your knowledge of weather or climate, it is designed to test how accurate you are at estimating your own uncertainty, and should highlight biases.

For each of the 15 questions below, please give a range (lower and upper) in which you are 90% confident that the actual value will lie between.

Question		Lower	Upper
1	What will the midday temperature recorded on Tuesday in London be (in C)?		
2	What will the midday temperature recorded on Tuesday in Edinburgh be (in C)?		
3	What will the midday temperature recorded on Tuesday in Reykjavik be (in C)?		
4	What will the midday temperature recorded on Tuesday in Amsterdam be (in C)?		
5	What will the midday temperature recorded on Tuesday in Barbados be (in C)?		
6	What will the midday temperature recorded on Tuesday in Sydney be (in C)?		
7	What will the midday temperature recorded on Tuesday in New York be (in C)?		
8	What will the midday temperature recorded on Tuesday in Dubai be (in C)?		
9	What will the lowest isobar on the Atlantic pressure chart be (in millibars):		
10	What will the highest wind speed be on the UK map for Wednesday's forecast (in mph)?		
11	What will the lowest wind speed be on the UK map for Wednesday's forecast (in mph)?		
12	What will the highest maximum temperature be on the UK map for Wednesday's forecast (in C)?		
13	What will the lowest maximum temperature be on the UK map for Wednesday's forecast (in C)?		
14	What will the minimum temperature forecast for London on Wednesday be (in C)?		
15	The weather page is towards the back of the paper. What numbered page will it be in Wednesday's Times?		

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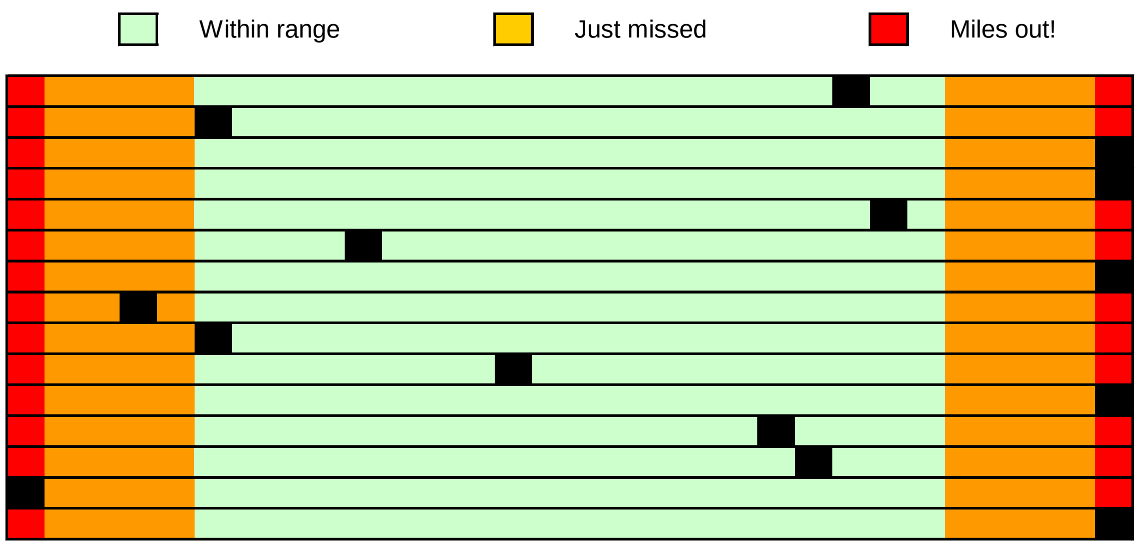
Session 1: Results of the weather questionnaire

15 questions – participants asked to give a range they were 90% confident the true value would lie between.

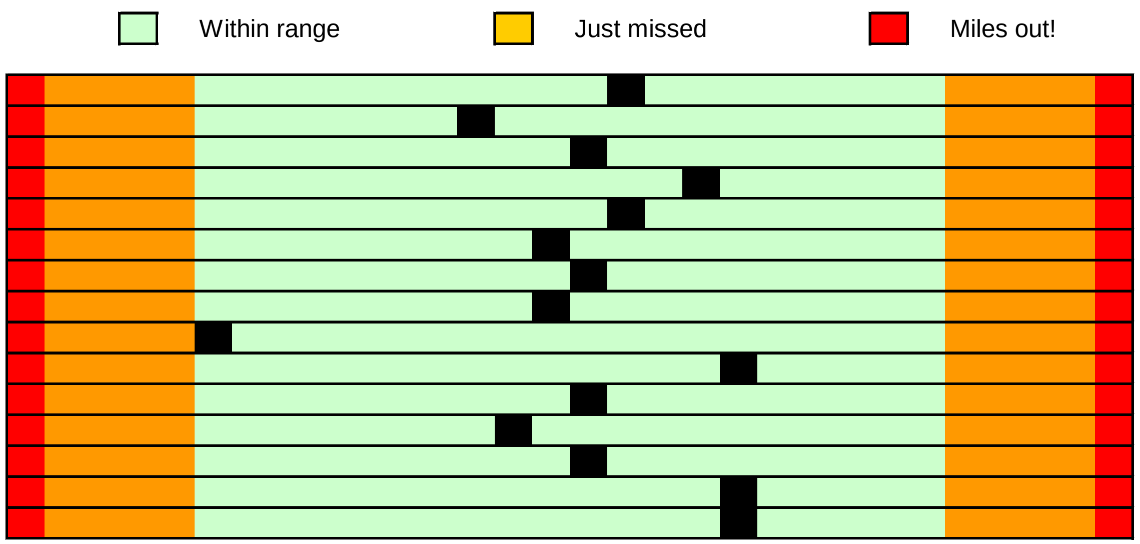
Scored between 0 and 2, with 1 being 'perfect' calibration.

Visual representation more revealing! Good result – would expect 1 or 2 answers outside the green zone.

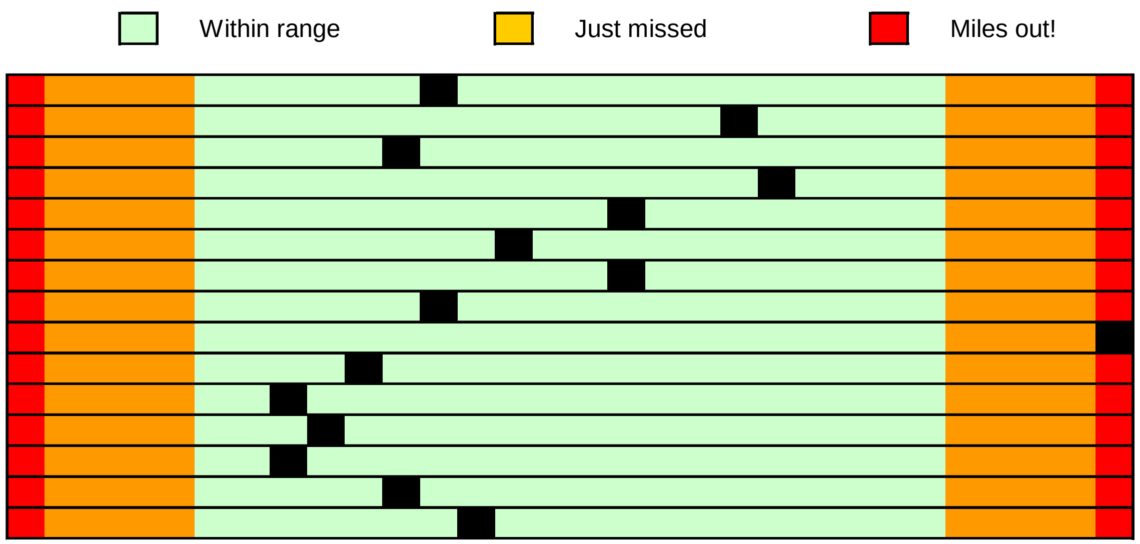
Over-confident – 1.663



Under-confident – 0.597



Well calibrated – 1.088



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Session 1: Uncertainty quantifier spreadsheet tool

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Uncertainty Quantifier

Name of uncertain parameter: Length of the River Severn Units/currency: miles

Intuitive estimate of the quantity (rounded): 1.50E+02
Intuitive estimate of uncertainty (a factor of): 2

1,200 miles	
1,000 miles	
850 miles	
700 miles	
580 miles	
480 miles	
400 miles	X
320 miles	3
270 miles	12
220 miles	20
180 miles	25
150 miles	20
120 miles	15
100 miles	5
85 miles	X
70 miles	
58 miles	
48 miles	
40 miles	
32 miles	
27 miles	
22 miles	
18 miles	
15 miles	

Part A

Complete the pale blue cells above.

1. Enter the name of the uncertain parameter.
2. Enter the units of measurement or currency for the parameter.
3. Give an intuitive estimate of the value of the parameter rounded to one or two significant figures.
4. Give an intuitive estimate of the amount of uncertainty that there is. This should be in the form of e.g. factor of 1.5, factor of 2, factor of 10, factor of 1000 etc. So it will be a number greater than 1.

When this is completed the form will allow you to complete Part B.

Chips remaining to place: 0

Probability	Log(value)
0.00	1.93
0.05	2.01
0.20	2.09
0.40	2.18
0.65	2.26
0.85	2.34
0.97	2.43
1.00	2.51

Part B

Ignore the intuitive estimates you gave in Part A (they should now be blacked out). A scale should appear at the left. Complete the following 5 steps:

1. Consider all sources of uncertainty for the parameter - if it helps, note them in the blue boxes on Page 2 below.
2. What sources of uncertainty haven't you thought of?
3. What would be a very high value for the parameter? How might this value arise? Working *up* the scale, select the first value that is *virtually impossible*. Are you sure? Put an X in the green box immediately above that value.
4. What would be a very low value for the parameter? How might this value arise? Working *down* the scale, select the first value that is *virtually impossible*. Are you sure? Put an X in the green box immediately below that value.
5. Imagine you have 100 casino chips. You need to distribute these between the green boxes that lie between the two Xs in proportion to the likelihood of the parameter value lying between the values above and below each box. Work your way alternately from the two Xs towards the middle of the range, entering a number of chips in each of the green boxes.

When you have finished, a 'cumulative distribution function' for the logarithm (to base 10) of the parameter will appear at the right.

A graphical representation of your distribution will appear on Page 2 below - review this - and make any adjustments if necessary. When you are finished, record the date, names of expert(s) and any useful notes in the blue boxes below.

1 Version 1.5

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Uncertainty Quantifier

Name of uncertain parameter: Length of the River Severn Units/currency: miles

Date completed: 28/08/2015

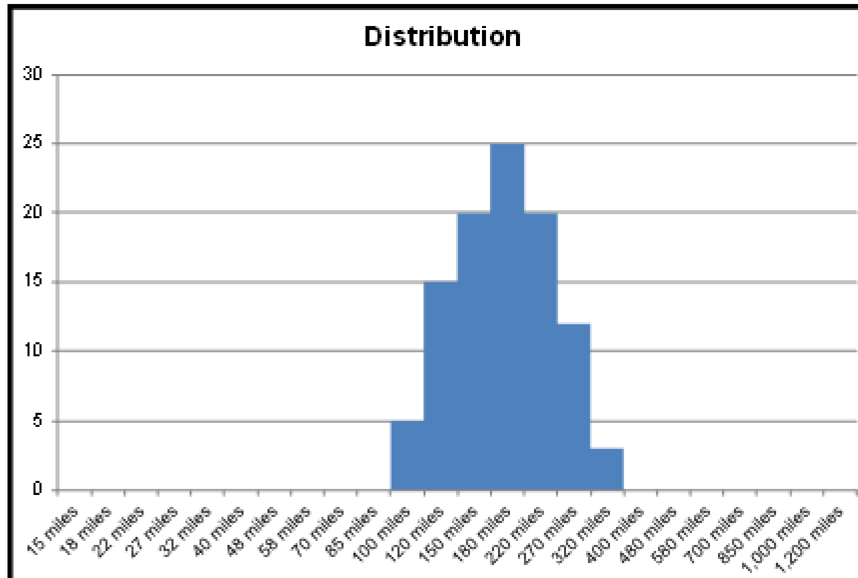
Expert(s): Mike Poole

Sources of uncertainty:

- Where does the river start and end?
- How wiggly is it?
- Is it reported accurately in e.g. Wikipedia

Notes:

The length of the River Severn is (according to Wikipedia) 220 miles.



This plot shows the percentage of probability lying between the values on the x-axis (note the axis is logarithmic) - the actual probability density function (PDF) is the same shape but normalised so that the total area = 1.

2 Version 1.5

Session 1: Proposed next steps

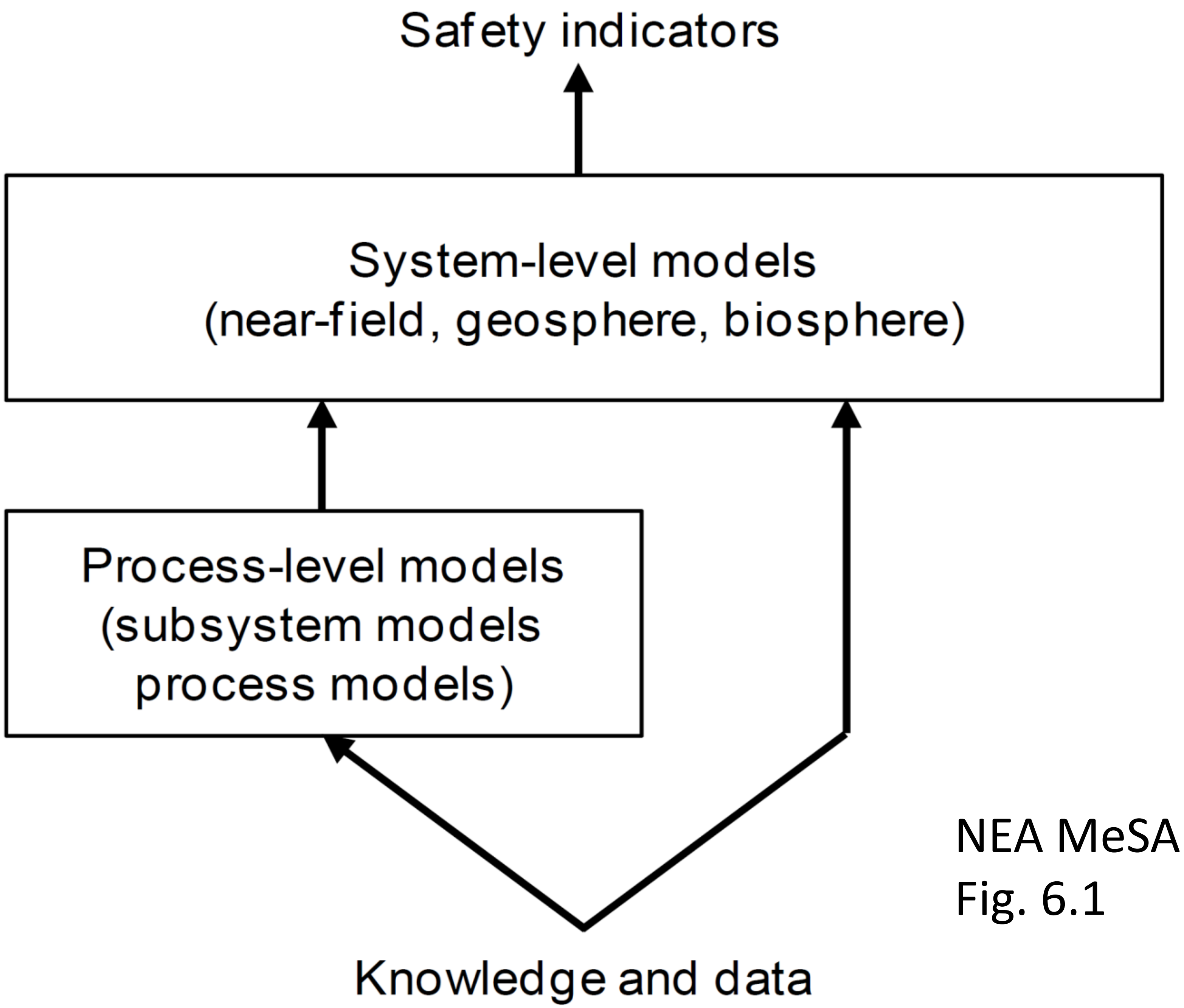
- Document in a report a proposed approach to uncertainty quantification and treatment, including multi-level approach, relation to management system and modelling approach, and the Uncertainty Quantifier tool
- Seek feedback – your views most welcome, also academics, regulators
- Is it possible to design a research project to demonstrate whether use of the tool (compared to a simple question asking for ranges) produces more accurate quantification of uncertainty – using parameters that can be known e.g. weather statistics?

Goal – an effective, intuitive, proportionate and well explained methodology for uncertainty quantification that is accepted internationally, by academics and used outside our own application

Session 2: Modelling aspects

- EC PAMINA project developed various techniques, some of which have been further extended and developed (e.g. by Nagra), but not all have been publicly documented
  - What problems are outstanding?
  - Where can value be added?
  - Where would collaboration be fruitful?
- Goal of this session was to take stock of progress since the EC PAMINA project and identify areas where further work may be needed

Session 2: Hierarchy of models used in safety assessment



NEA MeSA initiative (2012), Fig. 6.1

Session 2: Open questions?

A few findings from the NEA MeSA initiative

- "Overall, there is wide consensus on the modelling strategies to support a safety assessment and no major areas of disagreement have been identified"
- Three classes of models often used in safety assessment:
  1. Process models (often used to calculate inputs for system models)
  2. Total system models or PA models
  3. Insight models (simpler models, often used to enhance system understanding)
- Is there a trend for ever-increasing integration of process models into system models?
  - Is this a positive or negative thing?
  - What does it mean for the handling of uncertainties and the evaluation of the importance of uncertainties?

Session 3: Sensitivity analysis

- Session dedicated to recent developments and applications of sensitivity analysis methods to repository PA models
- Aim to identify what can be learned from recent developments and which techniques are most effective and reliable
- Three presentations:

1. Recent trends in sensitivity analysis (Elmar Plischke, TUC)
   - Analysis of input and output data in absence of model
   - Identification of hidden parameter dependencies and potential model errors
   - Visualisation techniques
2. Sensitivity and probability analysis of the safety of deep geological repositories in crystalline rock according to the Czech concept (Aleš Vetešník, CTU)
   - GoldSim model, with variance-based and fuzzy set theory sensitivity analysis
3. Methods for sensitivity analysis in the context of performance assessment (Dirk Becker, GRS)
   - Salt model, exhibiting non-linear and non-monotonic behaviour, making sensitivity analysis difficult

Session 3: Sensitivity analysis discussion

- A number of techniques were pioneered by PAMINA and some of these have been further developed
  - Would it be useful to conduct a review of the new techniques?
- How should we test for ‘false positives’?
- How can correlated input data be treated in sensitivity analyses?
- What is the best way to present the results of sensitivity analyses?
  - What is the best way to visualise the results of such analyses (CSM plots, cobweb plots, scatter plots, importance rank plot …)?
- Is it possible to produce guidelines or a ‘practitioners handbook’ to define a standardised approach to sensitivity analysis?
- Would such guidance help to convince a regulator or other stakeholders that appropriate techniques have been used?

Agreed workshop outcomes

- All participants agreed workshop had been extremely worthwhile, with excellent information exchange and discussion
- Good range of tools exist, but they need to be tested in safety assessment applications

Next Steps

- Specific areas for information exchange and collaboration between certain participants were identified (e.g. use of US datasets by GRS to test sensitivity techniques)
- Wider collaboration on methods for quantifying uncertainty for practical use in safety assessments would be valuable…
  - Ultimate goal: Development of an effective, intuitive, proportionate and well-explained methodology for uncertainty quantification that is internationally accepted (whilst not prescriptive) and ideally used both within and outside radioactive waste management
- Agreed to discuss with IGSC and IGD-TP

Potential IGSC collaboration: Working Group on handling uncertainty

- Workshop outcomes presented to IGSC on 6 October 2015
- IGSC members from following organisations expressed desire to join such a group
  - Posiva, Finland
  - Nagra, Switzerland
  - GRS, Germany
  - Niras-Ondraf, Belgium
  - SKB, Sweden
  - TUC, Germany
  - RWM, UK
  - USDoE (Sandia), US

Suggested way forward

- IGSC task group to develop proposals for further work based on workshop outcomes
- Consider:
  - methodology for uncertainty quantification as input to safety case
  - analysis of uncertainty in safety case outputs (sensitivity analysis)
- Welcome thoughts and input from the IGD-TP
- Aim for closer working and sharing of expertise between IGSC and IGD-TP

Thank you!

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