

**Summary Minutes of the
U.S. Environmental Protection Agency (EPA)
Science Advisory Board (SAB)
Expert Elicitation Advisory Panel Public Meeting, February 25-26, 2009**

Committee Members: (See Roster – Appendix A)

Scheduled Date and Time: From 8:00 a.m. to 5:00 p.m. (Eastern Time) on February 25, 2009;
and from 9:00 a.m. to 1:00 p.m. (Eastern Time) on February 26, 2009.
(See Federal Register Notice, Appendix B)

Location: Woodies Building, 1025 F Street, N.W., SAB Large Conference Room,
Room 3705, Washington, DC 20004

Purpose: To conduct a peer review of EPA's *Draft Expert Elicitation Task Force
White Paper*.

Attendees: Chair: Dr. James Hammitt
Committee Members: Dr. William Ascher
Dr. John Bailar
Dr. Mark Borsuk,
Dr. Wändi Bruine de Bruin
Dr. Roger Cooke
Dr. John Evans (February 26, 2009 only)
Dr. Scott Ferson
Dr. Paul Fischbeck
Dr. Christopher H. Frey (February 25, 2009 only)
Dr. James, H. Hammitt
Dr. Max Henrion
Dr. Alan J. Krupnick,
Dr. Mitchell J. Small
Dr. Katherine Walker
Dr. Thomas S. Wallsten

SAB Staff Office: Dr. Angela Nugent, SAB Staff Office, Designated
Federal Officer (DFO)
Dr. Vanessa Vu, Director of the SAB Staff Office

EPA Staff listed on the agenda:

Dr. Pai-Yei Whung, EPA Office of the Science Advisor
Dr. Kevin Teichman, EPA Office of Research and Development
(ORD)
Mr. Robert Brenner, EPA Office of Air and Radiation (OAR)
Mr. Robert Hetes, EPA ORD
Mr. Harvey Richmond, EPA OAR

Meeting Summary

The discussion addressed the topics included in the Proposed Meeting Agenda (See Meeting Agenda - Appendix C) and roughly followed the sequence summarized below.

Opening of Public Meeting

Dr. Angela Nugent, Designated Federal Officer (DFO) for the SAB Expert Elicitation Advisory Panel, opened the public meeting at 9:00 a.m. on February 25, 2009. She announced that the public had not submitted written comments or made any request for oral comments.

Dr. Vu welcomed panel members and EPA presenters. For the benefit of new panel members, she noted that the panel's report would receive a quality review from the chartered SAB and then be finalized to send to the EPA Administrator.

Introductions and agenda review

The chair of the committee, Dr. James Hammitt, welcomed members. He expressed interest in expert elicitation and noted the breadth of expertise on the panel. He asked committee members to provide the DFO with written comments related to the charge question to which they were assigned and committed to prepare a draft report reflecting the panel's views for discussion at a future teleconference.

Introduction to EPA's Draft *Expert Elicitation Task Force White Paper* and EPA's perspective on expert elicitation

A panel of EPA senior managers provided the panel with background on the white paper and its development. Dr. Pai-Yei Whung, EPA Chief Scientist in the EPA Office of the Science Advisor, introduced Dr. Kevin Teichman of EPA's Office of Research and Development to discuss EPA's overall view of expert elicitation and Mr. Robert Brenner of EPA's Office of Air and Radiation, to discuss the possible uses of expert elicitation to support rulemaking and policy.

Dr. Teichman presented the slides found in Appendix D. Mr. Brenner spoke without slides and provided his insights into how expert elicitation fits into the work of a policy office. He noted his observation that uncertainty can paralyze the policy process, and as a director of a policy office, he envisions expert elicitation as one method to keep that from happening. In his view, expert elicitation offers promise to help EPA's air programs with decisions relating to climate change, determination of health benefits, and determination of residential visibility benefits. He noted that EPA's Office of Air and Radiation had an interest in expert elicitation dating back to analyses of ozone effects the early 1980's. His office explored the use of expert elicitation for EPA's lead standard in the mid 1980's, for analysis of chronic ozone lung injuries in the late 1980's, and for health effects of fine particles, beginning in 2004. He noted that expert elicitation provided a way for EPA to gain a sense of experts' understandings of all the health-related studies in a structured, rigorous way, so that a controversial issue could be better understood. Mr. Brenner also spoke of his office's interest in possible opportunities to use expert elicitation on climate issues. He spoke of the importance of a recent study released by

Intergovernmental Panel on Climate Change, which made significant use of expert elicitation. The decision to use expert elicitation and assign probabilities to what experts seem to believe, in his view, transformed public perception of the climate change issue. The analysis increased public understanding of the scientific consensus among experts and range of views on issues. This understanding broke the science “out of the black box” and enabled the policy process to move forward. He concluded that EPA’s Office of Air and Radiation has increasing interest in expert elicitation. When conducted with care, such studies can be well-accepted. He emphasized the importance of collaborative work with SAB and other experts to advance how EPA conducts and use expert elicitation.

Panel members then engaged in discussion with Dr. Teichman and Mr. Brenner. The Agency managers identified several questions of most interest to them: 1) Can processes be made transparent enough to overcome concern that they may be manipulated?; 2) Can the rationales that experts use to explain their thinking be adequately conveyed to the public; 3) What are the necessary steps to take to minimize the biases of experts and elicit understandings of how they make probabilistic judgments; 4) How best to use peer review ; and 5) Are there alternatives to the time and resource-intensive approach, used for assessing the Particulate Matter premature mortality issue?

The managers also noted that expert elicitation might provide a way to overcome recent cynicism about the role of experts in environmental assessments. Typically, the media “pit one expert against another.” Expert elicitation may allow EPA to identify where there is a group of experts who have a similar view and communicate that consensus to the public.

The panel briefly discussed the cost of EPA’s recent expert elicitations. Agency staff noted that contract support for the PM expert elicitation cost \$500,000 and likely \$750,000 including(?) staff time. Part of that cost was the need to make the expert elicitation process and results transparent to the public. One panel member noted that much of the cost related to structuring the problem for the experts and decision makers and that this cost would benefit the entire analysis, not just the expert elicitation component. Members then observed that expert elicitation can be viewed on a continuum of different methods for obtaining expert judgment, with one panel member noted that “expert elicitations push experts into areas where consensus is rare and data are(?) light.” Members spoke of the value of EPA weighing the opportunity cost of conducting more research vs. expert elicitations. EPA managers noted that expert elicitations can be used to inform choices about research investments and set priorities. Members responded that elicitations could be planned for major, ongoing topics of interest for EPA, with expert elicitations used to help focus research, and research used to validate the results of expert elicitation. Finally, a member noted that it is much easier to quantify the costs than the benefits of expert elicitation; he welcomed EPA’s draft white paper as a positive step to engage in that discussion.

After the conclusion of the senior manager’s discussions, the panel received an overview briefing from Mr. Robert Hetes, EPA Office of Research and development and Mr. Harvey Richmond of EPA’s Office of Air and Radiation (Appendix E). After the presentation, members asked clarifying questions. In response, the Agency speakers spoke of their concern about secondary uses of expert elicitation results and explained that they excluded “societal values and

preferences” from the definition of expert elicitation in the white paper to focus on scientific judgment rather than the science supporting decision making. They clarified that the purpose and role of the white paper was to engage senior Agency managers in the Agency’s Science Policy Council in a discussion of whether and how expert elicitation should be used at EPA and whether guidelines for expert elicitation should be developed. The White Paper was not intended, itself, to provide those guidelines.

Charge question A - background and definition of expert elicitation

Does the White Paper provide a comprehensive accounting of the potential strengths, limitations, and uses of EE? Please provide comments that would help to further elucidate these potential strengths, limitations, and uses. Please identify others (especially EPA uses), that merit discussion.

Drs. John Bailar and Roger Cooke provided initial comments as lead discussants. Dr. Bailar commended EPA’s task force for the draft white paper and offered several comments to improve it. He recommended that the document be shortened, edited to reduce redundancy, and revised to have a more analytical tone. He called for the revised draft to convey a more Bayesian view of environmental analysis (what is the probability that the hypothesis is true), rather than express issues in terms of ordinary frequentist statistics (what happens if some hypothesis is true). He called for the addition of appendices that would present case studies of completed expert elicitations, cases chosen to illuminate issues that can crop up (such as differences in views among experts). He also recommended discussing what is known about how the results of expert elicitations compare to actual research observations. He noted a need for more discussion of how experts are chosen and cautioned against drawing a sharp contrast between experts and “mere mortals.” He also noted the important potential use of expert elicitation for research planning.

Dr. Roger Cooke provided his remarks as lead discussant in the form of slides (Appendix F). Among other points, he called for EPA to update the literature referenced in the white paper; eliminate the use of the term “clairvoyance test” (although he emphasized the importance of operationalizing effective ways to communicate assumptions and questions to experts); provide a discussion of dependence among uncertainties; and identify ways to identify, measure, and train to attain good performance.

After the lead discussants concluded their remarks, panel members discussed the charge questions further. Several members agreed that the draft white paper should be revised to provide a more even-handed discussion of advantages and disadvantages of expert elicitation. Other members advised that EPA introduce expert elicitation within the context of a larger discussion of its efforts to use expert judgment and to address uncertainty.

Members discussed EPA’s special needs for expert elicitations that will help them assess the consequences of a regulation. EPA is not generally interested in the degree of acceptance of a particular model or a hypothesis, *per se*; the Agency is interested in the consequences in the real world. Therefore, expert elicitations should generally be about quantities about which people can know the truth.

Members spoke of the value of eliciting the rationales behind experts' viewpoints. If EPA understands their rationale, it can understand where they agree or disagree; this information can help determine whether to combine expert judgments and how to combine them. Several members recommended that the white paper discuss the value of mental model research in eliciting rationales from experts. Other members spoke of the unique value of the quantitative judgments on uncertainty that experts provide in expert elicitation. Quantifying that distribution is difficult and should be pursued if(?) the result is useful for decision makers.

Other members questioned the nature of the performance evaluation of experts suggested by Dr. Cooke. They cautioned about bringing an external expertise into play in evaluating experts. Dr. Cooke suggested that expert judgments should be evaluated against measurable data, where possible.

Members recommended that the white paper include a more extensive discussion of various ways to encode expert judgment. Binary judgments may be more helpful than numerical estimates

Charge question C.1 – selecting experts

Section 5.2 considers the process of selecting of experts.

a) Although it is agreed that this process should seek a balanced group of experts who possess all appropriate expertise, there are multiple criteria that can be used to achieve these objectives. Does this White Paper adequately address the different criteria and strategies that may be used for nominating and selecting experts?

b) Are there additional technical aspects about this topic that should be included?

Drs. Thomas Wallsten and Mitchell Small provided initial comments as lead discussants. Dr. Wallsten noted that the white paper does a good job of addressing this issue and suggested that EPA consider different criteria for establishing an expert pool and for pulling experts from the pool. He also suggested EPA consider inviting stakeholders to nominate experts who meet the criteria. The process for choosing experts should be clear and should involve experts in expert elicitation, EPA staff, and stakeholders. The final group of experts should balance different expertise and stakeholder perspectives on the technical issue. Dr. Small agreed that it was important to consider political perspectives as well as disciplinary expertise and to “cover the sample space well.”

Other members asked why stakeholder perspectives should be considered and viewed the choice of experts more strictly as a scientific issue. One member spoke of the importance of including an expert with broad knowledge, who can understand the issue in context. It was generally agreed that there should be a plan for choosing experts, which should state in advance how the analysis will address combination of information from experts, where experts have the same distribution of answers and where they don't.

One member spoke of the desirability of involving larger numbers of experts to give expert elicitations credibility. In his view, it is difficult to cover the relevant range of views with

fewer than 10 people, the number allowed without OMB review under the Paperwork Reduction Act. He advocated mechanisms for expert elicitation that might use the Internet. Another member responded that the goal for the expert elicitation study would determine the appropriate size and approach. He envisioned 3 general goals: 1) survey/census of views; 2) political consensus – i.e., equilibrium of interest; and 3) rational consensus (equilibrium of arguments). Another expert noted that enlarging the pool of experts might result in less effort devoted to encoding and reduced quality of encoding. There would be a tradeoff; numbers would be greater but the quality of information per-person is likely to be less. Another panel member noted that Carnegie Mellon researchers have evaluated expert elicitation studies that quickly identify where there is agreement among experts, deviation among experts, or deviation from data. Yet others noted situations where large numbers of experts all agree and all are wrong and that “If you have N of 100, but they are poorly elicited, the results are not better than N of 10.” Enlarging the N as a goal in itself raises the question of whether EPA would be “voting or seeking knowledge.”

Members then discussed criteria for identifying expertise. One panel member suggested that since expert elicitation enriches available data by filling data with expert judgment, appropriate criteria might be familiarity with existing data, i.e., experts who have created data or have wide data citations.

Members then discussed whether reports of expert elicitations should link responses to individual experts. Several members noted that the general practice is to keep experts’ views private. They noted that with controversial issues, scientists’ hesitate to provide honest, in-depth information, if their responses would be made public. Other members noted that this convention might be viewed as suspect, because individual experts’ views were not transparent.

Charge question C.2 – multi-expert aggregation

Sections 5.4 and 6.7 present multi-expert aggregation.

a) Among prominent EE practitioners there are varied opinions on the validity and approaches to aggregating the judgments obtained from multiple experts. Does this White Paper capture sufficiently the range of important views on this topic?

b) Are there additional technical aspects about this topic that should be included?

Drs. Roger Cooke and Max Henrion provided initial comments as lead discussants. Dr. Cooke provided his comments in the form of slides (Appendix G), which emphasized the importance of performance assessment. Dr. Henrion then noted that experts can be grouped into “hedgehogs” (experts who don’t change their views) and “foxes” (experts who provide views that differ with context). He notes that the white paper stated that if experts disagree, their responses should not be combined. He observed, however, that if experts disagree on many parameters, lack of aggregation would result in a confusing number of reports. Furthermore, if the expert elicitation study results do not aggregate information, decision makers will themselves aggregate information, perhaps unsystematically. He favored a two-workshop approach that allowed for an initial workshop prior to an elicitation to improve expert’s understanding of the evidence and a second workshop that would allow experts to review their opinions. During this second workshop, he would give experts the opportunity to revise their views, but would also warn them that they must have good reason to do so and not revise to “get along” with others.

He noted that in reports averaging probability densities “is OK, but averaging values is not.” He noted that he is uncomfortable with averaging processes that result in multiple modes, because those results suggest that experts are over-confident.

Other members noted that they would accept a multi-peak distribution, unless there was a specific reason for not including it. One member suggested that the original briefing should be kept minimal, so that expert elicitation did not morph into a Delphi Method. Another member noted that the white paper inappropriately includes the Q method in the discussion of expert elicitation. Yet another member acknowledged the value of a second workshop but noted the cost. Several members noted that the purpose of the expert elicitation affects whether to aggregate data. Sometime decision makers only want the central tendency.

Members discussed research topics related to this question. One member recommended that a study be conducted comparing experts working alone with experts working together. Other members recommended more studies comparing the results of expert elicitation with actual data. Another member suggested taking that comparison and analyzing how each met decision-makers’ needs for information. Another member called for development of protocols for *ex post* evaluation of data from expert analysis.

Charge question C.3 – problem structure

Section 5.2.2 discusses how the problem of an EE assessment is structured and decomposed using an “aggregated” or “disaggregated” approach.

a) The preferred approach may be influenced by the experts available and the analyst’s judgment. Does this discussion address the appropriate factors to consider when developing the structure for questions to be used in an EE assessment?

b) Are there additional technical aspects about this topic that should be included?

Drs. Christopher Frey and Mark Borsuk provided initial comments as lead discussants. Dr. Frey noted that the domain of the expert will affect the approach for structuring the assessment. He suggested that Figure 6.1 employ an influence diagram or some other description that more clearly illustrates how the problem context will be communicated to experts.

Dr. Mark Borsuk noted that every elicitation needs to be conditional and needs to be explicit on what it is conditional on. He recommended that the white paper make this point more clearly and that Figure 6-1 be revised to show an influence diagram. He recommended that EPA include elicitation of correlation coefficients in its discussion and provide an explicit statement about the extent to which shared data are made available to experts. He also noted that scenario uncertainty and decision-rule uncertainty should not be described as variables appropriate for elicitation on pages 50-51, because they are part of the context provided to experts. He acknowledged that experts often desire to answer a question with a range of values, rather than the specific quantity requested by elicitors, i.e., “Second order uncertainties is something experts want to give.” In these cases, elicitors should request information about specific quantities, but record ranges, when provided. This information is important because some kinds of expert disagreements are within a range of values and pertain to epistemic uncertainty rather than

aleatory uncertainty. He suggested that use of probability boxes may be useful and recommended that density functions be used rather than distribution functions.

Panel members then provided comments. Several members expressed an interest in having the panel comment about the use of frequency distributions. One member rejected the notion that elicitors should accept responses in ranges, because the ultimate end-product of an expert elicitation includes a predictive distribution. Another member commented that EPA should reduce confusion in the report by using the term “aggregation” in only one way, for example, as aggregation of information from different experts, rather than as a stage in the process of encoding.

Several members discussed the necessity to use tools to aid encoding to check that elicited information is internally coherent and consistent, especially to determine if there has been an inversion in the data. One member noted that analysts should refrain from any coaching of experts, but aim to prevent experts from saying anything they will regret. In general, disaggregated models may be most useful to decompose questions, but this approach may not work well with all experts. Members agreed that elicitations should focus on the data, not the decision that would be affected. Several members also noted that it is useful to involve decision makers and stakeholders in framing questions, because if they can’t understand the questions, they won’t be able to understand the answers. A panel member also observed that questions should be pilot tested on at least one person per discipline. Questions should be phrased in ways that permit everyone to understand in the same way. In response, one member cautioned that the Paperwork Reduction Act imposes limits on collecting the same information from 10 or more people.

Charge question C.4 & 5 – findings and recommendations

4) *Sections 7.1 and 7.2, presents the Task Force’s findings and recommendations regarding: 1) selecting EE as a method of analysis, 2) planning and conducting EE, and 3) presenting and using results of an EE assessment. Are these findings and recommendations supported by the document?*

5) *Please identify any additional findings and recommendations that should be considered.*

Drs. Alan Krupnick and Scott Ferson provided initial comments as lead discussants. Dr. Krupnick emphasized the importance of strengthening the concluding section, because it may be the section that receives the most attention. He advised EPA to revise the section to provide a more balanced assessment of expert elicitation. He recommended that EPA discuss the alternatives to expert elicitation, such as meta-analysis, and discuss the opportunity costs of choosing among options. He recommended that the concluding section have a summary of the current use of expert elicitation at EPA and outside the Agency to inform readers about the extent of use and acceptance of the method. He noted that the white paper, given its purpose to engage a discussion at EPA, should not provide a “cookbook” to help implement expert elicitation, and instead should provide a clear statement of the defining characteristics and possible uses of expert elicitation and its advantages and disadvantages, compared to other

related methods.

Dr. Scott Ferson also commented that the white paper should present expert elicitation as one tool within a spectrum of tools. EPA Staff noted that the EPA is developing companion white papers on the use of probabilistic risk assessment and the use of a hierarchy of methods for addressing uncertainty. Dr. Ferson noted that the white paper should acknowledge these efforts under development.

Dr. Ferson also suggested that the final conclusion address the problems of surrogacy modeling, statistical sampling, boundary estimates, the need to elicit inter-variable dependences, the importance of framing, and the need for checking for coherence. Although he liked the discussion of cognitive biases, he noted important citations missing in the area of neuro-psychology. He also called for discussion of more alternatives to the use of P-boxes and linear pooling that “erases uncertainty that we want to propagate”

Other panel members then provided comments. One member advised EPA to provide a more expanded discussion of the important distinction between epistemic and aleatory uncertainty. He also disagreed with the notion that meta-analysis was an alternative to expert encoding, which is generally conducted when there are data gaps. The panel chair noted that the Particulate Matter expert elicitation on a much-studied topic, and the committee discussed how this topic was data rich. Some members expressed concern that the white paper did not clearly identify when expert elicitation is most appropriate and useful. One member noted that expert elicitation might be considered a “last resort - something you do if you can’t get answer in another way”

Panel members then discussed several other issues. One member advised EPA to communicate more clearly the subtle distinction that, although the result of expert elicitation does not substitute for empirical research, it is part of an ongoing process informing research. It is information about what experts think and what they are uncertain about. Another member suggested that the white paper expand the role of stakeholders. In the current draft, stakeholders are discussed primarily in terms of what they can tell investigators to inform experimental protocol. The panel member suggested that stakeholders could be involved to enhance the credibility of the elicitation results in important groups and enhance acceptability.

The meeting adjourned at 5:20 on February 25, 2009.

Opening of the Second Day of the Public Meeting

The DFO opened the meeting at 9:00 a.m. on February 26, 2009. The panel chair welcomed panel member Dr. John Evans to the meeting. Dr. Frey was unable to participate in the panel meeting on the second day.

Charge question B – transparency

Transparency is important for analyses that support Agency scientific assessments and for characterization of uncertainties that inform Agency decision making. Please

comment on whether the White Paper presents adequate mechanisms for ensuring transparency when 1) considering the use of EE (chapter 4), 2) selecting experts (chapter 5); and 3) and presenting and using EE results (chapter 6). Please identify any additional strategies that could improve transparency.

Drs. William Ascher and Wändi Bruine de Bruin provided initial comments as lead discussants. They presented comments in the form of slide presentations (Appendices H and I)

After their presentations, members discussed whether there were options for reducing the amount of documentation needed to make elicitations transparent, because the costs of documentation are high. Members also discussed how to address the high number of “50%” responses that Dr. Bruine noted really means the expert doesn’t know the answer. One member observed that use of paired comparisons or spinner sets, rather than numerical elicitations, would reduce the number of such responses.

Members acknowledged the good reasons for transparency, but noted the costs and discussed other possible disadvantages. Several members revisited the previous day’s discussion about whether the results of expert elicitation should report the responses of individual experts by name, because such reports would have a chilling effect on expert’s participation. A few members called for more transparency in reporting experts’ responses as a protection against gaming and corruption. Another member observed that formally elicited expert judgment efforts already provide a greater degree of transparency than other approaches to expert judgment (i.e., choice of experts is explicit, protocols outlined); requiring additional transparency might make it impossible to implement expert elicitation efforts in the future. In response to a question from panel members, Agency staff noted that in EPA expert elicitations conducted to date, the raw data on expert responses have not been provided to the Agency.

Members then discussed the validation of expert elicitation efforts. One member agreed with the white paper, that experts should review the elicitation process and not the data developed (i.e., experts’ elicited responses). In his view, it would not make sense to hold a peer review of the responses, because that would involve an unstructured review of structured information. Another member suggested that reviewers should review data to see if it passes a reality check. Other members suggested a different approach, that not only should the expert elicitation plan be reviewed beforehand, but the execution of the plan should be reviewed after the elicitation has taken place, to ensure that procedures (including procedures for elicitors to implement checks for consistency, coherence, and logic in elicitation) were properly conducted.

Charge question D – development of future guidance

As EPA considers the future development of guidance beyond this White Paper, what additional specific technical areas should be addressed? What potential implications of having such guidance should be considered? Do the topics and suggestions covered in the White Paper regarding selection, conduct, and use of this technique provide a constructive foundation for developing “best practices” for EE methods?

Drs. Paul Fischbeck and Katherine Walker provided initial comments as lead discussants. They presented comments in the form of a slide presentation (Appendix J). Dr. Fischbeck called for an expanded effort to pool information on expert elicitation that would foster research and validation efforts and help EPA and others view expert elicitation through a lifecycle analysis, where experts could see the extent to which future research validated their expert judgment.

Following their presentations, the panel Chair asked members to identify items that should be included in the panel report. Members generated and discussed the following list:

- 1) Put expert elicitation in longer-term context
- 2) Be explicit about how relations among variables are structured
- 3) Be more explicit that methods for conditioning and inference are needed
- 4) Provide a more thorough discussion of limits of use of technique. When is it OK to use technique and not (perhaps too easy to use instead of research)
- 5) Need research on making acceptable quality research trade-offs; how to make studies less costly, have more experts involved, less costly ways to have rigorous expert elicitation done)
- 6) More balanced survey of different elicitation methods and performance evaluation methods would help inform when to choose expert elicitation
- 7) Address difficulty of how to choose experts; clearer exposition of options for choosing experts and evaluation of options
- 8) Emphasize importance of verifying coherence, consistency, and internal logical relationships
- 9) Clarify what should be assessed are quantities that are observable in principle
- 10) Address how expert elicitation addresses model uncertainty
- 11) EPA can use expert elicitation when address two issues
 - a) Transparency restrictions vs. FACA and related rules
 - b) Reconcile understanding of uncertainty and variability
- 12) Re: combining expert responses, recognize subtlety of issue; right answer depends on decision-maker. Don't get too prescriptive
- 13) Would like research needs to have a separate section of report, especially methods to monitor process in addition to protocol
- 14) Propose that white paper include discussion of subjective probability as distinct from frequentist confidence intervals
- 15) More discussion of relative merits of expert elicitation vs. meta-analysis, expert committee report. Address issues common to all
- 16) Put in context of methods development, i.e., benefit-cost analysis, life-cycle analysis, general equilibrium analysis. EPA needs to improve all areas. Issue of opportunity costs
- 17) EPA needs program of empirical research on expert elicitation. Designated people to identify needs and see that they are met
- 18) For operations, EPA needs cadre of people expert in expert elicitation. Every expert elicitation needs involvement of dedicated unit
- 19) EPA needs unit of 3-5 professionals devoted to expert elicitation until EPA has broadened its staff knowledge of expert elicitation

- 20) Look at dependence elicitation; experts' beliefs about dependence among random variables
- 21) EPA should start off learning how to do expert elicitation; do studies, get criticism, consensus will emerge. Learn from experience
- 22) Create a documented location where experience can accrue, build on experience. EPA could host web site; give access to data, sources, audits
- 23) Lifecycle of expert elicitation should have all steps and get feedback at start and get evaluation at end
 - a) Important for experts to learn how to do expert elicitation; also whole community can learn
- 24) Need to know more about how to best ask experts questions. EPA needs expertise
- 25) Include survey design and risk communication experts in design of expert elicitation projects
- 26) White paper should identify areas where there is consensus, and panel should support that effort
 - a) Fairly well established literature on methods, e.g., aggregation issue-general consensus that mathematical aggregation is better approach
- 27) SAB panel report should recommend that guidelines be created for conducting expert elicitation
- 28) SAB panel report should address tradeoffs between different objectives for expert elicitation (including different methods for preparing experts) and transparency
- 29) Address cost-effective ways to do expert elicitation
- 30) Recommend that EPA invite nominations of expert elicitation methods that would be bench tested; identify how the system would be evaluated
- 31) White paper should add a clear statement of scientific matters that are being encoded separate from the decision issues that provide the context.

Dr Christopher Frey, who was unable to participate in the meeting, provided the following input via email:

I support that structuring should occur BEFORE meeting with experts as much as possible, and should be evaluated in a pilot elicitation. However, despite all preparations, I would expect occasionally an expert may not want to accept the structure posed by the elicitor, and may want to propose an alternative structure. There should be some flexibility to accommodate this when appropriate, as long as the Agency is still able to infer the model outcomes that it ultimately cares about (e.g., if the goal is to estimate avoided excess mortality, then one could accept alternative approaches to characterizing dose-response).

- Based on yesterday's discussion, I propose that we recommend that elicitations focus on empirical quantities that are in principle measurable or observable, even if not so at the current time. Ideally, such quantities should be model independent. I don't want to be too prescriptive about this, in case there might be some reasonable exception - it is a recommendation, not a requirement.

- The report might elaborate on our discussion about the "clairvoyance test" and alternative ways of conceptualizing it. - The EPA report states that uncertainty in "relationships" is within the scope of EE, but doesn't really address it. Per our discussion yesterday, we recommend that EPA focus on eliciting empirical quantities and then use that information to inform model selection and parameter estimation, rather than asking experts to provide judgments regarding parameter values. However, again, perhaps we don't want to be too prescriptive about this.

- The issue of dependency among quantities was discussed - we should include elicitation of conditional distributions as a topic in our report. I agree that it is difficult/impossible to elicit correlations directly.

- I echo comments about the report structure and content being redundant, and will supply comments via a marked up version.

- I strongly recommend that EPA prepare a more extensive glossary of terms that are jargon related to the topic area. These do not have the final internationally accepted definitions - the goal here is to let the reader know that the EPA means by these terms in the context of this document. Examples include "representativeness," "data gap," and many others (I will provide a list). It is fine if EPA adopts glossary definitions from existing documents.

One panel member noted that, although the panel had identified many issues associated with expert elicitation, it is "asking too much for EPA to resolve all these issues." He commended EPA for beginning a dialogue about the use of this important tool

Next Steps

The Chair asked panel members to send written comments relating to their charge question and suggestions for references that EPA should note to the DFO by March 2, 2009. He committed to drafting a report based on panel members input asked the DFO to set a date for a teleconference to discuss that draft report.

The meeting adjourned at 1:15 pm.

Respectfully Submitted:

/Signed/

Angela Nugent
Designated Federal Officer

Certified as True:

/Signed/

James K. Hammitt
Chair

NOTE AND DISCLAIMER: The minutes of this public meeting reflect diverse ideas and suggestions offered by committee members during the course of deliberations within the meeting. Such ideas, suggestions, and deliberations do not necessarily reflect definitive consensus advice from the panel members. The reader is cautioned to not rely on the minutes to represent final, approved, consensus advice and recommendations offered to the Agency. Such advice and recommendations may be found in the final advisories, commentaries, letters, or reports prepared and transmitted to the EPA Administrator following the public meetings.

Appendices

| | |
|------------|--|
| Appendix A | Roster |
| Appendix B | Federal Register Notice |
| Appendix C | Meeting Agenda |
| Appendix D | Presentation by Dr. Kevin Teichman, “SAB Review of Expert Elicitation Task Force White Paper – Overview” |
| Appendix E | Presentation by Mr. Robert Hetes and Mr. Harvey Richmond, “SAB Review of Expert Elicitation Task Force White Paper – Overview” |
| Appendix F | Presentation by Dr. Roger Cooke, “SAB EE; Charge question A” |
| Appendix G | Presentation by Dr. Roger Cooke, “Two Day Short Course on Expert Judgment” |
| Appendix H | Presentation by Dr. William Ascher, “Issues of Transparency for Expert Elicitation” |
| Appendix I | Presentation by Dr. Wändi Bruine de Bruin, “Transparency of EPA expert elicitation” |
| Appendix J | Presentation by Drs. Paul Fischbeck and Katherine Walker, “When is a method credible?” |

Appendix A: Roster

U.S. Environmental Protection Agency Science Advisory Board Expert Elicitation Advisory Panel

CHAIR

Dr. James K. Hammitt, Professor, Center for Risk Analysis, Harvard University, Boston, MA

MEMBERS

Dr. William Louis Ascher, Donald C. McKenna Professor of Government and Economics, Claremont McKenna College, Claremont, CA

Dr John Bailar, Scholar in Residence, The National Academies, Washington, DC

Dr. Mark Borsuk, Assistant Professor, Engineering Sciences, Thayer School of Engineering, Dartmouth College, Hanover, NH

Dr. Wändi Bruine de Bruin, Research Faculty, Department of Social & Decision Sciences, Carnegie Mellon University, Pittsburgh, PA

Dr Roger Cooke, Professor of Mathematics at Delft University of Technology and Chauncey Starr Senior Fellow for Risk Analysis at Resources for the Future, Resources for the Future, Washington, DC

Dr. John Evans, Senior Lecturer on Environmental Science, Harvard University, Kuwait Public Health Project, 135 Market Street, Unit C, Portsmouth, NH, 03801, Phone: 603-433-3956, Fax: 603-433-4174, (jevans@hsph.harvard.edu)

Dr. Scott Ferson, Senior Scientist, Applied Biomathematics, Setauket , NY

Dr. Paul Fischbeck, Professor, Engineering and Public Policy and Social and Decision Sciences, Carnegie Mellon University, Pittsburgh, PA

Dr. H. Christopher Frey, Professor, Department of Civil, Construction and Environmental Engineering, College of Engineering, North Carolina State University, Raleigh, NC

Dr. Max Henrion, CEO and Associate Professor, Lumina Decision Systems, Inc., Los Gatos, CA

Dr. Alan J. Krupnick, Senior Fellow and Director, Quality of the Environment Division, Resources for the Future, Washington, DC

Dr. Mitchell J. Small, The H. John Heinz III Professor of Environmental Engineering, Department of Civil and Public Policy, Carnegie Mellon University, Pittsburgh, PA

Dr Katherine Walker, Senior Staff Scientist, Health Effects Institute, Boston, MA

Dr. Thomas S. Wallsten, Professor and Chair, Department of Psychology, University of Maryland, College Park, MD

SCIENCE ADVISORY BOARD STAFF

Dr. Angela Nugent, Designated Federal Officer, 1200 Pennsylvania Avenue, NW
1400F, Washington, DC, Phone: 202-343-9981, Fax: 202-233-0643, (nugent.angela@epa.gov)

Appendix B: Federal Register Notice

Science Advisory Board Staff Office; Notification of Upcoming Meeting of the Science
Advisory Board Expert Elicitation Advisory Panel
PDF Version (2 pp, 71K, About PDF)

[Federal Register: January 29, 2009 (Volume 74, Number 18)]
[Notices]
[Page 5157-5158]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr29ja09-44]

ENVIRONMENTAL PROTECTION AGENCY
[FRL-8769-4]

Science Advisory Board Staff Office; Notification of Upcoming
Meeting of the Science Advisory Board Expert Elicitation Advisory Panel

AGENCY: Environmental Protection Agency (EPA).
ACTION: Notice.

SUMMARY: The Environmental Protection Agency (EPA or Agency) Science
Advisory Board (SAB) Staff Office announces a public meeting of the
Science Advisory Board Expert Elicitation Advisory Panel to review
EPA's draft Expert Elicitation Task Force White Paper.

DATES: The meeting dates are Wednesday, February 25, 2009 from 9 a.m.
to 5:30 p.m. through Thursday, February 26, 2009 from 9 a.m. to 1 p.m.
(Eastern Time).

[[Page 5158]]

ADDRESSES: The meeting will be held in the SAB Conference Center,
located at 1025 F Street, NW., Room 3705, Washington, DC 20004.

FOR FURTHER INFORMATION CONTACT: Members of the public who wish to
obtain further information about this meeting may contact Dr. Angela
Nugent, Designated Federal Officer (DFO). Dr. Nugent may be contacted
at the EPA Science Advisory Board (1400F), U.S. Environmental
Protection Agency, 1200 Pennsylvania Avenue, NW., Washington, DC 20460;
or via telephone/voice mail; (202) 343-9981; fax (202) 233-0643; or e-
mail at nugent.angela@epa.gov. General information about the EPA SAB,

as well as any updates concerning the meeting announced in this notice, may be found on the SAB Web site at <http://www.epa.gov/sab>.

SUPPLEMENTARY INFORMATION: Pursuant to the Federal Advisory Committee Act, Public Law 92-463, notice is hereby given that the SAB Expert Elicitation Advisory Panel will hold a public meeting to review EPA's draft Expert Elicitation Task Force White Paper. The SAB was established by 42 U.S.C. 4365 to provide independent scientific and technical advice to the Administrator on the technical basis for Agency positions and regulations. The SAB is a Federal Advisory Committee chartered under the Federal Advisory Committee Act (FACA), as amended, 5 U.S.C., App. The SAB will comply with the provisions of FACA and all appropriate SAB Staff Office procedural policies.

Background: EPA's Science Policy Council (SPC) formed the Expert Elicitation Task Force in April of 2005 to initiate a thorough discussion of Expert Elicitation, and to investigate how to conduct and use this method to support EPA regulatory and non-regulatory analyses and decision-making. The Task Force, with representation across EPA program offices and Regions, developed the Expert Elicitation Task Force White Paper. The White Paper discusses the potential utility of using expert elicitation to support EPA regulatory and non-regulatory analyses and decision-making, provides recommendations for expert elicitation "good practices" based on a review of the literature and actual experience within EPA and other federal agencies and describes steps for a broader application across EPA. EPA's Office of the Science Advisor has requested SAB review of EPA's draft Expert Elicitation Task Force White Paper to provide advice regarding the potential usefulness of expert elicitation, how to strengthen the scientific basis for its use, and the implications for possible implementation at EPA.

EPA's Science Advisory Board Staff Office formed the SAB Expert Elicitation Advisory Panel after announcing the advisory activity in the Federal Register on June 28, 2007 (72 FR 35463-35465) and requesting nominations of experts. Information on the panel and the advisory activities can be found on the SAB Web site at http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Expert%20Elicitation%20White%20Paper?OpenDocument. Availability of Meeting Materials: EPA's draft Expert Elicitation Task Force White Paper will be posted on the EPA Office of Science Advisor Web site at www.epa.gov/osa/spc/expertelicitation. The EPA technical contact for the draft Expert Elicitation Task Force White Paper is Mr. Robert Hetes, EPA Office of Research and Development. Mr. Hetes may be contacted by telephone at (919) 541-1589, or via e-mail at hetes.bob@epa.gov. The agenda and other material for the upcoming public meeting will be posted on the SAB Web site at <http://www.epa.gov/sab>.

Procedures for Providing Public Input: Interested members of the

public may submit relevant written or oral information for the SAB Panel to consider on the topics included in this advisory activity and/or group conducting the activity. Oral Statements: In general, individuals or groups requesting an oral presentation at a public meeting will be limited to five minutes per speaker, with no more than a total of one hour for all speakers. Interested parties should contact Dr. Nugent, DFO, in writing (preferably via e-mail) at the contact information noted above, by February 18, 2009 to be placed on a list of public speakers for the meeting. Written Statements: Written statements should be received in the SAB Staff Office by February 18, 2009 so that the information may be made available to the SAB Panel members for their consideration. Written statements should be supplied to the DFO in the following formats: one hard copy with original signature, and one electronic copy via e-mail (acceptable file format: Adobe Acrobat PDF, WordPerfect, MS Word, MS PowerPoint, or Rich Text files in IBM-PC/Windows 98/2000/XP format). Submitters are asked to provide versions of each document submitted with and without signatures, because the SAB Staff Office does not publish documents with signatures on its Web sites.

Accessibility: For information on access or services for individuals with disabilities, please contact Dr. Nugent at the phone number or e-mail address noted above, preferably at least ten days prior to the meeting to give EPA as much time as possible to process your request.

Dated: January 23, 2009.
Anthony F. Maciorowski,
Deputy Director, EPA Science Advisory Board Staff Office.
[FR Doc. E9-1919 Filed 1-28-09; 8:45 am]
BILLING CODE 6560-50-P

Appendix C: Agenda
U.S. Environmental Protection Agency – Science Advisory Board (SAB) Staff Office
Science Advisory Board
Expert Elicitation Advisory Panel
Public Meeting
February 25-26, 2009
Science Advisory Board Conference Center
1025 F Street, NW, Suite 3705, Washington, D.C. 20004

Meeting Agenda

Purpose: to conduct a peer review of EPA’s *Draft Expert Elicitation Task Force White Paper*.

Wednesday, February 25, 2009

| | | |
|------------|--|--|
| 9:00 a.m. | Welcome | Dr. Angela Nugent, EPA SAB Staff Office, Designated Federal Officer Dr. Vanessa Vu, EPA, SAB Staff Office |
| 9:05 a.m. | Introductions and agenda review | Dr. James K. Hammitt, Chair |
| 9:15 a.m. | Introduction to EPA’s <i>Draft Expert Elicitation Task Force White Paper</i> and EPA’s perspective on expert elicitation | Dr. Pai-Yei Whung, EPA Office of the Science Advisor Dr. Kevin Teichman, EPA Office of Research and Development (ORD) Mr. Robert Brenner, EPA Office of Air and Radiation Mr. Robert Hetes, EPA ORD Mr. Harvey Richmond, EPA OAR |
| 10:15 a.m. | Public comments | TBD |
| 10:30 a.m. | Break | |
| 10:45 a.m. | Charge question A - background and definition of expert elicitation | Lead discussants: Dr. John Bailar Dr. Roger Cooke Panel discussion |
| 11:45 a.m. | Charge question C.1 – selecting | Lead discussants |

| | | |
|------------|--|--|
| | experts | Dr. Thomas Wallsten Dr. Mitchell Small Panel discussion |
| 12:45 p.m. | Lunch | |
| 2:00 p.m. | Charge question C.2 – multi-expert aggregation | Lead discussants: Dr. Roger Cooke Dr. Max Henrion Panel discussion |
| 3:00 p.m. | Break | |
| 3:15 p.m. | Charge question C.3 – problem structure | Lead discussants: Dr. Christopher Frey Dr. Mark Borsuk Panel discussion |
| 4:15 p.m. | Charge question C.4 & 5 – findings and recommendations | Lead discussants: Dr. Alan Krupnick Dr. Scott Ferson Panel discussion |
| 5:15 p.m. | Preparations for second day of panel meeting | Dr. James K. Hammitt |
| 5:30 p.m. | Recess for next day | |

Thursday, February 26, 2009

| | | |
|------------|--|--|
| 9:00 a.m. | Open the public meeting | Dr. Angela Nugent |
| 9:05 a.m. | Charge question B - transparency | Lead presenters Dr. William Ascher Dr. Wändi Bruine de Bruin Panel discussion |
| 10:00 a.m. | Charge question D – development of future guidance | Lead presenters: Dr. Paul Fischbeck Dr. Katherine Walker Panel discussion |
| 10:30 a.m. | Break | |
| 10:45 a.m. | Charge question D – continued discussion | Panel |

| | | |
|----------|--|----------------------|
| 11:30 | Working lunch and identification of next steps | Dr. James K. Hammitt |
| 1:30 p.m | Adjourn | |

Appendix D: Presentation by Dr. Kevin Teichman, “SAB Review of Expert Elicitation Task Force White Paper – Overview”



SAB Review of Expert Elicitation Task Force White Paper - Overview

Kevin Teichman

Office of Research and Development
Office of Air and Radiation

Expert Elicitation Advisory Panel
Science Advisory Board
February 25-26, 2009

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Why the increased interest in Expert Elicitation (EE) at EPA?

- Scientifically robust environmental risk assessments are not simply the multiplication of a single exposure value by a single toxicity value.
- Probabilistic risk assessments often use Monte Carlo techniques to analyze distributions of both exposures and effects to estimate risks.
- Frequently assessors must account for both missing data (e.g., limited exposure data) and scientific uncertainties (e.g., dose-response data in a different species or at exposures levels above the range of environmental exposures).
 - To account for this missing information, assessors often rely on defaults for missing data and compound uncertainty factors.
 - Often there are important uncertainties (e.g., differences among study designs) that can't be characterized based on the available data.
- Expert elicitation is one approach to “fill in” data gaps and/or provide improved characterization of uncertainty to better inform environmental decisions.

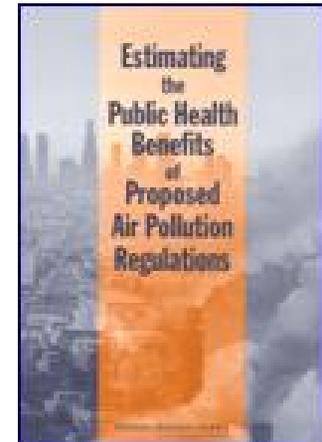


OMB (2003) Circular A-4

p. 41: "In formal probabilistic assessments, **expert solicitation** is a useful way to fill key gaps in your ability to assess **uncertainty**. In general, experts can be used to quantify the probability distributions of key parameters and relationships. These solicitations, combined with other sources of data, can be combined in **Monte Carlo simulations** to derive a probability distribution of **benefits and costs**."



Estimating the Public Health Benefits of Proposed Air Pollution Regulations (NAS 2002)



p. 134: "The committee agrees with EPA's statement that it would **require expert judgment to specify probability distributions** for many of the uncertain components of the health benefits analyses. ... EPA is correct that the elicitation of expert opinions in the form of probability distributions is a **difficult and uncertain process**. ... however ... these difficulties are (not) sufficient reasons for not trying to obtain such advice. ... As difficult and uncertain as these specifications are, they are **preferable to EPA's current practice** of treating important and highly uncertain model components as though they were certain."



EPA Cancer Risk Guidelines (2005)

- “In many of these scientific and engineering disciplines, researchers have used rigorous expert elicitation methods to overcome the lack of peer-reviewed methods and data.”
- “These cancer guidelines are **flexible enough to accommodate the use of expert elicitation to characterize cancer risks**, as a complement to the methods presented in the cancer guidelines.”



Is Expert Elicitation the Same as Expert Judgment?

- Expert judgment is inherent in the scientific process and covers a range of activities
 - Analysis – problem formulation, choices among studies and models, efforts to fill in data gaps, estimations of uncertainty
 - Evaluation and interpretation of results
- Expert peer review draws upon the expert judgments of others to provide feedback on planned or completed products and projects
- Expert Elicitation (EE) offers a formal, systematic, and transparent process for obtaining and quantifying expert judgment



Why the need for an Intra-Agency Task Force?

- While EPA acknowledges the potential value of this method:
 - Most EPA analysts/decision makers unfamiliar with method
 - No clear guidelines on how to conduct within EPA (or elsewhere)
 - Desire to promote consistency
 - Broad range of statutory, regulatory, policy issues to be addressed
 - Consider the potential impacts of precedents from near-term projects utilizing EE
 - Need to promote technically defensible assessments



Expert Elicitation Task Force Formation and Charge

- April 2005: SPC approves formation of an Agency-wide Task Force to develop a white paper on Expert Elicitation.
- Charge:
 - To initiate a dialogue within the Agency about the conduct (e.g., selection of experts) and use of expert elicitation
 - To facilitate future development and appropriate use of expert elicitation methods.
- Broad representation across Program Offices, ORD, and Regions
- SPC Champions: Bill Farland (ORD) and Rob Brenner (OAR)

Appendix E: Presentation by Mr. Robert Hetes and Mr. Harvey Richmond, “SAB Review of Expert Elicitation Task Force White Paper – Overview”



Expert Elicitation White Paper: Overview

- Chapter 1: Introduction
- Chapter 2: Background: Interest /experience in Expert Elicitation (EE)
- Chapter 3: What is EE?
- Chapter 4: What to consider in deciding whether to use EE
- Chapter 5: How to conduct an EE
- Chapter 6: How to present and use results
- Chapter 7: Findings and Recommendations
- Appendices:
 - Appendix A: Factors to Consider in Making Probability Judgments
 - Appendix B: Glossary of Terms

3

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



What is Expert Elicitation?

- Task Force defines EE as “formal systematic process of obtaining and quantifying expert judgment” – probability as degree of belief and is a subset of the broader category of approaches involving expert judgment
 - Focuses on science not societal values and preferences (other tools address values and preferences)
 - Characterizes state of knowledge not creation of new empirical data
- Task Force recognizes that EE represents one type of tool and that whether to use it and the degree of resources and time needed to conduct an EE depend on:
 - Nature of the question
 - Context
 - Intended use of the results
- Well suited for critical uncertainties and data gaps

4

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Is Expert Elicitation the Same as Expert Judgment?

- **Expert judgment** is inherent in the scientific process and covers a range of activities
 - Analysis – problem formulation, choices among studies and models, efforts to fill in data gaps, estimations of uncertainty
 - Evaluation and interpretation of results
- **Expert peer review** draws upon the expert judgments of others to provide feedback on planned or completed products and projects
- **Expert Elicitation** (EE) offers a formal, systematic, and transparent process for obtaining and quantifying expert judgment

5

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y

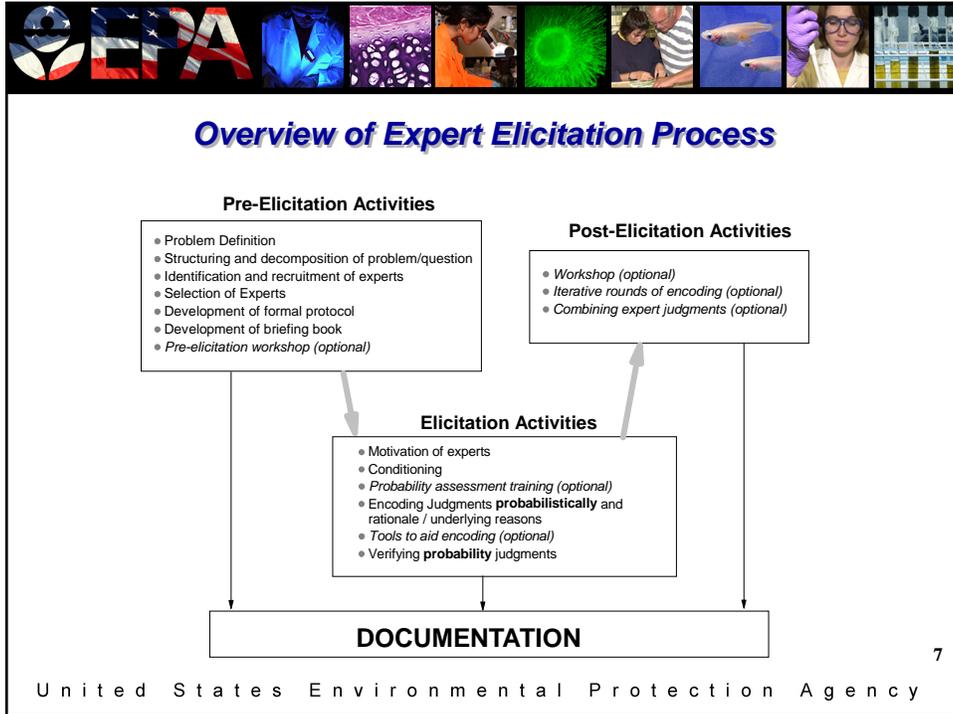


When is something an Expert Elicitation versus Expert Judgment?

- There is no bright line between EE and Expert Judgment
 - Depends on rigor and the needs of the assessment
- Minimum elements
 - Problem definition -- meets Clairvoyance Test,
 - Formal protocol -- required to ensure consistency in elicitation and control for heuristics and biases,
 - Identification, summary, and sharing of the relevant body of evidence with experts,
 - Formal elicitation -- encoding of probabilistic values or distributions of expert (interactively involving EE practitioner and subject matter expert), and
 - Output: judgment (degree of belief) is expressed quantitatively (in terms of probabilities)

6

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Ch. 4: What to Consider in Deciding Whether to Use EE

- How Important is it to Consider Uncertainty?
- What is the Nature of the Uncertainties to be Addressed?
- What are Other Methods to Characterize Uncertainty?
- What Role may Context play for an EE?
- What Resources are Required for an EE?

8

United States Environmental Protection Agency



Ch. 5: How to Conduct an EE

- What are steps in an Expert Elicitation?
- What are Pre-Elicitation Activities?
- What approaches are used to conduct Expert Elicitation?
- What Post-Elicitation activities should be performed?
- When and what type of peer review is needed for review of an Expert Elicitation?

9

United States Environmental Protection Agency



Ch. 6: How to Present and Use Results

- Does the presentation of results matter?
- What is the stakeholder and partner communication process?
- How can communications be stakeholder-specific?
- What is in a technical support document?
- What are examples of effective expert elicitation communications?
- How can EEs be transparent, defensible, and reproducible?
- Should expert judgments be aggregated for policy decisions?
- How can expert elicitation results and other probability distributions be integrated?
- How can an expert elicitation be evaluated post hoc?

10

United States Environmental Protection Agency



Chapter 7: (selected) Findings

- EE is powerful and accepted tool to characterize uncertainty/provide estimates for specific data gaps
 - EE is not always appropriate or best in all cases and is not a panacea in addressing emerging uncertainty requirements
 - EE is not equivalent to valid empirical data, nor should it be used as a substitute for collecting additional data, where such studies are feasible within timeframe and resources available
- Generally, EE requires significant investment of resources and time to provide sound results
 - Use of EE is appropriate for some situations and not for others
 - Users must be aware of both strengths and limitations of this approach
 - Analysts should keep in mind that there are other approaches
- Nature of the regulatory process introduces complexities and variety of considerations that will influence decisions on:
 - Whether to conduct an EE
 - How to conduct the EE
 - How to communicate and use the results.

11

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Chapter 7: (selected) Recommendations

- Decision to conduct an EE should involve discussions between staff organizing the EE and managers.
- EPA should develop guidance and/or policy, training and tools supporting the conduct and use of EE
 - Consult White Paper until they are ready
- Credibility, acceptability, and utility of using EE within EPA will depend on early efforts
 - Collaboration with knowledgeable staff within EPA and/or external EE practitioners
 - Provide training and tools (e.g., develop a clearinghouse on EE to facilitate sharing of methods, lessons learned, etc.
- Peer review of EE draft reports should focus on the process of elicitation and scientific evidence used

12

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Charge

- Does the White Paper provide a comprehensive accounting of the potential strengths, limitations, and uses of EE? Please provide comments that would help to further elucidate these potential strengths, limitations, and uses. Please identify others (especially EPA uses), that merit discussion.

13

United States Environmental Protection Agency



Charge (cont....)

- Transparency is important for analyses that support Agency scientific assessments and for characterization of uncertainties that inform Agency decision making. Please comment on whether the White Paper presents adequate mechanisms for ensuring transparency when
 - 1) considering the use of EE (chapter 4),
 - 2) selecting experts (chapter 5); and
 - 3) and presenting and using EE results (chapter 6).
- Please identify any additional strategies that could improve transparency.

14

United States Environmental Protection Agency



Charge (Cont...)

Please comment on the technical issues below and any other technical issues that are presented in the White Paper.

- Section 5.2 considers the process of selecting of experts.
 - Does this White Paper adequately address the different criteria and strategies that may be used for nominating and selecting experts?
- Sections 5.4 and 6.7 present multi-expert aggregation.
 - Does this White Paper capture sufficiently the range of important views on this topic?
- Section 5.2.2 discusses how the problem of an EE assessment is structured and decomposed using an “aggregated” or “disaggregated” approach.
 - Does this discussion address the appropriate factors to consider when developing the structure for questions to be used in an EE assessment?
- Sections 7.1 and 7.2, presents the Task Force’s findings and recommendations regarding:
 - 1) selecting EE as a method of analysis,
 - 2) planning and conducting EE, and
 - 3) presenting and using results of an EE assessment.Are these findings and recommendations supported by the document?
- Please identify any additional findings and recommendations that should be considered.

15

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y



Charge (Cont....)

- As EPA considers the future development of guidance beyond this White Paper,
 - what additional specific technical areas should be addressed?
 - What potential implications of having such guidance should be considered?
 - Do the topics and suggestions covered in the White Paper regarding selection, conduct, and use of this technique provide a constructive foundation for developing “best practices” for EE methods?

16

U n i t e d S t a t e s E n v i r o n m e n t a l P r o t e c t i o n A g e n c y

Appendix F: Presentation by Dr. Roger Cooke, "SAB EE; Charge question A"

SAB-EE

Charge question A

Roger M. Cooke
Resources for the Future and
Dept. Math
Delft University of Technology
Feb. 25, 2009

Summary of written comments

Plus

- That the document appears at all
- Recognize the importance of EE in uncertainty quantification
- Recognize that subjective probability is the primary formalism for encapsulating EE
- Findings chapter 7.

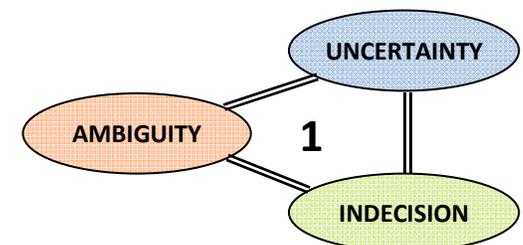
Min

1. Literature is very old
2. Insufficient focus on applications
3. No attention for performance validation
4. No attention for dependence between variables
5. Combination given very short shrift
6. Transferring expert distributions on observable quantities to parameters of a model (probabilistic inversion) is missing
7. Costing is unrealistic

There are more mins, but the plusses are more important.

1. Websites & Links

- *Radiation Protection Dosimetry* 90: (2000)
<http://rpd.oxfordjournals.org/cgi/content/short/90/3/295>
- *EU-USNRC Probabilistic accident consequence uncertainty analysis*
<http://www.osti.gov/bridge/basicsearch.jsp>
<http://www.osti.gov/energycitations/basicsearch.jsp>
- *EU Probabilistic accident consequence uncertainty assessment using COSYMA*
http://cordis.europa.eu/fp5-euratom/src/lib_docs.htm
- *Reliability Engineering and System Safety, Special Issue Expert Judgment vol 93 no 5, 2008.*
http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235767%232008%23999069994%23678744%23FLA%23&_cdi=5767&_pubType=J&_auth=y&_acct=C000022004&_version=1&_urlVersion=0&_userid=458509&md5=e172814069b8ed1945b6175effa797ff
- *RFF workshop expert judgment*
<http://www.rff.org/rff/Events/Expert-Judgment-Workshop.cfm>
- *TU Delft Website NASA 2 day EJ Short Course*
<http://dutiosc.twi.tudelft.nl/~risk/>



2&7: EU- USNRC EJ Uncertainty Analysis of accident consequence models \$4M(1990) incl \$15k per expert (\$260 per expert-variable; other studies ~ \$100/expert-vbl)

| Expert panel | Number of experts ¹ | Year | Reference |
|---|--------------------------------|------|---|
| Atmospheric dispersion | 8 | 1993 | Harper <i>et al</i> 1995 Cooke <i>et al</i> 1995 |
| Deposition (wet and dry) | 8 | 1993 | Harper <i>et al</i> 1995 Cooke <i>et al</i> 1995 |
| Behaviour of deposited material and its related doses | 10 | 1995 | Goossens <i>et al</i> 1997 |
| Foodchain on animal transfer and behaviour | 7 | 1995 | Brown <i>et al</i> 1997 |
| Foodchain on plant/soil transfer and processes | 4 | 1995 | Brown <i>et al</i> 1997 |
| Internal dosimetry | 6 | 1996 | Goossens <i>et al</i> 1998 |
| Early health effects | 7 | 1996 | Haskin <i>et al</i> 1997 |
| Late health effects | 10 | 1996 | Little <i>et al</i> 1997 |
| Countermeasures | 9 | 2000 | Goossens <i>et al</i> 2001 |

8 * 8 * 10 * ...9 > 67,000,000

3. Experts, and their combinations, are statistical hypotheses

| Case Name | weighting scheme | P-value | Mean Information |
|-----------------------|------------------|---------|------------------|
| DISPERSION | Perform | 0.9 | 1.024 |
| | Equal | 0.15 | 0.811 |
| DRY DEPOSITION | Perform | 0.52 | 1.435 |
| | Equal | 0.001 | 1.103 |
| WET DEPOSITION | Perform | 0.25 | 1.117 |
| | Equal | 0.001 | 0.793 |
| ANIMAL | Perform | 0.75 | 2.697 |
| | Equal | 0.55 | 1.778 |
| SOIL/PLANT | Perform | 0.0001 | 1.024 |
| | Equal | 0.0001 | 0.973 |
| INTERNAL DOSE | Perform | 0.85 | 0.796 |
| | Equal | 0.11 | 0.56 |
| EARLY HEALTH | Perform | 0.23 | 0.216 |
| | Equal | 0.07 | 0.165 |
| LATE HEALTH | Equal | ***** | 0.28 |

Table 3: Performance scores for equal weight and performance based combinations, per panel

4. Dependence

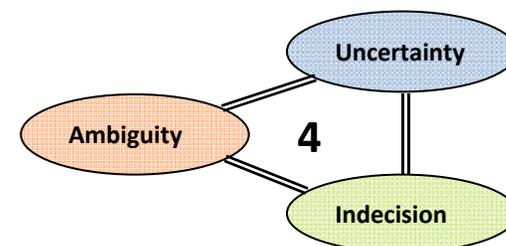
Dependencies:

Age Groups: Given that the true LD₅₀ for individuals over 40 years old is determined to be above your 50% value, what is the probability that the true LD₅₀ for individuals under 40 years old is also above your 50% value? Give your response by dose rate:

100 Gy/hr _____
 10 Gy/hr _____
 1 Gy/hr _____
 0.2 Gy/hr _____

Dose Rate: Given that the true LD₅₀ is determined to be above your 50% value for the higher dose rate, what is the probability that the true LD₅₀ is also above your 50% value for the lower dose rate? Give your estimates by age group.

| | | Under 40 | Over 40 |
|-----------|-----------|----------|---------|
| 100 Gy/hr | 10 Gy/hr | _____ | _____ |
| 10 Gy/hr | 1 Gy/hr | _____ | _____ |
| 1 Gy/hr | 0.2 Gy/hr | _____ | _____ |



5. Combination

Ship-borne NIS Reduce Great Lake Ecosystem Services:

A Structured Expert Judgment Study

Ecologists

John Rothlisberg

Center for Aquatic

University of Notr

Risk Analyst

Roger Cooke, Re

Economist

David Finnoff, U

Funding

NOAA Sea Grant

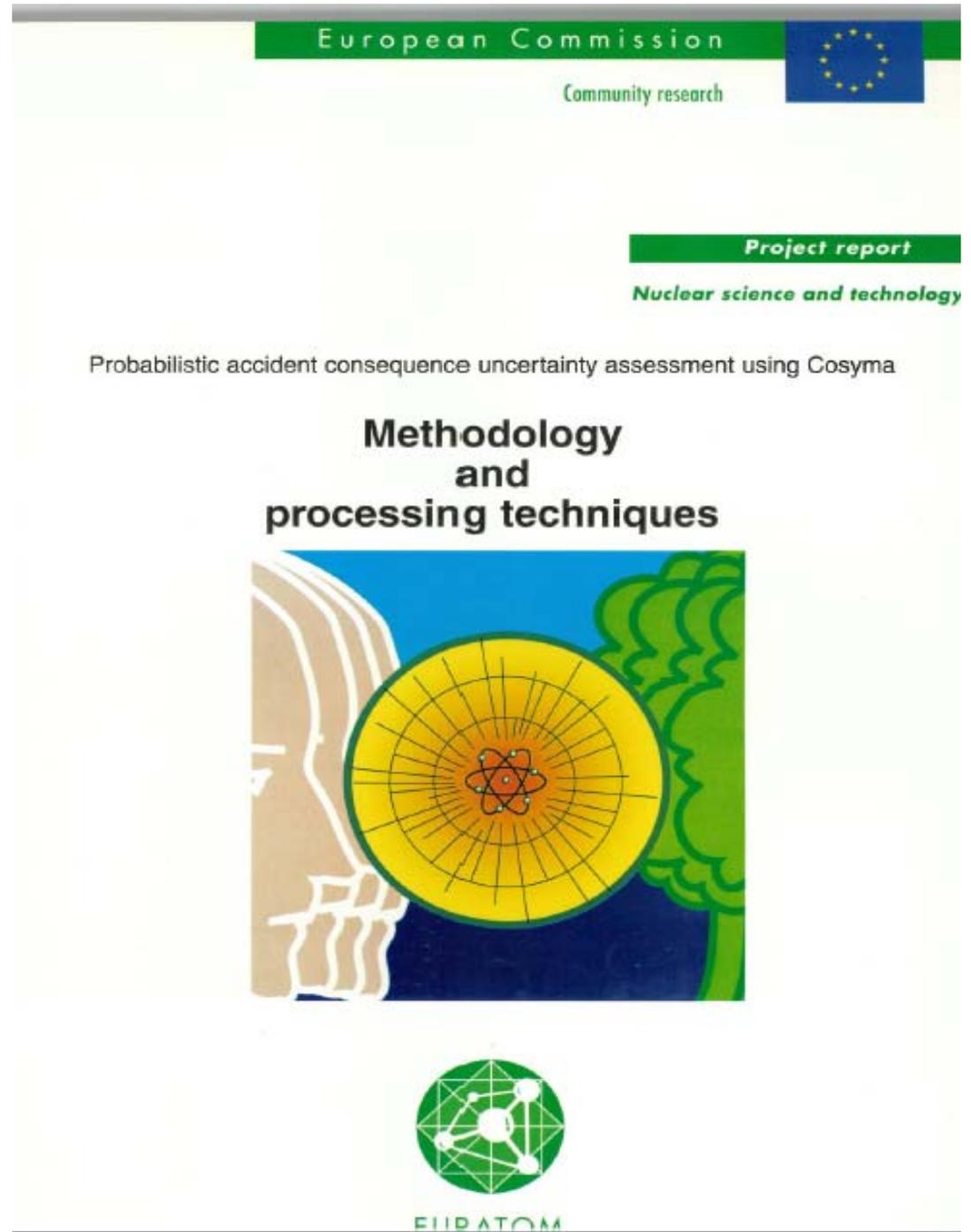
| expert | P-value | Mean rel. inf | # Calibr Vbls | Unnormalized weight |
|------------------|----------------|------------------|------------------|------------------------|
| 1 | 4.03E-05 | 0.801 | 13 | 3.79E-05 |
| 2 | 0.09646 | 1.007 | 13 | 0.06771 |
| 3 | 0.00012 | 1.522 | 13 | 0.0001476 |
| 4 | 0.00012 | 1.508 | 13 | 0.0001177 |
| 5 | 0.00075 | 0.5782 | 13 | 0.0008441 |
| 6 | 0.4539 | 0.4212 | 13 | 0.1244 |
| 7 | 0.00012 | 1.17 | 13 | 0.0001161 |
| 8 | 4.86E-06 | 1.372 | 13 | 6.64E-06 |
| 9 | 1.91E-09 | 2.336 | 13 | 5.47E-09 |
| PERF DM | 0.9281 | 0.4235 | 13 | 0.2403 |
| EQ WGT DM | 0.04411 | 0.2671 | 13 | 0.01353 |

5. Combination

- Pre 1990
 - Linear Pool? Geom mean? harmonic mean? etc.
 - Marginalization, zero preservation, independence preservation, Bayesian externality
 - Scoring rules
 - Self-weights, peer weights
 - Graduate students in psychology
- Post 1990,
 - Real experts
 - Performance measurement
 - Training
 - Evaluate combination schemes against data

**Even if you do not combine, you should validate performance,
Else NOT SCIENCE**

6. Probabilistic Inversion



Appendix G: Presentation by Dr. Roger Cooke, “Two Day Short Course on Expert Judgment”



AMBIGUITY

2 day short course on
Expert Judgment

UNCERTAINTY

INDECISION

Roger Cooke
Resources for the Future
Dept. Math, Delft Univ. of
Technology
April 15,16 2008



EJ for RATIONAL CONSENSUS:

[RESS-TUDdatabase.pdf](#)

Parties pre-commit to a method which satisfies necessary conditions for scientific method:

Traceability/accountability

Neutrality (don't encourage untruthfulness)

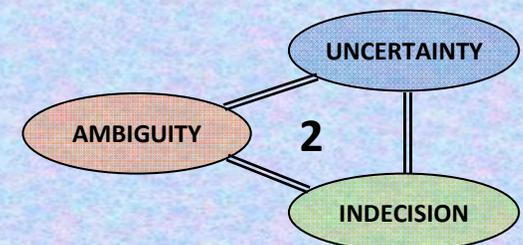
Fairness (ab initio, all experts equal)

Empirical control (performance meas't)

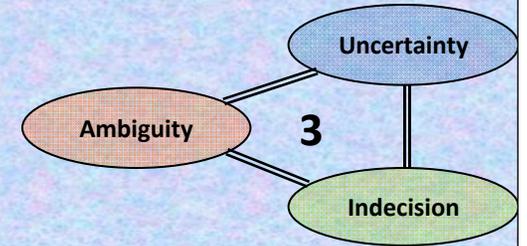
Withdrawal post hoc incurs burden of proof.

Goal: comply with principals and combine experts' judgments to get a **Good Probability Assessor**

“Classical Model for EJ”



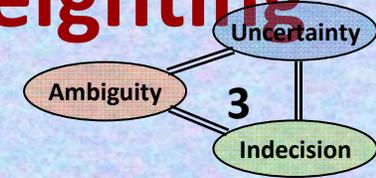
Experts CAN quantify uncertainty as subjective probability



| <i>TU DELFT Expert Judgment database 45 applications (anno 2005):</i> | # Experts | # variables | # elicitations |
|---|-------------------|--------------------|----------------------|
| Nuclear applications | 98 | 2,203 | 20,461 |
| Chemical & gas industry | 56 | 403 | 4,491 |
| Groundwater / water pollution / dike ring / barriers | 49 | 212 | 3,714 |
| Aerospace sector / space debris /aviation | 51 | 161 | 1,149 |
| Occupational sector: ladders / buildings (thermal physics) | 13 | 70 | 800 |
| Health: bovine / chicken (<i>Campylobacter</i>) / SARS | 46 | 240 | 2,979 |
| Banking: options / rent / operational risk | 24 | 119 | 4,328 |
| Volcanoes / dams | 231 | 673 | 29079 |
| Rest group | 19 | 56 | 762 |
| <i>TOTAL</i> | <i>521</i> | <i>3688</i> | <i>67,763</i> |

We CAN do better than equal weighting

[RESS-TUDdatabase.pdf](#)



R.M. Cooke, L.L.H.J. Goossens / Reliability Engineering and System Safety 93 (2008) 657–674

667

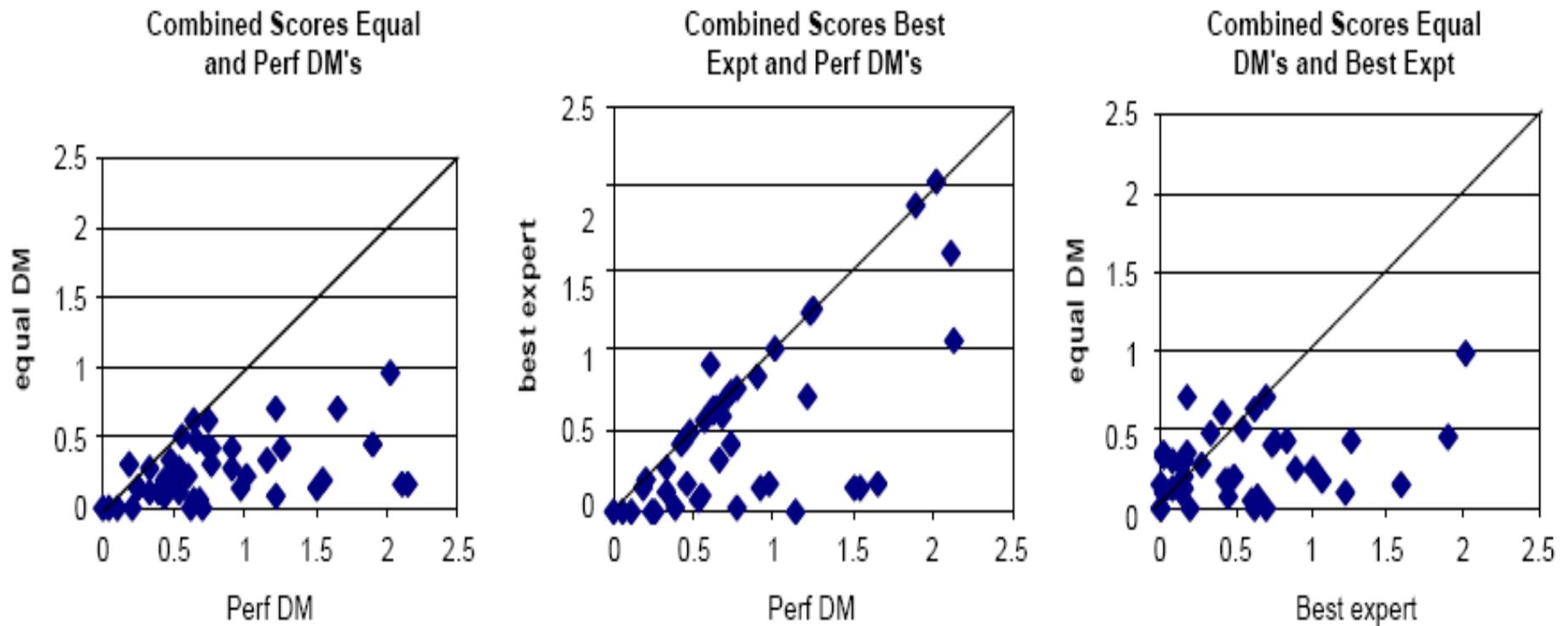


Fig. 1. Combined scores of equal weight DM, performance-based DM, and best expert.

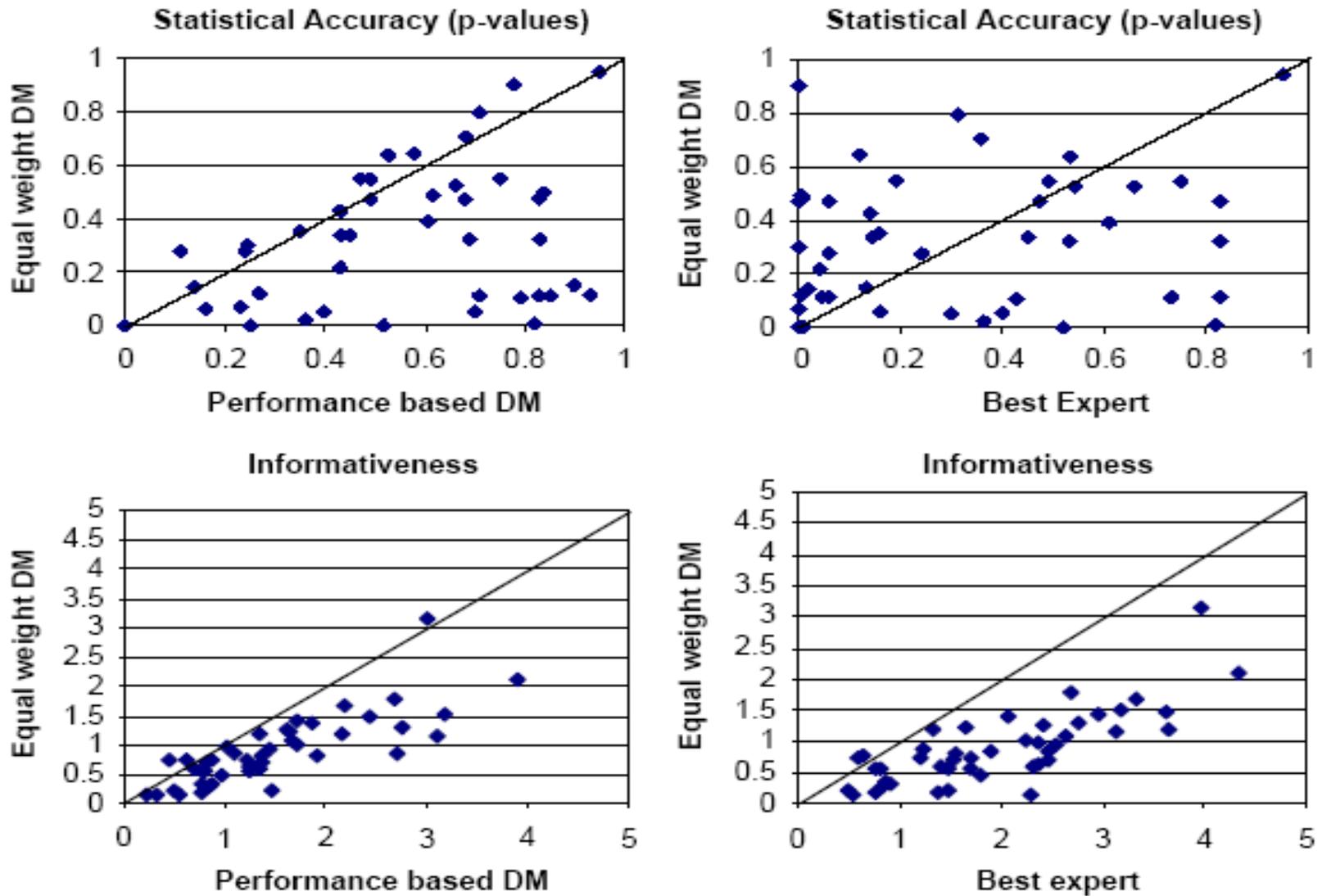
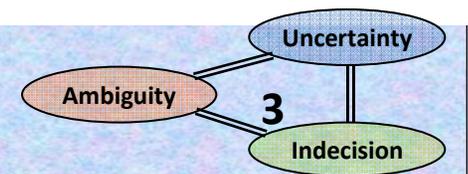
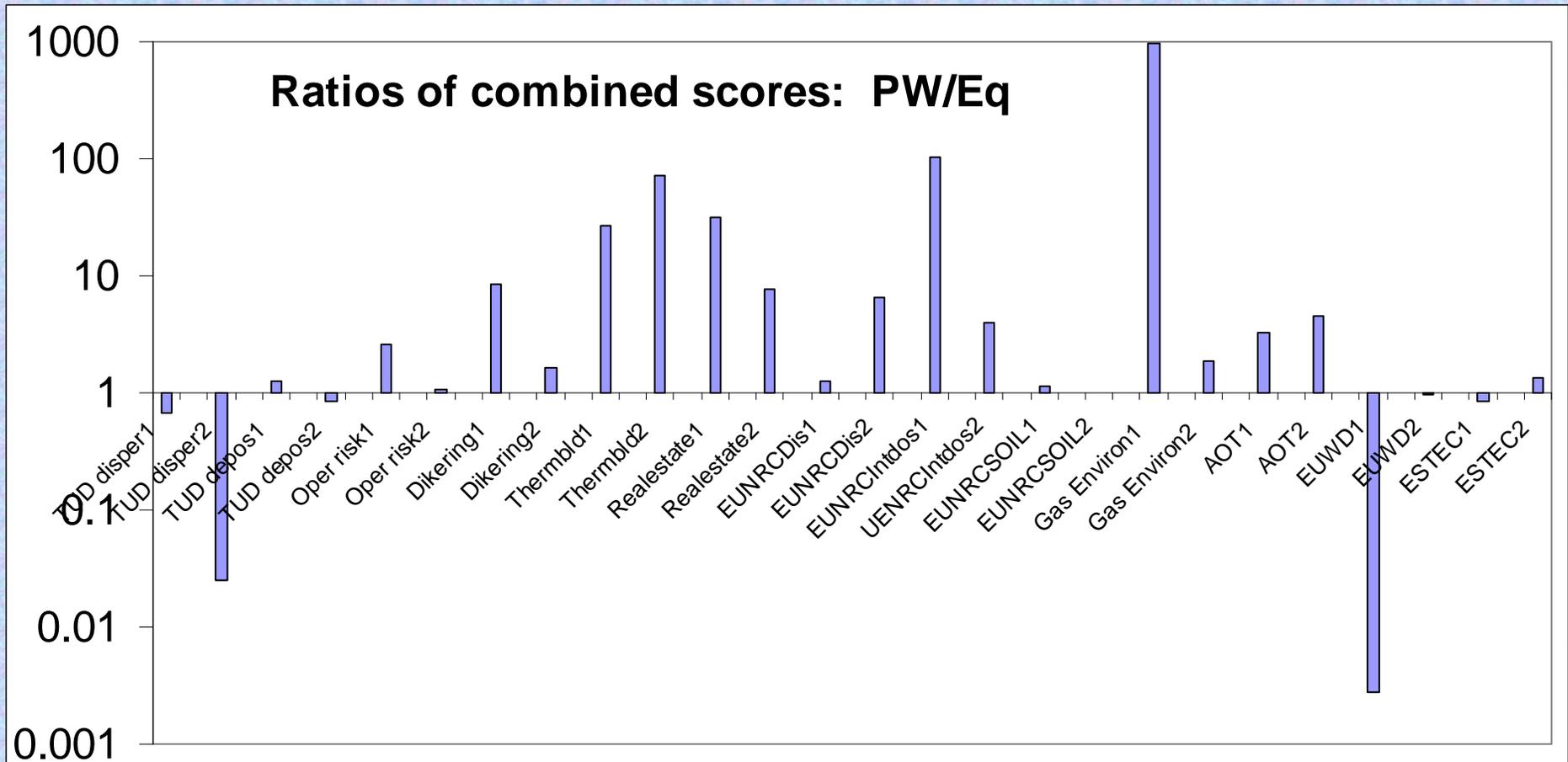
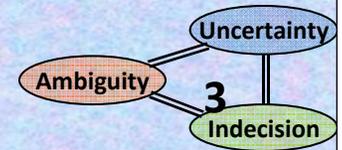


Fig. 2. Calibration (p -values) and information scores of equal weight DM, performance-based DM, and best expert.



Out-of-sample Validation

[RESS response2comments.pdf](#)



13 studies with ≥ 14 seed vbls, split, initialize on one half, predict other half



Aspinall & Associates

Proof of concept Elicitation Results



**Seventh Session of the Statistics and Risk Assessment
Section's International Expert Advisory Group on Risk
Modeling: Expert Elicitation Workshop, Ottawa 28 March 2008**

Results and findings from an Expert Elicitation Proof-of-concept Exercise

Summary report prepared by Aspinall & Associates

for

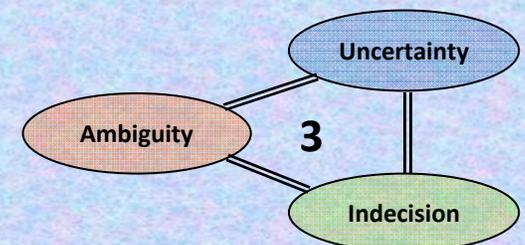
Public Health Agency of Canada

Contract reference: 4500180985
Vendor No. 1146454

Experts like performance assessment

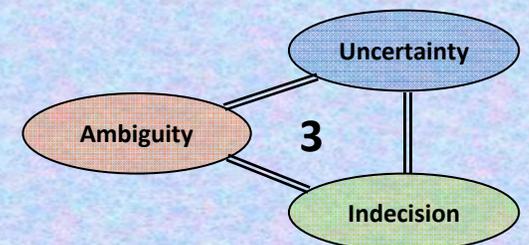
Ask them [Aspinall mvo exerpts.pdf](#), [Aspinall et al Geol Soc .pdf](#), [Aspinall & Cooke PSAM4 3-9.pdf](#), [SparksAspinall VolcanicActivity.pdf](#)

**Separate
scientific assessment of
uncertainty
from
decision making**



The choice is NOT whether to use EJ;
but:
do it well or do it badly?

“NASA must always strive for the highest level of accomplishment, to exceed the expectations of the Nation, and to do what is right...”(Return to Flight task group p.14)



Appendix H: Presentation by Dr. William Ascher, “Issues of Transparency for Expert Elicitation”

Issues of Transparency for Expert Elicitation

William Ascher
Claremont McKenna College

Why Transparency?

- Identify range of expertise
- Identify assumptions
 - Decide when the effort is obsolete
- Evaluate strengths & weaknesses ⇒
assign degree of credibility
- Increase credibility (p. 58)
- Withstand litigation

What Should Be Transparent?

- Assumptions/”basis of judgment” held by the experts
 - Specific interactions between elicitor & expert?
- Methodology
 - How judgments were solicited & combined
- Confidence intervals
- Characteristics of the experts

How to Enhance Transparency

- Select experts who can:
 - articulate basis of judgment
 - think consistently in terms of quantitative probabilities
- Select methods that are:
 - fairly straightforward & comprehensible
 - capable of illuminating bases of judgment

How to Enhance Transparency

- Present results by:
 - retaining enough information to clarify bases of judgment, differences, inconsistencies
 - conveying probabilities/confidence intervals

Appendix I: Presentation by Dr. Wändi Bruine de Bruin, “Transparency of EPA expert elicitation”

Transparency of EPA expert elicitation

Wändi Bruine de Bruin, PhD
Carnegie Mellon University
Dept. of Social and Decision Sciences

Transparency to whom

- Experts participating in the elicitation
- Users of the expert elicitation
 - Policy makers
 - Stakeholders
 - Members of the general public
- Review panel

Transparency to experts in the elicitation

- Good survey questions should
 - be interpreted in the *same way* by question designers and respondents from different backgrounds
 - allow respondents to express their full set of beliefs
- Failing to write good survey questions leads to missing, invalid, and protest responses
 - Including saying “50%” in response to quantitative probability questions (Bruine de Bruin et al., 2000; 2002)

How to develop good survey questions

- Involve experts from all relevant disciplines in pilot tests *before* conducting elicitation
 - Include read-aloud of protocol to ensure (shared) understanding
 - Invite them to add questions to express relevant beliefs
- Provide clear instructions on how to answer questions
- Ask quantitative questions that
 - Can be answered by experts in all relevant disciplines
 - Are specific enough to have an answer (under “clairvoyance”)
 - Avoid mental gymnastics as much as possible
- Write probability questions that avoid 50% responses
 - Present linear probability scale rather than fill-in-the-blank
 - Ask about “the percent of people” rather than “the probability that a person” will experience an event
 - Allow for “don’t know” response, or ask what 50% meant
- Ask for explanations of quantitative responses

Transparency to users of expert elicitation

- Effective risk communications
 - Should help policy makers to make more informed decisions
 - Should be understood by all of its potential users
- Existing communications are often not effective, because they
 - are not written with users in mind
 - do not provide decision-relevant information
 - use expert jargon
- Users may only read summaries or press releases
 - Press releases (of medical studies) often overstate results, failing to mention study limitations and industry funding (Woloshin & Schwartz, 2002)

How to develop effective communications

- Involve users *before* developing communications, even *before* conducting the elicitation
 - Find out what they need to know to make more informed decisions
 - Ensure that they understand and trust every step of the elicitation
- Present communications in simple terms
 - 6th grade reading level is recommended for public health pamphlets, can be used to present complex information, and benefits all readers (*i.e. 18 is too high*)
 - Use simple graphs and explain them in the accompanying text
- Pilot-test communications before releasing them
 - Conduct read-aloud protocols with users to ensure understanding
 - Fact-check with experts to ensure accuracy
- Use systematic presentation format for overall report, executive summaries *and* press releases

Examples of topics

to systematically cover in reports

- Research question
 - What is the main research question and what policy question will it inform?
 - Why was expert elicitation needed to answer the main research question?
- Methods
 - How was the elicitation conducted?
 - Who were the experts, how were they selected, and did they represent all relevant views and disciplines?
- Results
 - What is the degree of consensus?
 - Why did the experts disagree if/when they did?
- Conclusions
 - How do these results inform the policy question?
 - What are the main limitations?

Review panel

- Charge questions for the review panel should cover
 - The expert elicitation
 - The communication of results
- The review panel should include experts from relevant disciplines
 - Substantive experts from relevant disciplines
 - Technical experts
 - Survey design experts
 - Risk communication experts!
 - Intended users?

Relevant references

- Bruine de Bruin, W., Fischbeck, P.S., Stiber, N.A. & Fischhoff, B. (2002). What number is “fifty-fifty”? Redistributing excess 50% responses in risk perception studies. *Risk Analysis*, 22, 725-735.
- Bruine de Bruin, W., Fischhoff, B., Brilliant, L., & Caruso, D. (2006). Expert judgments of pandemic influenza risks. *Global Public Health*, 1, 178-193.
- Bruine de Bruin, W., Fischhoff, B., Millstein, S.G. & Halpern-Felsher, B.L. (2000). Verbal and numerical expressions of probability: “It’s a fifty-fifty chance.” *Organizational Behavior and Human Decision Processes*, 81, 115-131.
- Bruine de Bruin, W., Parker, A.M., & Fischhoff, B. (2007). Individual differences in Adult Decision-Making Competence. *Journal of Personality and Social Psychology*, 92, 938-956.
- Fischhoff, B. & Bruine de Bruin, W. (1999). Fifty-fifty=50%? *Journal of Behavioral Decision Making*, 12, 149-163.
- Fischhoff, B. (1994). What forecasts (seem to) mean. *International Journal of Forecasting*, 10, 387-403.
- Morgan, M.G., Fischhoff, B., Bostrom, A., & Atman, C. (2001). *Risk communication: The mental models approach*. New York: Cambridge University Press.
- Schwarz, N. (1996). *Cognition and communication: Judgmental biases, research methods and the logic of conversation*. Hillsdale, NJ: Erlbaum.
- Woloshin, S., & Schwartz, L.M. (2002). Press releases: Translating research into news. *Journal of the American Medical Association (JAMA)*, 287, 2856-2858.

Appendix J: Presentation by Drs. Paul Fischbeck and Katherine Walker, “When is a method credible?”

When is a method credible?

- Proven to be accurate
- Buy-in/involved a large number of experts
- Followed an accepted method
 - Is there an “acceptable” EE method?
 - Documentation
 - Of what?
 - To what detail?
 - Transparency
- To whom does the method have to be credible?
 - Consulting/forecasting
 - Government policy

Increasing Credibility

- EE is not only an EPA activity
- How to bring together a community EE?
- Web community Wiki?
- Database of EE
 - Annotated bibliography
 - Archiving assumptions, data, models, results
 - Retrospective analysis of accuracy
- Need for life-cycle analysis of EE

Wikipedia: Expert elicitation

- In [science](#), [engineering](#), and [research](#), **expert elicitation** is the synthesis of opinions of [experts](#) of a subject where there is uncertainty due to insufficient [data](#), when such data is unattainable because of physical constraints or lack of resources. Expert elicitation is essentially a [scientific consensus methodology](#). It is often used in the study of rare events. Expert elicitation allows for [parameterization](#), an "educated guess," for the respective topic under study. Expert elicitation generally [quantifies uncertainty](#).

Wikipedia

- Expert elicitation tends to be [multidisciplinary](#) as well as [interdisciplinary](#), with practically universal applicability, and is used in a broad range of fields. Prominent recent expert elicitation applications are to [climate change](#), [modeling seismic hazard](#) and damage, association of [tornado damage](#) to [wind speed](#) in developing the [Enhanced Fujita Scale](#), and [risk analysis](#) for [nuclear waste](#) storage.

References fro Wikipedia

- Apostolakis, G., 7 December 1990: The concept of probability in safety assessments of technological systems. [Science](#), 250 (4986): 1359-1364. DOI: 10.1126/science.2255906
- Arkes, Hal R., Jeryl L. Mumpower, and Thomas R. Stewart, 24 January 1997: Combining Expert Opinions. [Science](#), 275: 461-465. DOI: 10.1126/science.275.5299.461e
- Boissonnade, A., Hossain, Q., Kimbell, J., Mensing, R., and Savy, J., 2000: Development of a probabilistic tornado wind hazard model for the Continental United States, UCRL-ID-140922 Vol. I, [Lawrence Livermore National Laboratory](#), Livermore, CA, 131pp.
- Kerr, Richard A., 8 November 1996: Risk Assessment: A New Way to Ask the Experts: Rating Radioactive Waste Risks. [Science](#), 274 (5289): 913-914. DOI: 10.1126/science.274.5289.913
- SSHAC, 1997: Recommendations for probabilistic seismic hazard analysis: guidelines on uncertainty and use of experts, NUREG/CR-6372, UCRL-ID-122160, Vol. I, [Lawrence Livermore National Laboratory](#), Livermore, CA, 131 pp.

Question 1

- Need to frame the role, objectives, boundaries of guidance
 - Make clear the broader context of other guidance under development.
 - Avoid tendency to be too proscriptive (cookbook)
 - Consider a role for EE that is integrated into discussions about future research directions, value of future research to decisions at hand, rather than just for questions about particular quantities
 - Discussion of when EE is appropriate/not appropriate will be challenging
- Remain open to new research, applications that demonstrate benefits
 - Evolving field,
 - methods would benefit from additional research, innovations, improvements to existing approaches
- Avoid tendency of guidance to be locked in time
- Life cycle of EE

Question 2

- Generally heard yesterday that the topics covered seemed appropriate, but not comprehensive.
- Needs to be built on, updated.
- Document needs sharpening of concepts, definitions, and careful resolution of conflicting redundancies, before it is put forward as a basis for guidance.

Charge A

- Consider literature on how to gather rationales (Bruine de Bruin). Could help with peer review and transparency
- Consider other ways to encode judgments that are not quantitative probability encoding
- Literature on performance measurement, scoring is missing from document
- Protocols for ex-post evaluation of judgments to evaluate coherence including longer term (i.e. if relevant data become available) follow up of experts' performance.

Charge C.1: Selecting Experts

- Consider what the goal of the elicitation is (consensus, range of views, etc)
 - See for example, Cooke's
 - Survey
 - Political consensus
 - Rational consensus
 - Factors into evaluation of what “balance” means (e.g. role of stakeholders)
 - Factors into decisions about how to combine
- Need to clarify impact of OMB's paperwork reduction act on numbers of experts

Charge C.2: Expert Aggregation

- Generally needs more comprehensive, accurate discussion of alternative methods, their strengths and limitations
- Literature needs broadening - (e.g., Tatlock (hedgehogs v. foxes); Cooke performance based combinations) and updating (e.g., Copulas?) Bayesian model averaging?
- Need more careful discussion of when it is even appropriate to combine experts' distributions.
- Need more careful discussion of dependence, independence of experts

Charge C.3: Problem Structure

- Clearer discussion of what is appropriate for elicitation: definitions of quantity parameter, relationship (i.e. don't generally elicit parameters, avoiding second order uncertainty, dealing with resistance to giving point estimates (preferences for ranges)
 - Add clearer discussion of epistemic v. aleatory uncertainty, uncertainty v. variability
- Need discussion of importance for expert of understanding the context and for the variable being elicited, what it is conditioned on
 - Presentation of the model itself (into which the elicited value is going)
 - Influence diagrams and mental models
 - Did we discuss Bayesian belief networks ?
- Role of stakeholders in development of question

Charge C.4: Findings & Conclusions

- Append or reference specific examples of EE, other concepts
- Consider alternative tools for characterizing uncertainties, strengths and limitations (e.g. p-boxes)
- Update literature on cognitive biases - lots of new literature
- Needs fuller discussion of consistency, coherence of judgments
 - Nature, role, and appropriate use of feed back information/tools