

The Reduction of Risk Perception: Consensus-Making versus Truth-Seeking

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ABSTRACT

We concluded last year that the U.S. Department of Energy's (DOE's) policy of consensus-seeking (CR) for its Citizen Advisory Boards (CAB's or Boards) promoted risk misperception, a lack of education, and an anti-science bias about DOE's mission to cleanup its sites. Our conclusions countered an earlier study of the CAB's funded by DOE; using only subjective data, it had concluded that consensus-seeking was an improvement in American democracy. However, our conclusion was reached by comparing decision-making at the CAB's with results in the field at the DOE sites associated with the Boards. To extend our earlier findings, we looked at recent meetings of the Board Chairs and preliminary results from the laboratory. We hypothesize that CR and the truth-seeking from majority rules (MR) reflect a tradeoff between a single worldview derived from risk perceptions versus specific guidance from risk determinations. Based on both the field evidence and preliminary data from the experiment, we find that this tradeoff impacts site operations. At DOE's Hanford site, the risk perceptions of its Advisory Board (HAB) have contributed to "gridlock"; at DOE's Savannah River Site (SRS), the specific recommendations by its Board (SAB) have contributed to accelerating cleanup.

INTRODUCTION

During the 1980's, the extent of widespread contamination on and about DOE sites across its complex led to a significant loss of public trust in DOE [25]. To become more accountable, DOE formed Citizen Advisory Boards (CAB's or Boards) with members drawn from around many of its cleanup sites [26]. Nine Boards remain active. According to DOE policy (www.em.doe.gov/public/ssab) for the operation of these Boards, CAB's are "to work toward consensus". DOE's guidance for CR was derived from:

The Keystone Center, a non-profit environmental conflict management group, established a working dialogue among representatives of the federal government, Tribal governments, Native American organizations, and local citizen groups. The goal of the Federal Facilities Environmental Restoration Dialogue Committee (FFERDC, or the Committee) was to develop consensus policy recommendations aimed at improving the process by which federal facility environmental cleanup decisions are made, such that these decisions reflect the priorities and concerns of all stakeholders. ([56] p. 1)

However, in enacting its policy, DOE permits each Board to choose its own decision-making rules. The result is a natural field experiment consisting of four boards governed by consensus rules (CR) and five by majority rules (MR) [30].

As a continuation of earlier work [27,29], this paper considers differences between risk perception and risk determination from the perspective of policy makers, decision makers, and citizens. We also include pilot data from a laboratory experiment. In contrast to traditional models of consensus (e.g., [8]), our

thesis is that social perspectives around a site impact its operations. The primary consideration will be to determine whether differences between risk perception around a site and risk determination at the site affect waste and environmental management cleanup rates. We believe that CR places greater emphasis on perception and consequently abstract moral values rather than the focus derived from MR on common sense and specific actions. This paper will primarily draw a contrast between DOE's Hanford Site and its CR advisory board (HAB) with the Savannah River Site (SRS) and its MR advisory board (SAB), the two sites with the largest cleanup budgets, but we will also attempt to include a broader view by reviewing stakeholder involvement the United Kingdom (UK).

In 2003, DOE funded a review of the policy and decision-making at its CAB's [8]. Using only subjective data derived from interviews to build a case in support of CR, the authors concluded that CR was an improvement in democracy. Bradbury and her colleagues assumed that the cooperation necessary to achieve CR led to feelings of inclusion but also provided a better tool for a local community around a DOE site to assure that progress on the cleanup at its site was progressing satisfactory. Specifically, Bradbury and her colleagues believed that instead of a focus on instrumental action—the cleanup—CR gains “understanding” by forming “egalitarian ... public partners” to avoid “domination ... [of discussions about cleanup with] objective knowledge” (i.e., technical facts) ([8], pp. 133-141).

These conclusions are built on subjective data, the implicit assumption being that self-reports of behavior as its proxy are sufficient. There is widespread support in the literature for Bradbury's position. CR is seen as the primary tool to build a cohesive multicultural and communitarian society [16]. Using game theory, Insko and his colleagues [22] concluded that trust developed as a function of the cooperation among group members, that a group's interests were better served with cooperation than competition, and that individuals were more moral than groups. Dennett ([11], p. 304) flatly concluded that competition was “toxic”. Following Hardin [20] that coercion was necessary to impel cooperation for the common good, Ehrlich and Kennedy [14] argued that a “fair and sustainable” approach, driven by science and not the market place, is necessary to make decisions for the common good, that decisions made in this manner will protect against a “tragedy of the commons”, and that it will increase the likelihood of a more peaceful society for all. Suskind [50] concluded that not only coercion but also deception was necessary with CR to achieve the common good. Based on methodological individualism (game theory), Nowak and Sigmund [42] postulated that cooperation is necessary for civilized society; however, they concluded that the policy of cooperation remains arbitrary because scientists have been unable to establish a proof for it based on first principles or evidence.

In disagreeing with Bradbury and the literature on several fronts, we begin by assuming that there is nothing wrong with arriving at consensus, *per se*, only with seeking it, which promotes groupthink [23,29]. For now, we hypothesize that CR slows the cleanup at a site.

Neutrals

The key function of seeking CR is to convert neutrals into active participants (e.g., [8]). The active participation of neutrals supposedly increases their sense of ownership [66]. But the issue then becomes whether something is gained or lost as a consequence. From our perspective, decision-making is naturally dominated by a relative handful of opponents who arise spontaneously to frame a discussion, pace the debate, and drive the search for a solution, all of which DOE's policy for CR seeks to preclude [67]. In our view, neutrals are key to decisions because opponents must pitch arguments to sway them. MR discussions are likely to be dominated by the most knowledgeable players, neutrals the least, yet neutrals as judges promote civil outcomes; e.g., when neutrals are reduced in number or lost to a political process, violence becomes more likely [19] and democracy less possible [9].

Competition

Increasing neutrals in the decision-making process reflects an increase in competitive decision-making. Without the competition for the endorsement of neutrals, the discussion becomes less specific but also more likely to be hijacked. For example, the two DOE managers of Hanford wrote on HAB's membership: "The views of organized special interest groups appear to be dominating much of the Board's actions" [68]. The risk that CR can be controlled by a small group has also been recognized by the EU in its attempt to remove CR from its decision-making processes [15]: "The requirement for consensus in the European Council often holds policy-making hostage to national interests in areas which Council could and should decide by a qualified majority." (p. 29) In contrast, competition allows a group to "get quickly to the heart of the matter" [16].

We had attributed the lack of external competition among DOE scientists before 1985 to the widespread waste management problems across the DOE complex that caused DOE's initial loss of public trust [25]. By opening the management problems to public view and participation by citizens and outside scientists, increasing independent scientific peer review (e.g., Defense Nuclear Facilities Safety Board, National Academy of Sciences) and thus competition and accountability, public confidence in DOE has begun to recover [26]. However, we see more accountability around SRS than Hanford where "gridlock" has occurred, which we attribute in part to "truth-seeking" with MR by SAB versus CR by HAB [29,30].

Although CR supposedly reduces conflict among participants [8,16], its lack of practicality contrasts dramatically with risk determinations, creating a wider conflict between a Board and its sponsoring agency; e.g., DOE Manager of Hanford wrote that discussions on Hanford tanks with HAB "have become increasingly contentious and do not provide a supportive environment where individuals and organizations can work together to effectively address these issues" [64]. This wider conflict implies that CR is less adaptive.

Education

Bradbury and her colleagues [8] fear that without CR, education suffers from an excess of negative affect, but Coleman [10] found that divisive political campaigns even when one-sided are associated with an increase in public education about the issues in an election. By design, the barriers to discourse are purposively lower or non-existent with CR, reducing the primary driving force for education [30]. Thus, under CR, an individual's view no matter how uninformed or bizarre cannot be excluded. In contrast, barriers arise under MR as the discussion becomes dominated by technical arguments, making it more difficult for those without knowledge or skills to compete, and by challenging the prevailing risk perceptions, increasing the number of neutrals, education and evolution of a group.

The contrast between risk perception and risk determination affects citizen groups in Europe as well. To address this uncertainty in the European Union, a precautionary principle is used before conclusive scientific evidence is available to urge action by regulators in order to reduce the possibility of harm to the public, workers, or the environment [63]. Like consensus-seeking, the precautionary principle emphasizes risk perception rather than risks determined by scientific evidence. The precautionary principle may preclude an activity even when it may not cause harm (e.g., Genetic Modified Organisms), when the scientific evidence indicates that the harm is negligible (e.g., banning phthalates in the EU), or it may precipitate the treatment of an activity like global warming where even greater uncertainty exists on the costs and benefits of remediation (whether to withdraw CO₂ or to reduce its emission). In 2002, the embargo of British beef by the French during an episode of Bovine Spongiform Encephalopathy (BSE) was determined by the European court of justice to be illegal, illustrating that the precautionary principle can have multiple interpretations (www.guardian.co.uk/bse/article).

Another example is the banning of DDT in 1972 by the USEPA based on risk perceptions in Rachel Carson's *Silent Springs* in 1962 that increased "public pressure" on EPA to ban DDT (www.epa.gov/history/publications/formativ6.htm). The ban was enacted despite a National Academy of Sciences conclusion that "To only a few chemicals does man owe as great a debt as to DDT ... In little more than two decades, DDT has prevented 500 million human deaths, due to malaria, that otherwise would have been inevitable" ([38] p. 432). Based on the scientific evidence, the EPA Administrative Judge declared in 1972 that "DDT is not a carcinogenic hazard to man ... DDT is not a mutagenic or teratogenic hazard to man ... The use of DDT under the regulations involved here do not have a deleterious effect on freshwater fish, estuarine organisms, wild birds or other wildlife." [51]. However, with malaria infections rising to 300-500 million, there are an estimated 2.7 million deaths per year today. A test spraying with DDT combined with drug treatments led to a 91% drop in malaria cases in KwaZulu Natal, Africa [12]. Yet the U.N.'s Stockholm Treaty [54] still calls for a phase-out of DDT by 2007.

In the U.S., a study of risk perception by Slovic and colleagues in 1991 with questionnaires led to his prediction that the negative images associated with a nuclear waste repository at Yucca Mountain would harm the Las Vegas economy by reducing tourism; however, ten years later Slovic admitted that tourism continued to make Las Vegas the fastest growing community in the U.S ([48] pp. 102-3).

Risk perceptions are subjective. There is ample experimental evidence that subjective data is biased, that questions can be structured to achieve any desired outcome [13], and that empirically unchecked biases can infect public anxiety with misperception and misjudgment [33], strengthening risk perceptions (e.g., [28]). MR establishes barriers as part of a vetting process where only the sufficiently worthy ideas can contribute, other participants remaining neutral to the deliberations, consequently determining the winning argument. In the cleanup at SRS compared to Hanford as Bradbury noted, SAB had a steeper learning curve than any other Board in the DOE complex ([8], p. 127), thus SAB members have fewer misperceptions of risk about the cleanup. Further, linking conflict and learning, Dietz and his colleagues [76] have concluded that although "conflict is inherent in decision making, if it does not escalate to the point of dysfunction, conflict can lead to learning and change" (p. 1909).

Scientists and negotiations in public

When criteria based on science are established for policy purposes, scientists often do not want the public to witness their negotiations which might expose their uncertainties associated with risk determination. The problem is that the public is often unaware of how well-knit are the stories presented to them by scientists (e.g., [37]), having left out the uncertainty that arises in the give and take among scientist colleagues. Consequently, disclosures of cover-ups that reveal this uncertainty feed public perception of a lack of accountability in what until then remains an opaque process to the average citizen.

For example, DOE claimed before 1983 that its actions "Protect ... [the] environment [and] health and safety of employees and public" [61]. After the media exposed DOE's coverup of environmental contamination during the 1980's [25], public expectations that DOE was being accountable collapsed and led eventually to the establishment of DOE's Boards to recover its lost trust. Today, the cleanup is estimated to cost about \$100 billion for SRS and Hanford alone [69].

There is another approach. Recall that prior to 1983, DOE was self-regulated [26], removing the claims of its scientists from competitive challenges by external scientists. According to Trustnet [53], however, conflict in public among scientists provides a powerful means for stakeholders to penetrate the "exclusion zone" that often surrounds technical expertise for public acceptance of scientific evidence.

Generalizations

From a general perspective, the problem of injecting subjectivity without constraints into social science by DOE [8] is not the only case. DOE's Argonne National Laboratory (ANL) scientists have designed a computational game theory model of electricity markets (EMCAS) that gives ANL a platform to discuss electricity policy scientifically, but we have criticized EMCAS as unvalidated [70]. For example, Conzelmann et al. [71] justifies EMCAS by stating: "The purpose of an ABMS model is not necessarily to predict the outcome of a system, rather it is to reveal and *understand* [emphasis added] the complex and aggregate system behaviors that emerge from the interactions of heterogeneous individuals." As with DOE's study by Bradbury and her colleagues, the critical flaw is that subjective bias interjected into EMCAS with interviews of human players and experts has not been constrained by field results, but with the goal for "*understanding*" [emphasis added] rather than instrumental validation. From a different perspective, Shafir and LeBoeuf [77] have also criticized expert decision-making by concluding that it is no more or less rational than non-expert decision-making.

On a cautionary note, DOE's National Nuclear Security Administration has no plans for Citizen Boards. Yet, the DOE Inspector General has cited wastes as an issue between NNSA and DOE that SAB and Congress want DOE to address (in [27]).

Recent Stakeholder Engagement/Dialogue within the UK Nuclear Industry

The UK nuclear industry has consulted stakeholders widely in recent years, however, the method of engagement varies to that of the citizens boards in the US and has been carried out with the understanding that engagement will 'inform' the final decision made by the decision maker.

Engagement is currently being carried out at local and national levels within the UK, many nuclear licensed sites forming local residents/stakeholder groups to discuss specific site related issues. However, it has been recognized that national dialogue is also required so that an informed view can be obtained regarding some of the key issues now facing the industry.

With the establishment of the Nuclear Decommissioning Authority in April 2005, engagement at national level has received added impetus. The NDA's main task is to develop an overall strategy for dealing with the UK nuclear energy and reprocessing legacy safely, securely and in accordance with national and international environmental requirements. Clearly, if it is to do this effectively stakeholder views are required.

Recent Examples of Engagement Activities: To date, engagement and dialogue activity has been consensus driven rather than majority based decision making. The industry at a national level via the British Nuclear Fuels (BNFL) National Stakeholder Dialogue and more recently the NDA driven National Stakeholder Group has aimed to receive stakeholder feedback on the challenges currently facing the industry on issues such as legacy waste and nuclear materials. At the same time as this process is taking place, individual sites are also contacting stakeholders regarding site specific projects.

BNFL National Stakeholder Dialogue: The BNFL National Stakeholder Dialogue was active between 1998 and 2004, via an independent conveyor. BNFL recognized that the nuclear industry had a long history of poor relationships with many of its stakeholders and decided to pursue a policy to try and engage stakeholders. This recognized that the 'conversation' that BNFL had typically been having with its stakeholders should become more positive and less antagonistic.

BNFL brought together a number of key stakeholders who agreed to explore the potential for working together, via a series of meetings, on some of the most challenging issues facing the UK nuclear industry.

This led to the formation of a deliberative process, the aim of which was: “to inform BNFL’s decision-making process about the improvement of their environmental performance in the context of their overall development” [75].

This aim of the process sought to identify and build on areas of consensus, whilst recognizing differences of opinion (Note, as we have reported previously [29], there is nothing wrong with arriving at consensus decisions, only with seeking one; e.g., the percentage of consensus decisions by the majority-ruled SAB is about the same as the consensus-ruled HAB). By helping stakeholders work through the difficult technical issues together, it was hoped that a number of beneficial outputs would develop. These benefits were both visible (such as reports, agreements, etc.) and invisible (such as a positive change in relationships, common understanding and mutual respect). This was considered to be a distinct advantage, given the previous antagonistic relationship between BNFL and some of its stakeholders.

The process comprised approximately 200 individuals that represented 70 organizations and has covered in detail the following topics:

- Waste
- Discharges
- Spent Fuel
- Plutonium
- Socio Economic issues
- Security
- Business Futures

The Dialogue process comprised a Main Group of stakeholders that was responsible for deciding what issues were tackled within the Dialogue and how they were addressed. Smaller Working Groups were formed to look at each one of these issues, such as the Waste Working Group (WWG) and the Discharges Working Group (DWG) that formed Phase 1 of the process.

The Main Group was open to national organisations and regional groups as well as expert or specialist concerns provided that participants were willing to abide by agreed Ground Rules.

A Significant output of the process was to consolidate the recommendations and responses made during the process and to give each a unique reference number. A classification template was developed, enabling all the recommendations to be grouped into the 12 categories shown below:

- THORP (Thermal Oxide Reprocessing Plant) programme
- Magnox reprocessing programme
- Cleanup and decommissioning programme
- Programme delivery
- Contingency planning
- Socio-economic impacts/mitigation
- Vitrification performance
- Discharges
- Waste
- Plutonium
- Other BNFL Sites
- Ongoing use of reports and methodology

BNFL has used this format to produce the Company's responses to the Main Group Meetings, including the nomination of Executive Directors to respond to recommendations falling within their area of responsibility. BNFL has produced responses to the consolidated recommendations. These can be used as a "baseline" of information against which the allocation of the recommendations to the NDA can take place.

NDA National Stakeholder Group: In November 2001, the UK Government announced radical changes to current arrangements for the clean up of the UK nuclear legacy [73]. To achieve these changes, the Government set up the Nuclear Decommissioning Authority (NDA). Since April 2005, NDA has provided the strategic direction for cleaning up Britain's civil public sector nuclear sites. It will have due regard for safety, security, the environment and value for money. Openness, transparency and ensuring public confidence is a key principle of the NDA.

To achieve this, the NDA National Stakeholder Group (NSG) commenced in October 2005. The structure of the dialogue process is currently being defined, with the author being involved in this process. It is not yet in a fixed form, and the first two meetings have been an opportunity to shape the future of the Group and to meet the NDA objective to develop mutual trust and respect with all of its stakeholders (Note: based on surveys reported in DOE, 1996, trust at SAB was greater than or equal to HAB; in [29]).

At the first meeting, it was agreed that the following areas would be discussed in future meetings:

- Contaminated land
- Waste management
- Management of nuclear materials, THORP and plutonium
- Site end points and new build
- Socio and economic wellbeing and skills availability
- Stakeholder relations

In addition, two National Interest Groups (NIGs) on waste and nuclear materials have been established as part of the process and will report to the main group at scheduled intervals. The first meeting of these groups is scheduled for February 2006.

It is important to highlight that both the above examples have been/are consensus driven and operate at a UK national level to inform a wide range of stakeholders. The NDA process aims to ensure that the learning and experiences of individual nuclear sites (via local site stakeholder groups) is highlighted as part of the National Stakeholder Dialogue process and applied at a national level to assist progress. However, this process is at a very early stage, where the precise methods of engagement are currently being explored.

The ongoing PhD research carried out by the co-author aims to investigate the effectiveness of consensus based decision making in the UK nuclear industry, or that carried out at a UK national level relevant to the industry. For example, how effective is the currently dominant consensus approach, when compared against more competitive methods? It is also the intention to carry out a comparison of decision-making methodology and approach between the UK and US to highlight the effectiveness of consensus or majority ruled approach at nuclear licensed sites. For example, although majority rule approach has been used effectively at the US SRS, could this be equally effective within the UK situation? To what degree does current UK policy for the nuclear industry influence the nature of the decision making approach?

Organization Theory: Tradeoffs between Risk Perceptions and Determinations

Game theory assumes a direct link between the preferences expressed by participants and the values given in a static configuration of numerical choices offered to them in a game matrix as if that is how decisions are actually made by humans [67]. But Kelley [57] found no relationship between preferences and actual choices made in games. Shafir et al. [72] found no association between decisions and subsequent justifications. Eagly and Chaiken [13] concluded that the link between beliefs and actions among humans was not established by research. Moreover, the self-beliefs of individuals do not determine their behavior; e.g., self-esteem, arguably the most well-research self-concept, correlates weakly with either academic or job performance, although, and of theoretical importance, it does with other aspects of an individual's worldview, such as life satisfaction [4].

An unstated theme of this study has been to not focus on the individual as the primary source of information or the target of conceptual attack, the overwhelming tendency in psychology and game theory. Instead, our focus has been on the social interaction and its consequences (e.g., decisions made by organizations). Physical scientists believe that more can be learned about a phenomenon by its interactions with other phenomena. Applied to organizations, individual beliefs are constrained by interactions however loosely. In our approach to develop new organizational theory, we are bolstered by Kelley's inability with games to link an individual's choices when alone and in an interaction, by Tversky's failure to find a link between individual justifications and decisions, and by Baumeister's failure to find a significant link between an individual's self-esteem and academic or work performance.

But the state of organizational theory is poor [65]. Regarding groups and organizations, aggregating the preferences of individual members does not determine the choices that a group or organization will make [31]. Jensen summarizes this effect: "Interaction is able to produce properties at the collective level that are simply not present when the components are considered individually." (in [36], p. xi) Against the very concept of groups until near the end of his career, Allport [1] reversed himself to conclude that the shift from individual to group member was the major unsolved problem in social psychology. However, the lack of validation with organizational decision-making in the laboratory led Klein to formulate "naturalistic decision-making" [24]. Instead of following Klein's lead, we side more with Allport that the problem is an absence of first principles to address the phenomenon of social interaction, characterized by interdependent uncertainties, before applying theory to decision-making in organizations.

Bohr [6] criticized game theory by recognizing that multiple but arbitrary interpretations of social reality exist, which led Von Neumann and Morgenstern ([62] p. 148) to fear that if Bohr was correct, a rational theory of decisions was "inconceivable", which we regard as the primary flaw of game theory [67]. The implication is that while multiple but static interpretations available of social reality can be selected by an individual to guide or justify its behavior converges into a stable worldview in order to reduce cognitive dissonance, the result is insufficient to predict or recover the behavior of an agent. This leads us to set aside traditional notions about cooperation. At the social level, our past research [29] suggests that either DOE's Boards focus on a single moral worldview (CR) based on risk perceptions or on specific cleanup actions (MR) based on risk determinations, but not both simultaneously, indicating an interdependence or tradeoff. The exceptions to CR noted above suggest that worldviews and actions are interdependent, that CR focuses the energy available to a Board into resolving cognitive dissonance among its members, and that MR works by increasing the energy brought to bear on a problem, increasing the likelihood from the quantum perspective of signal detection that a solution will be discovered [34].

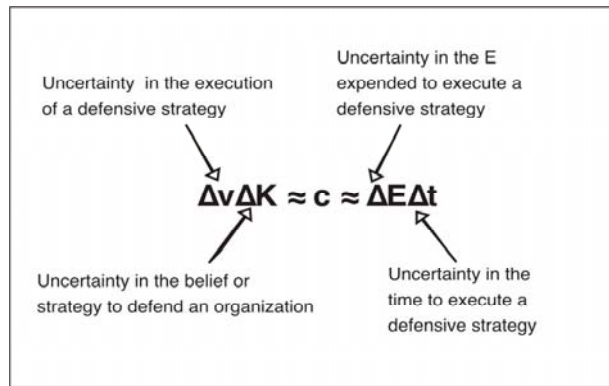


Fig. 1. The uncertainty relations, Equations 1 (left side) and 2 (right side)

From Bohr [6], we assume that a theory of decisions can be developed from information theory by considering the interdependent uncertainties in an interaction. In the figure above (Fig. 1.), the uncertainty relations for social interaction are represented by two bi-sided or coupled sets of interdependent uncertainties: on the left side of the equation, by strategy, plans, or knowledge uncertainty, ΔK (where $K = f(x)$), and by uncertainty in the rate of change in knowledge or its execution as $\Delta v = \Delta (\Delta K / \Delta t)$; or on the right side of the equation by uncertainty in the energy expenditure committed to enact knowledge, ΔE , and by uncertainty in the time it takes to enact knowledge, Δt . The left side of the equation indicates that the greater the focus brought to bear on a problem, the more the focus will be executed; alternatively, from the right side, the more energy available to attack a problem (competition), the more quickly a solution will be detected.

LABORATORY RESEARCH PILOT RESULTS

At present, we have successfully completed a pilot study and initiated a full experiment to test Fig. 1 in the laboratory with human subjects.

Background: DOE uses CAB's to provide it with advice on cleaning up the widespread contamination and legacy wastes stored at its sites [26]. DOE's policy is to use CR to provide advice based on the fairest and widest basis possible. However, in the application of its policy, DOE allows Boards to self-organize. The result is that five of the nine active Boards across the U.S. use MR (a "truth-seeking", conflict-based approach to decision-making) and four use CR (a cooperative based approach), setting the stage for a successful field experiment [29]. This pilot study attempted to replicate the field study.

Hypothesis: Majority-rule (MR) decisions not dominated by a single person should lead to more information processing than CR decisions. First, the result should be no significant difference between MR and CR on participant endorsements. Second, however, CR decisions take considerable time to complete [66], reducing the rate of decisions by the CR compared to the MR group [16]. Third, MR decisions should be characterized by practicality; an outside group judging these decisions should favor them over CR. And, fourth, time for both groups will be fixed at 30 minutes.

Preliminary Results. The differences in a t-test between the two groups based on participant endorsement of the decisions made by MR over CR was larger but not significant ($t(98) = 0.35$, p . n.s.). A chi-square two-tailed test of the number of decisions made were significantly greater in frequency for the MR than the CR group ($\chi^2(1) = 4.83$, $p < .05$). A chi-square two-tailed test of the number of decisions judged by an

outsider were found to be significantly more practical for the MR than the CR group ($\chi^2(1) = 4.12$, $p < .05$). The time for both groups was set at 30 minutes and not allowed to vary.

Preliminary laboratory conclusion: The hypotheses for the pilot study were supported.

FIELD RESEARCH BOARD CHAIRS

The thesis of Fig. 1 is that a tradeoff occurs between fully knowing either strategy or its execution at one point in time, but not both; similarly for energy-time uncertainty. Thus, as cooperation increases risk perceptions (increasing ΔK), it interdependently dampens the motivation to make concrete decisions based on specific risk determinations (decreasing Δv). Competition reverses this tradeoff by emphasizing specific cleanup actions rather than risk perceptions. In support of this latter tradeoff, Brown [7] concluded that it is more important to make decisions that reduce actual risks, rather than perceived risks. Similarly, Justice Holmes [21] wrote that "the best test of truth is the power of the thought to get itself accepted in the competition of the market ... " Based on our earlier findings [32], we concluded that it is more important that a decision be derived in the market place of ideas based on an open and transparent struggle in public that establishes a precedent, such as the decision initially opposed in 1999 but now accepted to operate the WIPP repository for transuranic wastes in New Mexico.

In contrast, the "gridlock" recently experienced at Hanford, while not a direct result of CR on HAB, has grown as a result of HAB's unchecked focus on risk perceptions rather than specific cleanup actions. Characteristic of these risk perceptions is the Washington State Initiative 297 passed in 2004 (www.secstate.wa.gov).

- End dumping of radioactive waste in unlined soil trenches near the Columbia River;
- Protect Washington from risks of 70,000 truckloads of radioactive waste and "mixed radioactive hazardous" waste – keeping thousands of truckloads from going through downtown Spokane;
- Require cleanup of deadly liquid High-Level Nuclear Waste tanks, and leaks from the tanks, which the Bush Administration has adopted plans to abandon. The initiative would create thousands of jobs as well as protecting the Columbia River from these wastes; [and],
- Require landfills and tanks leaking contamination and violating hazardous waste laws be cleaned up before more waste is added from other nuclear weapons plants run by the U.S. Department of Energy.

HAB's risk perceptions were the focus of a letter to the Acting Assistant Secretary for DOE Environmental Management [5] when the Board Chairs asked that DOE sponsor a national forum to address "the potential gridlock resulting in skyrocketing costs and completion delays throughout the DOE system ... contingencies for Yucca Mountain ... [and] pre-1970 Transuranic wastes". Assistant DOE Secretary Golan [17] rejected their request for a National Forum and said instead that he was "very interested in any proposals [the Chairs] might offer to overcome specific obstacles to the system-wide waste and material disposition plans" which DOE is pursuing.

Characteristic of the gridlock at Hanford is the recent stand-down in constructing its high-level waste (HLW) vitrification facility until at least 2006 [52]. Before vitrification startup, the delay could add up to four more years to the schedule for full scale operations in 2011.

In a second letter [49], the Chairs asked DOE to prepare contingency plans in the event that gridlock at Hanford spreads to Yucca Mountain and other DOE sites. The second letter from the Board Chairs reiterated the requests in their first letter. DOE-EM again turned down the Chairs requests for a national forum [2], instead offering briefings on "a series of disposition strategies for the various waste types within the EM complex." But some SAB members concluded that this recommendation removed DOE's focus from accelerating the waste cleanup at least at SRS by potentially removing a disposition path for

vitrified its high-level waste (HLW) canisters. Believing that contingency plans would be a distraction, SAB wanted DOE to remain focused on opening the Yucca Mountain repository for the HLW at SRS.

Compared to SRS [27], Hanford had built more tanks from an earlier to a later time (149 single wall tanks and 28 double wall tanks), had experienced more tank problems, and has had significantly more tank leakage. Yet from 1994 to the fall of 2005, HAB made only 14 recommendations on HLW. The thrust of the HAB recommendations was to get started on HLW treatment, to determine what should be in environmental impact statements, and to consider a fraction of HLW as transuranic. In contrast, SAB has written 29 motions on HLW operations at SRS. For example after a Federal judge in 2003 effectively stopped the disposition of HLW and tank closure programs across the U.S., including at SRS (previously known as WIR for “wastes incidental to reprocessing”), SAB motivated DOE-EM to sponsor legislation to overturn the judge. Subsequently, an amendment by Senator Lindsey Graham (R-SC) became law as Section 3116 of the National Defense Authorization Act for 2005. HAB did not take a stand on WIR, possibly one reason why the new 3116 Law excludes Hanford. Under NRC oversight, the new law allows SRS to resume closing HLW tanks and to pursue a treatment path for its tank contents. Since then, DOE has drafted plans for salt removal and the closure of two of its tanks [58,59]; it has received reviews from the Academy on its first set of plans [40].

SAB remains committed to pushing SRS to accelerate its HLW program, including vitrification and tank closures. One of SAB’s concerns is that without salt removal from tanks, SRS will be unable to continue to vitrify HLW. “The SRS CAB has ... stated that shutting down the Defense Waste Processing Facility (DWPF) [its HLW vitrification facility] ... or reducing its production rate is unacceptable” [45]. Further, SAB rejected the NAS [40] recommendations to postpone closing old tanks and waiting for the initiation of salt operations until new technology had been developed:

... SRS CAB cannot support waiting on new technologies to be developed. Once the waste determination basis is completed and the performance objective satisfied SRS should determine when waste cleanup is finished using the performance assessment and then can immediately proceed with negotiations with SCDHEC [its State regulator to] ... support the FFA schedule. [46]

Further, SAB [47] has recently endorsed EPA’s new standards for Yucca:

We have reviewed those standards and find them equitable to all interested parties and responsive to the public needs regarding the disposal of HLW in the Repository at Yucca Mountain. We have consistently, over the past several years, made the Department of Energy (DOE) aware of our firm support for the timely opening of this repository. We have a very acute need for this repository to be in operation so that our extensive inventory of HLW can be disposed of in a safe, effective, and efficient manner.

Subsequently, the Chairs in a third letter continued to request that a national policy be developed for “pre-1970 Transuranic wastes”; in exchange for SAB’s support, the Chairs compromised on Yucca Mountain by offering “some support” for its opening. But during the development of this new letter, HAB’s Chair stated that he doubted that a specific recommendation even to provide “some support” to open Yucca Mountain could be passed by HAB [35]. Subsequently, in an email from Todd Martin, Chair, HAB [41]:

The Hanford Advisory Board met last week and we were unable to reach consensus on signing the letter we produced at the SSAB meeting in Idaho Falls. As I pointed out during that meeting, there was the possibility that several seats on our Board would object to the language concerning [Yucca Mountain] repository standards. While there were several seats that were concerned, the State of Oregon was adamantly opposed to the language and chose to block consensus. Even had Oregon not done so, we may have ended up in this position with some of the other seats.

In contrast, although SAB barely supported the letter, the minority took exception to the Chairs’ weak support to open Yucca Mountain coupled with the request for a national policy for buried alpha wastes by filing a minority report (Note: it was drafted by the first author; see [3]).

HAB has pushed to have pre-1970 transuranic wastes at Hanford considered for removal ([18]; the policy for transuranic wastes was not enacted until 1970, making these alpha wastes). Currently there are 75,800 m³ buried at Hanford (31,660 are soils contaminated from liquids pumped into unlined cribs and trenches) and 4,500 m³ at SRS, with a total in DOE of about 126,000 m³ total [55]. If implemented, recovery of these buried alpha wastes could bankrupt the cleanup budgets. The National Academy of Sciences concluded that recovery of the buried transuranics may “result in little reduction in risk compared to disposing of it in situ while substantially increasing other risks, impacts and costs.” ([39] p. 139).

To prevent the gridlock at Hanford from spreading to SRS, SAB recommended that SRS take transuranic wastes from DOE's Battelle Columbus site destined for Hanford. In the process, SAB requested and got commitments from DOE to remove all of the remote handled transuranic wastes from SRS by 2009, to accelerate and certify its large container transuranic waste transport system to ship from SRS its large containers of TRU wastes to WIPP by 2007, and to continue to develop ARROWPAK to ship from SRS its high activity transuranic wastes which do not have a disposition path [44].

In addition to the Battelle transuranics, and since full support to open Yucca Mountain had not been provided, SAB affirmed that as stated by Frank Marcinowski at the Chairs meeting [60], the current DOE policy for the disposition of pre-1970 alpha waste continue to be determined at the local level in negotiations between the individual sites and their regulators (e.g., at SRS, it is SC-Department of Health and Environmental Control or DHEC and EPA-Region IV), along with public review and comments by their Citizen Advisory Boards and citizens. SAB concluded that removing buried alpha wastes may set a policy for decisions to be made at a national level with remedies that could be imposed on SRS regardless of its regulators' and community's position. The Academy [39] disagreed by recommending that a national policy for buried transuranic wastes be established to set uniform standards.

However, no member of SAB voiced support for the suggestion implicit in the Chairs' letter to develop a National Policy to retrieve the pre-1970 alpha wastes buried at SRS in its Old Radioactive Waste Burial Ground (ORWBG). The ORWBG is in the final stages of being officially closed by SRS and its regulators to meet an SRS Federal Facility Agreement milestone [43]; i.e., at SRS a final record of decision (ROD) under CERCLA has been issued for the ORWBG and implementation of the remedy is currently underway. SAB has recently passed a new motion to reaffirm that it wants the ORWBG to remain closed; that it wants decisions on pre-1970 alpha to be decided locally in negotiations between SRS, its regulators, and its citizens; that the pre-1970 alpha wastes should not be dug up because the costs would be prohibitive and dangerous to workers at SRS; and, more importantly, the Plutonium buried in the ORWBG is bound to SRS soils and is nearly insoluble (it has a high Kd). Thus, SAB concluded that the Pu buried in the ORWBG at SRS is safely disposed where it is. The CERCLA ROD issued by the regulators indicates that they agreed.

In agreement with the minority report to the Chairs' letter [3], recently, Assistant DOE Secretary J.A. Rispoli responded to the CAB Chairs letter [79]. After thanking them “for their support for the disposition of high level wastes” without referring to Yucca Mountain, he then stated that DOE would continue its existing policy regarding pre-1970 transuranic waste sites:

This waste is regulated by the Environmental Protection Agency (EPA) through its “Superfund” remedy selection process. The criteria established in this program are derived from the statutory requirements of Section 121 of the Comprehensive Environmental Response, Compensation and Liability Act (Superfund), as well as technical and policy considerations that have proven important for selecting among remedial alternatives. The Department is required and committed to follow these regulations. The appropriate action to take at each buried TRU site is determined at the local level based on regulator decisions and community input, and DOE will continue to work with these parties in reaching these decisions.

CONCLUSIONS, RISK PERCEPTION AND RISK DETERMINATION

Based on a literature search (e.g., [23]), an analysis of a study funded by DOE [8], and a comparative field study of HAB-Hanford versus SAB-SRS across the topics of transuranic (tru) wastes, high-level reprocessing wastes (HLW), and environmental remediation (ER), we determined that Bradbury's support for DOE's policy was unjustified. Specifically [27], CR retards cleanup; the freedom under CR to express unchallenged beliefs removes responsibility from citizens to process and resolve scientific information discrepant with their own worldviews; and the cooperative relationships necessary to seek consensus requires coercion [20] and censorship [50], reducing accountability across the site-public matrix. CR increases misperceptions of risk and public alienation from DOE as has happened around Hanford, consequently denying citizens the means to better educate themselves about DOE's nuclear mission.

We found few specific recommendations by HAB asking Hanford to enact instrumental actions. In contrast, we found that SAB consistently pushed SRS with specific recommendations to lead in HLW vitrification, closing HLW tanks, and sending transuranic waste to the federal repository in NM while HAB has not pushed DOE to accelerate the cleanup of Hanford.

By contrasting societies where debate is absent with those where it is present (e.g., Palestine and Israel, respectively; in [27]), we conclude that truth-seeking from majority rule is key to the evolution of a culture or society. Evolution does not occur under consensus rule because beliefs citizens hold are less likely to be challenged, promoting a lack of education and authoritarianism, but diluting personal responsibility for misjudgments, mistaken beliefs, and misperceptions of risk regarding nuclear waste cleanups. The goal of CR is moral authority to better focus DOE's beliefs; however, freedom is not reformed by external ethical norms [9]. Under majority rule, by accelerating the cleanup, social welfare has improved; under consensus seeking, gridlock has rooted and grown.

Of course, problems can occur with both approaches to decision-making, such as factions or cabals with sufficient strength to preclude the meaningful processing of information available to solve a problem confronting a group. But decisions under CR or MR pose a structural tradeoff between a moral worldview based on risk perceptions that block social progress and a common sense approach contingent on the available technical facts or risk determinations that accelerate social evolution [16,70]. Under both approaches, leaders exploit advantages afforded by the structure available to them by driving decisions to one extreme or the other, accruing power if successful. In an absolute sense, neither approach is better but represents a tradeoff between moral authoritarianism and accelerating the cleanup, a choice rooted in the manner that the information available becomes processed. In this larger picture, social authority is strengthened under CR, social welfare under MR.

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