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Unique NAVIS-based Strategy for Framing Dialog Regarding Complex, High-Consequence Systems

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Overview

1. Discussion of problem & partial solution
2. Perceptions & communication involving siting of complex, high-consequence systems
3. The NAVIS-based taxonomy of biases
4. The NAVIS-based communication strategy
5. Communication examples using NAVIS-based strategy
6. Discussion / Conclusions

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Discussion of Problem

- **Problem: Debate concerning the introduction or expansion of complex, high-consequence systems can quickly deteriorate into heated exchanges between supporters and detractors. The general public may then *forgo benefits* and/or *incur costs* due to distorted perceptions of these systems.**

“Pro” **versus** **“No”**

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Discussion of Problem

- **As the complexity & potential consequences of systems increases, it becomes increasingly important to improve methods of communication *within* and *between* groups of stakeholders/decision makers about the cost and benefits of such complex, high-consequence systems.**
- **A few examples:**
  - Expanded use of nuclear energy for electricity generation
  - Sequestration of carbon emissions from fossil fuel plants
  - Hydrogen as a “zero emission” energy carrier for transport vehicles

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Discussion of Problem & Partial Solution

- **Problem: Rapidly polarized debate emerges regarding complex, high-consequence systems – *due to unhelpful biases*, which paralyzes efforts to realize system benefits**

- **Partial Solution Proposed: Improve communication using a "risk comparability" or "first do no harm" approach:**
  - ***Characterize biases/perspectives of stakeholders using unique, recently developed process***
  - ***Develop a "maximally practicable failsafe design" that is perceived as exceptionally safe by the vast majority of stakeholders (e.g., 5 –10X cost envisioned by supporters)***
  - ***Begin* broad discussion with "maximally practicable failsafe design"**
  - ***Progressively* discuss/debate less expensive, "riskier" system designs using an environmental impact statement analogous approach**

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Perceptions & communication involving siting of complex, high-consequence systems

- Achievements of science & technology have been important & impressive—leading to unprecedented physical safety & material wealth, but at cost of individuals' increased interdependence risk $\Rightarrow$ Amplifies need for TRUST
- Trust in program officials impacts public response to hazardous facilities for their "backyard," along with:
  - Perceived risk to health & safety of nearby residents
  - Perceived need for the facility
  - Trust in public officials who will manage & oversee

Flynn, J., W. Burns, C. K. Mertz, and P. Slovic Risk Analysis 12 (1992): 417-430.
Williams, B., S. Brown, and M. Greenburg. Environment and Behavior 31 (1999): 354-371.
Kunreuther, H., K. Fitzgerald, and T.D. Aarts. Risk Analysis 13 (1993): 301-318.
Jenkins-Smith, H.C. and H. Kunreuther. Risk Analysis 21 (2001): 371-382.

Perceptions & communication involving siting of complex, high-consequence systems

Survey of perceived risk & uncertainty for management of nuclear waste
(among those living in Colorado & New Mexico)

- **Scientists**
  - Perceived least risk
  - Some certainty regarding their perception of risk
  - With new information – willing to revise risk perception
- **Business People**
  - Perceived slightly more risk than scientists
  - Some certainty regarding their perception of risk
  - With new information – willing to revise risk perception
- **Environmentalists**
  - Perceived much greater risk than other groups
  - The most certain about their perception of risk
  - With new information – willing to revise risk perception, but a bias toward higher risk

Jenkins-Smith, H.C. and J. G. W. Bassett. "Perceived risk and uncertainty of nuclear waste: differences among science, business, and environmental group members." Risk Analysis 14 (1994): 851-856.

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Perceptions & communication involving siting of complex, high-consequence systems

Survey regarding siting of prison, landfill, hazardous waste incinerator, radioactive waste disposal plant (1,234 randomly selected US residents)

- All facilities viewed more positively when benefits/safety package provided
- 40% would accept a prison, but < 10% would initially accept rad waste plant
- Percentages willing to change opinions: 69% (prison), 73% (landfill), 66% (incinerator), & 56% (rad waste repository)
- Final % of supporters for landfill, incinerator, or repository was at least 10% higher when economic benefits were offered *before* additional safety measures
- Best economic benefits: $ for those most affected via property value guarantees & medical costs for physical illness/injury
- Worst economic benefits: $ directly to residents (e.g., tax rebates)
- Approval of facility design by local officials *negatively* impacted facility acceptance
- Largest factors: Perceived risk, Perceived trust of independent inspection agency, Perceived need of facility

Jenkins-Smith, H.C. and H. Kunreuther. "Mitigation and benefits measures as policy tools for siting potentially hazardous facilities: determinants of effectiveness and appropriateness." Risk Analysis 21 (2001): 371-382.

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Perceptions & communication involving siting of complex, high-consequence systems

Key (related) points from a number of previous studies:

- Perceptions regarding complex, high-consequence systems can be changed
- Negotiating additional safety measures can increase system acceptability
- As long as local officials are not given the responsibility for final, "detailed system design approval" then the "maximally practicable failsafe design" (MPFD) concept is not unreasonable

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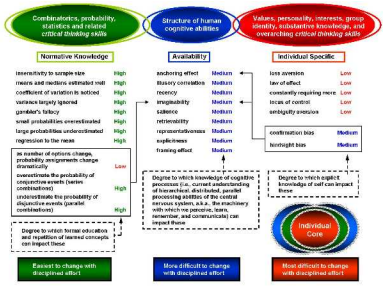
The NAVIS-based Communication Strategy

Biases Involving Uncertainty

- Roughly 80% of information used to understand our relationship to outside world is obtained visually
- Normative, Availability, & Individual Specific Bias Processes (27 bias processes in the NAVIS taxonomy)
- Culture: e.g., language habits in Western culture → People speak as if they are certain when they are only fairly certain; people perceive opinions to be worthless when they are only weakly supported
- Limitations of working memory
  - *"The magical number seven plus or minus two: Some limits on our capacity for processing information"* Miller (1956), Psychological Review, 63, 81-97.
  - Note: from those familiar with the research – stick to 5 or less distinctions that need to be held in working memory during a brief presentation & encoded in long-term memory

NAVIS



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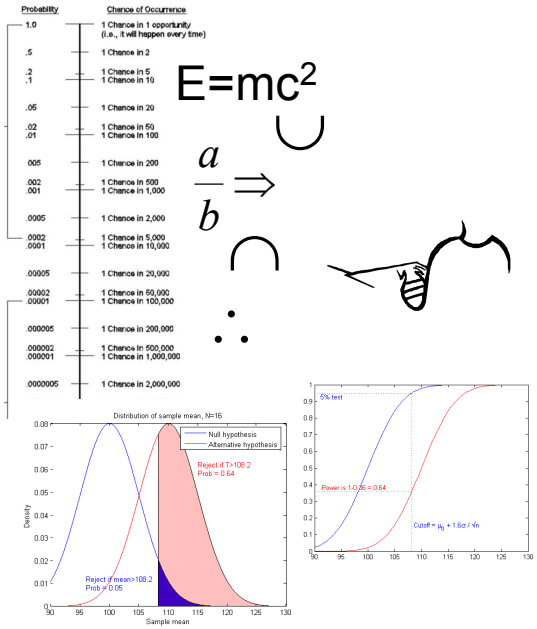
Combinatorics, probability, statistics and related *critical thinking skills*

Structure of human cognitive abilities

Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*

Normative Knowledge

$$p(A \mid B) = \frac{p(B \mid A)p(A)}{p(B)}$$



Number sense & analytical skill

Availability

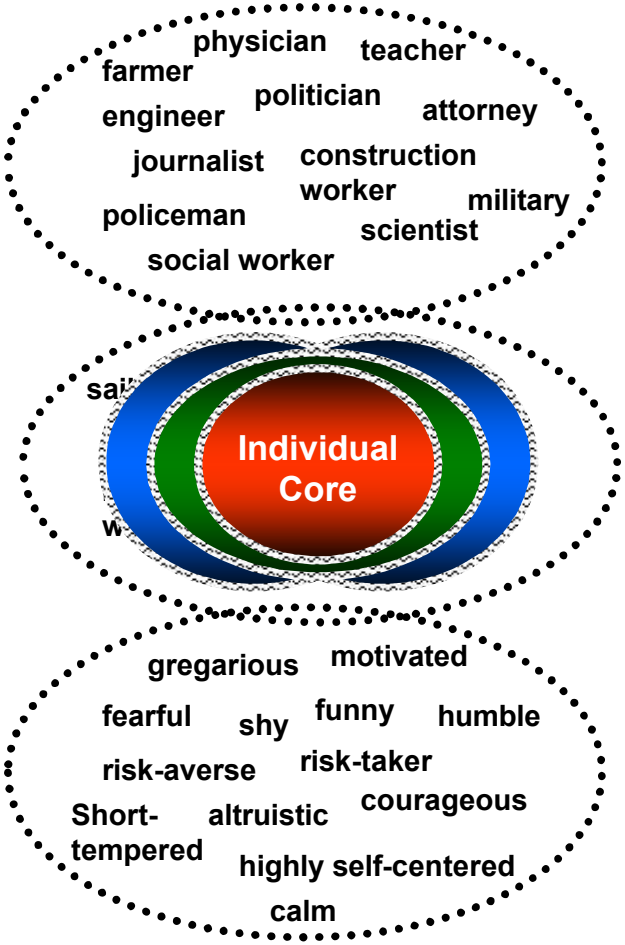
perception

memory learning

communication

The human 'machinery'

Individual Specific



A specific person

Combinatorics, probability, statistics and related *critical thinking skills*

Structure of human cognitive abilities

Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*

Normative Knowledge

insensitivity to sample size

means and medians estimated well

coefficient of variation is noticed

variance largely ignored

gambler's fallacy

small probabilities overestimated

large probabilities underestimated

regression to the mean

as number of options change; probability assignments change dramatically

overestimate the probability of conjunctive events (series combinations)

underestimate the probability of disjunctive events (parallel combinations)

11

Availability

anchoring effect

illusory correlation

recency

imaginability

salience

retrievability

representativeness

explicitness

framing effect

9

Individual Specific

loss aversion

law of effect

constantly requiring more

locus of control

ambiguity aversion

confirmation bias

hindsight bias

7

27 biases/tendencies that are related to each of the 3 main categories

Combinatorics, probability, statistics and related *critical thinking skills*

Structure of human cognitive abilities

Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*

Normative Knowledge

insensitivity to sample size	High
means and medians estimated well	High
coefficient of variation is noticed	High
variance largely ignored	High
gambler's fallacy	High
small probabilities overestimated	High
large probabilities underestimated	High
regression to the mean	High
as number of options change, probability assignments change dramatically	Low
overestimate the probability of conjunctive events (series combinations)	High
underestimate the probability of disjunctive events (parallel combinations)	High

Degree to which formal education and repetition of learned concepts can impact these

Easiest to change with disciplined effort

Availability

anchoring effect	Medium
illusory correlation	Medium
recency	Medium
imaginability	Medium
salience	Medium
retrievability	Medium
representativeness	Medium
explicitness	Medium
framing effect	Medium

Degree to which knowledge of cognitive processes (i.e., current understanding of hierarchical, distributed, parallel processing abilities of the central nervous system, a.k.a., the machinery with which we perceive, learn, remember, and communicate) can impact these

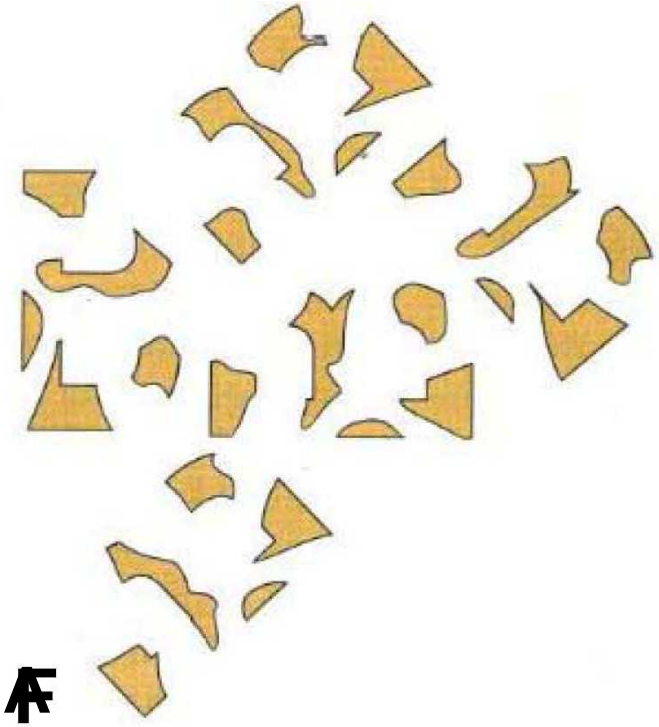
More difficult to change with disciplined effort

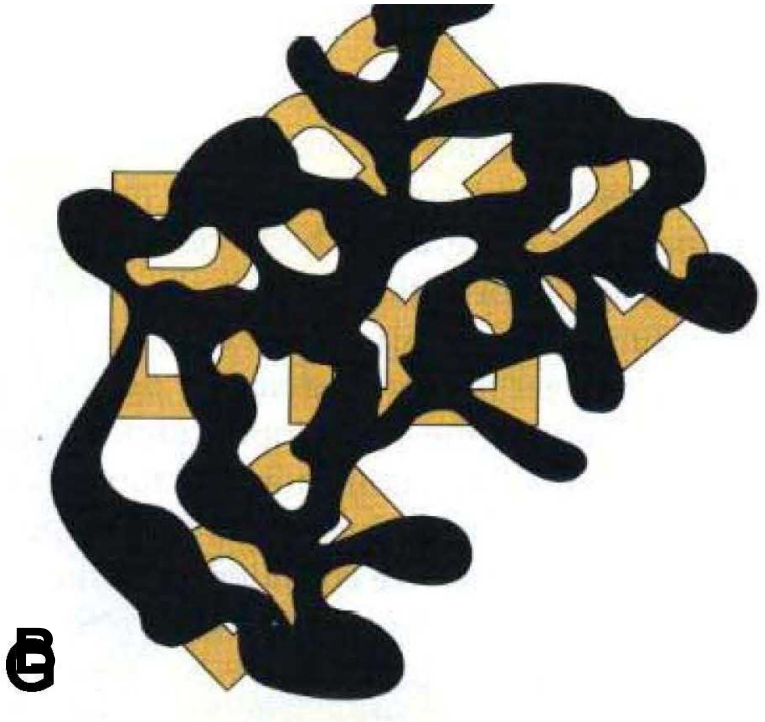
Individual Specific

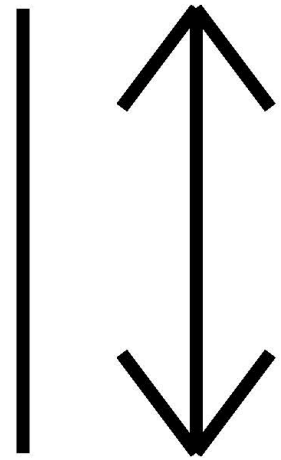
loss aversion	Low
law of effect	Low
constantly requiring more	Low
locus of control	Low
ambiguity aversion	Low
confirmation bias	Medium
hindsight bias	Medium

Degree to which explicit knowledge of self can impact these

Most difficult to change with disciplined effort







Visual Biases

NAVIS-based Communication Strategy

1. Perform NAVIS-based self inventory of stakeholder team
2. Review knowledge base / technical basis for system
3. Develop near-indisputable “failsafe” system (i.e., MPFD)
4. Perform NAVIS-based assessment of various stakeholder groups
5. Refine MPFD & prepare communication materials & fora
6. Widely publicize MPFD process & encourage participation by all stakeholder groups
7. Iteratively discuss MPFD and “riskier” system designs among stakeholders

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Combinatorics, probability, statistics and related *critical thinking skills*

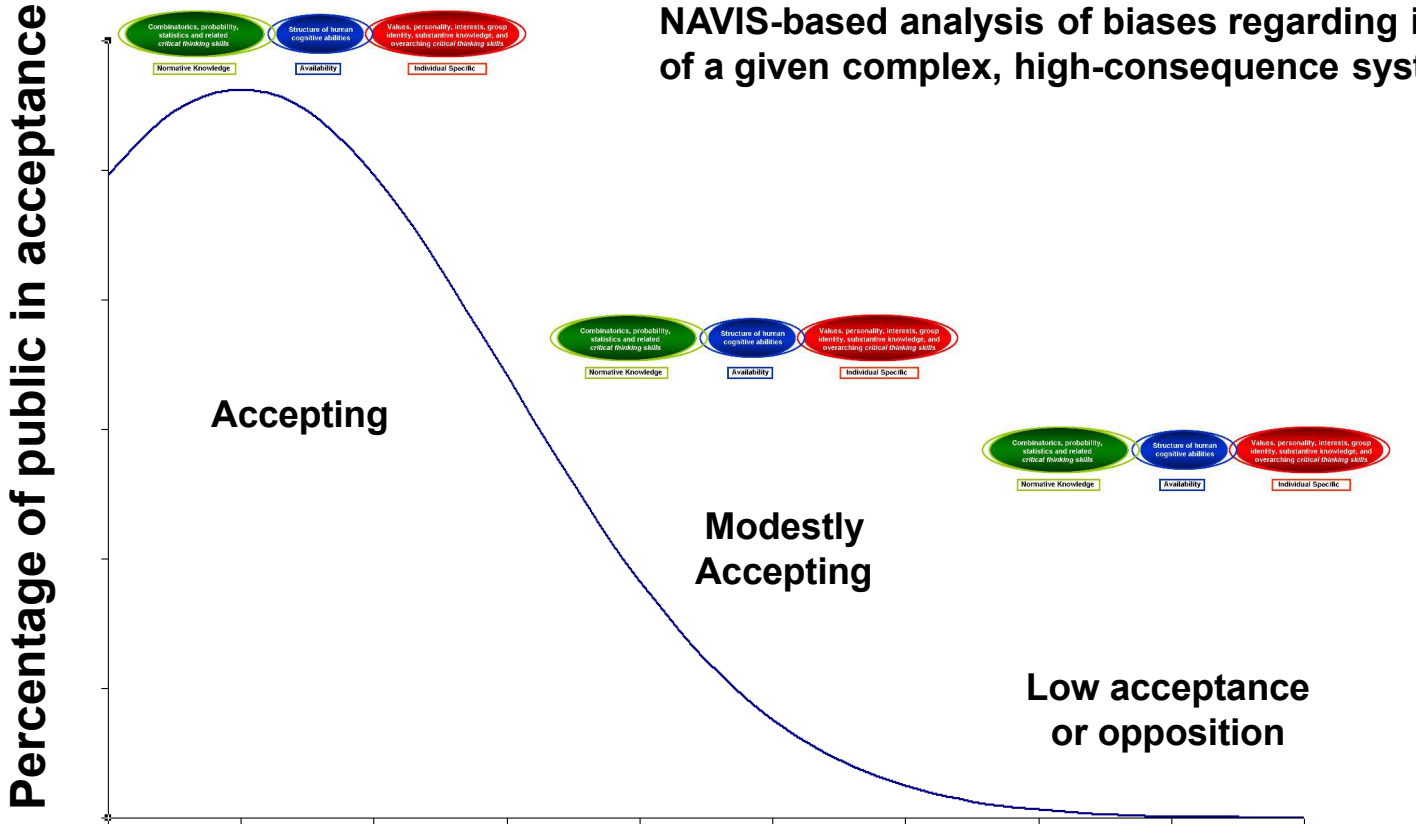
Structure of human cognitive abilities

Values, personality, interests, group identity, substantive knowledge, and overarching *critical thinking skills*

Normative Knowledge

Availability

Individual Specific



NAVIS-based analysis of biases regarding implementation of a given complex, high-consequence system

Discover what drives positive & negative perceptions relative to 27 known bias processes?

A new approach for framing dialog, debate, & decision making for complex high-consequence systems emerges...

Levels of acceptance for implementation of a given complex, high-consequence system

NAVIS-based Communication Strategy

For each design option, develop a simplified Environmental Impact Statement type of analysis (e.g., an extended fact sheet)

- **Considerations of environmental impacts**
- **Adverse environmental impacts which cannot be avoided**
- **Alternatives to the proposed action**
- **Relationship between local short-term uses of the human environment and maintenance/enhancement of long-term productivity**
- **Irreversible & irretrievable commitment of resources involved**

Goals: Build *trust* & enable many stakeholders to *provide input* to the cost versus benefit decision – beyond a single acceptance or rejection of one design option

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Communication examples using NAVIS-based strategy

1. Expansion of nuclear power for electricity production
2. Underground carbon sequestration facility/reservoir
3. Hydrogen-power personal vehicle refueling station

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Multiple of current cost

$1x

$2x

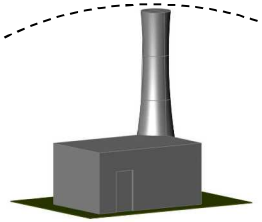
$10x

Safety Level

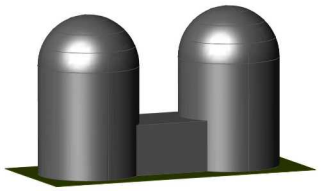
Extensive

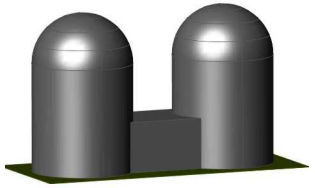
Very Extensive

Maximally practicable failsafe design



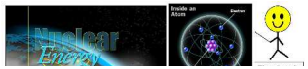
Reasonable cost & safety per NPP industry

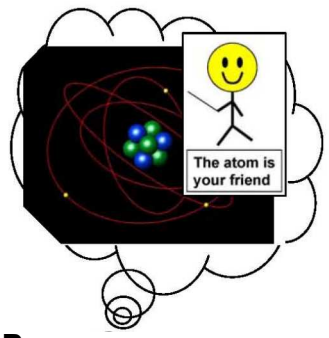




Start Here

Move this direction





NP Best!

Benefit!

vs. Cost

Highly supportive

Cost vs. Benefit?

Accepting to Modestly Accepting

Cost! vs. Benefit

NP Evil!

Strongly oppose

% of people willing to live at particular distance

4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

0
10
20
30
40
50
60
70
80
90
100

Distance in miles from power plant

Communication examples using NAVIS-based strategy

2. Underground carbon sequestration facility/reservoir
   - Benefit: Trap global warming gasses underground
   - Cost: Potential rapid, large-scale leakage of CO_2 $\Rightarrow$ risk at low level to people; risk at high-level in form of climate change
   - MPFD: Extensive containment, monitoring, & emergency response components
3. Hydrogen-power personal vehicle refueling station
   - Benefit: Clean emissions from vehicle exhaust
   - Cost: Potential rupture & explosion of high pressure (e.g., 30K psi) vessels at refueling stations & in-vehicle storage tanks (e.g., 5K psi)
   - MPFD: Extra protective features for pressure vessels at stations & inside vehicles, and extra features for refueling equipment at stations

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Discussion

- NAVIS-based strategy proposed to be effective in the battle against biases causing technological “stalemates”
- Previous studies lend support for basic strategy
- *However*, over emphasis of “safety-related costs” versus “benefits” of complex, high-consequence systems could be problematic—details are crucial
- Further research is needed to verify & validate the basis of the “maximally practicable failsafe design” concept for improving dialog

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Conclusions

The NAVIS-based strategy for framing dialog regarding complex, high-consequence system is *proposed* to be helpful in improving communication (i.e., mitigating biases & building trust) between groups with historically opposing views.

- Enables greater consensus on benefits & costs
- Facilitates advances in technology instead of protracted stalemates

Does anyone want to try it?

Questions?