Organizations, perturbations, and generating information

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Approaches to Organization Theory

- "Methodological individualism" => consensus (Nowak & Sigmund, 2004)
  - Assumption: Reality is stable with *I* that is mostly accessible
  - But Arrow impossibility & Nash possibility theorems within consensus-rules (CR) => ∑(multiple preferences) ≠ CR
    - CR: converts group d.m. into individual rationality
    - CR: consensus-seeking -> groupthink (Janis, 1982)
- Mathematical physics of uncertainty => competition
  - Assumption: Reality is bistable with *I* that is mostly inaccessible
  - surveys ≠ groups (Levine & Moreland, 1998) = M problem
  - M problem: M(Group) -> individual (classical) *I*
- Rational individual d.m. ≠ group d.m

Background: Current ABM's use MI to sum rational individual cooperative agents into organizations

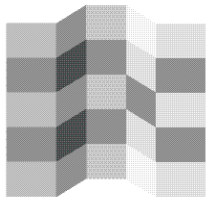
- Mathematically, MI groups stable under consensus-seeking, dictatorships & low diversity (May, 2001)
- Cooperation requires coercion (Axelrod, 1984, Hardin, 1968)
- Cooperation does not prevent asymmetric *I* (terrorism, corruption, and blackmail)
- EC: "The requirement for consensus in the European Council often holds policy-making hostage to national interests in areas which Council should decide by a qualified majority." (WP, 2001, p. 29)

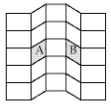
Background: MI in Organizations

- Traditional organizational models
  - Game Theory and Social Learning Theory
    - Static nature (≈ movies, tv), no inertia (VN&M, 1953)
    - Normative values (cooperation) (Nowak & Sigmund, 2004)
  - Teamwork & consensus (Bradbury et al., 2003)
  - Competition has low social value (Nash, 1950) and is "toxic" (Dennett, 2003)
- However, **MI organizational theory has failed** (Werck & Quinn, 1999), little advanced from Lewin's (1951) idea of "disturbance" to overcome "inertia" (Schein, 1996)
  - **MI cannot account for the social benefits of competition** (e.g., science, free markets, democracy, armed defenses, innovation, etc.)

MI: Autonomy and Control of Robot Organizations

- DARPA: Organizations ≈ 1 soldier + multiple robots w/"live weapons", but not w/o validation
  - 5-6 humans per Predator w/staff of 20 (Russ Richards, JFC, 2003); 4 airborne over OIF (Moseley, 2003)
- Organizations based on "methodological individualism":
  - Tambe (2003): ABM autonomy currently not possible
  - Bankes (2002): validating social ABMs not possible
- ANL's EMCAS (North, 2005): "**The purpose of an ABMS model is not necessarily to predict the outcome of a system, rather … to reveal and understand** the complex … system behaviors that emerge…" However, EMCAS is unconstrained by Field Results, thus:
- The danger is that ABM's are "toys" (Macy, 2004).





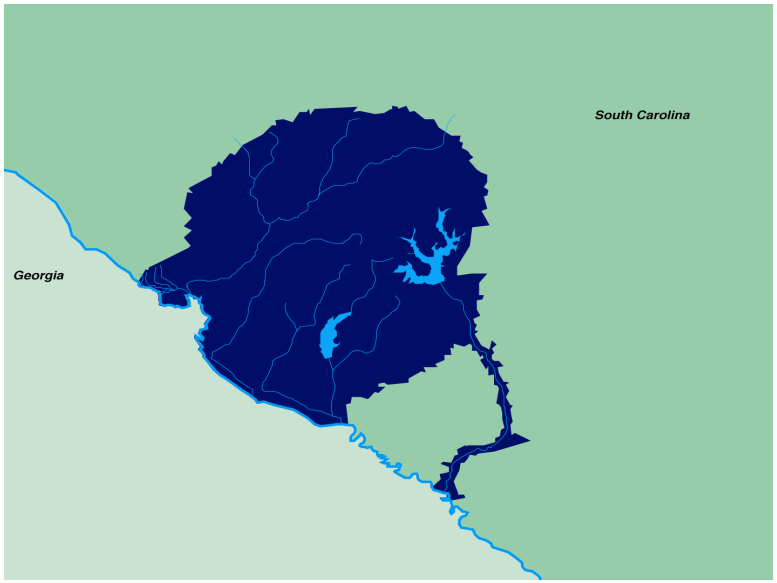
Alternative: Math physics of uncertainty => Bistable *I*

- Bistable *I* is non-obvious for several reasons:
  - **The brain has two independent cognitive and action systems** (Rees et al. 1997)
  - Under uncertainty, the brain searches and selects the best solution (**paintings**; in Gibson, 1986; **illusions**; in Cacioppo, 1997)
  - Solutions are based on convergence and marginalization (Campbell, 1996; Tajfel, 1970)
- Organizations based on bistability:
  - If M(bistable MAS) -> classical *I,* how to control?
- Examples: illusions, movies, action-observation, mergers

MI v MPU : Claims versus Actions

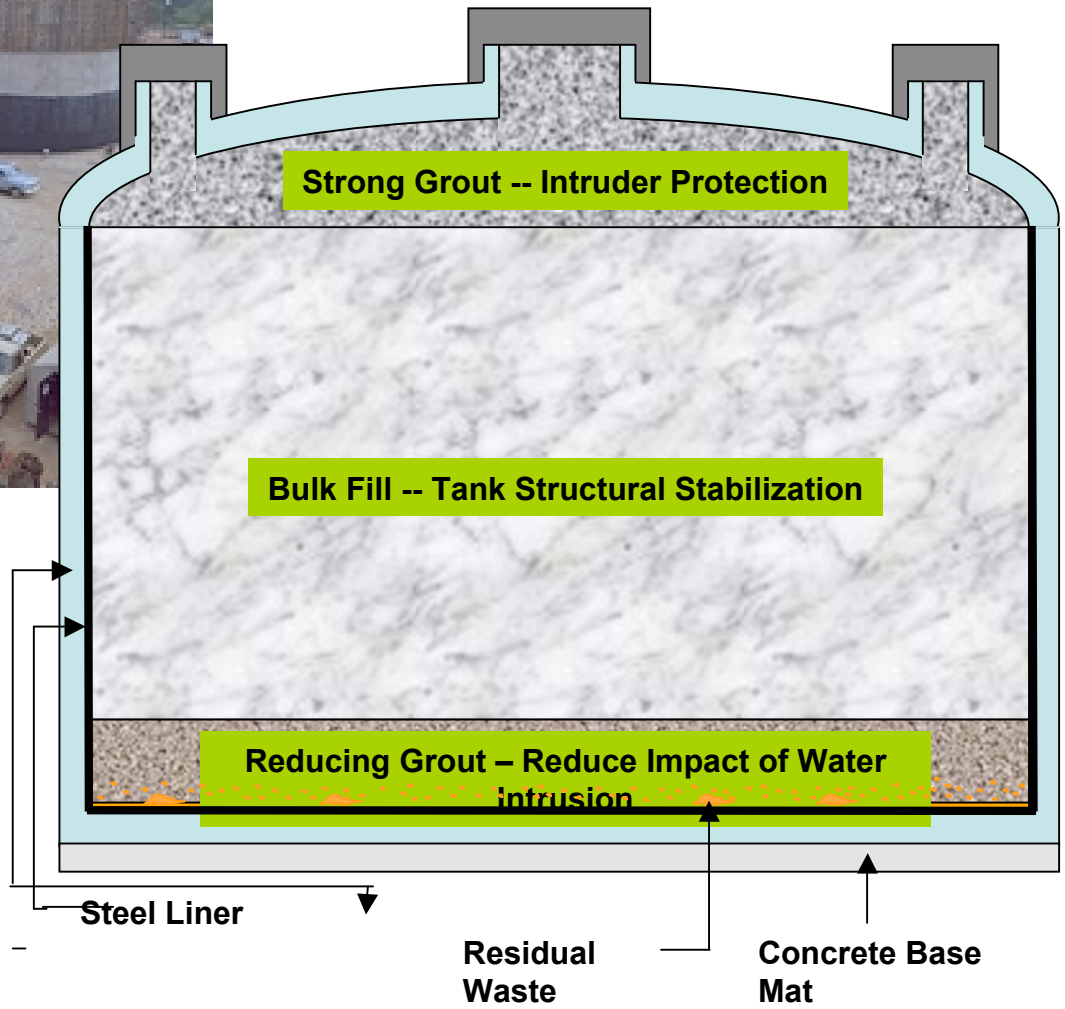
- DOE claimed before 1983 that its actions "Protect … [the] environment [and] health and safety of employees and public" (ERDA 1537, 1977)
- Cleanup of SRS and Hanford alone est. at $100 B (Lawless, Bergman, & Feltovich, 2005)
- PhD: How can a leading technology agency like DOE with world-class scientists & engineers mislead Congress and the public?

DOE Savannah River Site, Aiken, SC



Seepage Basins and Trenches (Z-9)

Tank 17F and 20F Closure



Site Contrasts => MI v MPU (bistability)

	MI	**MPU**
	Hanford/HAB **(CR: cooperation)**	Savannah River Site/SAB **(MR: competition)**
ER	ER about 7.1% in 2002	ER cleanup today ~ 62%
HLW	0/177 HLW tank closures postponed indefinitely HLW vitrification maybe in 5 y	2/51 HLW tanks closed 1997, closing tanks 19 (2005) and 18 (2006) 1,775 of 5060 canisters of v-HLW (≈ 32 ci/gal) Low-curie salt processing from tanks ~ 10/2005
Tru	TRU at ≈ 20% of SRS & w/much larger legacy	14,558 drums (≈ 1/2) legacy tru wastes shipped to WIPP w/Trupact II => close out of legacy tru at SRS in 2008
Results	**Significant struggles**	**Very Successful**

Lawless, Bergman, & Feltovich, 2005

Mathematical physics model of Bistable Uncertainty = H.U.P.

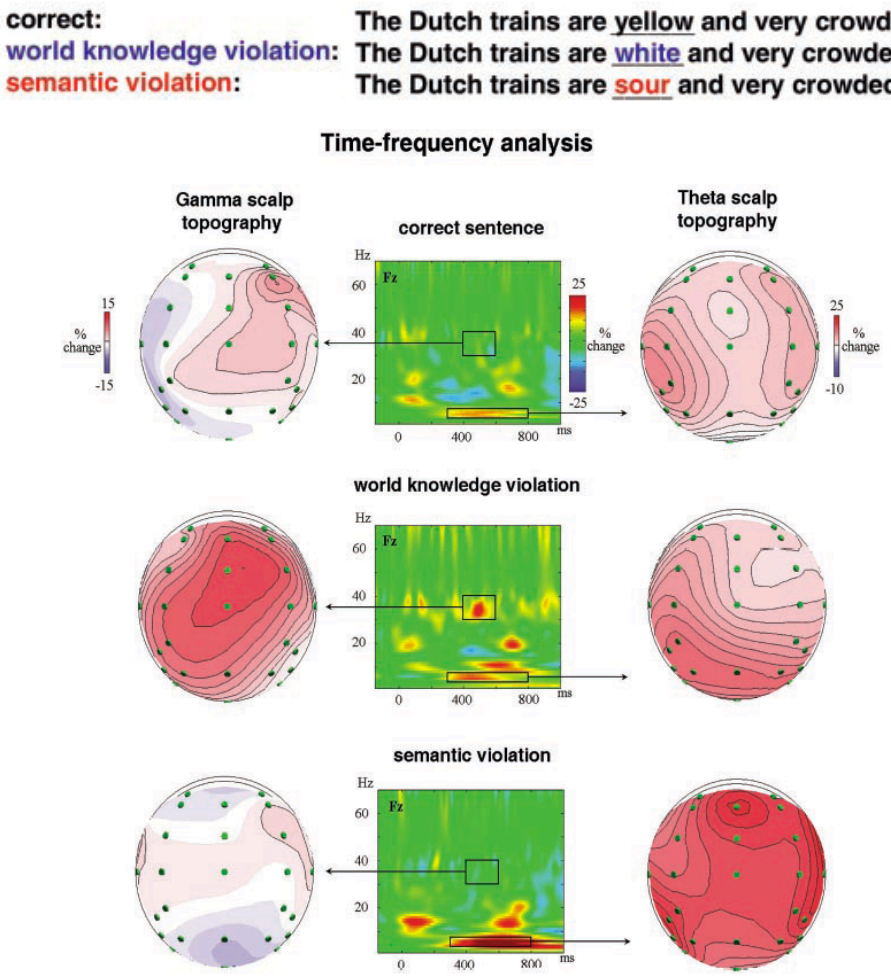
- Let $K = f(x)$; ΔK = belief uncertainty = I (Shannon's I);
  - $K = f(x) \approx$ f(group, experience, location) (Latane, 1981; Tajfel, 1970)
- Let $\Delta v = \Delta\ (\Delta K/\Delta t)$ = action uncertainty;

$$\Delta v \Delta K \geq c \qquad (1)$$

  - **USAF**: In combat pilot experiment, book K ($\Delta K \rightarrow 0$) did not predict wins-losses, E availability, or expert ratings, but training did ($\Delta a \rightarrow 0$) (Lawless et al., 2000a)
  - **DOE Study #1**: SRS CAB (MR) v HAB (CR): "competition of ideas" ($\Delta K \rightarrow \infty$) improved nuclear waste cleanup + trust
  - **Computational**: Expert forecasters best over short term, collaborators close 2nd and better over longer term, NCWF worst
  - **Nations**: the more competitive a nation, the more associated w/increased E, SW, H, EF and trust and with less corruption (Lawless et al., 2000b)

$$\Delta v \Delta K \approx c \approx \Delta t \Delta E \qquad (2)$$

What is the constant "*c*" ? Penrose: $\Delta t \Delta E \geq h \Rightarrow \Delta t \Delta \omega \geq 1$

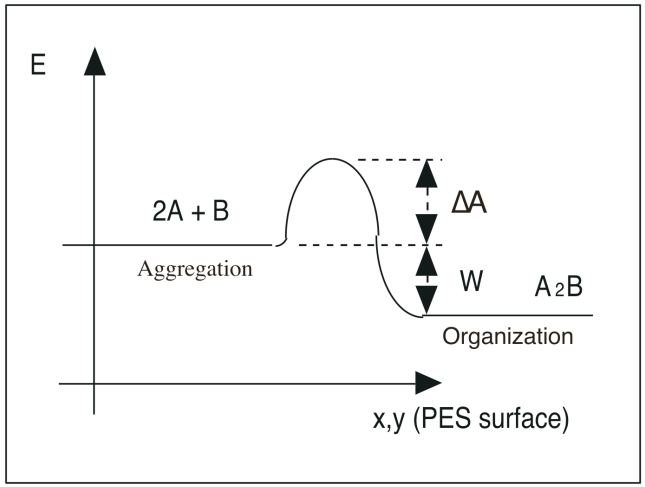


K conflicts: EEG data adapted from Hagoort et al., 2004, Science, 304, 438-441, Fig. 2 [Note: 29 EEG recordings per subject, 30 subjects].

- **$N = 30 \Rightarrow c = h$ for groups**
- **Gamma Waves (feature binding): $\Delta t = 1/\Delta\omega = 1/(40\ \text{Hz}) = .025\ \text{s} \geq 25\ \text{ms}$**
  <-- EEG data ≈ 50-75 ms
- **Theta Waves (episodic and working memory tasks): $\Delta t = 1/\Delta\omega = 1/(5\ \text{Hz}) = .200\ \text{s} \geq 200\ \text{ms}$**
  <-- EEG data ≈ 3-400 ms
- **Voice data agrees (NRL: Kang & Fransen, 1994)**

Assumption:ΔK-DFT (ΔK density)

- $E^{PES}(x,y) = min_{z,Rorg}\, E^{TOT}(x,y,z,R_{org})$ Sallach (2002) (3)
  - Function, hierarchy, organization => Hamiltonian **-> E_{min}**
- $H = H_0 + H_{int}$ = (location within an organization) + (interaction) (4)
  - $H_0 = E_b^A \sum_k n_k + E_b^B \sum_k m_k + V^{A\text{-}B} \sum_k n_k m_k$
  - $H_{int} = 1/2 V_{1n}^A \sum_{k,a} n_k n_{k+a} + 1/2 V_{2n}^B \sum_{k,b} n_k n_{k+b} + 1/2 V_{1n}^B \sum_{k,a} m_k m_{k+a} + 1/2 V_{2n}^B \sum_{k,b} m_k m_{k+b} + 1/3 V_{trio}^B \sum_{k,a,a'} m_k m_{k+a} m_{k+a'} + \ldots$



W =>Perturbation Theory (Lawless & Chandrasekara, 2002)

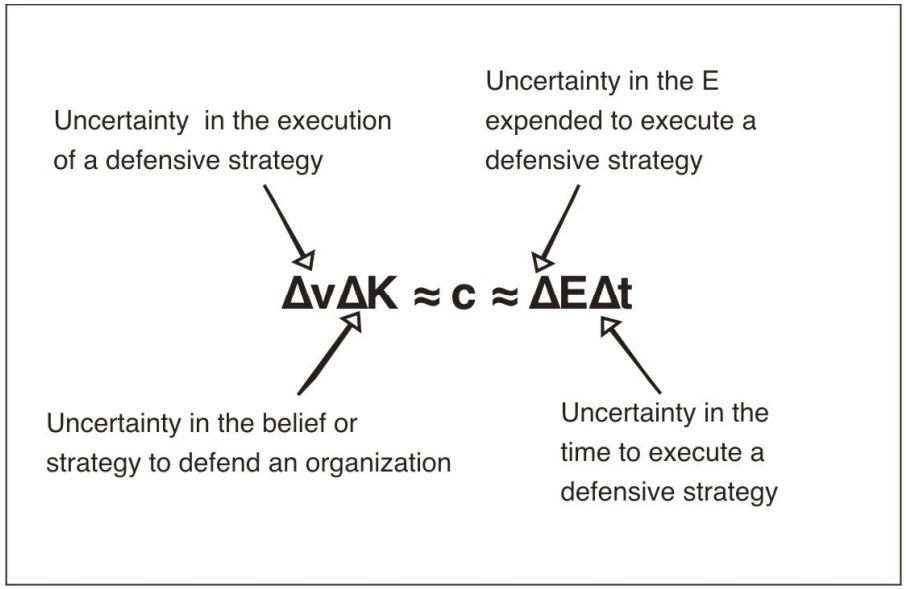
Assumption conclusions, Equations 2-4 (Lawless & Grayson, 2004a)

- Once organization forms or merges -> E_{min}, low I:
  - Social Loafing (Latane, 1981)
  - Audience Skills enhancement (Zajonc, 1998)
  - Terror Mgt (Rosenblatt et al., 1990)
  - Health (House et al., 1988)
  - Firms (Coase, 1937)
- Mergers require $E(\Delta A)$, post mergers -> - costs (Andrade & Stafford, 1999)
- W/growth heterogeneous island stresses reduce from Hi to Low (**terrorism**)
- Utility Theory for organization barriers: $\Gamma_P = n_A n_B v \sigma_{AB} exp(-\Delta A/k_B T)$
  - Winners & losers (market share, military) = $f(N)$ = # of fourier comp's
- **Resonance cross-section** affects rate of χ: $\sigma_{AB} = \alpha_\chi (\omega^4/(\omega^2-\omega_0^2)^2)$
  - Clinical matching (experience & treatment) => resonance = HXS
  - Friends ≈ vocal harmonic oscillators => resonance = HXS
  - terrorists seek a LXS w/cooperation => reactance ≈ 1/resonance
- **E_{min} => Perturbation Theory -> I (Lewin, 1951)**
  - **Afghanistan campaign -> "intelligence"** (Feitz, 2004, Ass't Sec. Def.)

Perturbation Hypothesis

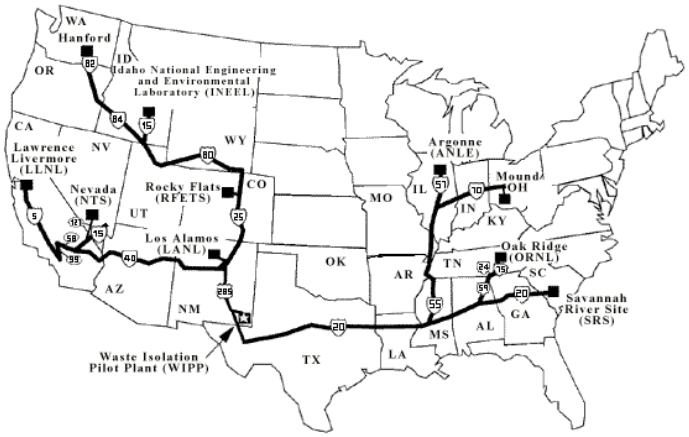
- Organizations under attack coalesce ($E = f(\omega) = f(1/\lambda)$ => tighter, agitated, cooperative groups (Rosenblatt et al., 1990)
  - Ants (May, 2001) & Slime Molds (Nicolis & Prigogine, 1989)
  - Iraqi Defense Forces (Kagan, 2004); Terror impacted elections in Spain and Israel, 2004
  - Corporate mergers (Lawless & Grayson, 2004b)
    - Transformation strategy success: + # Fourier elements
  - Perturbations => coupled oscillators
- "Values" ∋ cooperation replaced with science
- **Attacks of bistable organizations generate I and M problems [M($\Delta K, \Delta p$) strategy<-->execution]**

H Test: Perturbations & Measurement problem (e.g., hostile merger of PeopleSoft by Oracle)



Lawless & Grayson, 2004

- NAS (1/04) -> M (field test)
- DOE Tru waste repository opened at WIPP in 1999
- Asst Sec Roberson called for acceleration in 2002



TRU: Radioactive waste contaminated with uranium 233 or elements beyond uranium on the periodic table and existing in concentrations of more than 1 ten-millionth of a curie per gram of waste. These isotopes, mostly pu-239, have half-lives of over 20 years and are all manmade. clinton2.nara.gov/OMB/inforeg/glossary.html

M (field test): In 2003, 13 Recommendations by DOE Scientists & Engrs to CABs (N=105) for citizen endorsement to accelerate disposition of Transuranics to WIPP, NM

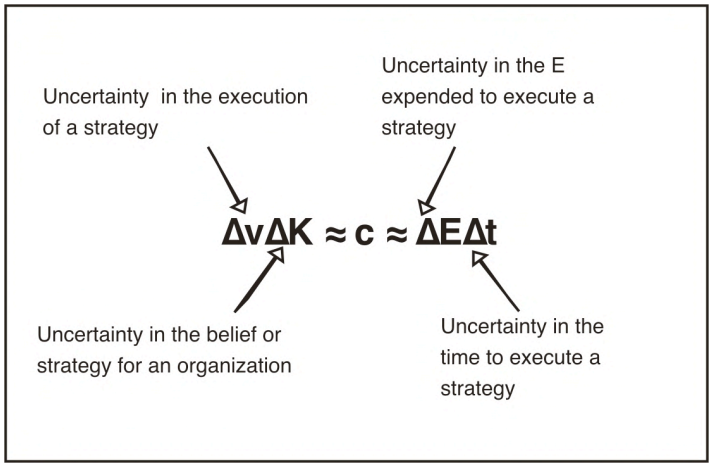
- DOE characterize TRU waste as required to reduce risk and minimize transportation and handling of waste while making confirmation process cost effective
- Therefore, to meet Site Specific needs, DOE allocate and coordinate resources complex-wide to optimize shipping to maximize the receiving capacity of WIPP
- DOE in concert with stakeholders and regulators initiate an ongoing program to identify, correct and revise those requirements that interfere with the safe, prompt and cost effective management of TRU waste
- DOE identify volumes and disposition pathways for all potential TRU waste streams
- DOE in consultation with stakeholders and regulators initiate action to assure that WIPP has the capacity to accommodate all of the above listed TRU waste
- DOE accelerate TRU waste container design, licensing and deployment
- DOE streamline TRU waste management by accepting demonstrated process knowledge for TRU waste characterization
- **DOE, in consultation with stakeholders and regulators, reexamine the categorization of TRU waste using a risk-based approach**
- DOE identify the inventory of orphan TRU waste and assign a corporate team to identify a path forward
- DOE evaluate the concept of one or more locations to characterize TRU waste for WIPP disposal
- DOE finish its analyses and make a decision with adequate public involvement regarding where to characterize TRU waste for disposal
- DOE expedite the design, fabrication and certification of container transport systems Arrowpak and TRUPACT III and accelerate the adoption of rail transport as appropriate
- DOE revitalize its efforts in coordinating its transportation issues with States and Tribes and assist in updating and disseminating information to the public about transportation risks and safety and provide public participation opportunities on transport issues

M (field test): In 2003, Representatives (N=105) of 9 Site Specific Citizen Advisory Boards (SSAB's) (total N=250) associated w/DOE Sites met to decide on scientific recommendations

Active SSAB's (N = 9; about 250 members total)	Decision Process	Inactive SSAB's (N = 3)	Decision Process
Fernald	CR	Pantex	CR
Hanford	CR	Sandia	CR
Idaho	CR	Monticello	MR
Nevada Test Site	MR		
Northern New Mexico	MR		
Oak Ridge	MR		
Paducah	MR		
Rock Flats Plant	CR		
Savannah River Site (SRS)	MR		

Perturbation -> M problem: Request by

DOE Scientists to adopt plan to accelerate Tru waste shipments to WIPP

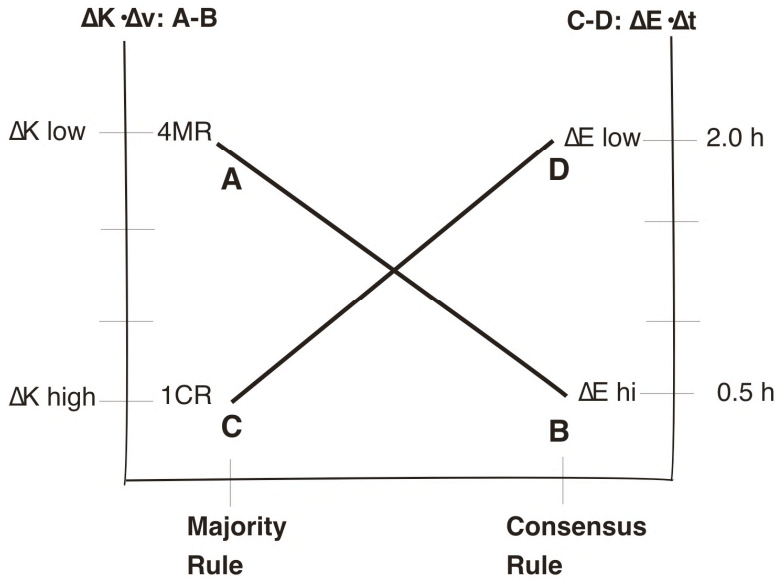


- Strategy Uncertainty: Would Boards believe in the plan?
- Execution Uncertainty: Would the Boards vote for the plan?
- Energy Uncertainty: Would Boards expend effort in support?
- Time Uncertainty: Would support by the Boards be timely?

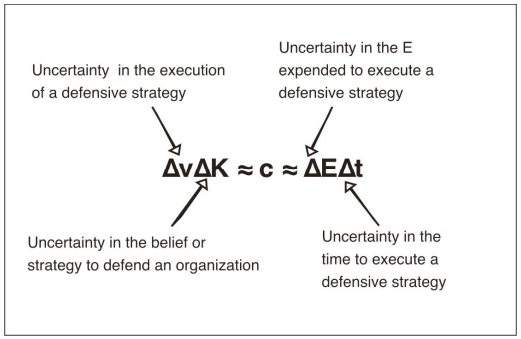
Measurement Problem: A Field Test

(Lawless, Bergman & Feltovich, 2005)

The SSAB Transuranic Workshop in Carlsbad, NM, reached consensus Recommendations Regarding Transuranic Waste Characterization across the DOE complex (2003, January; *N*=105). The result: Five of nine Boards returned to their respective sites and approved these Tru waste recommendations (*Majority Rule Boards*: SAB (SRS), Oak Ridge, Paducah, Northern New Mexico; *Consensus Rule Boards*; Rocky Flats Plant); four of the nine Boards disapproved (*Majority Rule Boards*: Nevada Test Site; *Consensus Rule Boards*: Hanford, Fernald, Idaho), giving $\chi^2(1)=2.74$, $p\approx.10$.



Mathematical interdependence: **A**. MR Boards bring opposing views together to seek the best decision and compromise (ΔK low; Lawless & Schwartz, 2002), generating instrumental action (Δv high; shown: 4 MR Boards agreed, not shown: 1 MR Board did not). **B**. For multiple reasons (ΔK high; Bradbury et al., 2003), CR Boards could not accept the complex request on Tru wastes by the DOE Scientists (Δv -> *0*; shown: 1 CR Board accepts; not shown: 3 CR Boards do not). **C**. Conflict on MR Boards is intense (ΔE -> ∞; e.g., Hagoort, 2003; Lawless et al., 2000b) but among few participants and thus short-lived (shown: $\Delta t = 0.5$ hours). **D**. Instead of instrumental action, CR Boards repeatedly restate values (high *I*, low $K \approx$ boredom => ΔE low; e.g., HAB, 2003) with many speakers over long and uncertain periods of time (shown: $\Delta t = 2$ hr).



Applications to MAGTF Metoc: Uncertainty => Tradeoffs with Planning & Execution

- Klein & Miller (1999): Planning occurs under time pressure and uncertainty
- Smith (2004) effects-based operations => uncertainty w/execution and force
- Lawless, Bergman, & Feltovitch (2005) => tradeoffs betw 4-i factors:
  - OIF M: execution before enemy d.m. was key (Franks, 2004); consensus slows, weakens execution (Lawless et al., 2005 ; MST's A)
  - CE: M: Coordinating, E**xploitation of weather impacts across battlespace is critical** (Gepp, 2003)
  - + Satellite costs, small bandwidth slows reachback (KNXP; Gepp, 2003)
  - In Metoc, Evis saves 40% of time to produce a strike forecast (Ballas, 2004)
- **Attacks generate *I* ("Fighting for intelligence",** LtGen. Boykin, 2004)
- **<u>Although Incomplete,</u> Field Test of M problem => MPU <u>works</u>**

Additional Reading

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