Cognitive Aspects of Decision Making

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ERDC Engineer Research and Development Center

Workshop Goals

- **Summarize state-of-the-science in areas related to Cognitive Aspects of Decision Making**
  - **Summary presentation during the workshop**
  - **WG papers after the workshop**
  - **Summary paper based on the workshop**
- **Identify problems and propose solutions/ analytical methods**
  - **Focus on individual and group decision making**
  - **Risk Assessment (ecological and human health)**
  - **Decision Analysis**
- **Establish collaborative teams and possible projects**
- **Have Fun!**

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Overview

- **Why Cognitive Aspects?**
- **Why Decision Analysis?**
- **Why Risk Assessment?**
- **Why Us and Why Now?**

- **Agenda**

Actions for Change
Bottom Line Up Front

"The Corps is responsible for the projects we build and manage, and we are accountable to the American people ….. for those who doubt us, words alone will not restore confidence. We are mindful that the public trust is earned when we follow through on our actions."

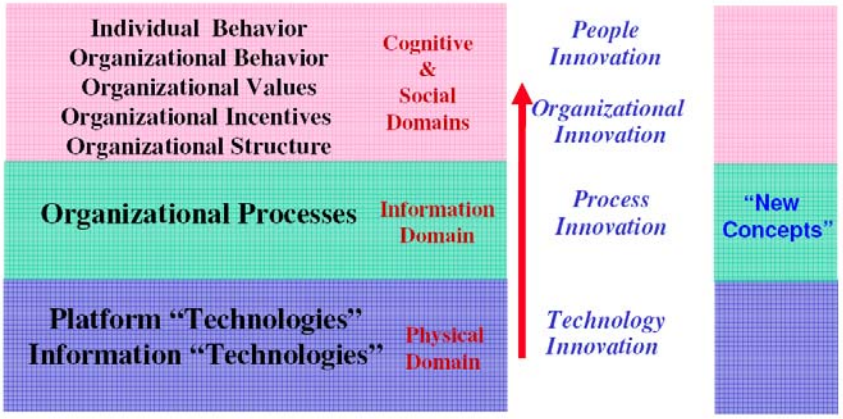
– Lieutenant General Carl A. Strock

ACTIONS for CHANGE

Overcoming Impediments to Innovation & Transformation

Forces Transformation & Resources

Vision and Leadership are key to overcoming Impediments to Innovation



Increasing Level of Difficulty for Change

From J. Garstka, 2007

Chief's 12 Actions ⇒ 4 Themes

Theme 1 - Comprehensive Systems Approach

- Action 1 - Employ integrated, comprehensive and systems-based approach
- Action 5 - Employ adaptive planning and engineering systems
- Action 6 - Focus on sustainability

Theme 2 - Risk Informed Decision Making

- Action 2 - Employ risk-based concepts in planning, design, construction, operations, and major maintenance
- Action 7 - Review and inspect completed works

Theme 3 - Communication of Risk to the Public

- Action 9 - Effectively communicate risk
- Action 10 - Establish public involvement risk reduction strategies

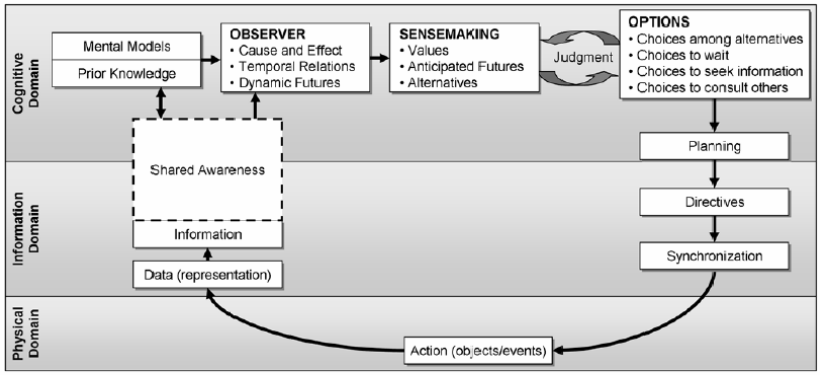
Theme 4 - Professional and Technical Expertise

- Action 3 - Continuously reassess and update policy for program development, planning guidance, design and construction standards
- Action 4 - Employ dynamic independent review
- Action 8 - Assess and modify organizational behavior
- Action 11 - Manage and enhance technical expertise and professionalism
- Action 12 – Invest in research

ACTIONS for CHANGE

Cognitive Aspects

Decision Analysis

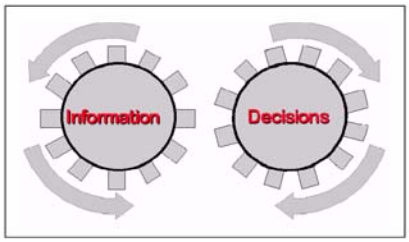


After Smith, 2006

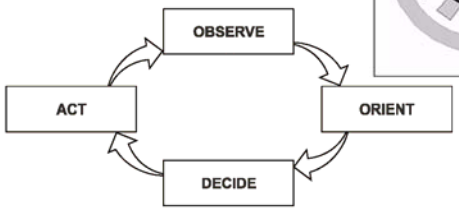
Risk Assessment

Why Decision Analysis?

Information gathering and decision-making are two separate cycles

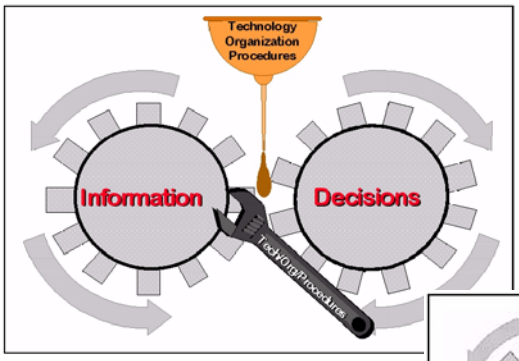


After Roman, 1996

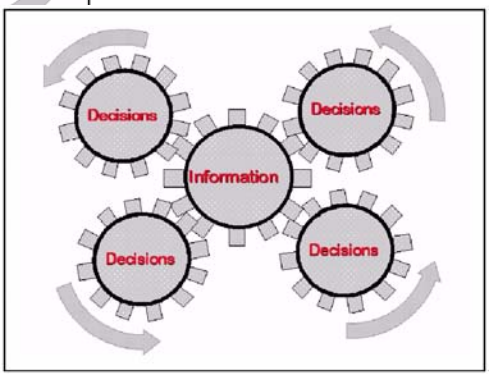


	Revolutionary War	*Civil War*	*World War II*	*Gulf War*	*War of Tomorrow*
Observe	Telescope	Telegraph	Radio/Wire	Near Real Time	Real Time
Orient	Weeks	Days	Hours	Minutes	Continuous
Decide	Months	Weeks	Days	Hours	Immediate
Act	A Season	A Month	A Week	A Day	Less Than An Hour

Source: Sullivan, Gordon R. and James M. Dubik, *War in the Information Age.*



Now-
Technology-based Fix in Information Age



Need for Revolutionary Changes

After Roman, 1996

Evolving Decision-Making Process

Military/DHS Decision-Maker(s)

Decision Analytical Frameworks
- Agency-relevant/Stakeholder-selected
- Currently available software
- Variety of structuring techniques
- Iteration/reflection encouraged
- Identify areas for discussion/compromise

Decision Integration

Risk | *Sensing Intel Data* | Reso urces | Morale/ Politics

Sharing Data,Concepts and Opinions

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Why Risk Assessment?

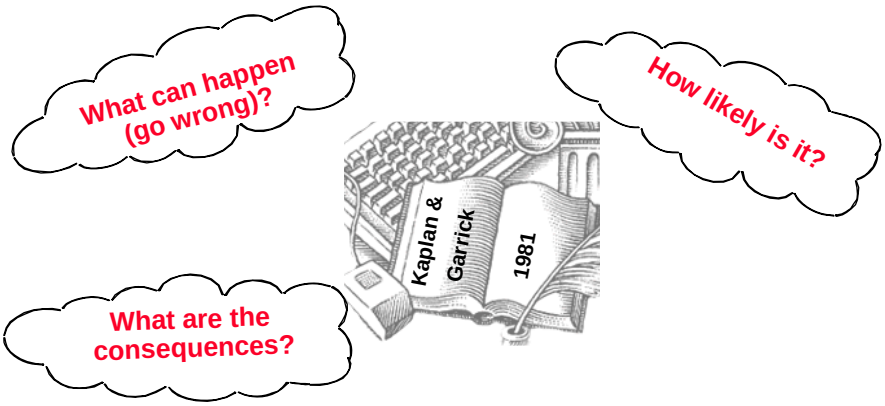
Risk as Descriptor for Physical Domain

- ***Risk:*** **The likelihood or probability of an adverse outcome**
- **Examples**
  - **Being hit by a car while taking a walk**
  - **Structural failure of a dam**
  - **Breaching of a levee during a flood**
  - **Reduced performance of a lock measured in terms of tow transits per day**
- **For use in decision making, event probability is combined with a description of consequences**

Risk-Based Decision-Making

- ***Risk assessment*****: A process for developing a quantitative understanding of the processes shaping the scope and nature of risks and uncertainties that is sufficient to support decision making**
  - **What is the risk?**
  - **Why and how are the risks occurring?**
  - **What is the uncertainty associated with the risk estimate?**
  - **How do the management alternatives differ in terms of risk reduction performance?**

Risk Assessment Formulation



Risk Assessment: Experts and Stakeholders

- **Two types of "correct" risk assessment:**
  - **Expert: Risk = Hazard • Exposure • Magn • Prob**
  - **Layperson: R = Hazard • Perception**
- **For stakeholders, the root issue is: fear of becoming a victim to (uncompensated) loss**
- **Core concerns tend to be: trust, control, process, information and timing.**

Why Us?

- **~40 scientists, by invitation only, leaders in the field**
- **Interdisciplinary**
  - **Engineering, physics, psychology, oceanography, biology, cognitive science, operations research, communications…**
- **Balanced representation from Academia, Government and Consulting**

Agenda: Monday AM

AM

Introduction

8:00 **Representatives from Sponsoring Organizations:** Welcomes
8:15 **Linkov:** Scientific Background, Goals, and Workshop Overview

1. ***Needs and Desired Directions***
   8:45 **Alberts:** Collective C2 in a Network Centric Environment
   9:05 **Ritchie:** Medical/Cognitive
   9:25 **Gabbrielli:** Integrated Risk Management - DHS
   9:45 **Bridges:** Civil Works (Infrastructure, Environmental, Ecological)

   10:00 *Coffee Break*

2. ***Identifying Best Way Forward: Opportunities for Synergistic Cross-Discipline Collaboration?***
   Panelists: Lachow, Ross, Morel, Franz, Lemyre
   10:30 Brief Presentation
   11:10 Discussion

   11:45 *Lunch*

Agenda: Monday PM

3. Cognition and Decision Making
- **1:00** **Gold:** Mechanisms of learning a perceptual decision
- **1:20** **Braithwaite:** Research from Non-primate Animals
- **1:40** **Wang:** Evolutionary, ecological and social rationality of decision making under risk

4. Concepts, Methods and Tools
- **2:00** **Veinott:** Ill-Defined Goals: Implications for Planning and Decision Making
- **2:20** **Bonnano:** Resiliance
- **2:40** **Silverman:** Soci-cognitive agents for DIME-PMESII games"
- **3:00** **Perlovsky:** Cognitive Algorithms: Concepts, Emotions, Cultures

3:30 *Coffee Break*

5. Opportunities for Cross Disciplinary Research (Panel Discussion)
Panelists: Anderson, Kiker, Gonzales, Groeger, Ditmer
- **4:00** **Brief Presentation**
- **4:30** **Discussion**

5:00 ***Formation of Working Groups and Review Of Charge***
WG1: Cognitive aspects of risk-based decision making at the individual/small group level
WG2: Cognitive aspects of risk-informed decision-making at the large group/societal level

6:00 *SOCIAL HOUR (Sponsored by Decision Partners)*

Working Group Organization

- **WG1: Cognitive aspects of risk-based decision making at the individual/small group level**
  - **Co-Chairs: Anderson and Goodwin**
  - **Facilitator: TBA**
  - **Rapporteurs: Smith and Linthicum**
- **WG2: Cognitive aspects of risk-informed decision-making at the large group/societal level**
  - **Co-Chairs: Ditmer, Mukherjee, Linkov**
  - **Facilitator: Butte**
  - **Rapporteurs: Wiliams and Saner**

Working Groups

	Name		Affiliation	e-mail	Area of research	Wrk. Group
1	Anderson	James	Univ of WA	jjand@u.washington.edu	animal behavior, agent-based modeling	1
2	Braithwaite	Victoria	Penn State Univeristy	v.braithwaite1@mac.com	ecology, population modeling and decision analysis	1
3	Bridges	Todd	US Army ERDC	Todd.S.Bridges@usace.army.mil	Ecological Risk Assessment, Contaminated sites	1
4	Budrene	Elena	MIT	ebudrene@gmail.com;	experimental biology, behavior of bacterial and simple organis	1
5	Ginzburg	Lev	State University of NY	lev@ramas.com;	population modeling, ecology, risk assessment	1
6	Gold	Josh	Univ of PA	jigold@mail.med.upenn.edu	neural mechanisms for sensory stimuli	1
7	Goodwin	Andy	US Army ERDC	Andrew.R.Goodwin@usace.army.mil	animal sensory and cognitive ecology	1
8	Kiker	Greg	Univ of Florida	gkiker@ufl.edu	ecology + agriculture, population modeling and decision analy	1
9	Linthicum	Alex		aslinth@gmail.com;	engineering, operations research	1
9	Morel	Benoit	Carnegie Mellon University	bm1v@andrew.cmu.edu	complex systems, non-linear dynamics	1
10	Perlovsky	Leonid	Air Force Research Lab	Leonid.Perlovsky@hanscom.af.mil	Neural networks, intelligent systems, cultural modeling	1
11	Saner	Lelyn	Carnegie Mellon University	ldsaner@gmail.com	agent-based modeling, social network analysis	1
12	Smith	Dave	US Army ERDC	David.L.Smith@usace.army.mil;	ecology, habitat modeling, restoration	1
13	Stiber	Niel	US EPA	Stiber.Neil@epamail.epa.gov;	environental risk assessment	1
14	Beth	Veinott	ARA, Inc.	bveinott@decisionmaking.com;	decision analysis, operations research	2
15	Butte	Gordon	Decision Partners	gbutte@decisionpartners.com	mental modeling, risk communication	2
16	Cooke	Roger	Resources for the Future	cooke@rff.org	risk analysis, uncertainty analysis, expert judgment	2
17	Ditmer	Renae	STRATCOM	renae.ditmer@stratcon.us;	national security, national defense and strategic analysis	2
18	Fredrickson	Herb	US EPA	Fredrickson.Herbert@epamail.epa.gov	environmental risk assessment	2
19	Glasgow	Kimberly	CACI	kimberly.glasgow1@gmail.com	social netwrork analysis, security	2
20	Groeger	Niki	US Army ERDC	niki.c.goerger@usace.army.mil	Military programs, decision analysis	2
21	Lambert	Jim	University of Virginia	lambert@virginia.edu	systems risk assessment, engineering	2
22	Lemyre	Louise	University of Ottawa	llemyre@uottawa.ca	psychosocial aspects of terrorism, emergency preparedness	2
23	Liberman	Steve	Naval Postgraduate School	stlieber@nps.edu	augmented cognition, decision making	2
24	Linkov	Igor	US Army ERDC	Igor.linkov@usace.army.mil	Risk Assessment and Decision Analysis, Strategic planning	2
25	McEver	Jimmie	Evidence Based Research, Inc.	McEver@EBRINC.COM;	complex systems, command and control	2
26	Miller	Allen	DHS/Risk Management	Allen.Miller@dhs.gov;	homeland security, agency-wide risk management	2
27	Mukherjee	Amlan	Michigan Tech University	amukherj@mtu.edu;	system dynamics, discrete event simulations and agent based n	2
28	Ross	Bob	DHS/S&T Directorate	Bob.Ross@dhs.gov;	risk assessment (environmental and infrastructure)	2
29	Silverman	Barry	University of PA	BaSil@seas.upenn.edu;	agent-based modeling for human physiology, and relationship	2
30	Wang	XT	Univ of South Dakota	XT.Wang@usd.edu;	evolutionary psychology, behavioral decision making	2
31	Williams	Laurel		sugarsapling@gmail.com	ecology, risk assessment	2
32	Alberts	David	DOD OASD/ NIII	David.Alberts@osd.mil;	Military operations, command and control research program	Monday only
33	Bonanno	George	Columbia University	bonanno@exchange.tc.columbia.edu;	resilience, psychology	Monday only
34	Franz	David	Midwest Research Institute	dfranz@mriresearch.org;	military medicine, biological warfare, chem/bio defense	Monday only
35	Gabbrielly	Tina	DHS/Risk Management	Tina.Gabbrielli@dhs.gov	homeland security, agency-wide risk management	Monday only
36	Gonzales	Coty	Carnegie Mellon University	conzalez@andrew.cmu.edu	agent-based modeling, social network analysis	Monday only
37	Lachow	Irv	National Defense University	LachowI@ndu.edu	Network-centric operation, decision analysis, military program	Monday only
38	Ritchie	Cam	DOD Office of Surgent General	Elspeth.Ritchie@us.army.mil	psychiatry, combat mental health	Monday only

Agenda: Tuesday

AM **8:00** **Linkov and Goodwin:** Brief Review of Day 1 Presentations

6. Working Groups Meeting 2

Work Group Tasks

Identify Issues and Challenges
Identify Needs and Opportunities for Research
Identify Value to DoD and Scientific Community

9:45 *Coffee Break*

10:15 **WG Chairs:** Brief Reports and Coordination

5. Opportunities and the Future for Simple, Robust Tools of Decision Making

10:35 **Ginzburg:** Dealing with Uncertainty: Cognitive Aspects
10:55 **Butte and Mukherjee:** Mental Modeling
11:15 **Lambert:** Multi-criteria Decision Analysis
11:35 **Anderson/Goodwin:** Agent-based Modeling: `Modeling between reflex and cognition`

12:00 *Lunch*

PM ***Working Groups Meeting 3***

3:00 *Coffee Break*

3:30 ***Working Groups***

7:00 *DINNER (TBD)*

Agenda: Wednesday

8:00 ***Working Groups Reports/ Coordination***

7. Preparation of Work Group Summary Presentations

8:30 **Preparation of Work Group Summary Presentations**

10:00 *Coffee Break*

8. Summary Presentations

10:30 **Summary Presentations from Work Groups**

12:00 *Lunch*

PM

9. Discussion

1:00 **Where are We Now and Where Can DoD Go in Coming 5-10 Years**

10. Wrap-up & Next Steps

2:00 **Linkov:** Summary of Key Results and Research Needs

2:15 **Discussion**

3:00 **Adjourn**