
Linking Risk Assessment and Decision Analysis with Military & Corporate Decision-making Processes



Igor Linkov

Intertox Inc., 83 Winchester Street Suite 1
Brookline, MA 02446, ilinkov@intertox.com



KING'S
College
LONDON

University of London



American Systems Corporation

 Old Dominion UNIVERSITY

Igor Linkov

Intertox Inc., 83 Winchester Street Suite 1
Brookline, MA 02446, ilinkov@intertox.com

Chris Shilling and David Slavin

Pfizer Inc., Sandwich, UK

Eitan Shamir

King's College London, UK.

George Fenton

American Systems Corporation
Dumfries, VA

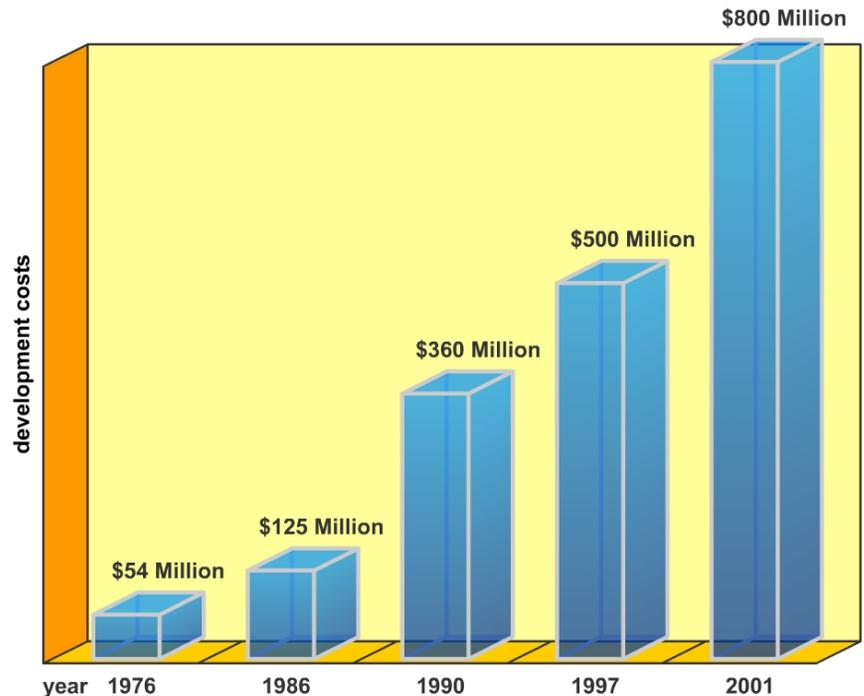
Ryland Gaskins

Old Dominion University

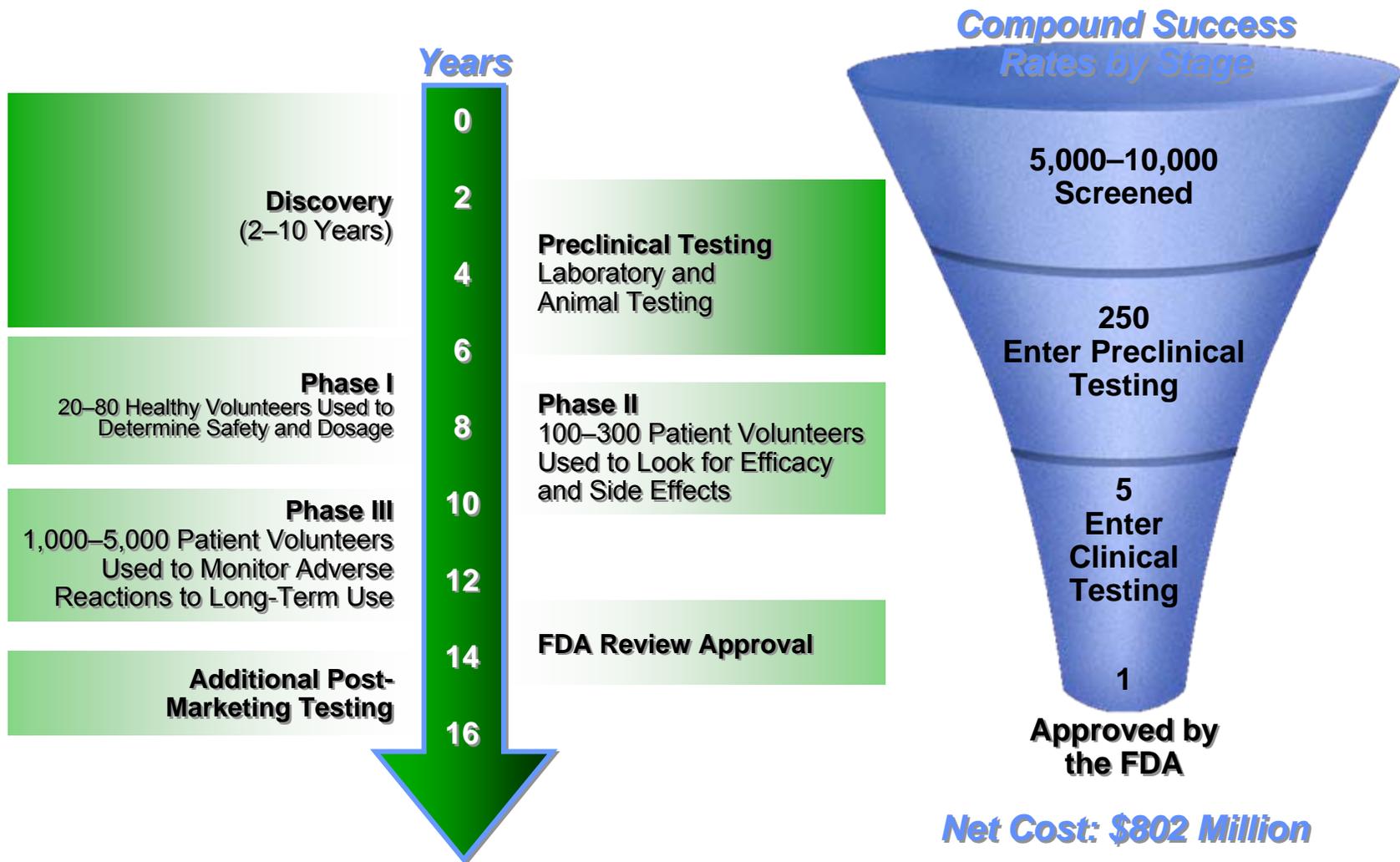
Cost of Getting Drug to Market

- The average cost of developing a single drug, from initial discovery through to approval, is currently estimated at ~\$800 million
- Most drugs do not make it to approval but still incur costs. The different phases of drug development cost around:

- Discovery - \$10-20 million
- Phase I - \$5-10 million
- Phase II - \$20-100 million
- Phase III - \$200-800 million

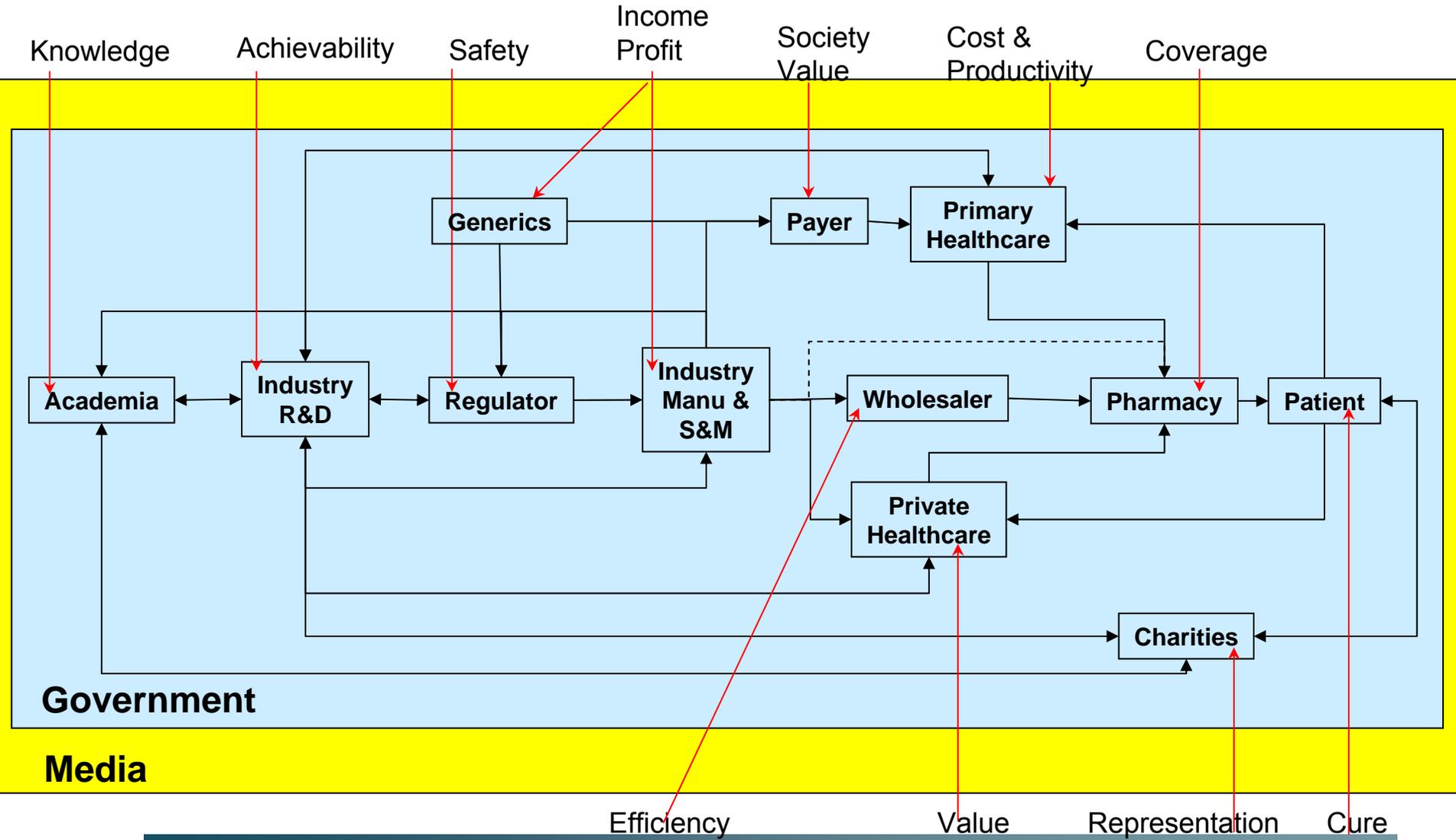


New Product Development – A Risky and Expensive Proposition



Source: Tufts Center for the Study of Drug Development

Healthcare Supply Chain



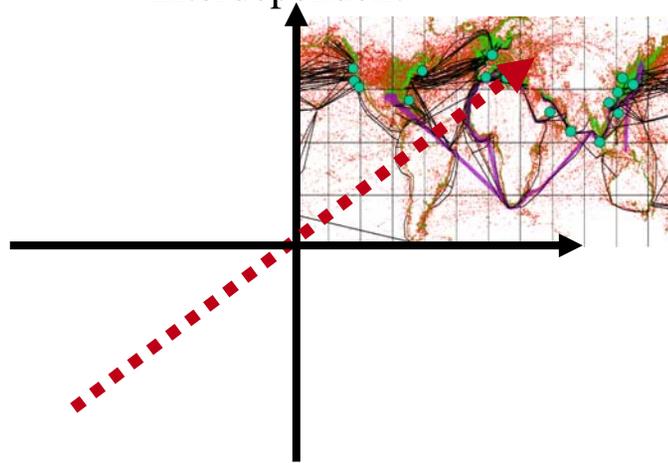
Outline

- **Introduction**
 - **Global trends and military needs**
 - **Emerging needs in risk assessment and decision analysis**
- **From Mission Command to Network-Centric Operations**
 - **Mission Command – history and current implementation, deficiency and need to change**
 - **Tenets of Mission Command Doctrine**
 - **Importance of Cognitive Domain and need for formal tools**
- **Tools of Risk Assessment and Decision Analysis and its applicability to NCO**
 - **Historical perspective on RA**
 - **Mental Modeling and Jointness**
 - ◆ **Case Study: Cognitive Leadership Training**
 - **Multi-criteria Decision Analysis**
 - ◆ **Case Study: Capability Gap Prioritization for Small Arms Program**
 - **Linkage of RA and MCDA with NCO**
- **Implications for Corporate/Organizational Performance**
- **Conclusion**

Global Trends and Military

Information Age

- Short Cycle Time
- New Competencies
- Adaptive Planning
- Integrated Joint
- Interdependent



Globalization II

- Developed Rules
- Mature Markets
- Narrowing Customer Base
- Security=Defense

Globalization III

- Emerging Rules
- Market Opportunities
- New Customer Base Emerging
- Security=All Else+Defense

Industrial Age

- Long Cycle Time
- Well Developed Tools/Processes
- Deliberate Planning
- Deconflicted Joint
- Tortured Interoperability

After Cebrowski, 2003

Future Soldier

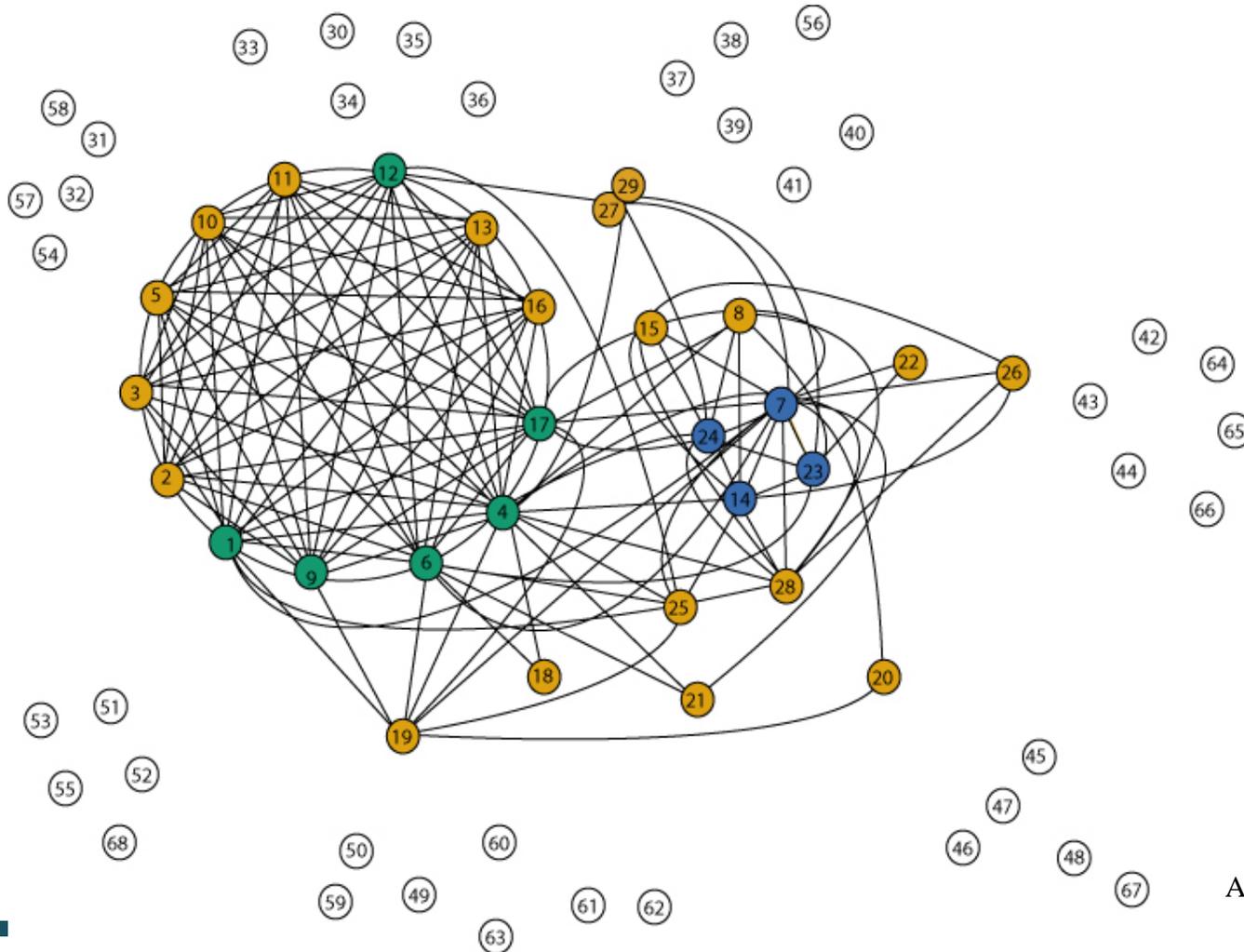
Fully integrated Infantry Fighting System

- *Combines Sensors, Computers, Lasers, Geo Location and Radio with Soldier Mission Equipment*
- *Digitized reporting; brings dismounted soldier into digital battlefield/situational awareness*
- *Video capture and transmission*



After Cebrowski, 2003

Enemy: Militant Groups Network

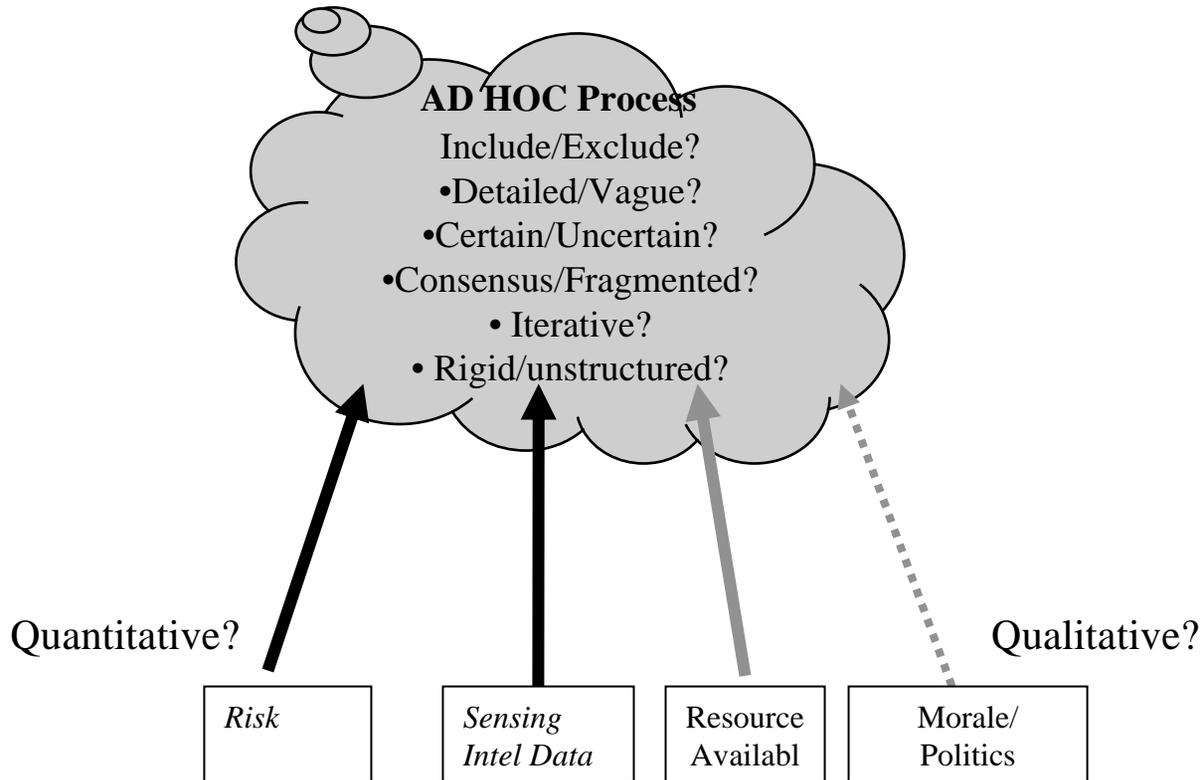


After Cebrowski, 2003

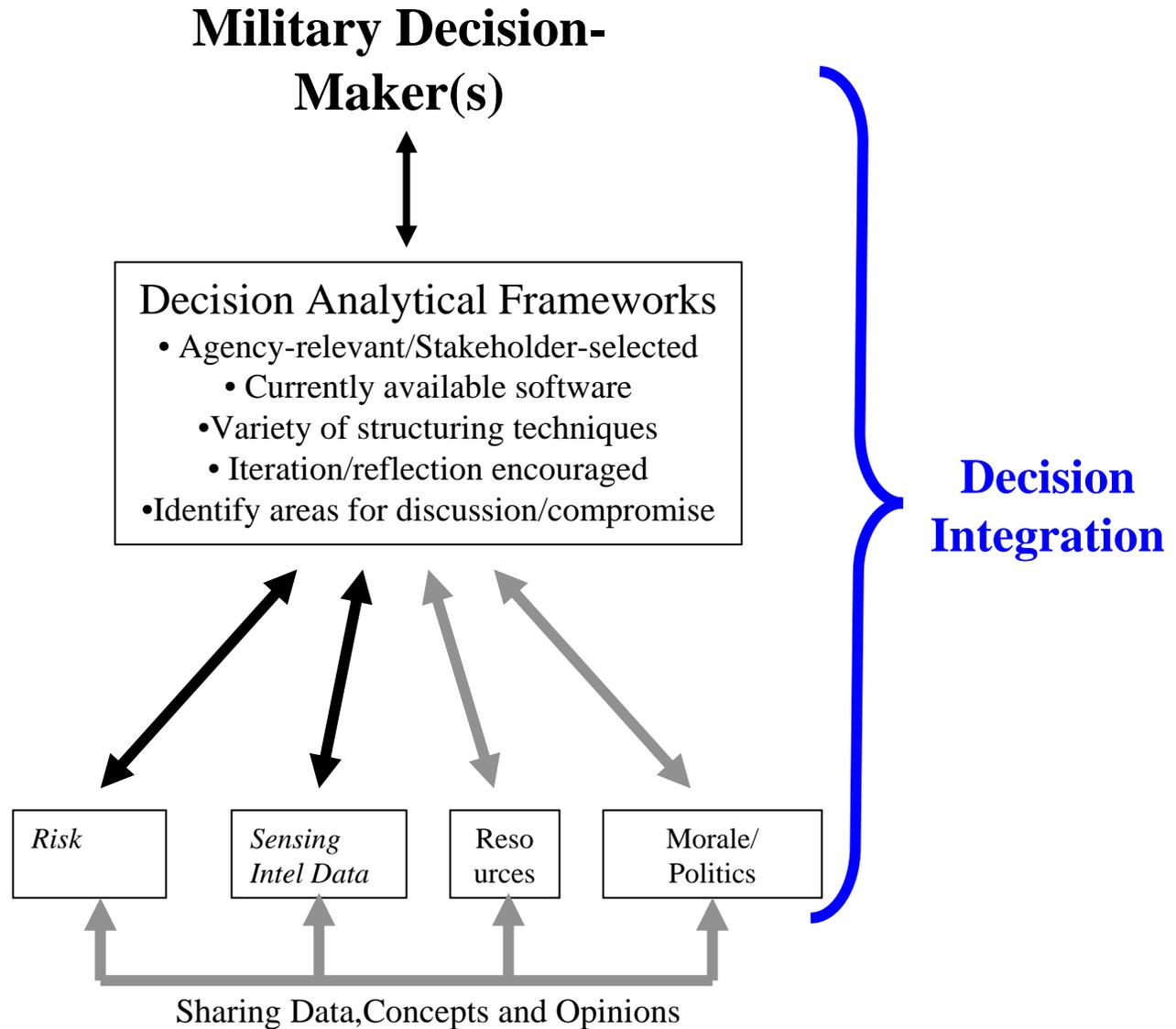
Military Decision-Making Processes

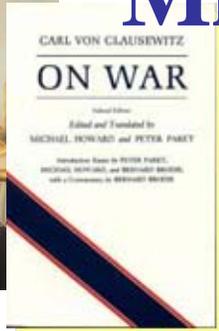
At all levels, military needs to make decisions

Military Decision-Maker(s)



Evolving Decision-Making Process





Mission Command (19th Century)

•A commander gives his orders in a manner that ensures his subordinates understand his intentions, their own missions and the context of those missions.

•Subordinates are told what effect they are to achieve and the reason why it needs to be achieved.

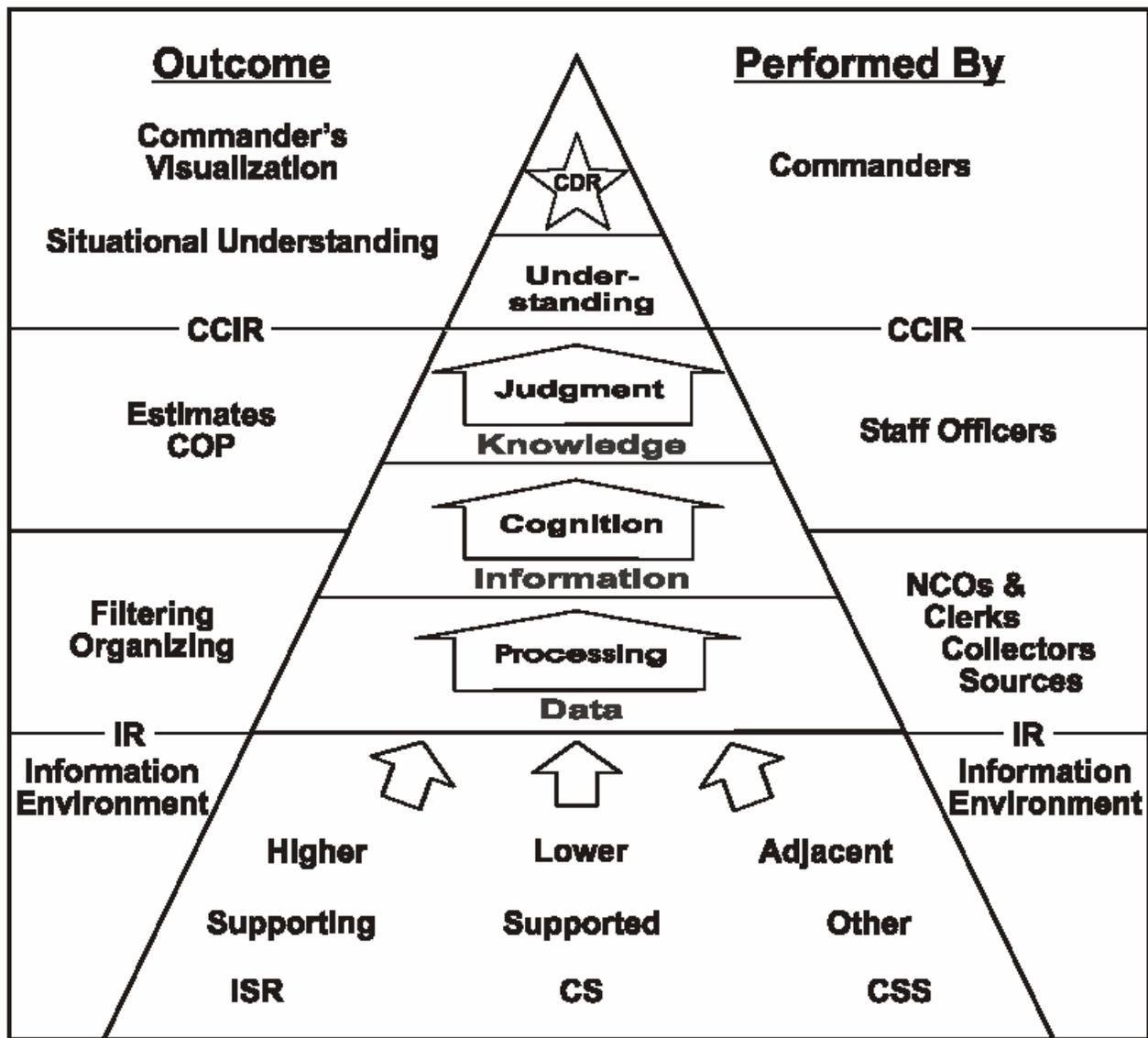
•Subordinates are allocated the appropriate resources to carry out their missions.

•A commander uses a minimum of control measures so as not to limit unnecessarily the freedom of action of his subordinates.

•Subordinates then decide within their delegated freedom of action how best to achieve their missions.

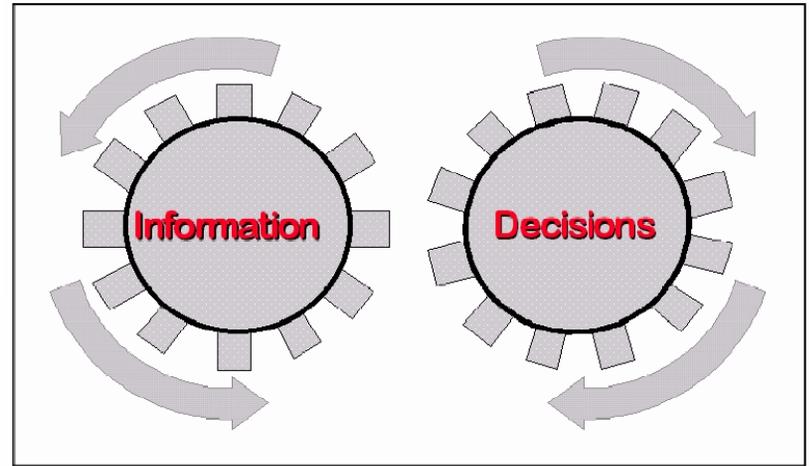
Detailed Command 	
Assumes war is	<ul style="list-style-type: none"> • Deterministic • Predictable
Accepts	<ul style="list-style-type: none"> • Order • Certainty
Tends to lead to	<ul style="list-style-type: none"> • Centralization • Coercion • Formality • Tight rein • Imposed discipline • Obedience • Compliance • Optimal decisions, but later • Ability focused at the top
Communication types used	<ul style="list-style-type: none"> • Explicit • Vertical • Linear
Organization types fostered	<ul style="list-style-type: none"> • Hierarchic • Bureaucratic
Leadership styles encouraged	<ul style="list-style-type: none"> • Directing • Transactional
Appropriate to	<ul style="list-style-type: none"> • Science of war • Technical/procedural tasks

Mission Command – Current Implementation

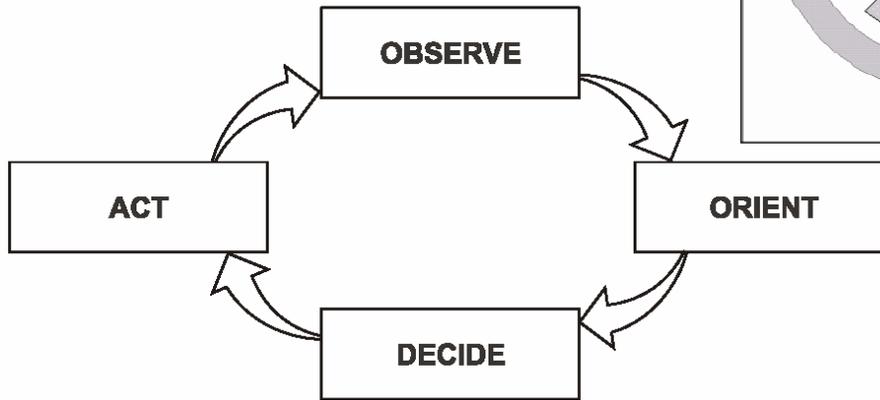


Mission Command and Decision Cycles

Information gathering and decision-making are two separate cycles under Mission Command



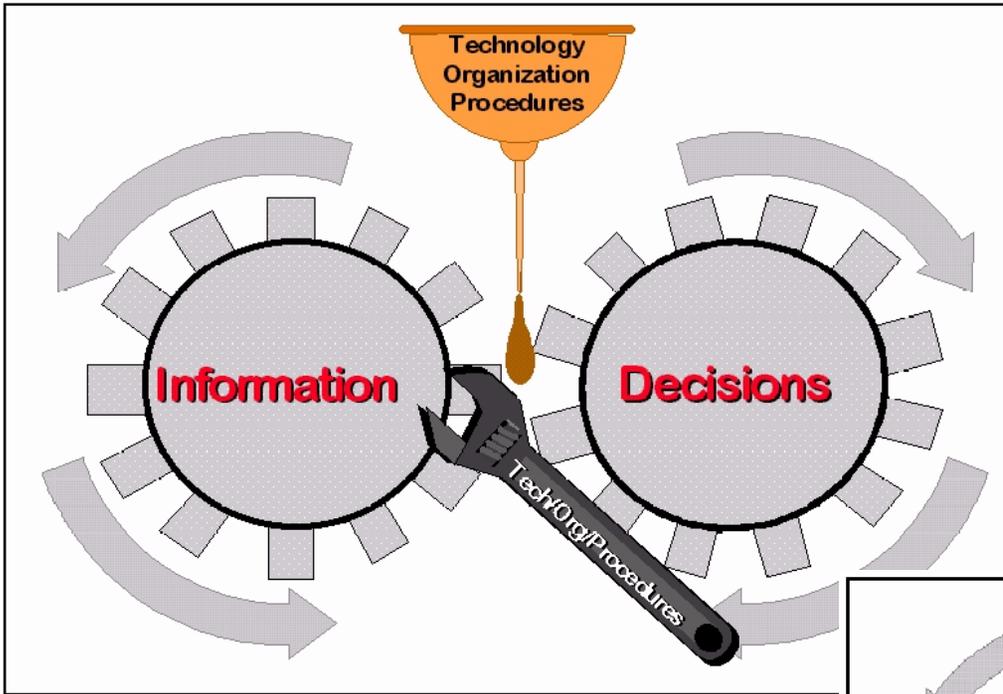
After Roman, 1996



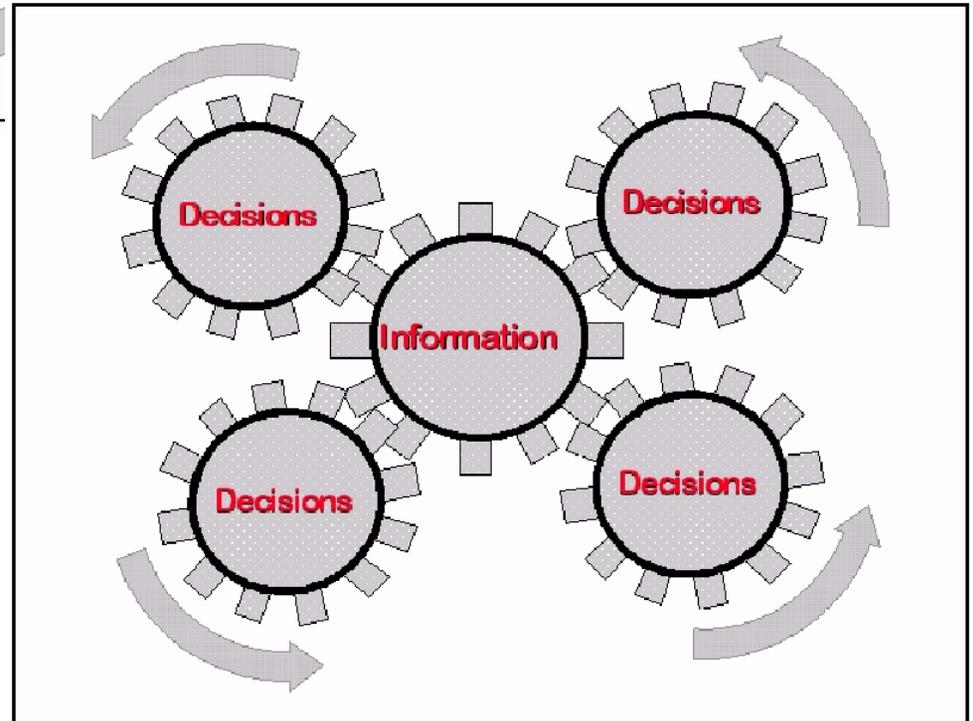
	<i>Revolutionary War</i>	<i>Civil War</i>	<i>World War II</i>	<i>Gulf War</i>	<i>War of Tomorrow</i>
Observe	Telescope	Telegraph	Radio/Wire	Near Real Time	Real Time
Orient	Weeks	Days	Hours	Minutes	Continuous
Decide	Months	Weeks	Days	Hours	Immediate
Act	A Season	A Month	A Week	A Day	Less Than An Hour

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

Mission Command – Technology-based Fix in Information Age



Mission Command – Need for Revolutionary Changes



Military Response to Information Age

Translates an Information Advantage into a decisive Warfighting Advantage

Characterized by:

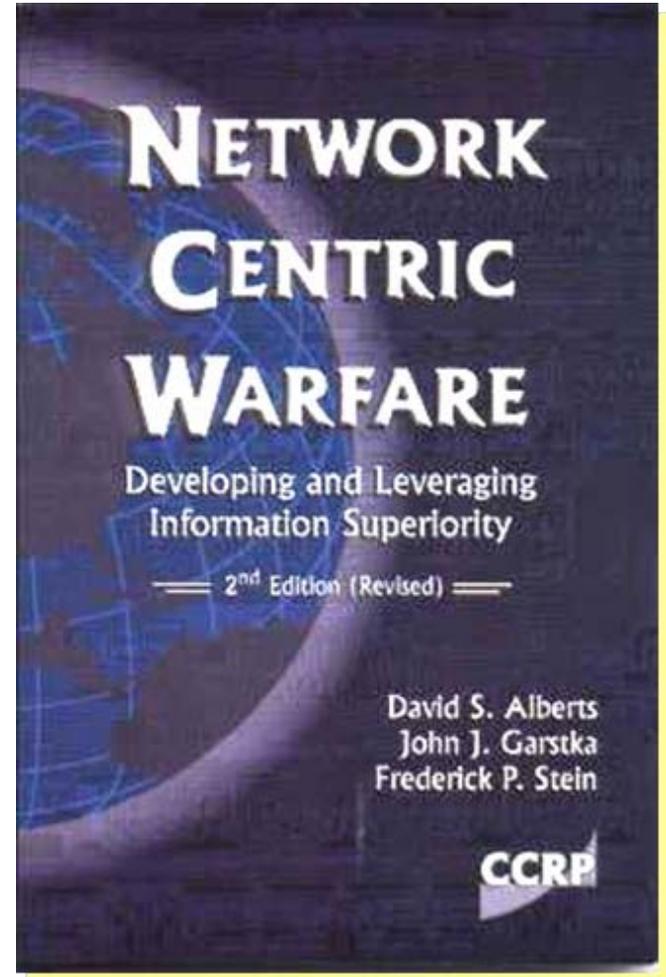
- Knowledge of commander's intent
- Information sharing and collaboration
- Shared situational awareness

Information Advantage - **enabled by the robust networking of well informed geographically dispersed forces**

Warfighting Advantage - **exploits behavioral change and new doctrine to enable:**

- Self-synchronization
- Speed of command
- Rapid Lock-out

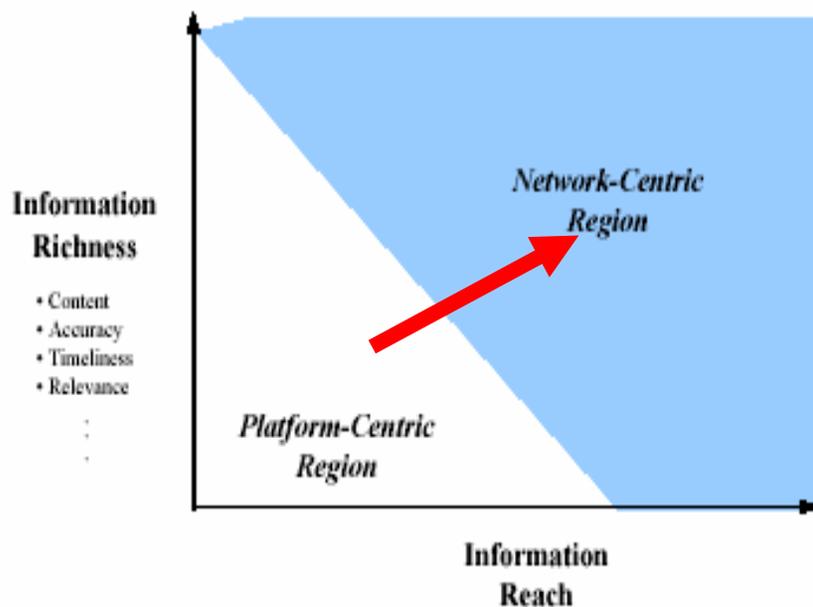
Based on Human Behavior



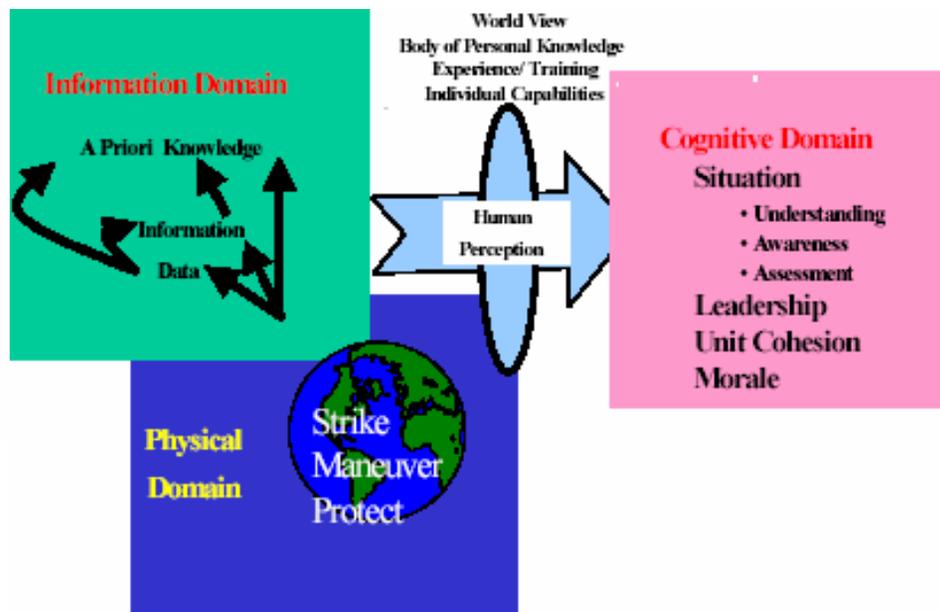
After Cebrowski, 2003

Tenets of Network Centric Operations

- A robustly networked force improves information sharing
- Information sharing and collaboration enhances the quality of information and shared situational awareness
- Shared situational awareness enables collaboration and self synchronization, and enhances sustainability and speed of command
- These in turn dramatically increase mission effectiveness



Warfare Domains



Joint Operations Concepts

Concept: Effects Based Operations

- Speed of Command
- Innovation in Execution

Concept: Shared Awareness

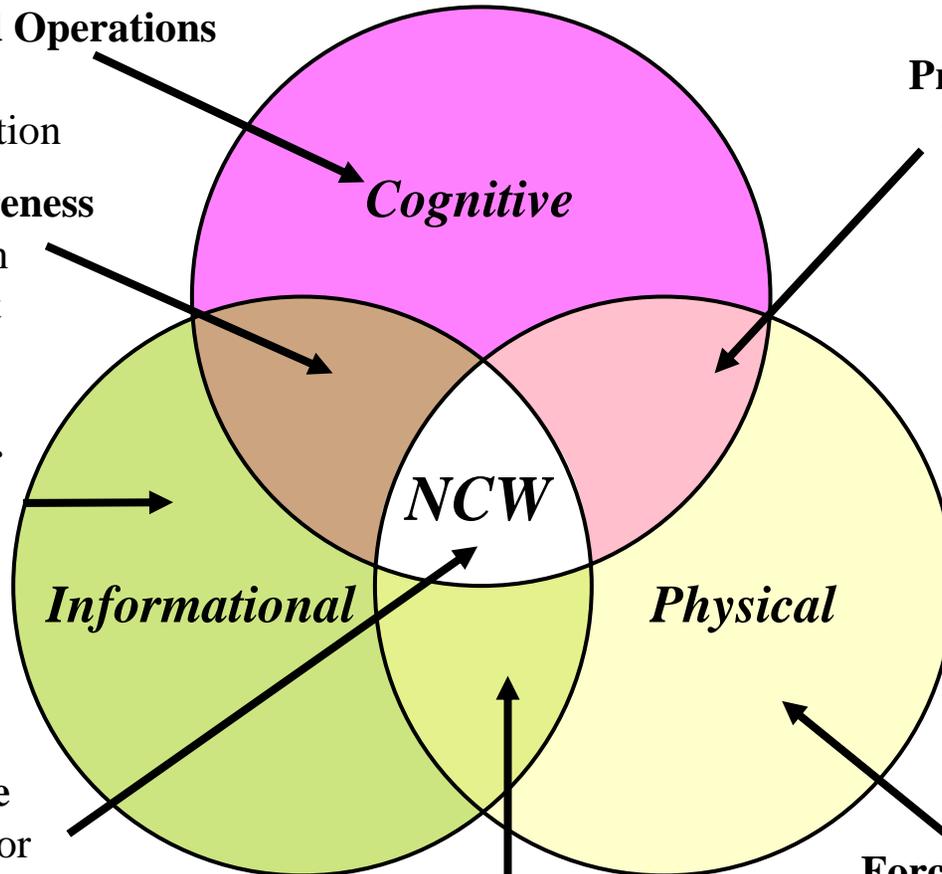
- Self Synchronization
- Commander's Intent

Concept: Fight First for Information Superiority

Information Age Warfare

Based on Human Behavior

- Informed by Info Age Concepts and Phenomena
- Creating New Dominant Sources of Military Power
- Hence, A New Theory of War



Cognitive

NCW

Informational

Physical

Non-Linear Ops

- Precision
- Maneuver
- Strike Protection
- Protection

Precision Effects

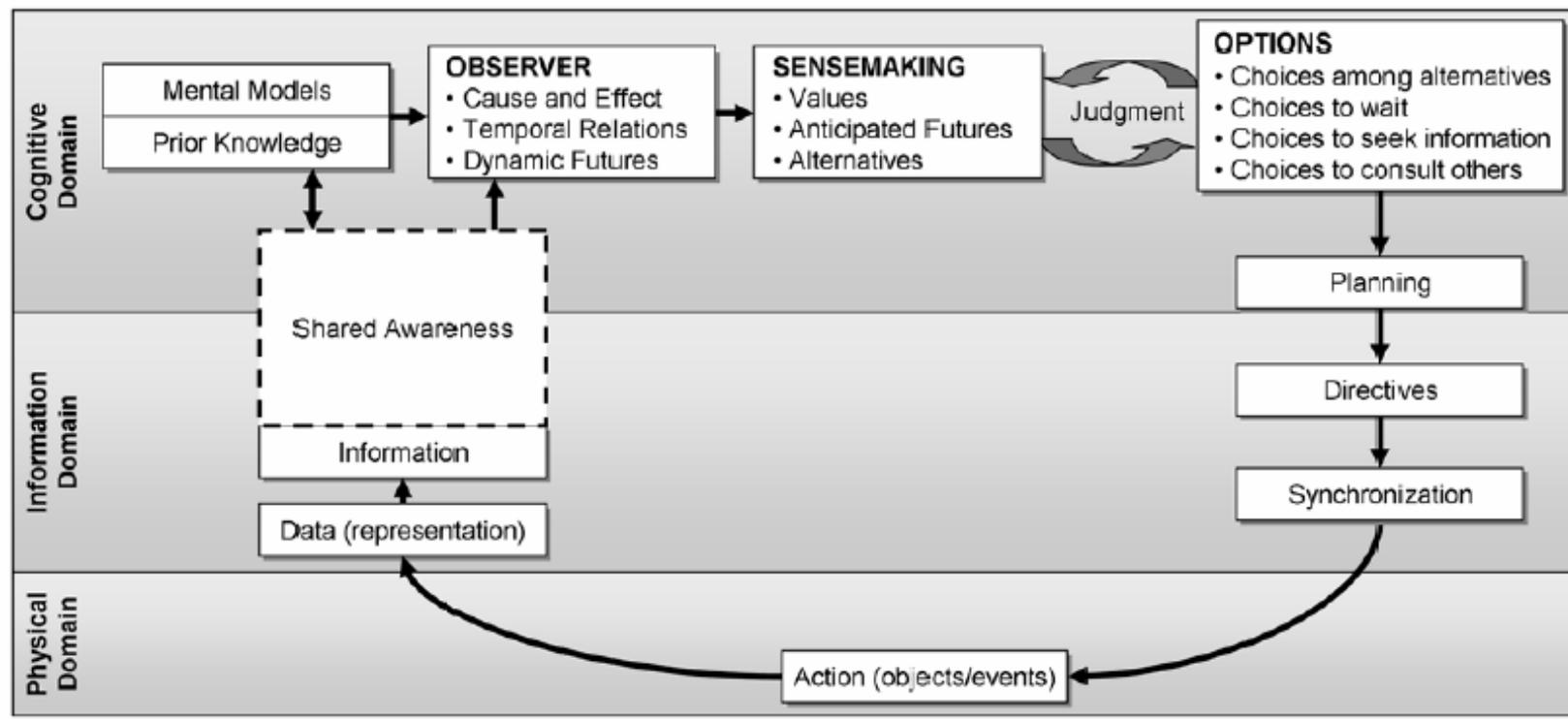
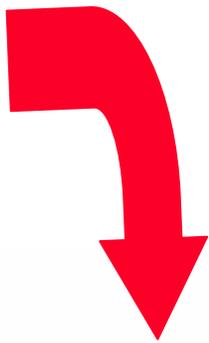
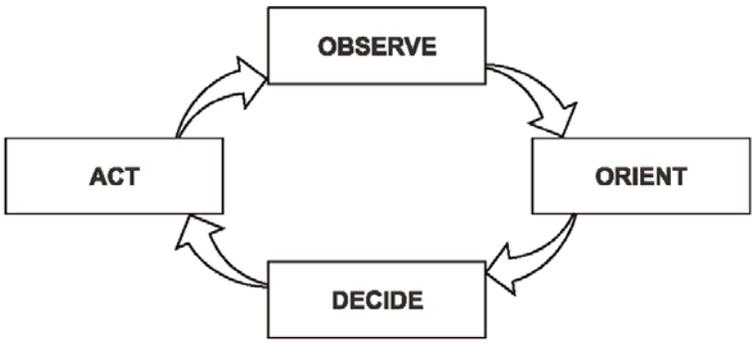
Concept: Deter Forward

- High Rates of Change
- Closely Coupled Events

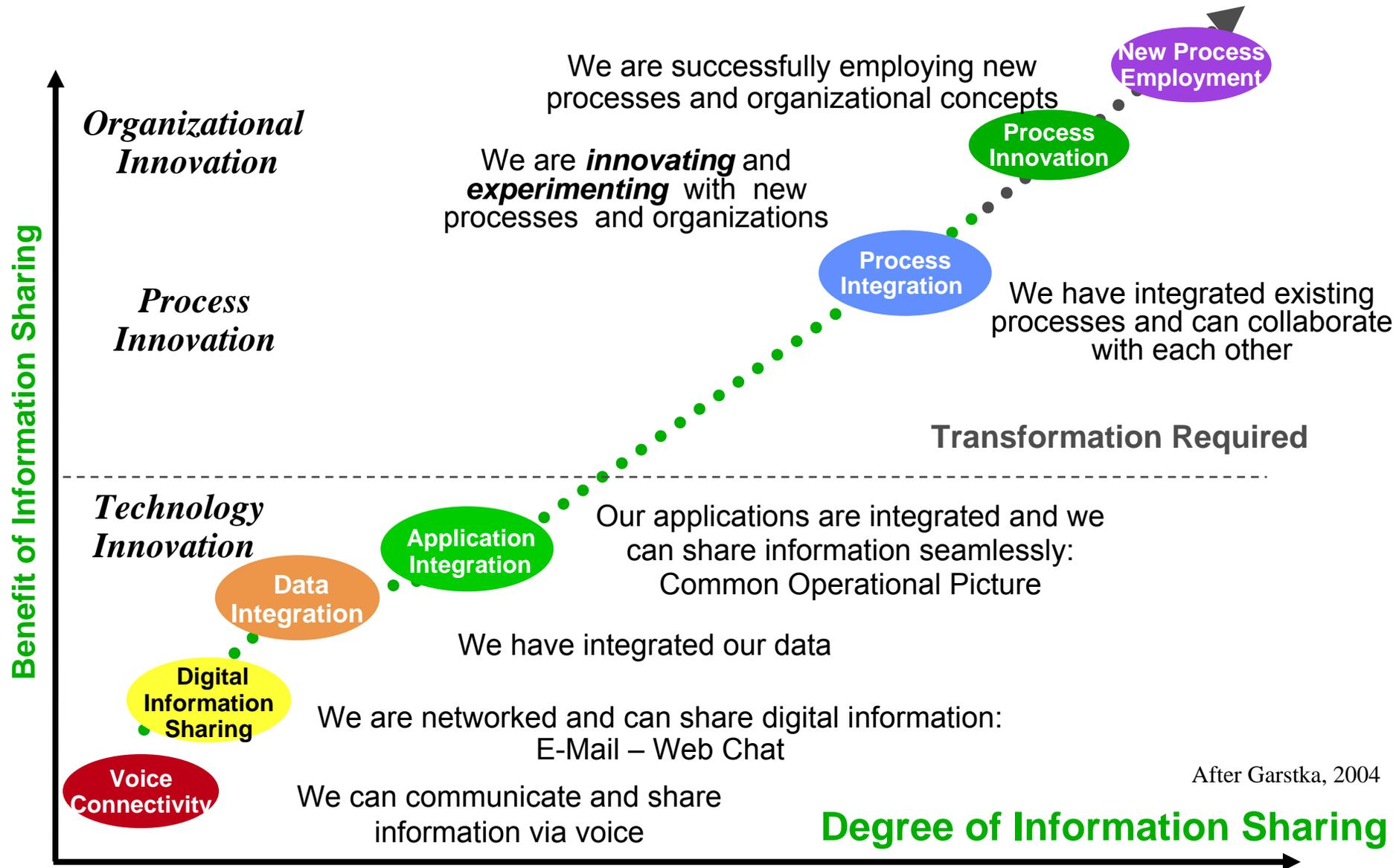
Force Through Time & Space Concept: Operational Maneuver

- From the Sea
- From Strategic Distance

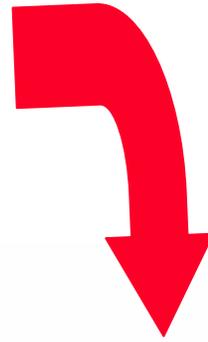
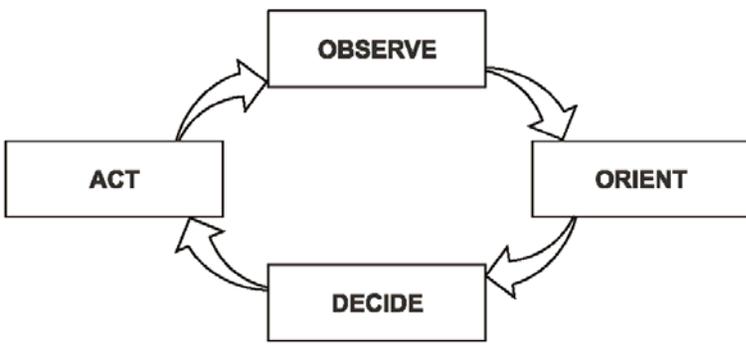
From Mission Command to Network-Centric Operations



Innovation: Military and Organizational

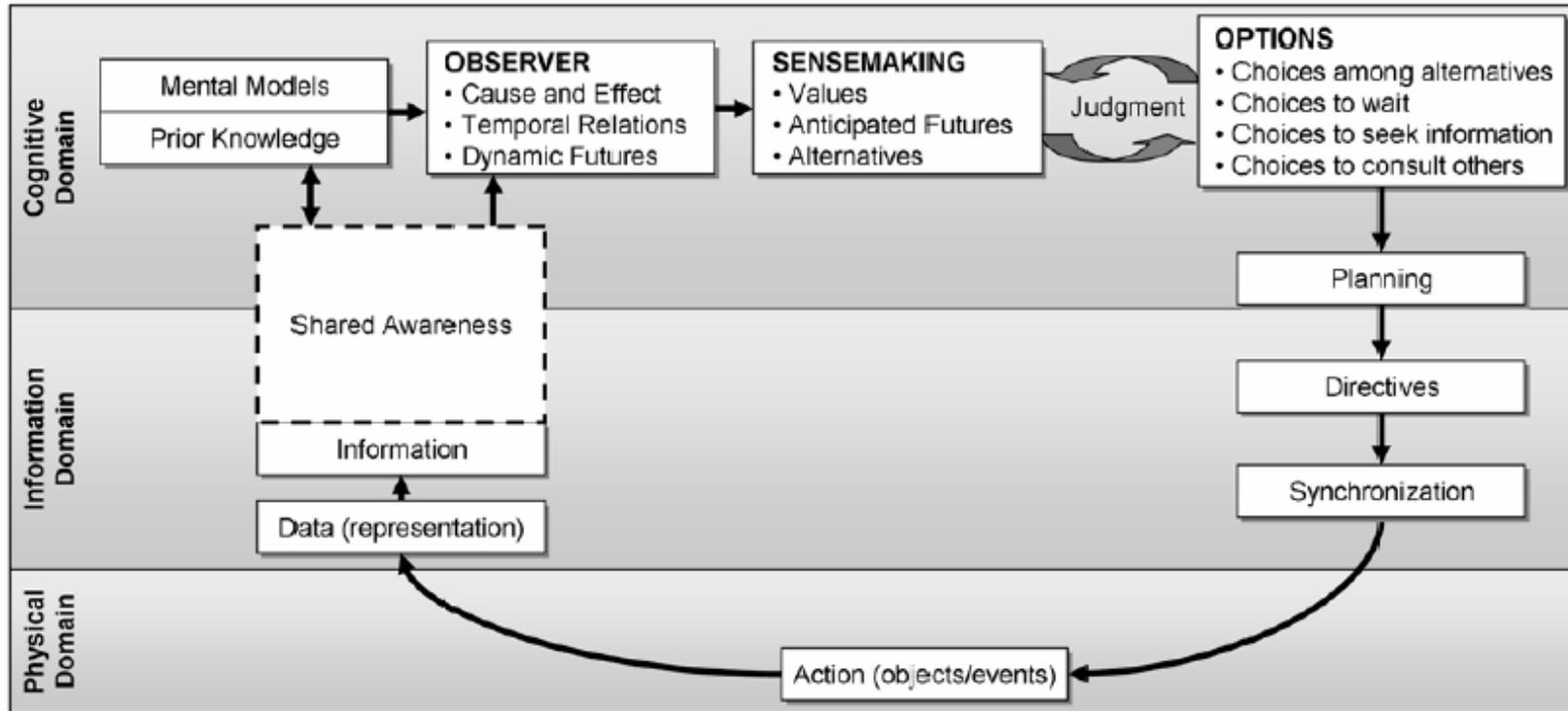


From Mission Command to Network-Centric Operations



Mental Modeling

Decision Analysis



Risk Assessment

Risk *Defined*

- ***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

Uncertainty *Defined*

- ***Uncertainty*: Lack of confidence in an analysis, assessment, prediction, inference or conclusion**
 - **An important distinction:**
 - Making a prediction and
 - Attaching a measure of confidence to that prediction
 - **Nature of Uncertainty**
 - Natural variability
 - ◆ Known population heterogeneity
 - ◆ Cannot be reduced only characterized
 - Epistemic uncertainty
 - ◆ Lack of knowledge or understanding
 - ◆ Can collect more data/information
-

Risk-Based Decision-Making

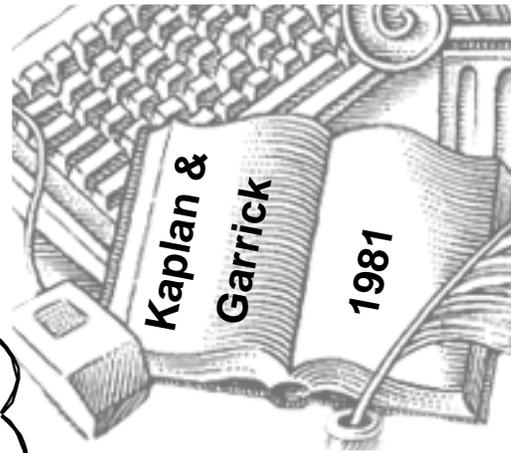
- ***Risk assessment:*** A process for developing a quantitative understanding of the processes shaping the scope and nature of risks and uncertainties that is sufficient to support decision making
 - What is the risk?
 - Why and how are the risks occurring?
 - What is the uncertainty associated with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

Risk Assessment Formulation

What can happen
(go wrong)?

How likely is it?

What are the
consequences?

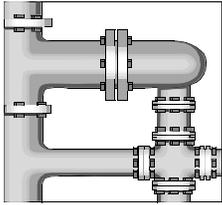


Risk-Based Decision-Making

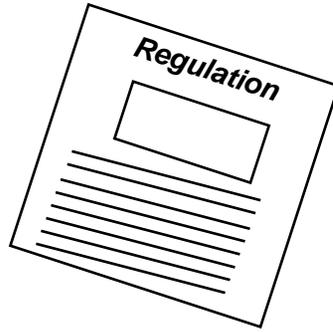
- ***Risk management: Actions taken to reduce risks to acceptable levels and manage uncertainties in a manner that is informed by facts about the risks***
 - **How do I balance the trade-offs inherent to decision making?**
 - **How do I apply the rules of decision-making in a consistent and transparent way?**
 - **How do I develop an understanding of the influence of values in my decision?**
- **As a general rule, the technical analysis of risks should be distinguished/separated from the decision process concerned with what to do about those risks**
 - **Risk Assessment should be dominated by science and engineering**
 - **Risk Management will and should involve policy, the use of values, and trade-offs**

Applications of Risk Assessment:

Types of Situations to Which Risk Assessment is Applied



**Infrastructure
Interruption**



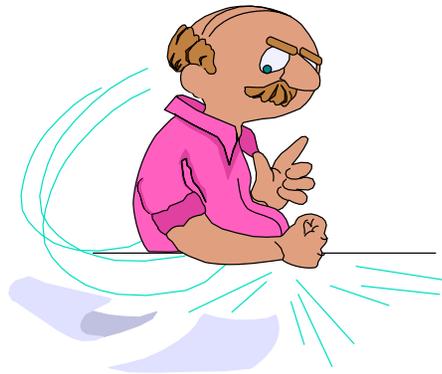
Regulatory



**Health &
Safety**



Environmental

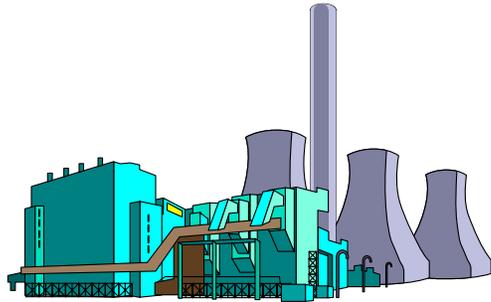


**Individual
behaviour**

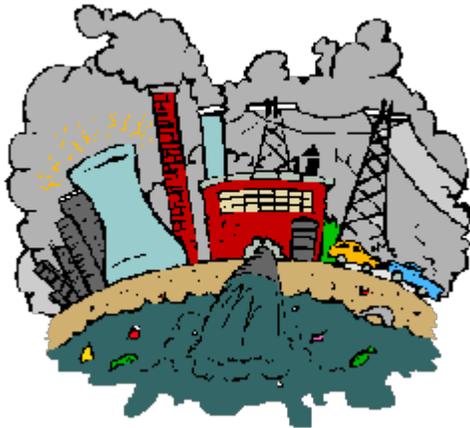


**Business/
Comemrcial**

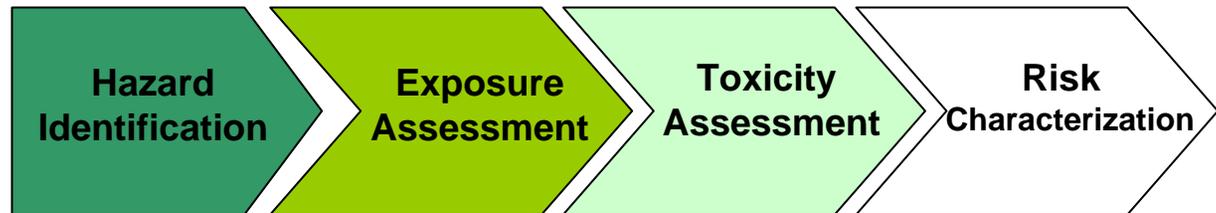
Risk Assessment Process



Acute Risks



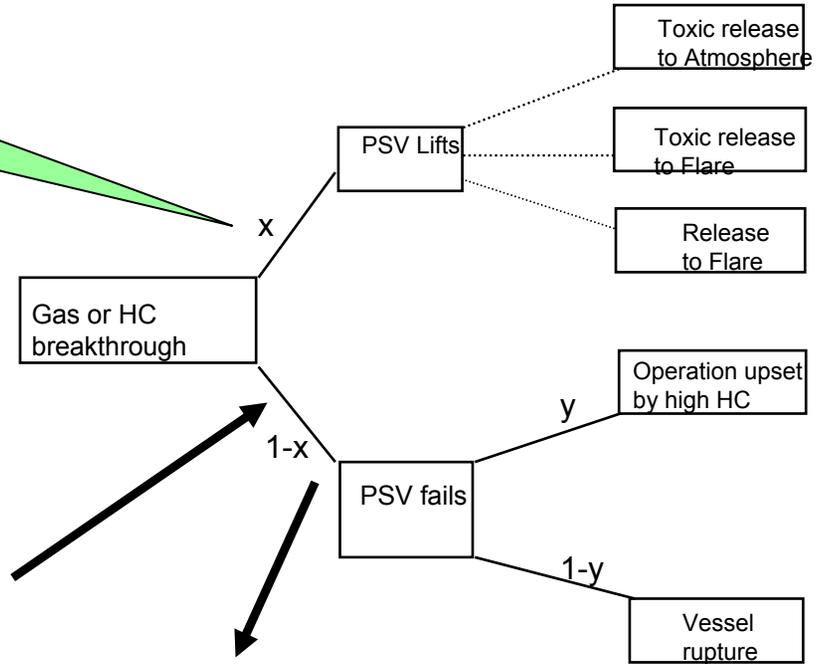
Chronic Risks



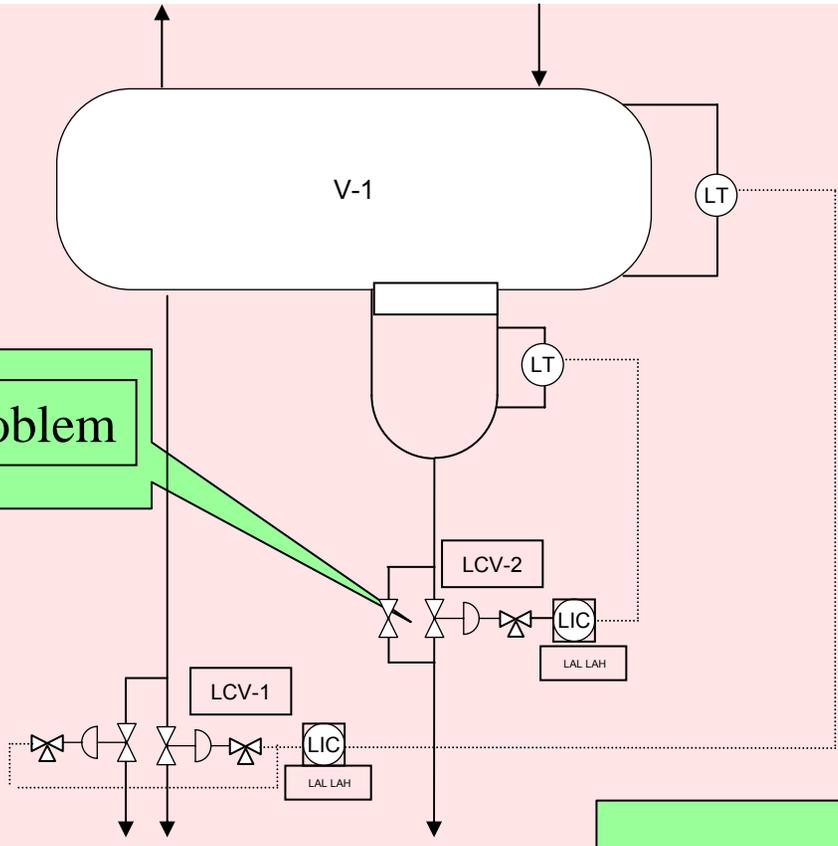
National Research Council, 1983

Risks/Hazard Control Options

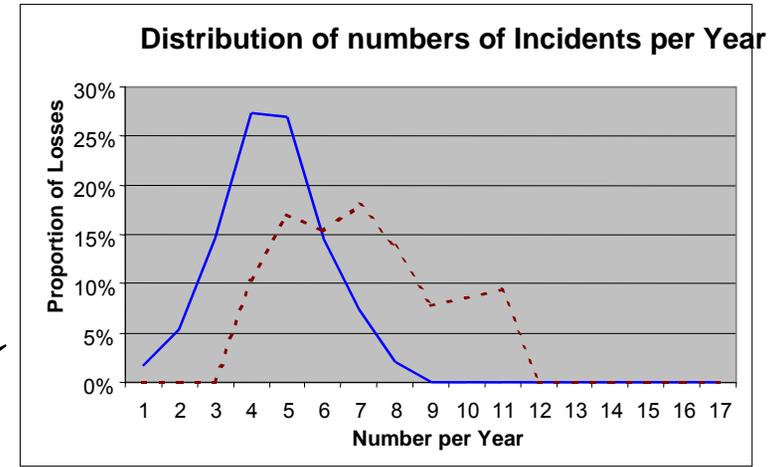
Scenario Analyses



Problem



Risk



Evolution of Risk Assessment and Military Doctrine

19th Century
-present

<ul style="list-style-type: none"> • Probabilistic • Unpredictable 	Assumes war is	<ul style="list-style-type: none"> • Deterministic • Predictable
<ul style="list-style-type: none"> • Disorder • Uncertainty 	Accepts	<ul style="list-style-type: none"> • Order • Certainty
<ul style="list-style-type: none"> • Decentralization • Spontaneity • Informality • Loose rein • Self-discipline • Initiative • Cooperation • Acceptable decisions faster • Ability all echelons • Higher tempo 	Tends to lead to	<ul style="list-style-type: none"> • Centralization • Coercion • Formality • Tight rein • Imposed discipline • Obedience • Compliance • Optimal decisions, but later • Ability focused at the top
<ul style="list-style-type: none"> • Implicit • Vertical and horizontal • Interactive 	Communication types used	<ul style="list-style-type: none"> • Explicit • Vertical • Linear
<ul style="list-style-type: none"> • Organic • Ad hoc 	Organization types fostered	<ul style="list-style-type: none"> • Hierarchic • Bureaucratic
<ul style="list-style-type: none"> • Delegating • Transformational 	Leadership styles encouraged	<ul style="list-style-type: none"> • Directing • Transactional
<ul style="list-style-type: none"> • Art of war • Conduct of operations 	Appropriate to	<ul style="list-style-type: none"> • Science of war • Technical/procedural tasks

Pre-19th
Century

2000-present

Risk Assessment

1980-2000

Probabilistic
 Monte-Carlo Simulations
 Bayesian methods
 Neural Nets
 Spatially/temporally explicit

Deterministic
 Conservative
 Fixed in space and time
 Overcomplicated models
 Regulatory-driven

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.**

Mental Modeling

- Are a complex web of deeply held beliefs that operate below the conscious level to affect how an individual defines a problem, reacts to issues, learns, and makes decisions
- Facilitate communication and coordination in team settings
- Facilitate learning
- Help build effective teams
- Involve knowledge about the team's task, individual members' responsibilities, and potential situations the team may encounter

Mental Modeling and Jointness

- **Jointness is required for modern combat**
- **Misconceptions about culture of different service branches may stand in the way of successful mission completion**
- **Case Study – Cognitive Leadership Training:**
 - **Develop a computer-mediated training environment for enhancing Joint Task Force Cognitive Leadership skills**
 - **Draw upon our experience in supporting Joint Task Force operations**
 - **Draw upon state-of-the-art tools such as mental modeling and decision analysis**

Related Efforts and Studies

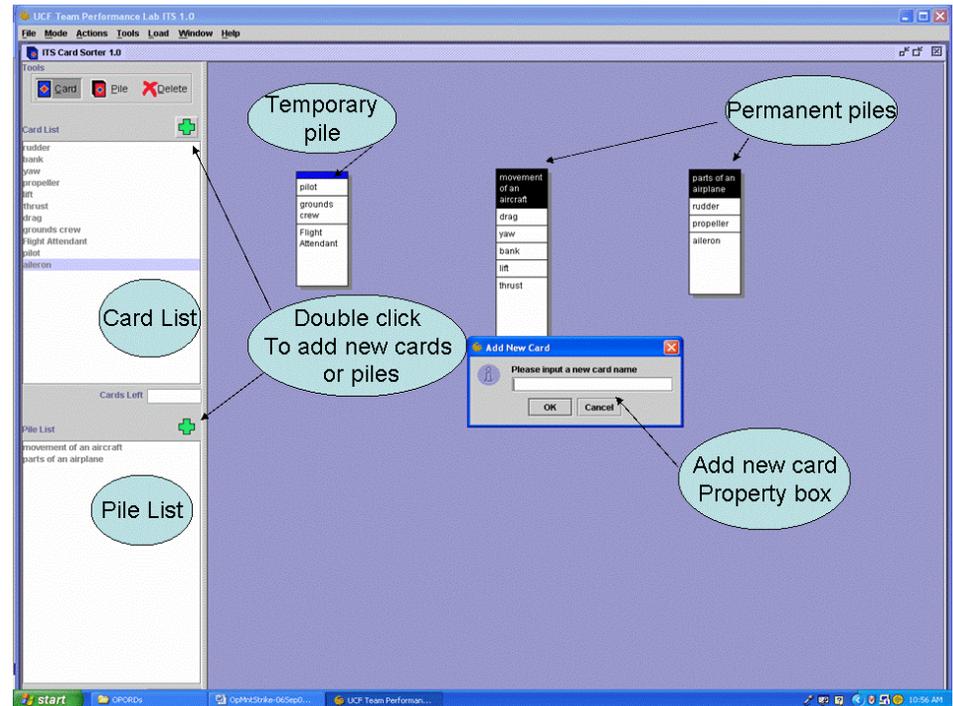
- **Leadership Training Tools:**
 - *Think Like a Commander*, ARI
 - Army Excellence in Leadership (AXL) at USC's Institute for Creative Technologies
 - ARI ELECT
 - The Virtual Soldier Skill Assessment project
 - Several past SBIR projects
- **Jointness Training Tools:**
 - Joint Readiness Training Center, Joint Knowledge Online (JKO) through JFCOM
- **Cognitive Aspects:**
 - Training fidelity to real life, efficiency of transfer, positive vs. negative training, retention
- **Conclusion**
 - Many leadership training tools, but very little discussion of jointness; few tools yet developed with emphasis on joint training
 - Cognitive aspects are part of some of the training tools, but focus is more on individual decision process and less on teamwork

Mental Modeling Review Summary

- **Mental models:**
 - Are a complex web of deeply held beliefs that operate below the conscious level to affect how an individual defines a problem, reacts to issues, learns, and makes decisions
 - Facilitate communication and coordination in team settings
 - Facilitate learning
 - Help build effective teams
 - Involve knowledge about the team's task, individual members' responsibilities, and potential situations the team may encounter
- **Goal:**
 - Map each service's culture and then develop training vignettes to enhance cross-service communication

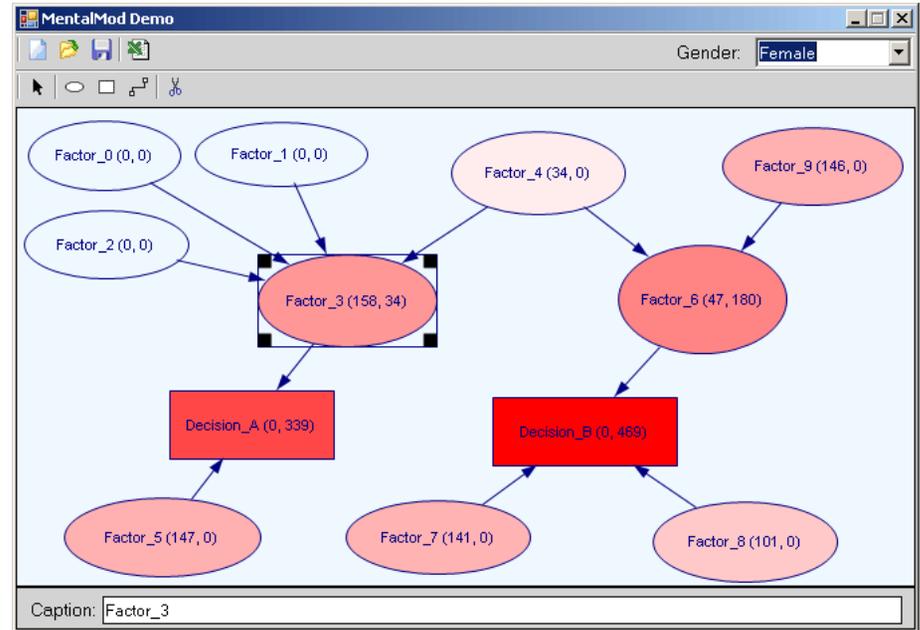
Mental Modeling Using Card Sorting Method

- **Tool was initially developed for JFCOM (J9) project on Adaptive thinking in Battlefield Environment**
- Purpose: To uncover the internal representation and organization of information utilized by an individual
- Technique: structural knowledge elicitation through conceptual mapping by card sorting, manipulation of concepts by participants, similarity ratings
- Applications: Assessment of knowledge shared within a team and the inadequacies of the information



Mental Modeling Using Structure Interview and Text Analysis

- **Method has been used widely in multiple risk communication projects**
- Purpose: Elicit concepts and values through semi-structured interview and focus follow-up training on identified gaps
- Technique: Structural knowledge elicitation through semi-structured interview with follow-up text analysis
- Applications: Assessment of knowledge shared within a team and the inadequacies of the information



Features:

- up-to-date software development technologies (Microsoft .NET, XML, etc.)
- integration with standard software environment for mental modeling research (Microsoft Excel)
- integration into Web-based solutions

Joint Staff Force Awareness for Service Culture

Key Components for Cognitive Awareness

➤ Joint Framework

- Joint Operating Concepts: Major Combat Ops, Stability & Supportability Ops

➤ Services

- Army, Marines, Navy, Air Force, National Guard
- Service Mission Essential Tasks

➤ Major Warfighting Elements

- Combat Arms, Combat Support, Combat Service Support

➤ Brigade Level and Higher

➤ Preparing for Combat

- Doctrine, Organization, Trng, Mat'l, Ldrshp & Ed, Personnel, Facilities (DOTMLPF)

Joint Staff Force Awareness for Service Culture

A Matrix Approach

Operating Concept—Homeland Security

Operating Concept—Stability Operations

Operating Concept—Major Combat Operations

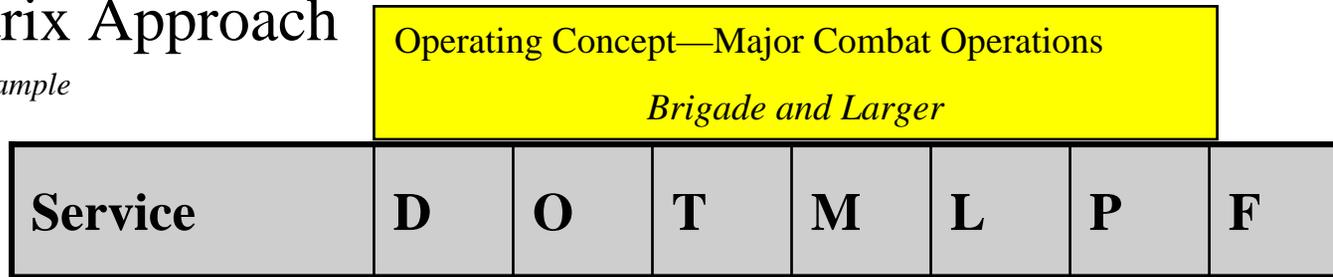
Brigade and Larger

Service		D	O	T	M	L	P	F
Army	Combat Arms Combat Support Combat Service Spt							
Marines	Combat Arms Combat Support Combat Service Spt							
Air Force	Combat Arms Combat Support Combat Service Spt							
Navy	Combat Arms Combat Support Combat Service Spt							
National Guard	Combat Arms Combat Support Combat Service Spt							

Joint Staff Force Awareness for Service Culture

A Matrix Approach

An Example



Marines

Combat Arms

D Combined Arms; Expeditionary

O MAGTF—MEF, MEB, MEU

T Live Fire-Combined Arms

M Osprey, F-18, AAV, LAV, M1A1

L Rank & File

P

F Pre-Po, Amphib, Air

Service Capabilities emphasized via detailed examination of

Doctrine, Organization, & Materiel

Service Tasks by BFA Via Major Combat Ops

		Army			Marine Corps
BFA	Task Identifier			Task Identifier	
Maneuver	2.1	Perform Tactical Actions associated with Force Projection and Deployment		1.1	Conduct Expeditionary Operations
	2.2	Conduct Tactical Maneuver		1.1.1	Conduct Ship-to-Objective Maneuver
	2.3	Conduct Tactical Troop Movements		1.2	Offense
	2.4	Conduct Direct Fires		1.2.0.18	Conduct Noncombatant Evacuation Operations
	2.4.1	Conduct lethal Direct Fire against a Surface Target		1.2.1.16	Conduct Mobility Operations
Fires	3.1	Decide Surface Targets to Attack		3.1	Conduct Direct Fires
	3.2	Detect and Locate Surface Targets		3.2	Conduct Indirect Fires
	3.3	Employ Fires to Influence the Will, and Destroy, Neutralize, or Suppress Enemy Forces		3.3	Conduct Non-lethal Engagement
	3.3.1	Conduct Lethal Fire Support		3.4.1.4	Coordinate NSFS
	3.3.2	Conduct Nonlethal Fire Support—Offensive Information Operations		3.4.1.6	Coordinate Close Air Support
Intel	1.1	Support to Situational Understanding		2.1	Plan Intel Support
	1.1.1	Perform Intelligence Preparation of the Battlefield (IPB)		2.1.2	Prepare and refine Intel and Intel prep of the Battlefield
	1.2	Support to Strategic Responsiveness		2.1.5	Plan and Coordinate Geodesy Imagery and Services (GI&S) Support
	1.3	Conduct Intelligence, Surveillance, and Reconnaissance (ISR)		2.1.6	Plan and Coordinate Signals Intel
	1.4	Provide Intelligence Support to Effects		2.1.8	Provide Tactical Counter-Intel/Human Intel Support

DOTMLPF by Service

Macro Representation

Additional levels of detail to be examined in Phase II

Service	Warfighting Unit	D	O	T	M	L	P	F
Army	Unit of Action	Maneuver Warfare	Corps-Division, BCT, ACR	Combined Arms- Force on Force	M1A2, M2A2 (BFV), Apache			Strategic Reserve Storage Activity Europe, Air, Land systems
Marines	MAGTF	Expeditionary Maneuver Warfare-Ship To Objective Maneuver	MAGTF-MEF, MEB, MEU	Combined Arms- Live Fire	Osprey, F-18, AAV, LAV, M1A1			Prepositioned, Amphibious, Land and Air systems
Air Force	Wing	Air Warfare	MAJCOM-Wing, Group	Air Combat-Close Air Support, Air Interdiction	F/A -18E, F/A-22A			Expeditionary Airfields
Navy	Battle Group	Naval Warfare: Sea Power 21-Sea Shield, Sea Strike, Sea Basing			Surface Ships Aircraft Carriers Submarines			Air and Sea based platforms
National Guard	Unit of Action	Maneuver Warfare	Division, BCT	Combined Arms- Force on Force	M1A2, M2A2 (BFV), Apache			Strategic Reserve Storage Activity Europe, Air, Land systems

DOTL-Materiel-PF x Battlefield Functional Area

Service Mission Essential Pacing Items

Representative examples--Additional levels of detail to be examined in Phase II

Service	Maneuver	Fires	Intel	Logistics	C2	Force Protection
Army	M1A2, M2A2 (BFV), AH-64 Apache, OH-58D Kiowa Warrior, Comanche	M109A6 Paladin 155mm Self Propelled Howitzer (SPH), M198 Medium Towed Howitzer	LRAS3, Ground surveillance radar systems	M978 (Fuel Tanker), M985 (Ammo/Cargo Truck and Wrecker), CH-47 Chinook	M1A2, M2A2 (BFV)	M1A2, M2A2 (BFV), AH-64 Apache, Q36 and Q37 radars
Marines	AAV, AAV, LAV, M1A1 V-22 Osprey	M198 Medium Towed Howitzer F/A -18, Cobra Gunship	Ground surveillance radar systems	Fuel Tankers, Ammo Trucks, V-22 Osprey	M1A1, F-18	M1A1, LAV Cobra Gunship
Air Force	F/A-18E, F/A-22A, F117A Nighthawk Stealth Fighter	B1 AND B2 Bombers, A10 Warthog	Reconnaissance and surveillance aircraft	KC-135 Stratotanker	F/A-18E, F/A-22A	F/A-18E, F/A-22A, AN FPS 115 radar
Navy	Aircraft Carriers, Guided Missile Cruisers, Destroyers, Wolverines	Guided Missile Cruisers, Destroyers	Reconnaissance and surveillance aircraft ANSPQ-11, SURTASS	Military Sealift Command (MSC) ships	Command ships (AGF-3, AGF-11) Amphibious Command ships (LCC-19, LCC-20)	Frigates
National Guard	M1A1, M2A2 (BFV), AH-64 Apache, OH-58D Kiowa Warrior	M109A4 SPH, M198 Medium Towed Howitzer	Ground surveillance radar systems	Ditto Army	Ditto Army	M1A1, M2A2 (BFV), AH-64 Apache

Multi-Criteria Decision Analysis

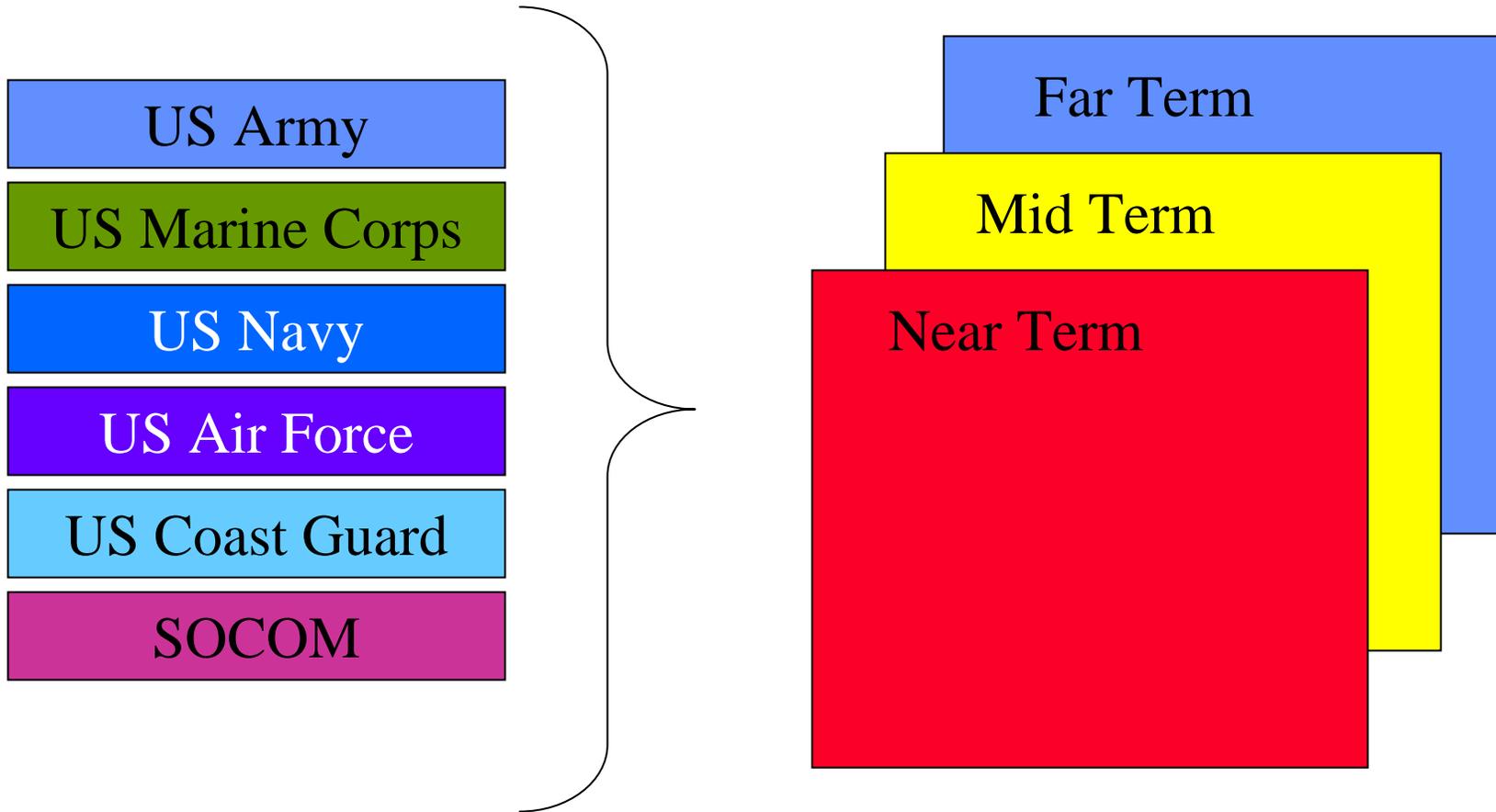
- Refers to a group of methods used to impart structure to the decision-making process
- Generally consists of four steps:
 - ◆ Creating a hierarchy of criteria relevant to the decision at hand, for use in evaluating the decision alternatives
 - ◆ Weighting the relative importance of the criteria
 - ◆ Scoring how well each alternative performs on each criteria
 - ◆ Combining scores across criteria to produce an aggregate score for each alternative

Case Study: Use of MCDA to Support Acquisition Planning

- **Problem: Prioritization of projects to fund**
- **Capability Gaps:**
 - **72 gaps;**
 - **Harmonization across 6 DOD Service Commands;**
 - **Three time horizons.**

Challenge 1:

Harmonization Across Six Commands and Three Time Frames

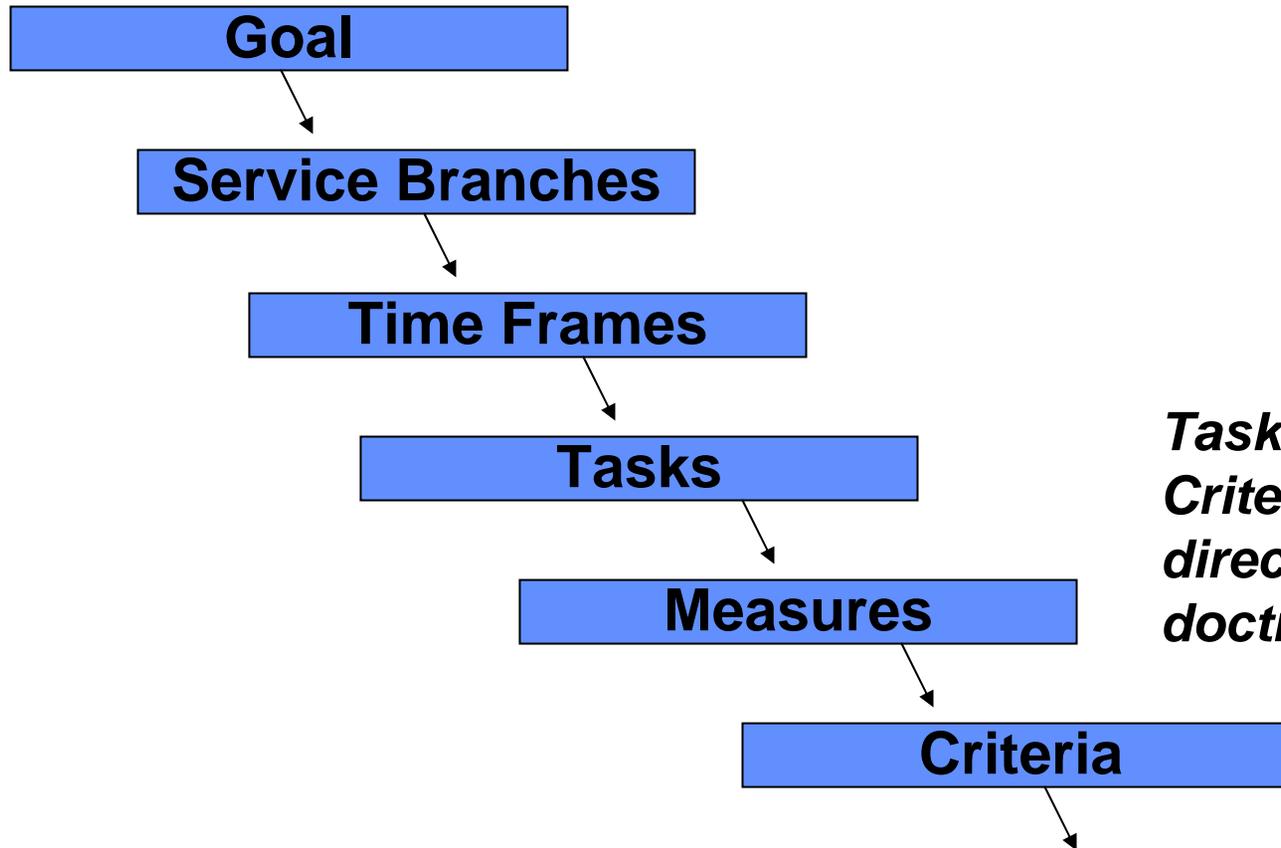


Approaches to Prioritization

- **Available Approaches for Prioritization:**
 - **Subjective Prioritization (Gut Feeling)**
 - ◆ **Pros: easy to do**
 - ◆ **Cons: no rigor, potential mistakes, not transparent and not reliable**
 - **Ad hoc weighting using Excel Spreadsheets**
 - ◆ **Pros: everybody can use Excel, relative ease of implementing**
 - ◆ **Cons: requires arbitrary weighting for multiple criteria, difficult to modify/adjust for specific commands**
 - **Multi-Criteria Decision Analysis**
 - ◆ **Pros: transparent, state-of-the-art tool, can be tailored/modified in real time, records and visualizes differences among commands and individual opinions**
 - ◆ **Cons: relatively intense, may require advanced sensitivity analysis**
-

Conceptual Approach

- Tiered criteria hierarchy for MCDA:

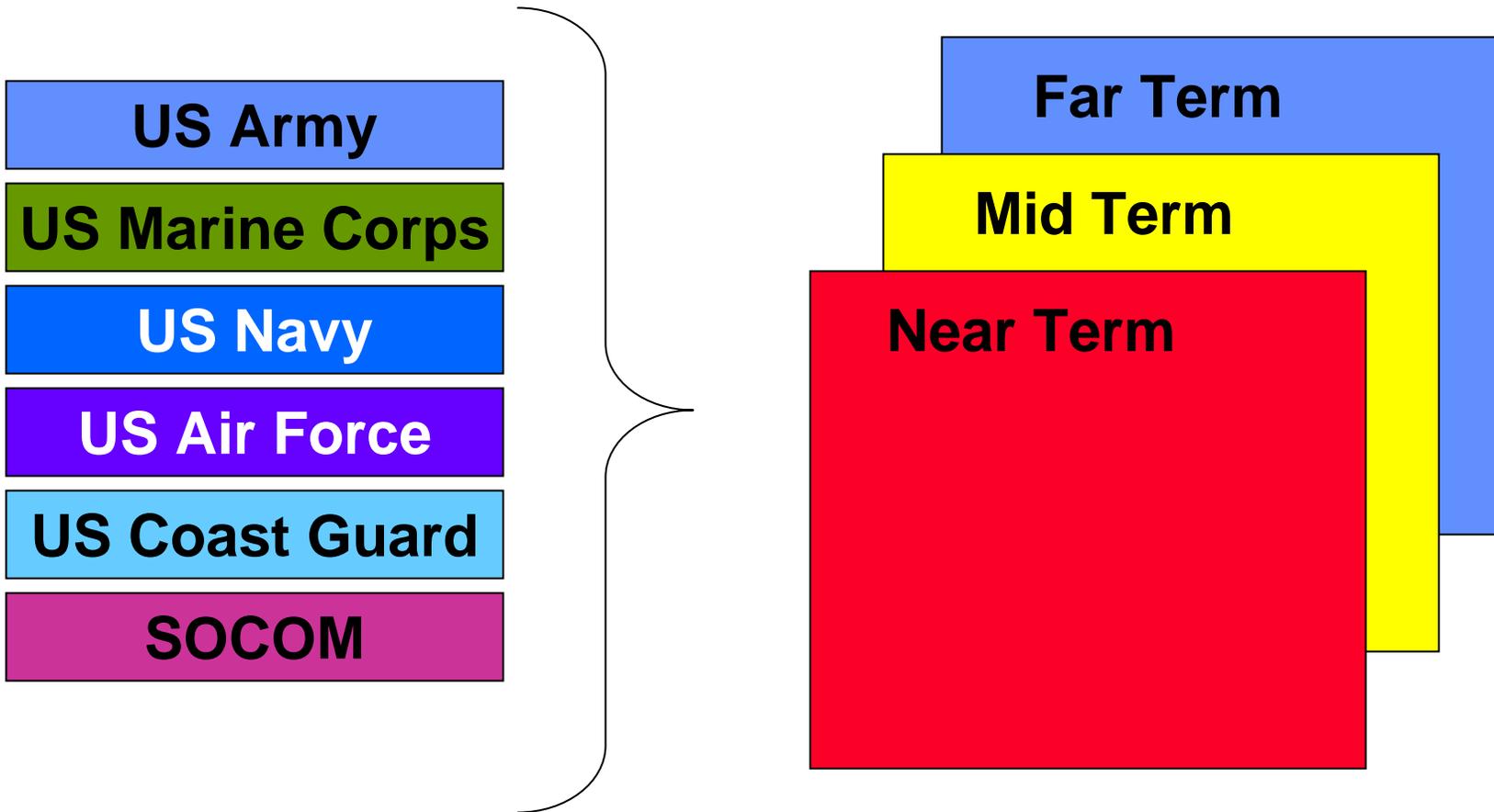


Tasks, Measures, and Criteria were taken directly from military doctrine

Gaps correspond to specific criteria within a specific Time Frame

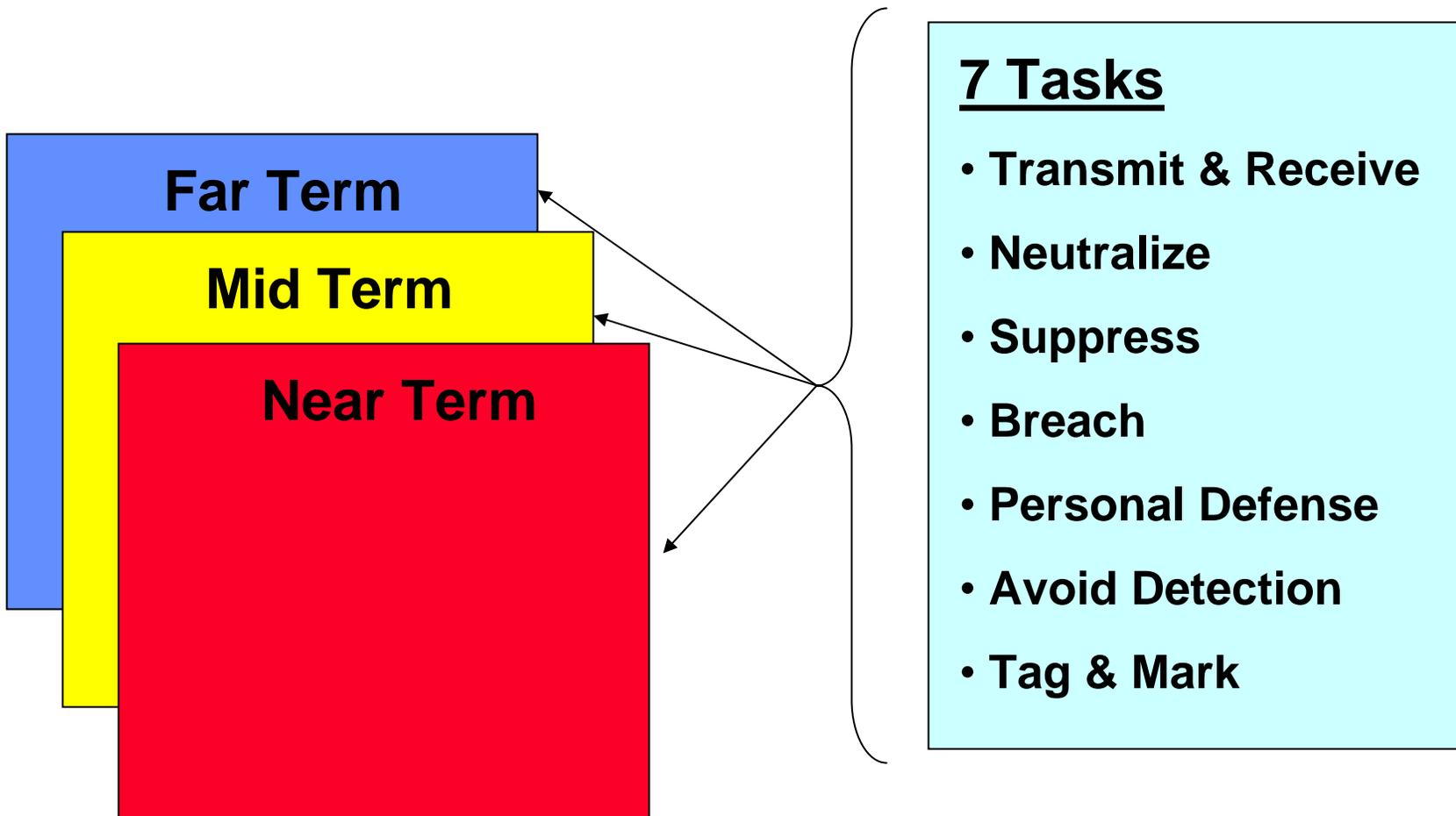
Approach (1)

Each survey respondent weights the relative importance of three Time Frames (Near, Mid and Far Term)



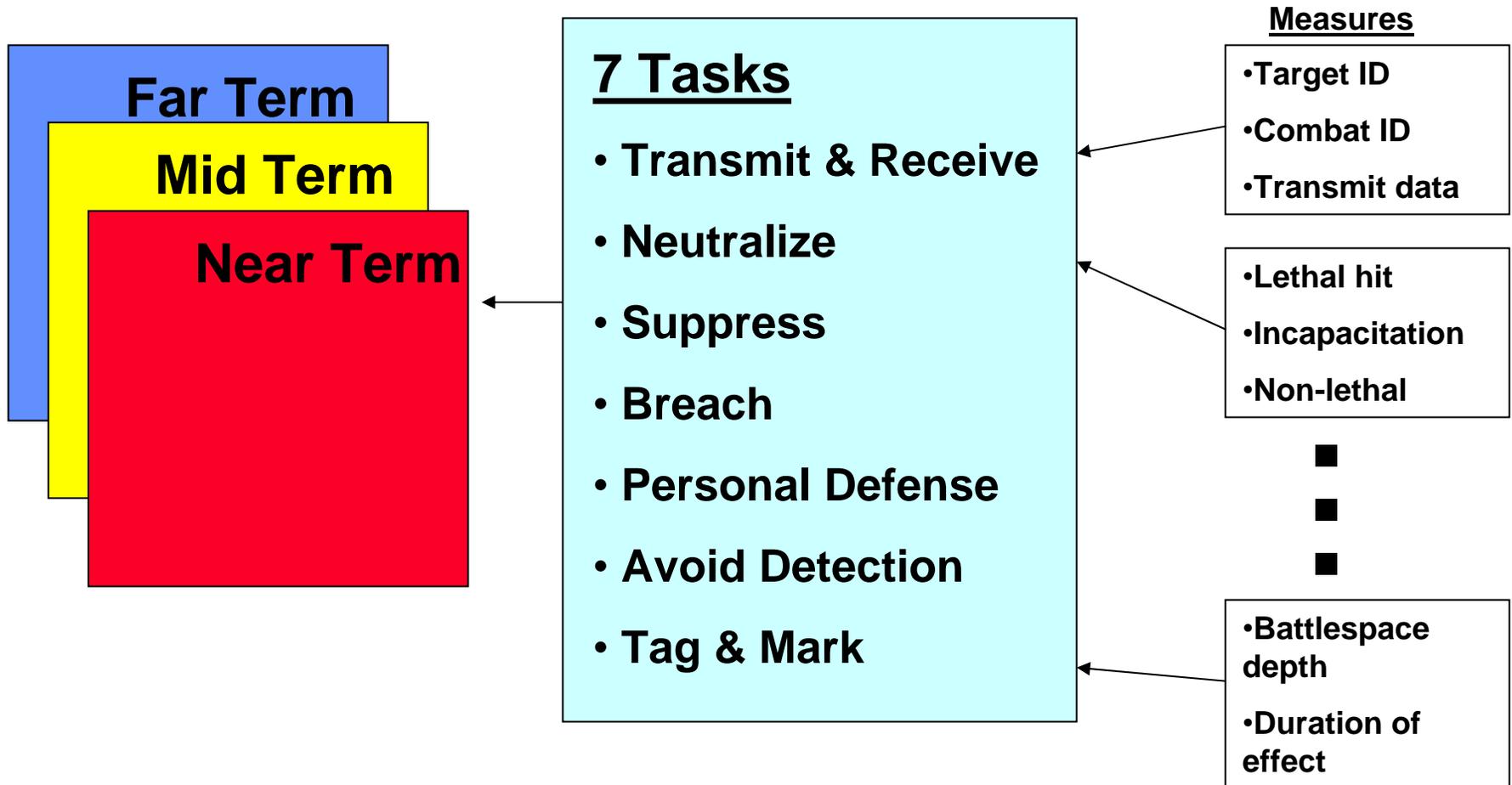
Approach (2)

Each survey respondent weights the relative importance of the 7 Tasks with respect to each Time Frame



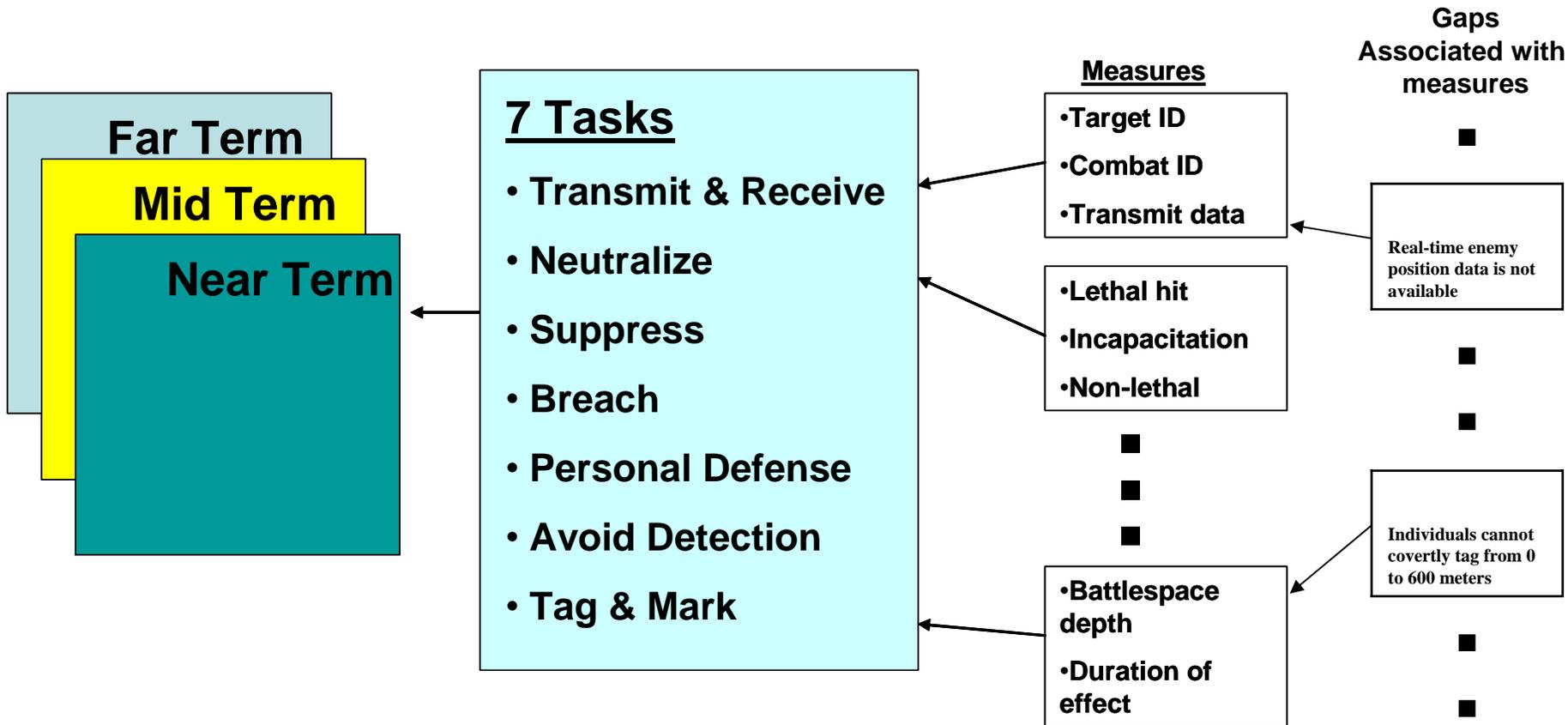
Approach (3)

For each Time Frame, each survey respondent weights the relative importance of the Measures within each Task



Approach (4)

Gaps were assigned to measures and ranked according to the relative weight calculated for each measure



Criteria Weighting

- Each Service weights the Tasks / Measures / Criteria through a series of pairwise comparisons
 - Implementation of the Analytical Hierarchy Process
 - The importance of one Task is compared relative to the importance of another
 - Scored numerically (example below)

“Please rank the relative importances of the following tasks with reference to small arms military capabilities in the Near-Term”

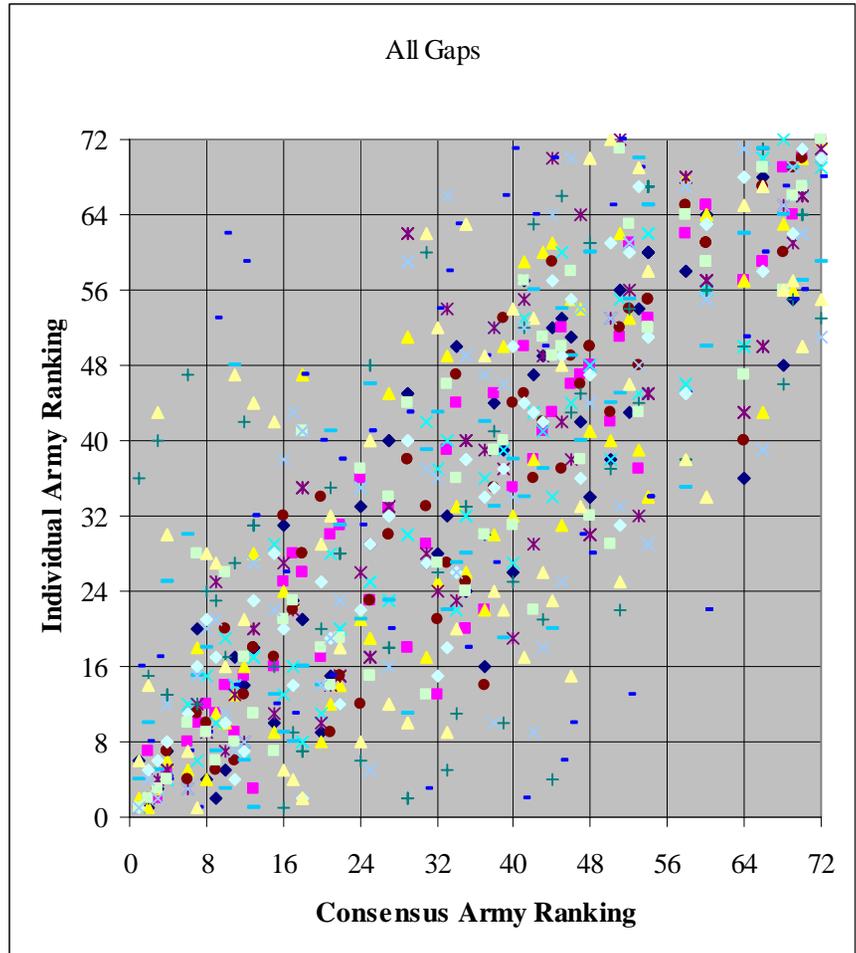
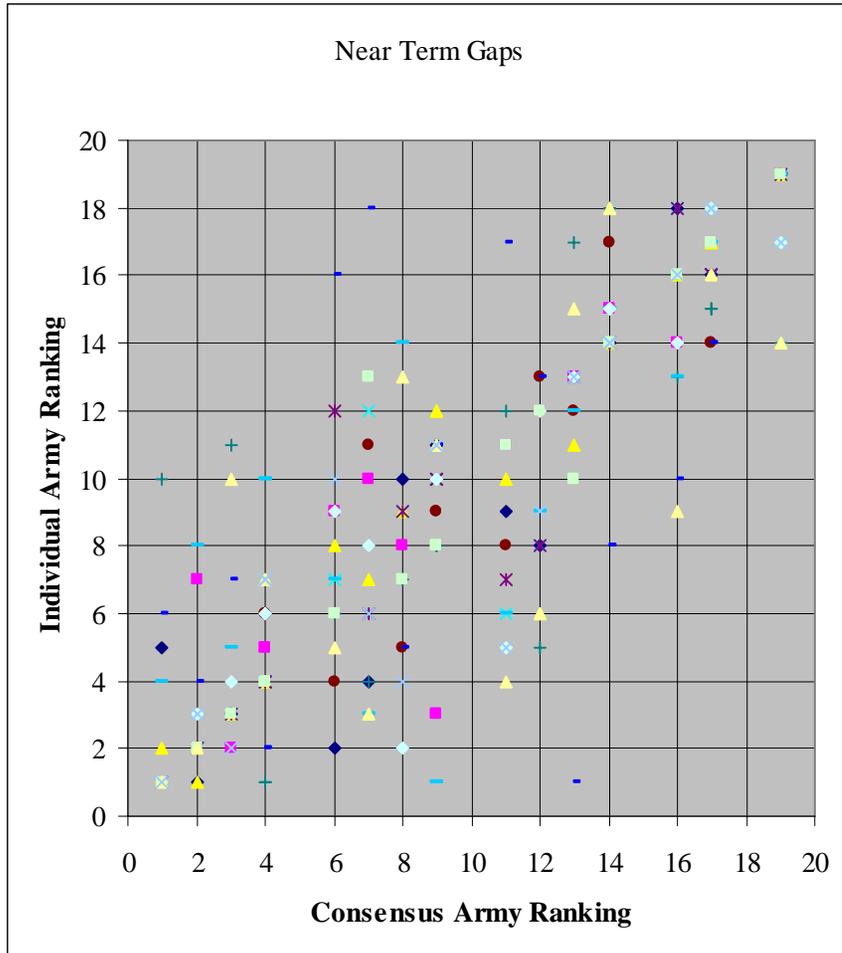
Transmit & Receive Data										Neutralize Target										
9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9				
More important									Equal			More important								

Survey Responses

- As shown on previous slides, each Time Frame, Task, Criteria, and Measure was weighted based on pairwise comparison questions in an **online preference survey**
- Only complete surveys were used
- Number of complete surveys received from:
 - Army: multiple respondents
 - Marine Corps: multiple respondents
 - Air Force: consensus response
 - Coast Guard: consensus response
 - Navy: consensus response
 - SOCOM: consensus response

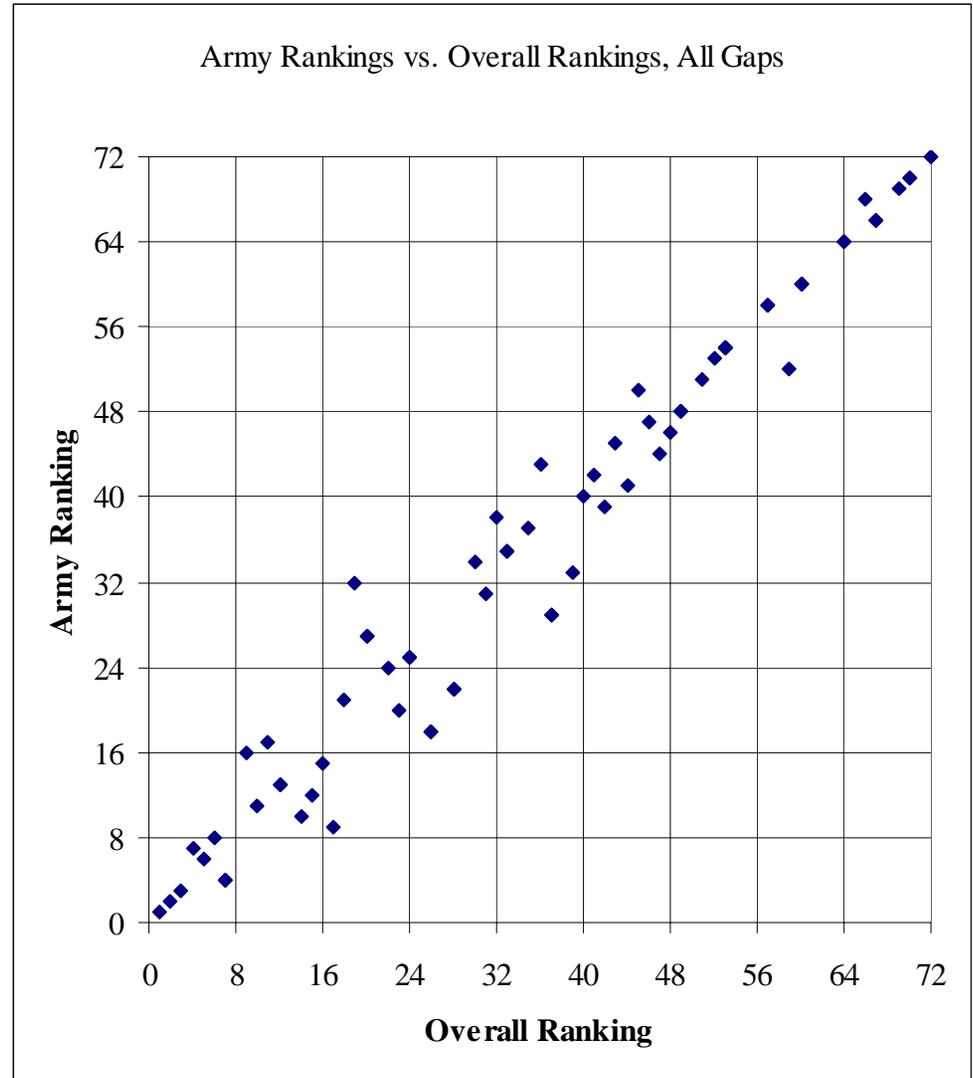
Army Ranking: Individual vs. Army Consensus

Individual Army respondents show variability, but there is a clear trend in ranking implying that consensus ranking for Army is a robust one



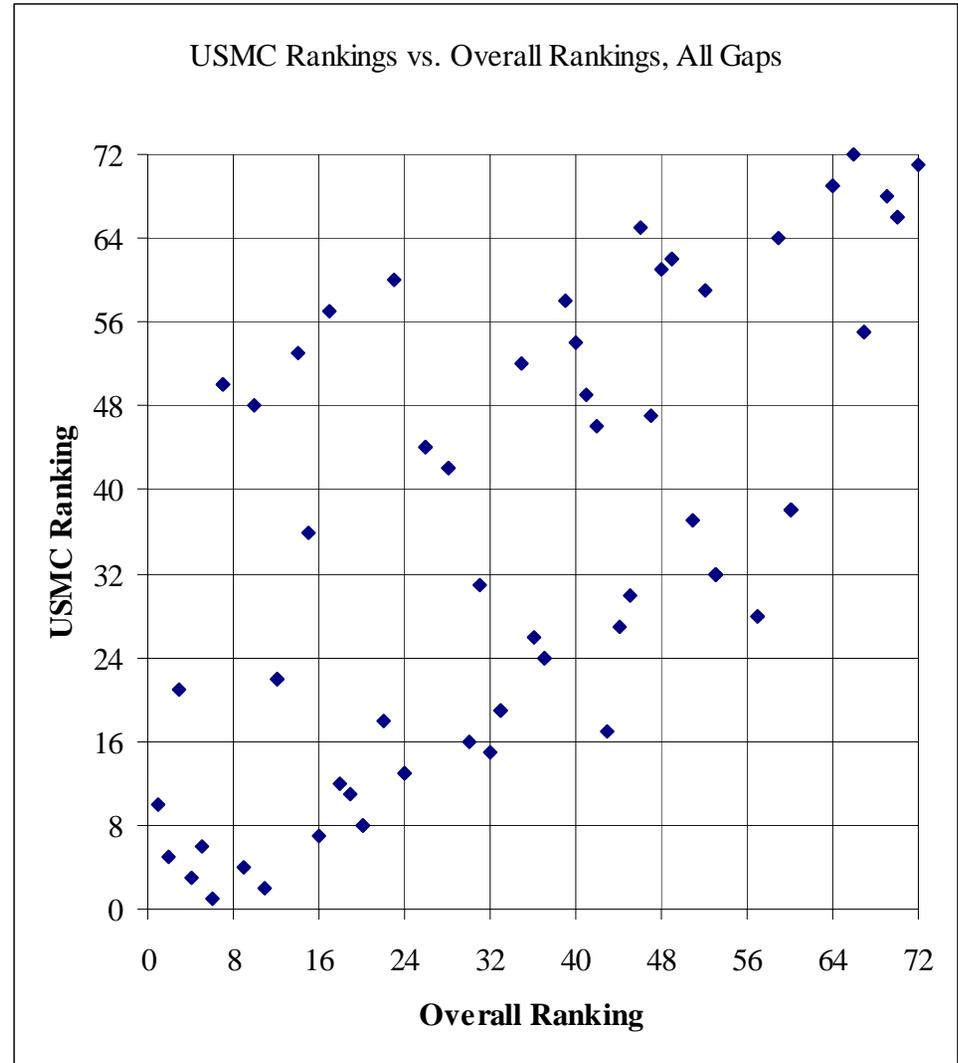
Army vs. the Overall Consensus

Army's rankings were quite similar to the overall results

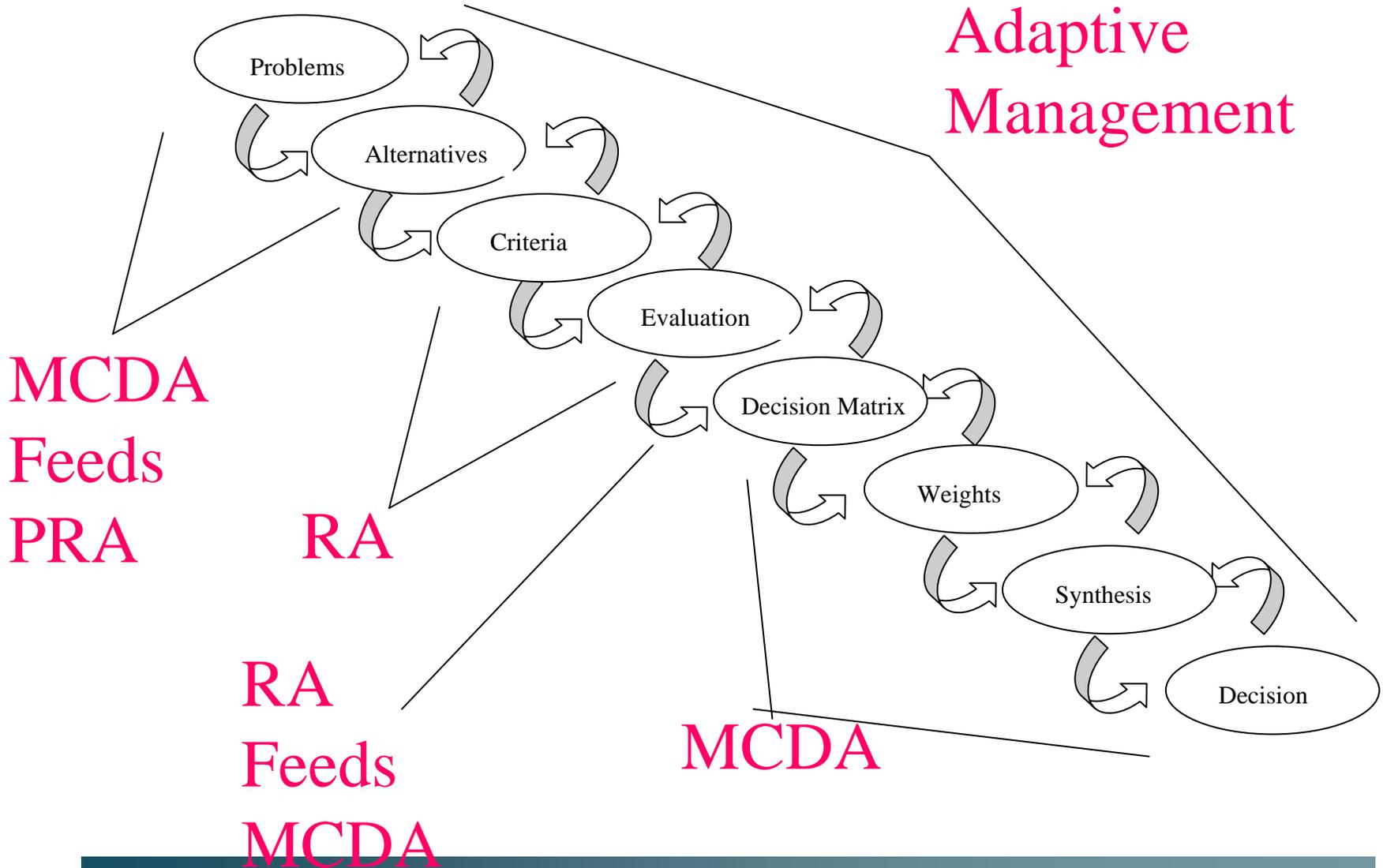


Marines vs. the Overall Consensus

USMC's rankings were less similar to the overall results, due primarily to being the only service to value the Mid and Far Terms higher than the Near Term



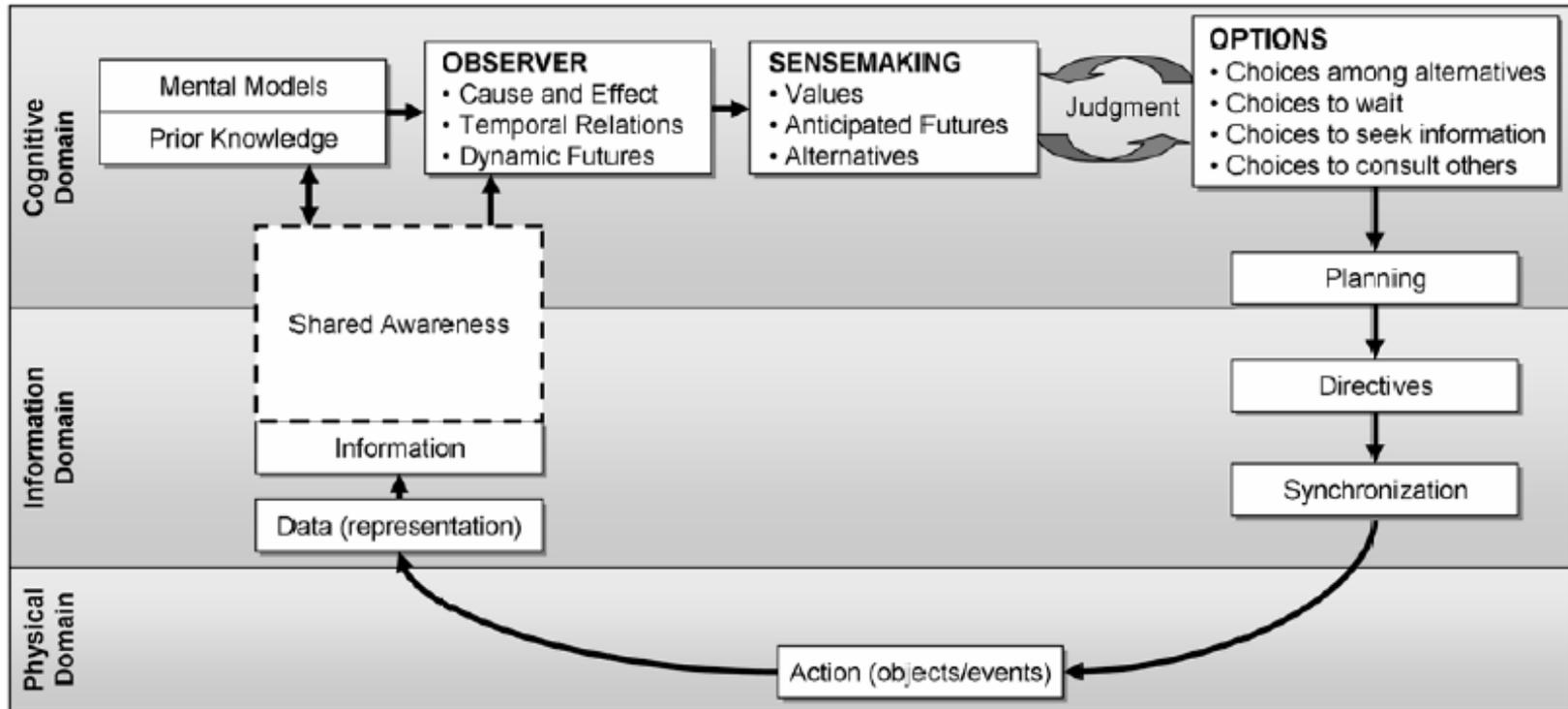
Linking RA and MCDA



Linking RA, MCDA and NCO

Mental Modeling

Decision Analysis



Risk Assessment

Summary: Essential Decision Ingredients

People:

Policy Decision Maker(s)



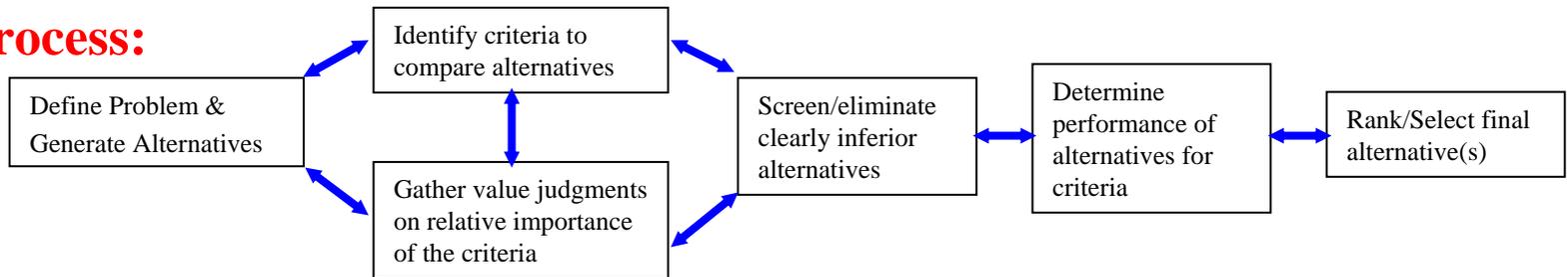
Scientists and Engineers



Stakeholders (Public, Business, Interest groups)



Process:



Tools:

Environmental Assessment/Modeling (Risk/Ecological/Environmental Assessment and Simulation Models)

Decision Analysis (Group Decision Making Techniques/Decision Methodologies and Software)