# Module 1: Traditional $C^2$

Network Enabled Command and Control
Short Course

Dr. David S. Alberts
October 2009

# Questions Addressed

- What is $C^2$?
- How has $C^2$ evolved as a function of technology?
- What assumptions does Traditional $C^2$ make?
- What do we want from a definition?
- How has Traditional $C^2$ been defined?
- Summary

# Agenda

- $C^2$ raison d'etre
- Evolution of Military $C^2$
- Traditional $C^2$ Assumptions
- Nature of Definitions
- Models as Definitions
- Models of Traditional $C^2$
- Summary

# The Reason for $C^2$

The goal of $C^2$ is to create the conditions necessary for

task/mission success

in anticipated and unanticipated situations and circumstances

by the appropriate utilization of available resources

# Context for $C^2$

- Command and Control can be considered at the

  - enterprise level (set of current and future missions)

  or

  - in the context of a particular task or mission

- Mission contexts vary greatly by type and scale

  - neutralize German forces in Italy
  - determine who, what, where, when of impending attack
  - safe convoy of NGOs
  - protect "cyberspace"

# $C^2$ Shapes and Employs

Command and Control both ***shapes*** the force and ***employs*** it

Shaping is C2 at the Enterprise level
- Creates the "Force"
- Determines Capabilities over time

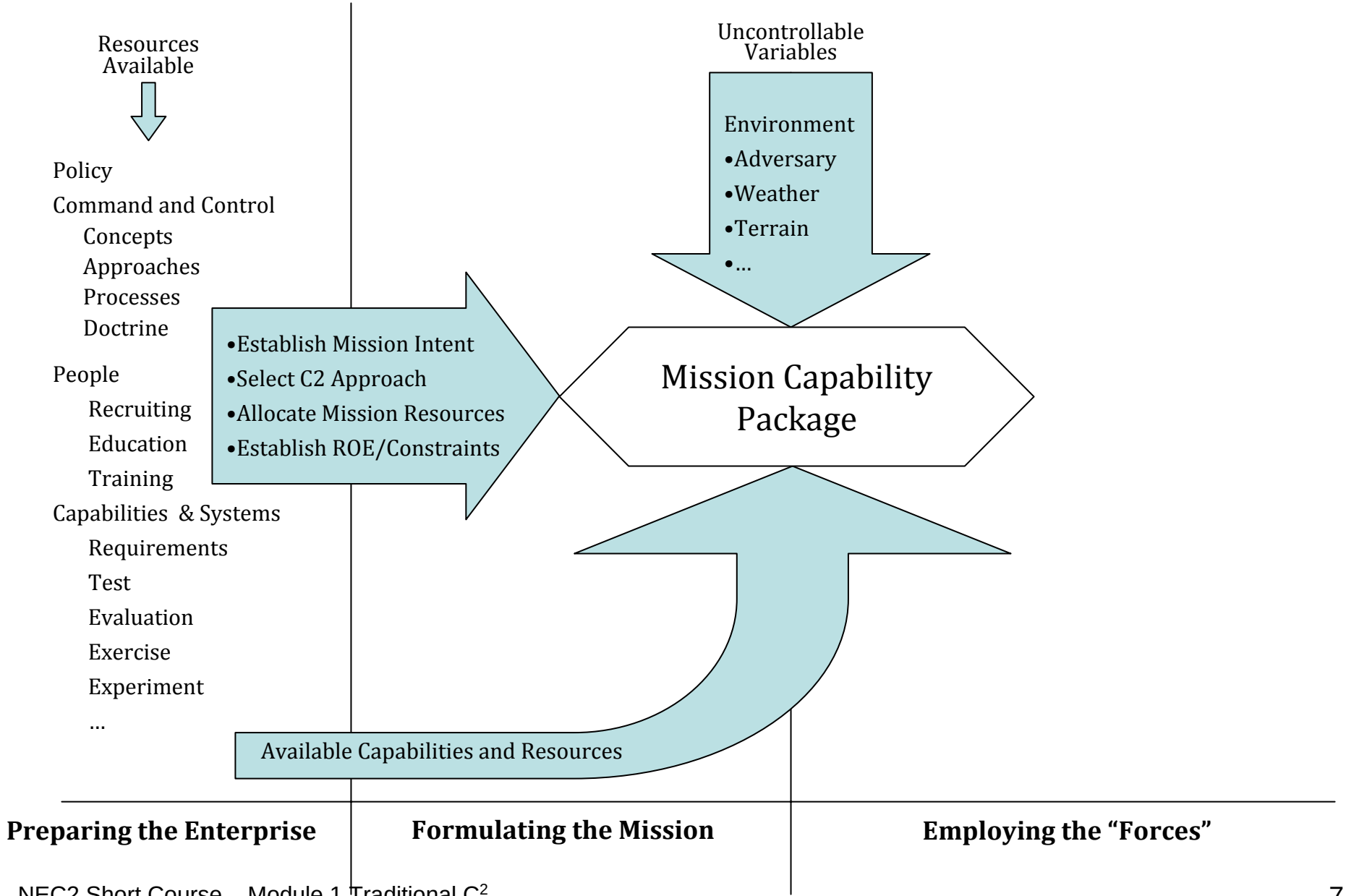
***Shaping Determines What is Possible***

***Employing Determines the What and How of an Operation***

Employing is C2 at the Mission level
- Establishes Intent
- Creates/Instantiates a Mission Capability Package at time ***t*** for purpose ***p***

**$C^2$ creates the initial conditions for an operation**

# Spawning Mission Capability Packages



# Limits of $C^2$

- Command and Control is not an end unto itself; rather, it is a means (enabler) of value creation

- While even "perfect" command and control can not guarantee success, better command and control can improve the probability of success by more appropriately scoping missions and utilizing available assets

# Evolution of Command and Control ($C^2$)

- Historical emergence:
  - Gustavus Adolphus (1594-1632) standing, professional staff
  - Napoleon Bonaparte: formal staff structure
- Command-centric view resulted from political figures and nobles in leadership roles
- First use in the modern sense of $C^2$ by Jomini, *The Art of War* (1838), "The Command of Armies and the Supreme Control of Operations"
- Truman to MacArthur, after WWII: "Take command and control of the forces in the Far East"
- The "Art" of Command was often separated from the "Science" of Control

# Impact of Technology

- Historically communications were perceived as the pacing factor in $C^2$
- Major advances include: semaphore, telegraph, telephone, radio with increasing ranges and reliabilities, and digital communications.
- Language evolved to reflect latest advances: $C^2$, $C^3$, $C^3I$, $C^4I$, $C^4ISR$, etc with everything after the first two Cs supporting the basic functions of $C^2$
- In the latter half of the $20^{th}$ Century, technical interoperability became the "Holy Grail" pushing aside consideration of both semantic interoperability and "Cooperability" (the ability and willingness to cooperate)

# Traditional Military $C^2$ Assumptions

- There is someone that is recognized to be "in charge"
- There exists a single chain of command
- There is doctrine that defines patterns of interaction
- Information distribution follows the chain of command

*The term **Command and Control** has become synonymous with these assumptions*

# $C^2$ Economy

- The term $C^2$ has been adopted by other disciplines, notably economics – but its connotation is not positive

- "A planned economy or directed economy is an economic system in which the state or workers' councils manage the economy. It is an economic system in which the central government makes all decisions on the production and consumption of goods and services. Its most extensive form is referred to as a command economy, centrally planned economy, or ***command and control economy***. In such economies, central economic planning by the state or government is so extensive that it controls all major sectors of the economy and formulates all decisions about their use and about the distribution of income. The planners decide what should be produced and direct enterprises to produce those goods. Planned economies are in contrast to *unplanned economies*, such as a market economy, where production, distribution, pricing, and investment decisions are made by the private owners of the factors of production based upon their own interests rather than upon furthering some overarching macroeconomic plan." - source: wikipedia

Why does Command and Control have
a good connotation for the military
but a negative connotation for economists?

# Definitions

- A definition should make a concept definite, distinct, clear, and observable

- A useful definition should
  - enable us to recognize / classify / measure
  - provide a conceptual framework for increasing understanding
  - provide a basis for action

# Models

- Models can be useful ways of defining concepts if they
  - capture what is known (or thought to be true)
  - can be applied to practical problems, and
  - are testable
- Models come in a variety of forms
  - symbolic, iconic, simulation
- Models can focus on different things
  - functions, processes, value
- Models are always incomplete and thus "wrong"; but some models can be very useful to both theorists and practitioners

# An Example of a Definition

Car = any vehicle on wheels
Vehicle = any means in or by which someone travels or something is carried or conveyed

- This definition provides a sense of purpose and three conditions
  - must have wheels
  - must be able to carry a person(s) or other cargo
  - must move
- Does not distinguish among a large set of wheeled vehicles
  - size, via road v. rail, how powered, covered or uncovered
- Does not provide a basic set of "design parameters"
- Does not provide understanding of how a car works

# Questions re: Definition of Car

Car = any vehicle on wheels
Vehicle = any means in or by which someone travels or something is carried or conveyed

- Does a car need to have a means of steering?
- Can a car be tethered (a long electrical cord)?
- Is a car that can no longer "move" still a car?
- Is a "toy" car (model) a car?
- Is a car that needs external energy (need to be pushed) a car?
- How does one compare on car to another to see which is "better"?

at best, a dictionary definition allows
one to identify an object as a member of the set of cars

# A Useful Definition of $C^2$

- A definition of $C^2$ is useful to the extent that it addresses the following:
  - what is $C^2$ trying to accomplish?
    - (objectives)
  - how does $C^2$ seek to accomplish its objectives?
    - (means)
  - are there different approaches to $C^2$?
    - (available options)
  - what are the metrics associated with $C^2$?
    - (quality - progress benchmarks)
  - under what circumstances are these approaches suitable?
    - (application of theory)

# DoD Definition of $C^2$

Joint Publication 1-02 definition* of Command and Control :

"The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission..."

*Is this a useful definition?*

*Source: Defense Technical Information Center. DoD Dictionary of Military and Associated Terms.

# Model Validity and Utility

- Validity
  - Does the model include all of the relevant variables, all of the significant relationships?
  - Are the individual parameters supported by empirical evidence (empirical validity) or expert opinion (face validity)?
  - Does the model generate reasonable results?
  - Has the model be appropriately applied?
- Utility
  - Can the model address the specific issues under consideration?
  - Are the explicit or implicit assumptions meaningful for the application?

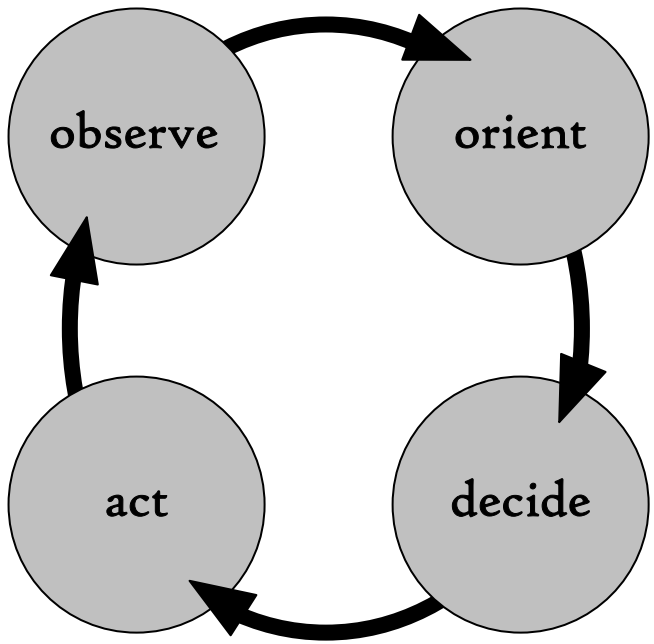
# Industrial Age Conceptual Models of $C^2$

- Two dominant Industrial Age modeling approaches
  - Control Theory (Cybernetics)
    - Joint (Hayes, Headquarters Effectiveness Assessment System or HEAT)
    - USAF (Boyd, Wohl, and Levis)
    - USN (Lawson)
    - US Army (Hayes, Army Command and Control Evaluation System or ACCES)
  - Decision Making:
    - Janis (Groupthink)
    - Klein (Recognition Primed and Naturalistic Decision Making)
    - Weick (Sensemaking)
    - Pigeau and McCann (Re-conceptualizing Command and Control)

# $C^2$ Process Model

(circa 1975)

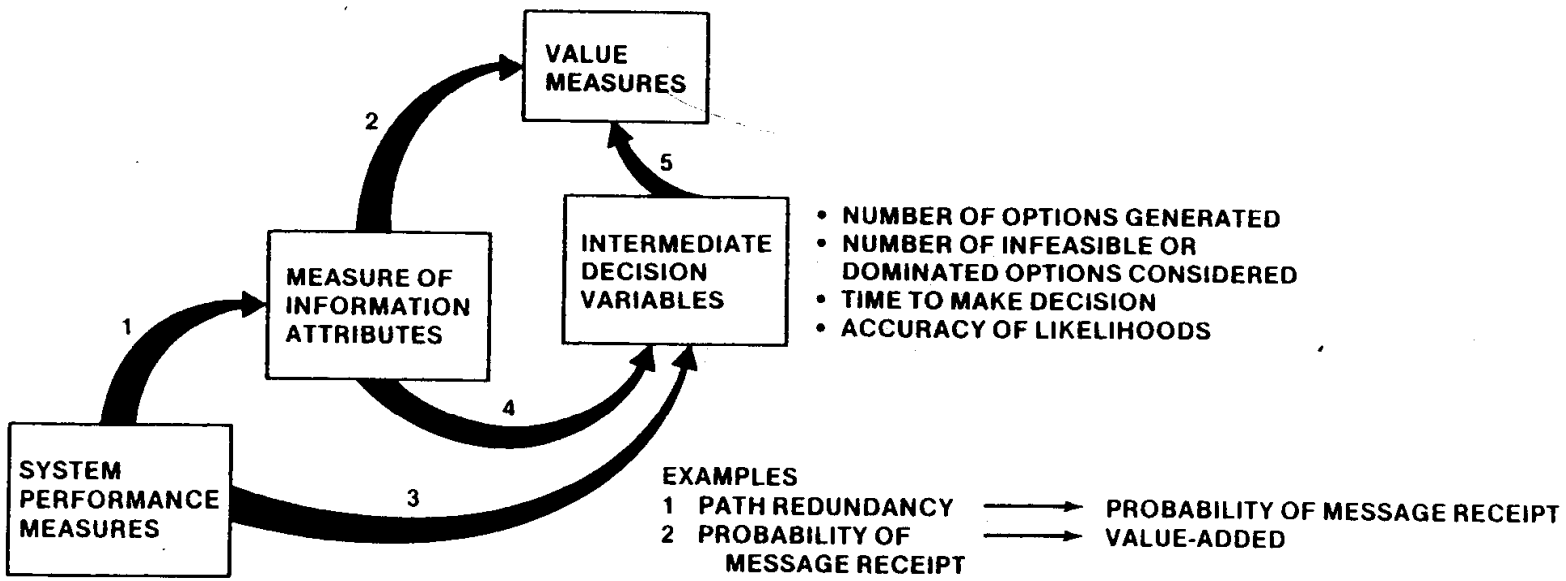
- Boyd's "OODA" loop is a process model that depicts command and control
  - from the perspective of an individual
  - as a decision process
  - with feedback and iteration



# Decision-oriented Value Model

(circa 1975)*

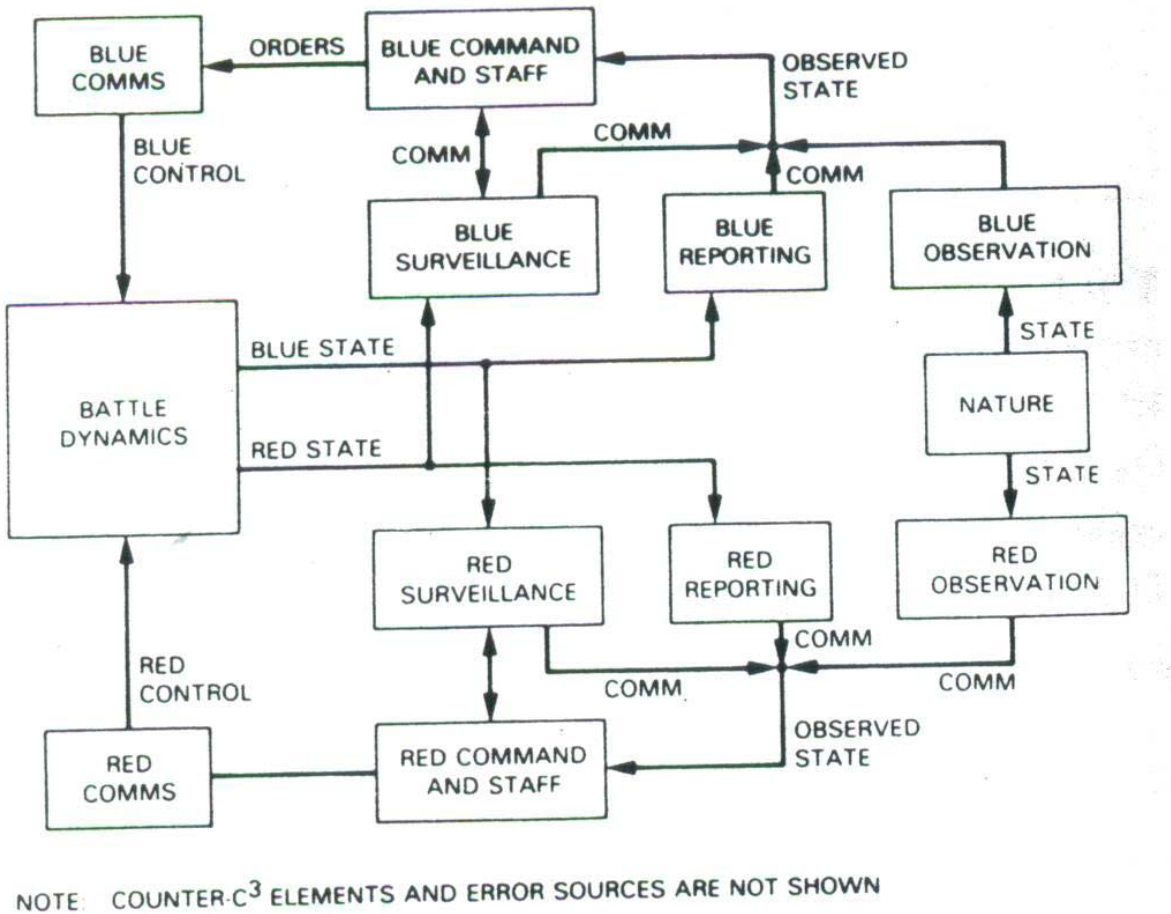
- Links $C^2$ system performance to measures of $C^2$ and mission value
- Introduces indicants of decision quality




*Alberts (1976)

# A State-Vector Model

circa (1975)*




NOTE: COUNTER-C$^3$ ELEMENTS AND ERROR SOURCES ARE NOT SHOWN

* Harry Van Trees

# A "Word" Model

*"Confronted with a task, and having less information available than is needed to perform that task, an organization may react in either two ways. One is to increase its information-processing capacity, the other to design the organization, and indeed the task itself, in such a way as to enable it to operate on the basis of less information. These approaches are exhaustive; no others are conceivable. A failure to adopt one or the other will automatically result in a drop in the level of performance."*

Martin van Creveld (*1985*), *Command in War*

# A "Word" Model

*Identifies the "controllable" variables*

*"Confronted with a task, and having less information available than is needed to perform that task, an organization may react in either two ways. One is to increase its information-processing capacity, the other to design the organization, and indeed the task itself, in such a way as to enable it to operate on the basis of less information. These approaches are exhaustive; no others are conceivable. A failure to adopt one or the other will automatically result in a drop in the level of performance."*

Martin van Creveld (*1985*), *Command in War*

# Traditional $C^2$ Models

- What variables do they include - leave out?
- What do they tell us about $C^2$?
- What don't they tell us?
- What assumptions are embedded in these models?
- What can these models be used for?

# Determining the Quality of $C^2$

- Since $C^2$ is not the sole determinant of mission success, mission success or failure is not an appropriate measure of the quality of $C^2$
- $C^2$ Quality is appropriately measured by examining how well the functions associated with $C^2$ have been performed
- Dilemma: If "crafting" the mission is considered a $C^2$ function, then one could "craft for success"; thus an external test of the appropriateness of mission objectives is required

# Traditional $C^2$-related Value Metrics

- Speed
- Correctness
- Precision
- Stealth

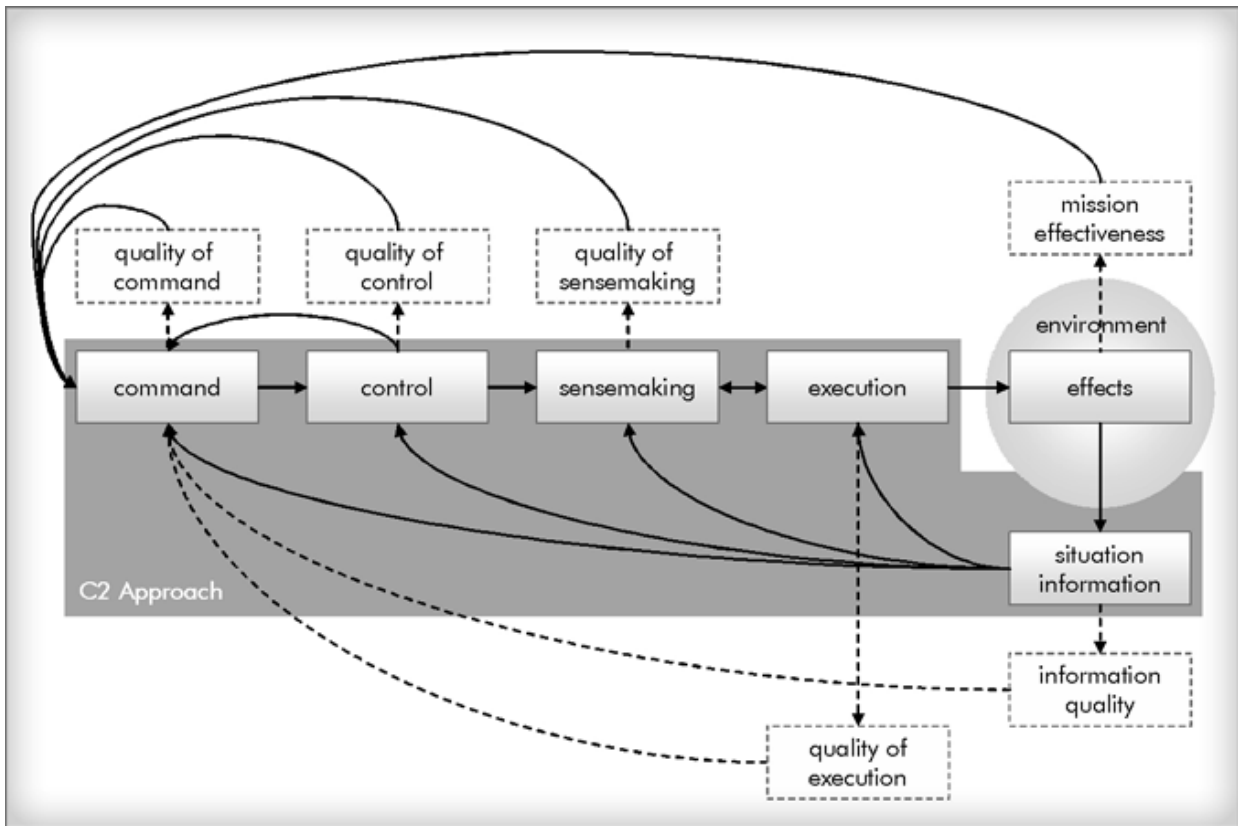
# $C^2$ Functions and Approaches

in a Mission Context

- The mission provides the context for considering which $C^2$ functions are critical and how well they are performed
- Functions of $C^2$ include:
  - Establishing, communicating and ensuring understanding of appropriate intent
  - Determining roles, responsibilities, and relationships
  - Establishing rules and constraints
  - Allocating assets
  - Monitoring and assessing the situation and assessing progress
  - Revising the above
- A $C^2$ Approach determines how these functions are accomplished

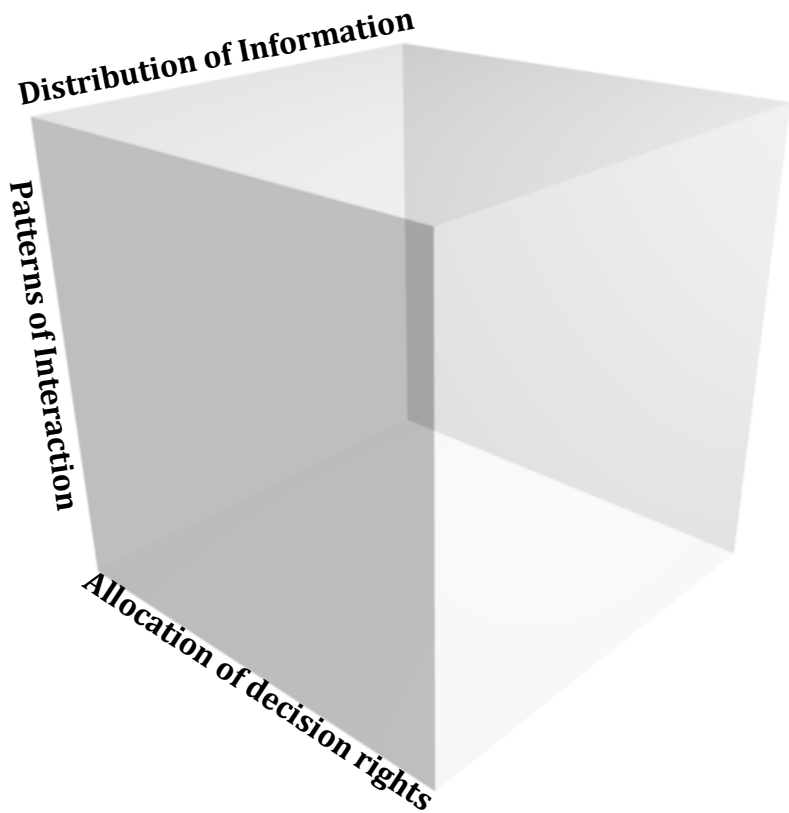
# $C^2$ Conceptual Model: Overview
(circa 2006)

- Combines process and value views with integrated feedback
- Defines the scope of a "$C^2$ Approach"



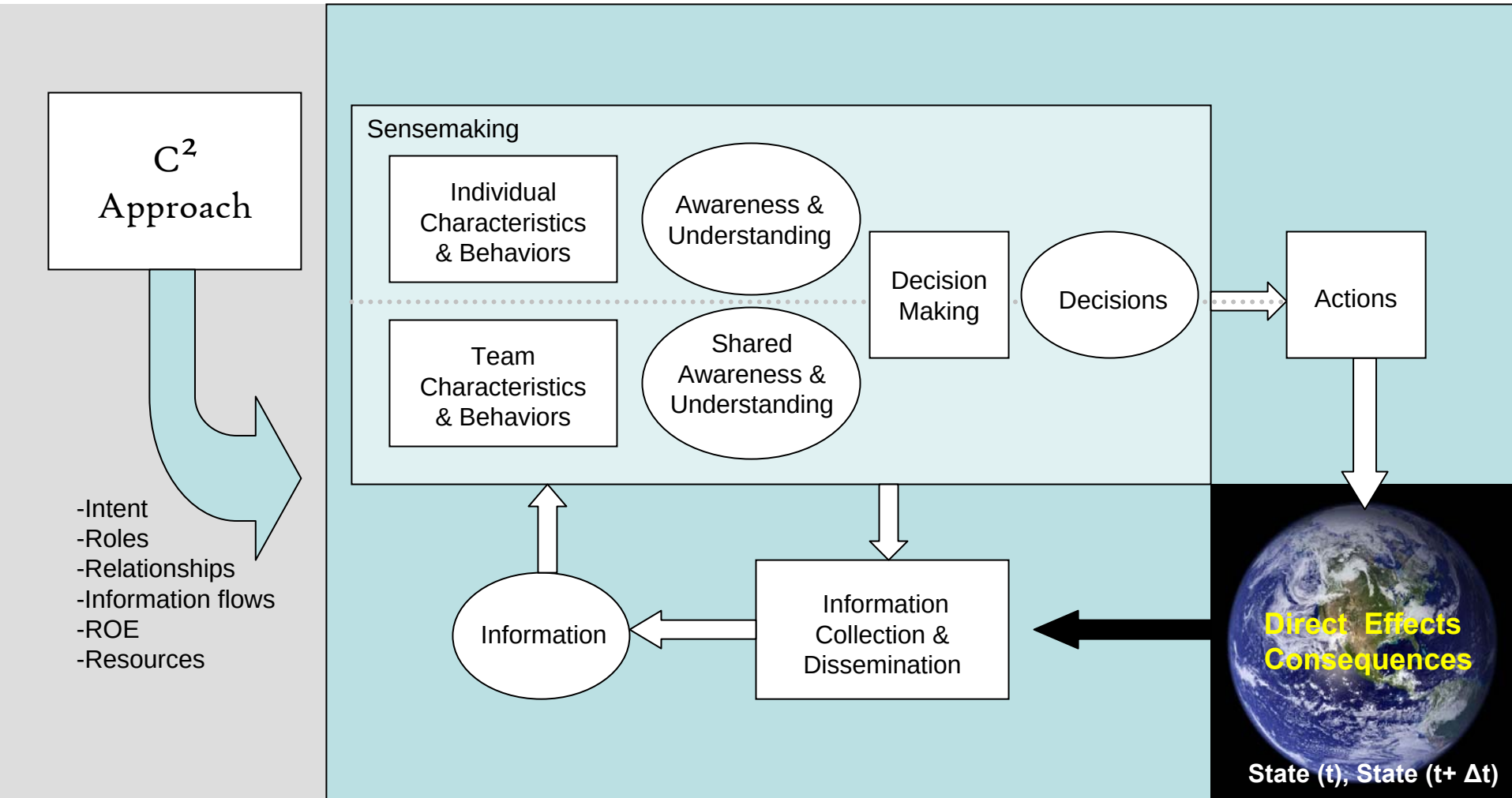
# $C^2$ Approach Space
(circa 2006)

- Explicit recognition that there are different ways of accomplishing the functions associated with command and control
- $C^2$ Approach has 3 inter-related dimensions
  - Allocation of Decision Rights
  - Patterns of Interaction
  - Distribution of Information



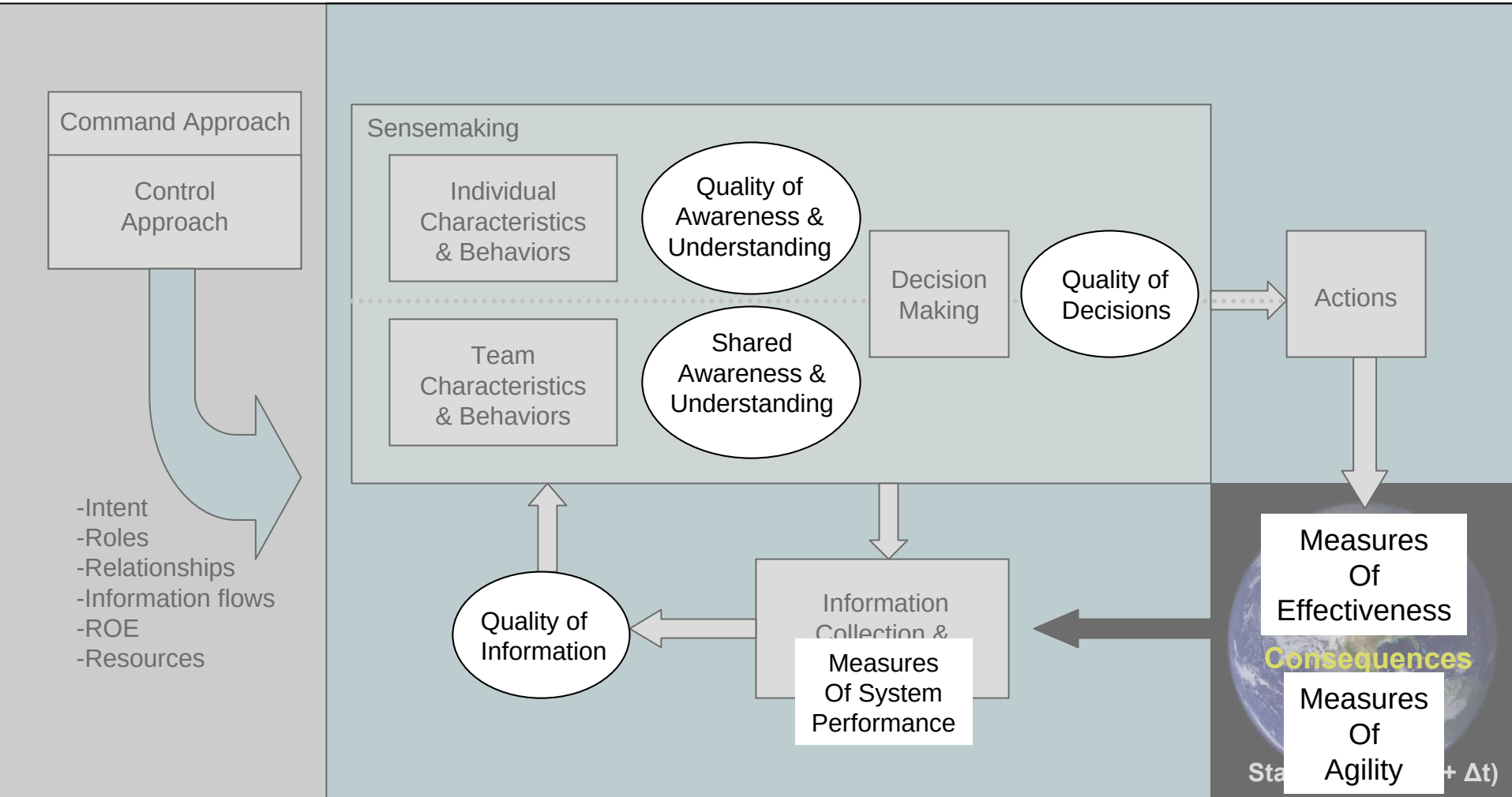
# NATO $C^2$ Conceptual Reference Model

An approach to Command and Control determines the nature of the endeavor, the way individuals and organizations relate to one another, and determines the information positions of all participants

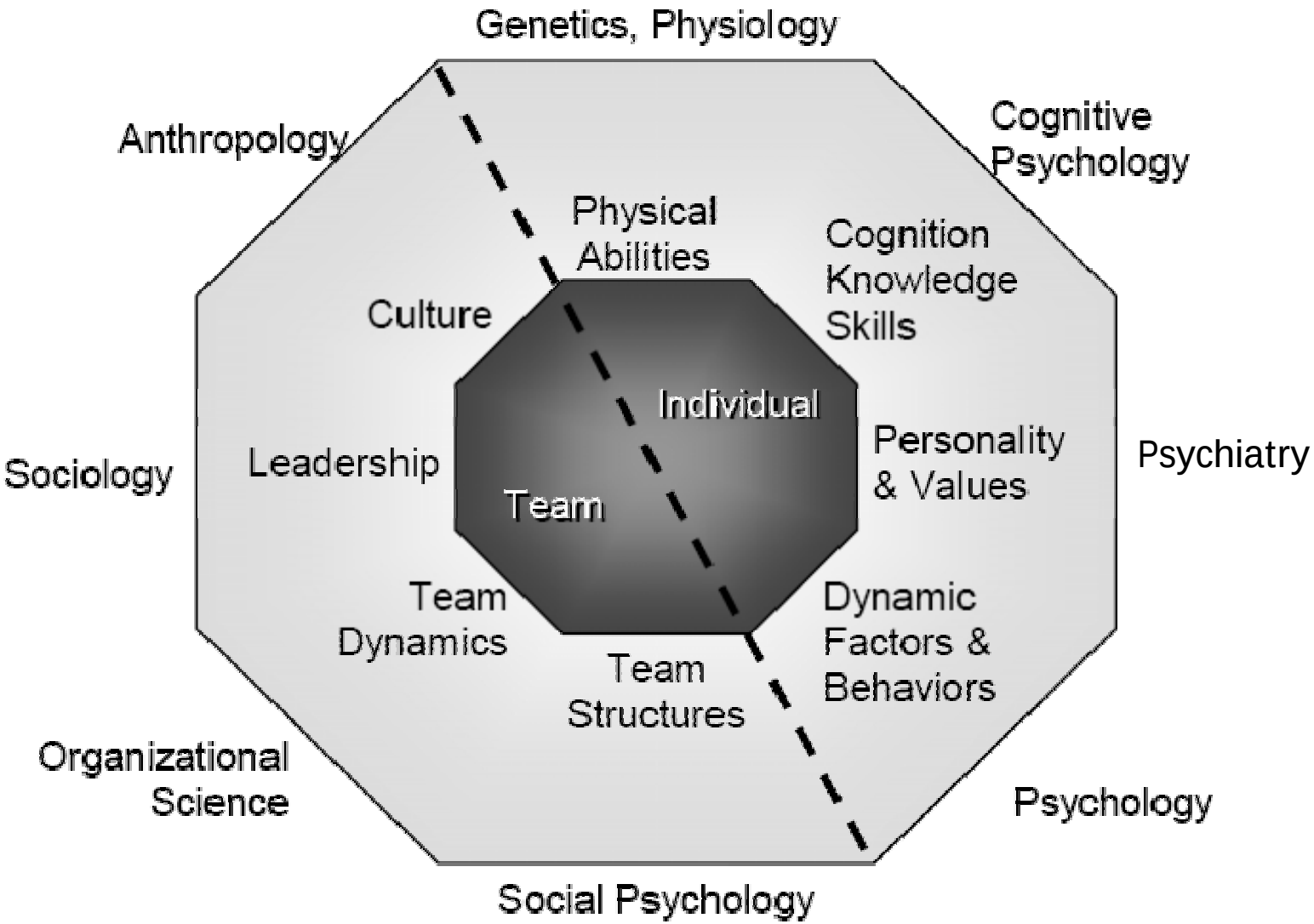


# $C^2$ CRM – Value View

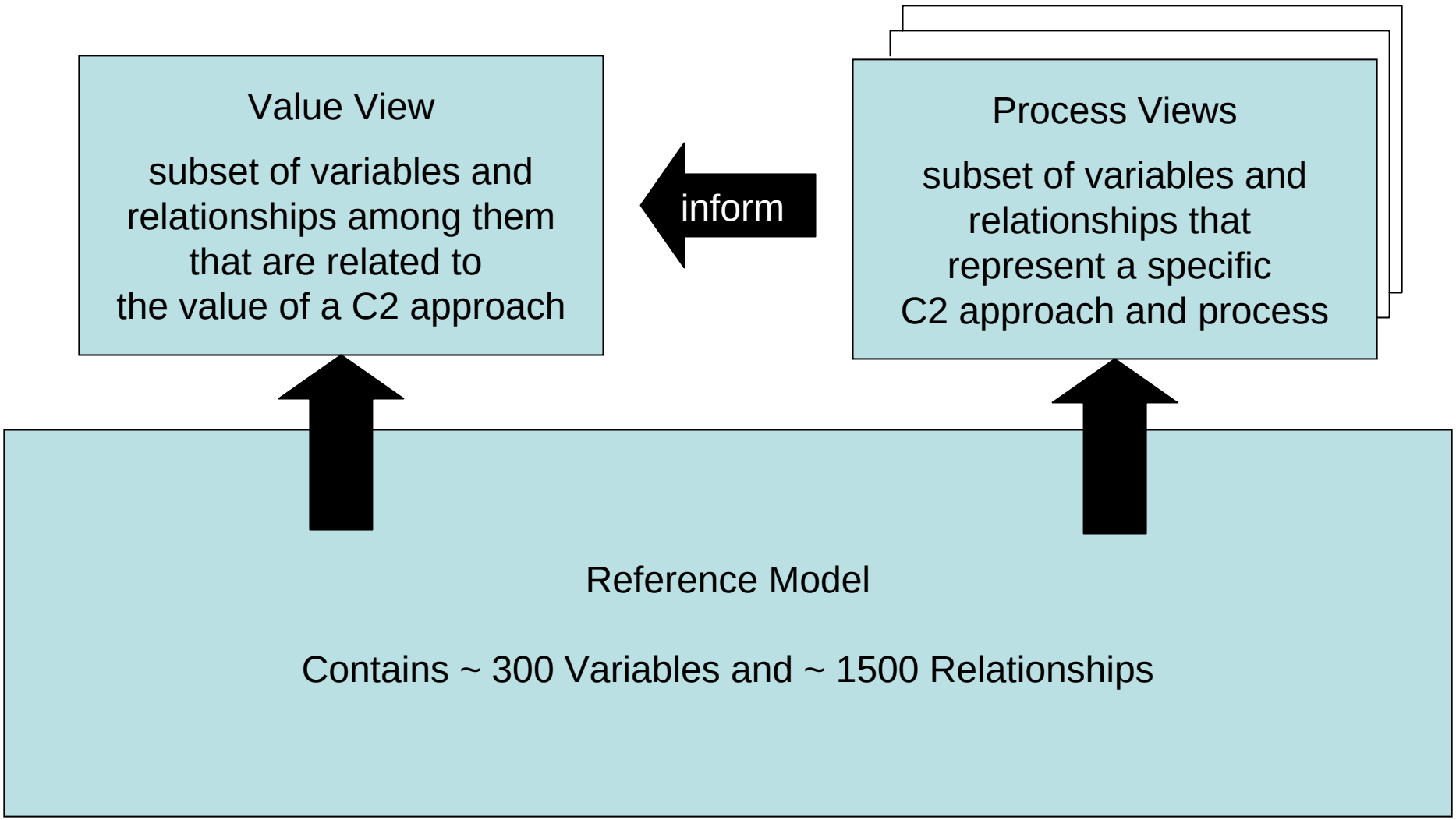
The "Value View" contains a subset of variables from the Reference Model that have been selected to represent the value or utility of a Command and Control approach.



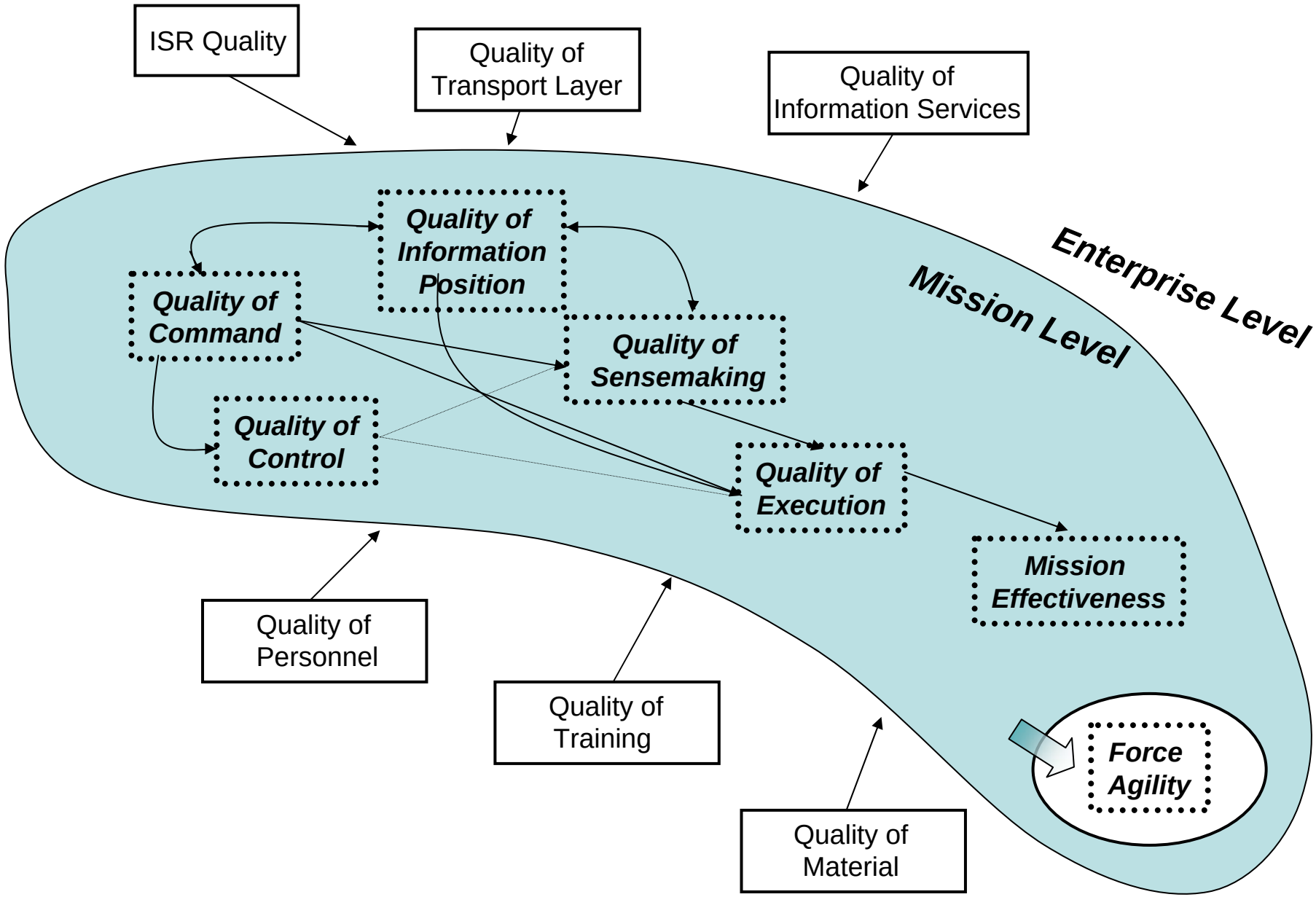
# Individual and Team Variables Related Science Domains

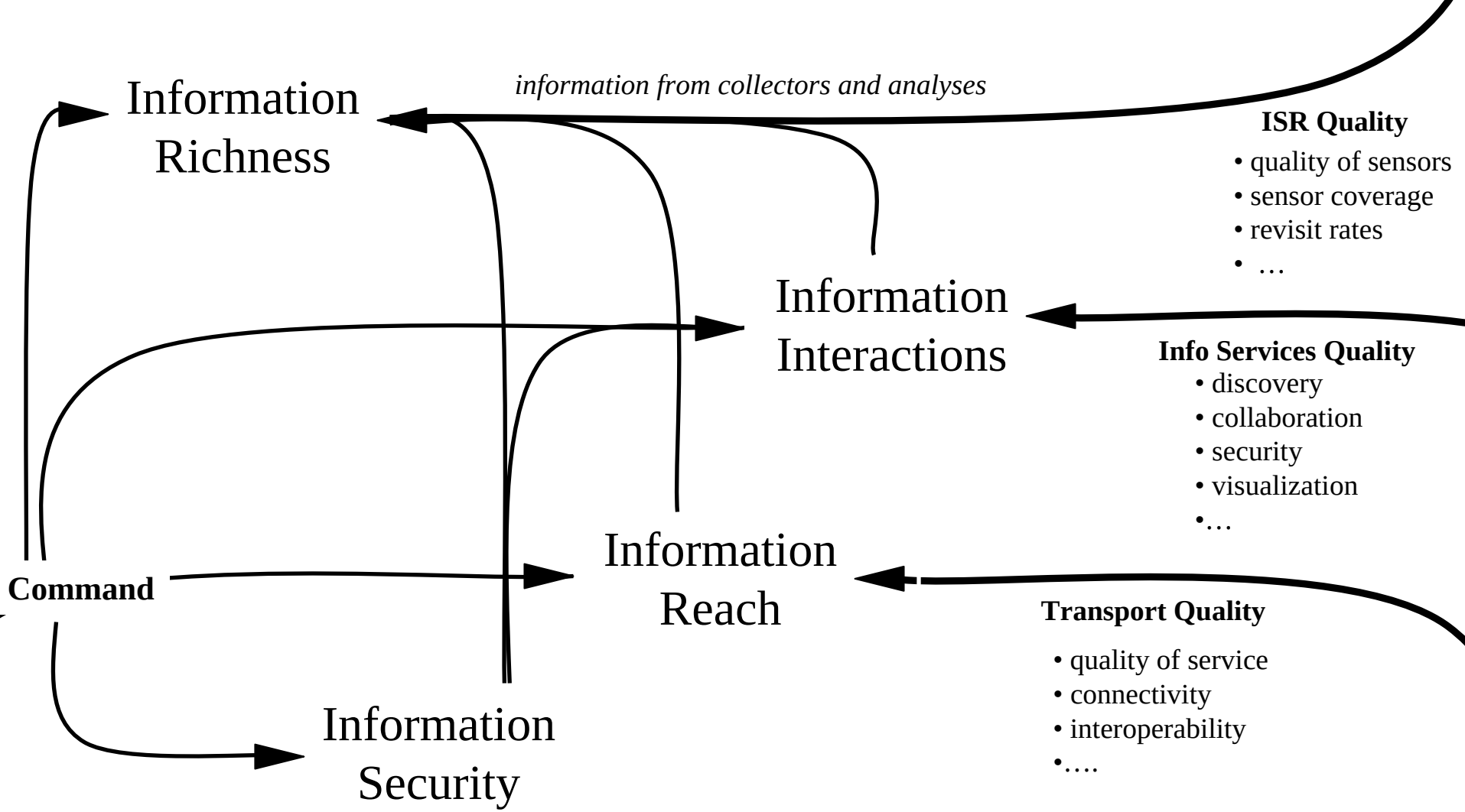


# Value and Process Views



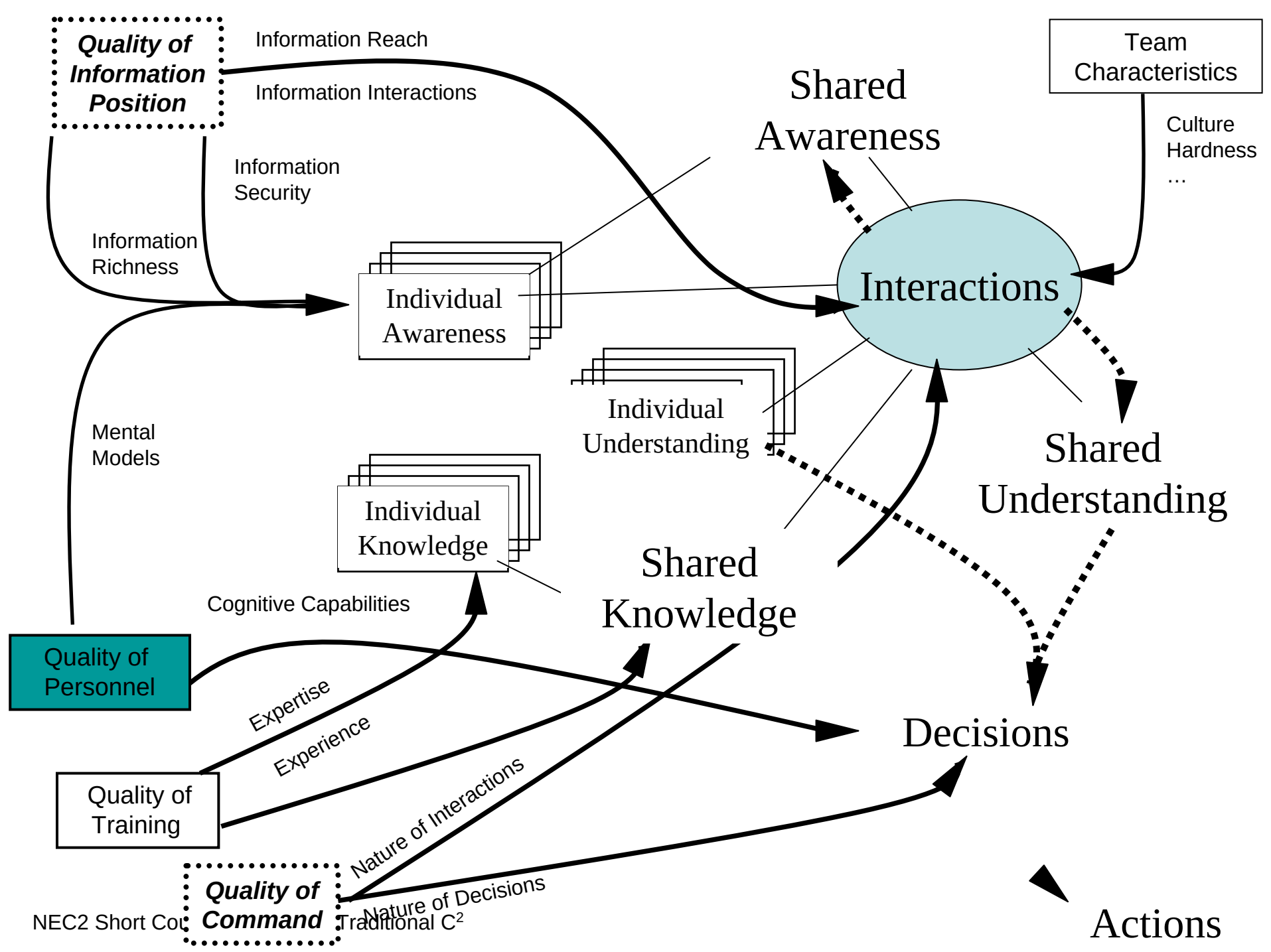
# Enterprise and Mission Value Views






# C²CRM Detail

Sensemaking


Quality of Information Position
Information Reach
Information Interactions
Information Security
Information Richness
Mental Models
Cognitive Capabilities
Expertise
Experience
Nature of Interactions
Nature of Decisions
Quality of Personnel
Quality of Training
Quality of Command
Individual Awareness
Individual Understanding
Individual Knowledge
Shared Awareness
Shared Understanding
Shared Knowledge
Interactions
Team Characteristics
Culture
Hardness
...
Decisions
Actions
NEC2 Short Co
Traditional C²

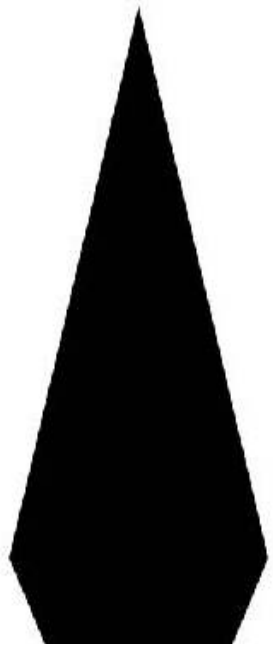
# Metrics: Quality of Individual Awareness

- Correctness
- Currency
- Relevance
- Accuracy
- Precision
- Timeliness
- Consistency
- Uncertainty
- Completeness

# Industrial Age $C^2$ Approaches

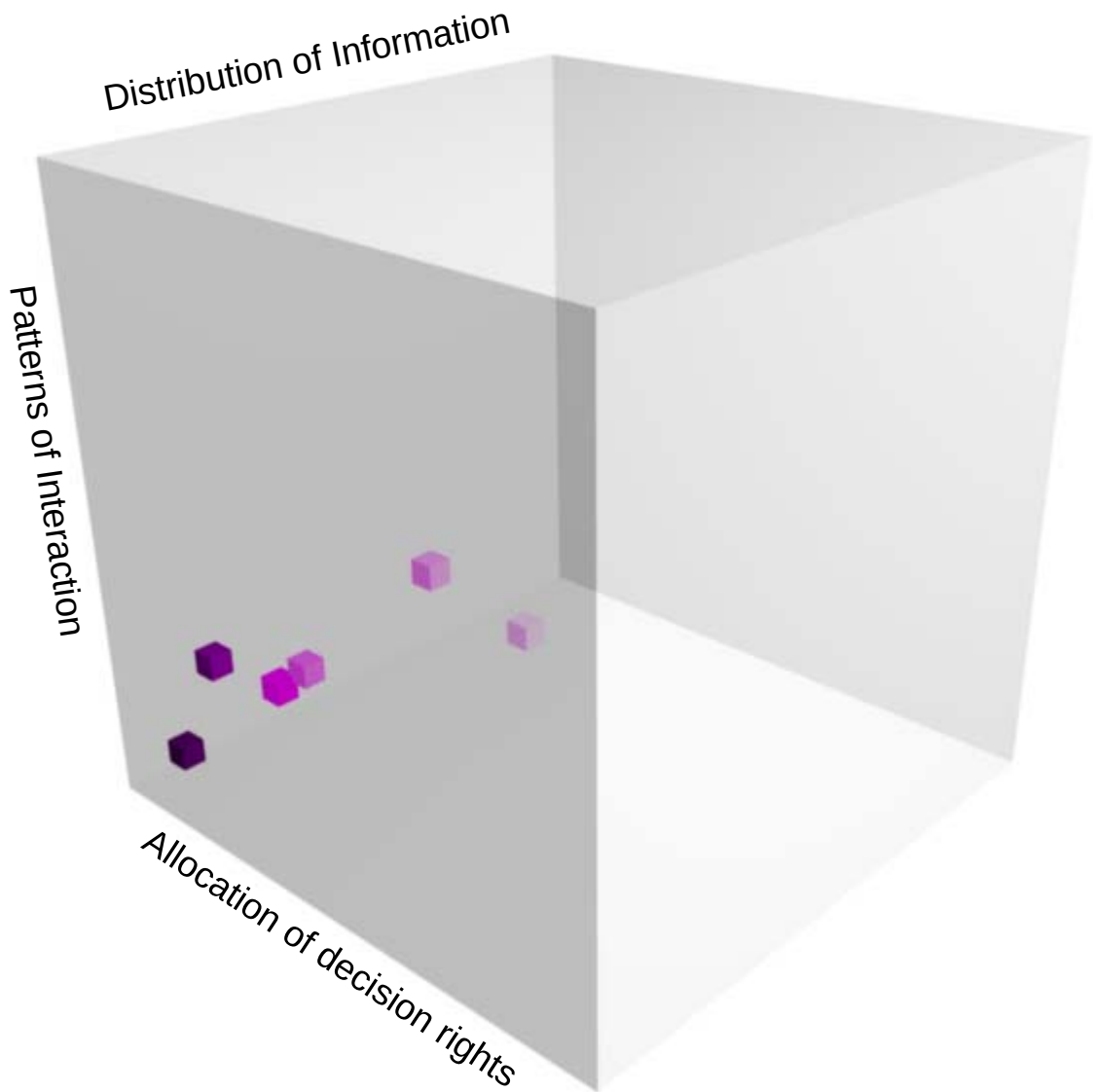
different approaches to $C^2$ have been successful for different militaries under difference circumstances

| DIRECTIVE SPECIFICITY | COMMAND APPROACH | EXAMPLE |
|---|---|---|
| Mission-Specific | Control-Free | WWII German |
| | Selective-Control | Israeli Army |
| Objective-Specific | Problem-Bounding | British Army |
| | Problem-Solving | U.S. Army |
| Order-Specific | Interventionist | Modern Soviet |
| | Cyclic | Chinese Army |



**Information processing capacity**

# Industrial Age $C^2$ Approaches

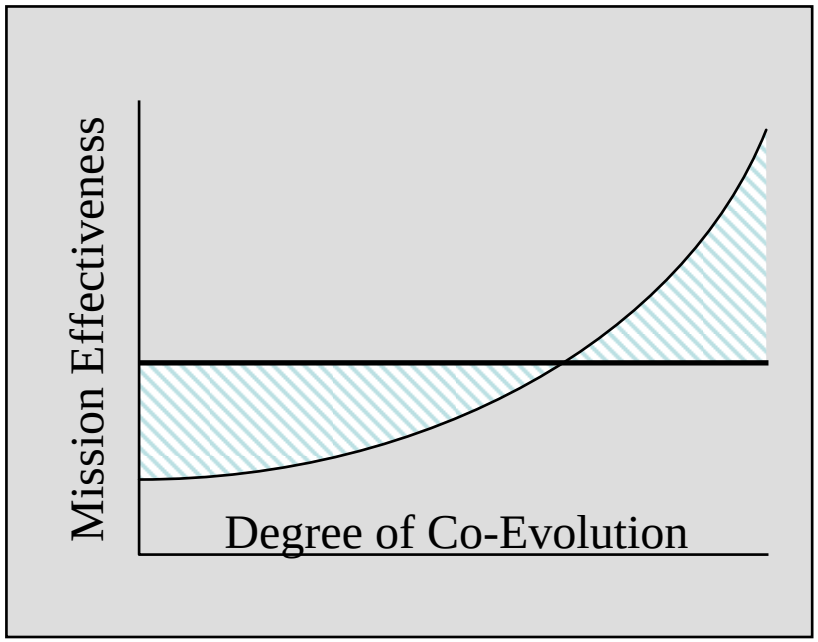



- Control-Free
- Selective Control
- Problem-Bounding
- Problem-Solving
- Interventionist
- Cyclic

# Co-evolution of $C^2$

The $C^2$ Approach must remain

- internally consistent and
- consistent with technological and systems capabilities



# Summary

- $C^2$ shapes and employs (prepares and executes)
- $C^2$ concepts and practices have co-evolved with communications and information technology
- Co-evolution has been limited by traditional military assumptions
- A model of $C^2$ provides a more useful definition than dictionary definitions
- No one approach to $C^2$ is best in all situations and circumstances