Dynamics of Enterprise and Technical System Architectures:

Early insights from Combat Air Operations

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Motivation

- Changing nature of competition
- Increased uncertainty
- Increased interdependence between users, partners, suppliers, other stakeholders
- Increased technical complexity and interdependence between enterprises and technical systems
- Commercial *and* military contexts

Goal: flexible and adaptable enterprises

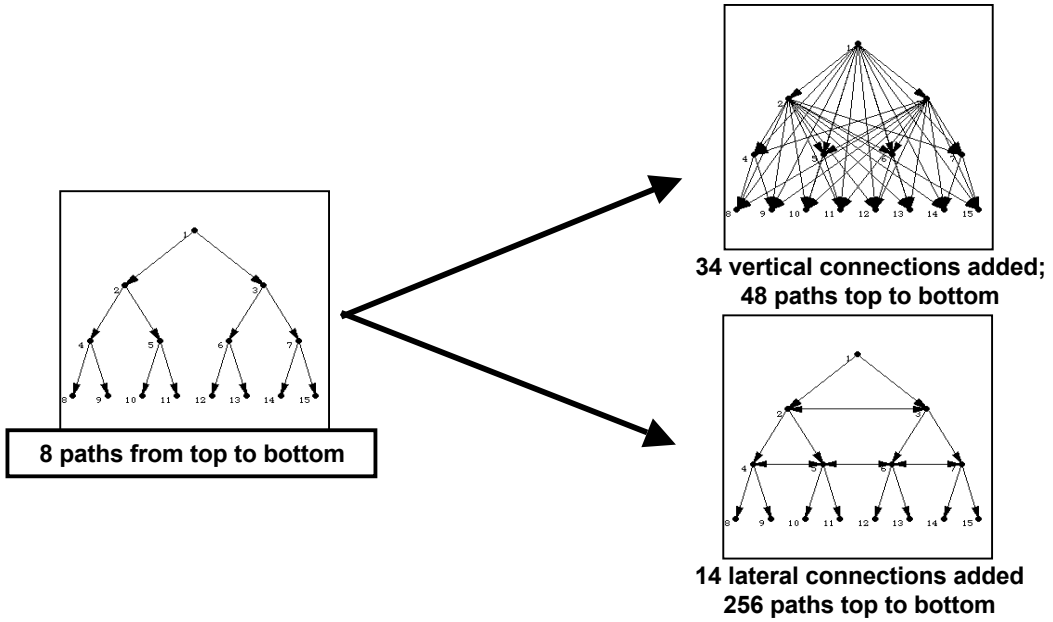
Concept: Network-Centric Warfare

… in operations and acquisition

*Cebrowski, Garstka, 1998

The Basic Idea

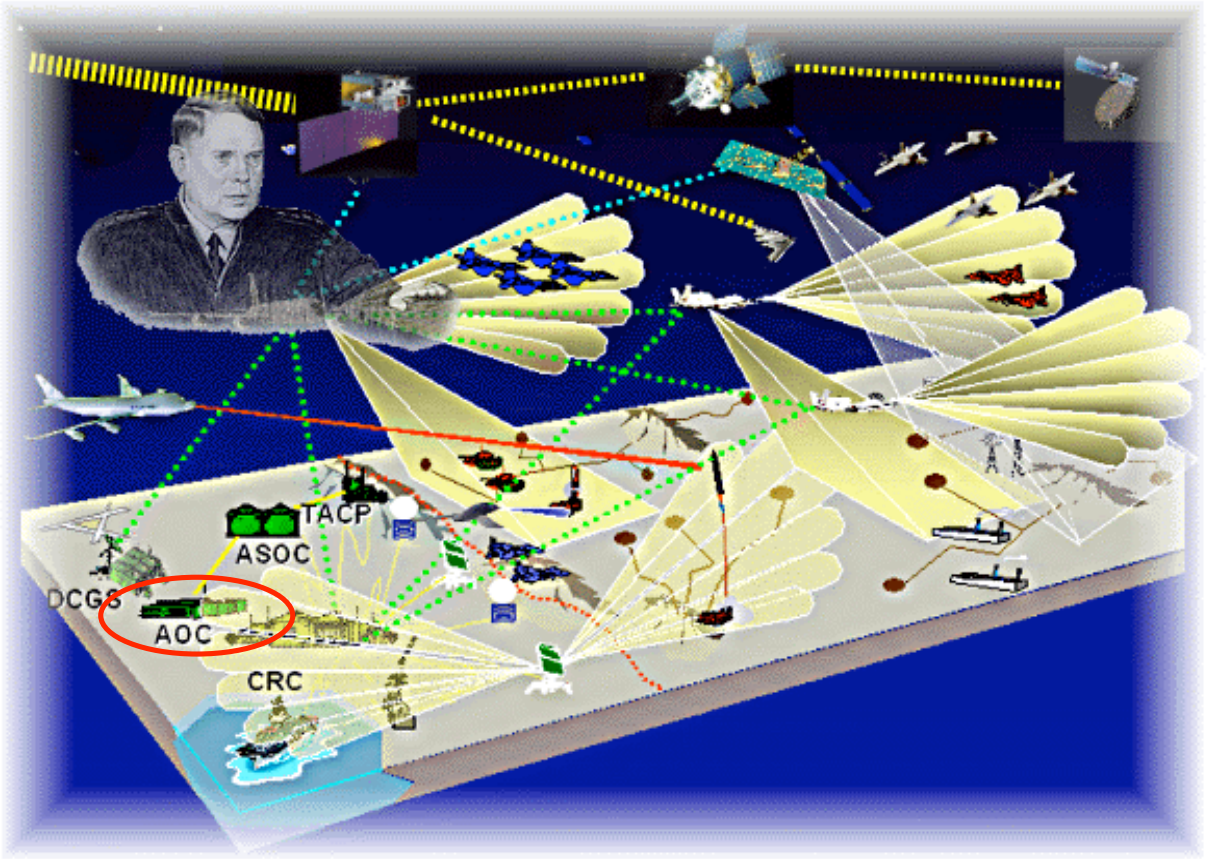
- Classic hierarchical tree structure as the foundation
  - Two basic modifications to create all varieties of structures
    - vertical connections
    - lateral connections (within layers)
- Hypothesis: enterprises with more lateral vs. vertical connections will perform better in complex, dynamic and uncertain environments, both operational and acquisition



Approach

- If we examine architectures of operational military enterprises, we may be able to identify features that
  - correspond to desired attributes
  - provide insights into mechanisms that drive enterprise architectures, such as:
    - Key stakeholder dynamics
    - Doctrines
    - Cultures
    - Other external factors
  - impact and are impacted by technical system architectures and social architectures

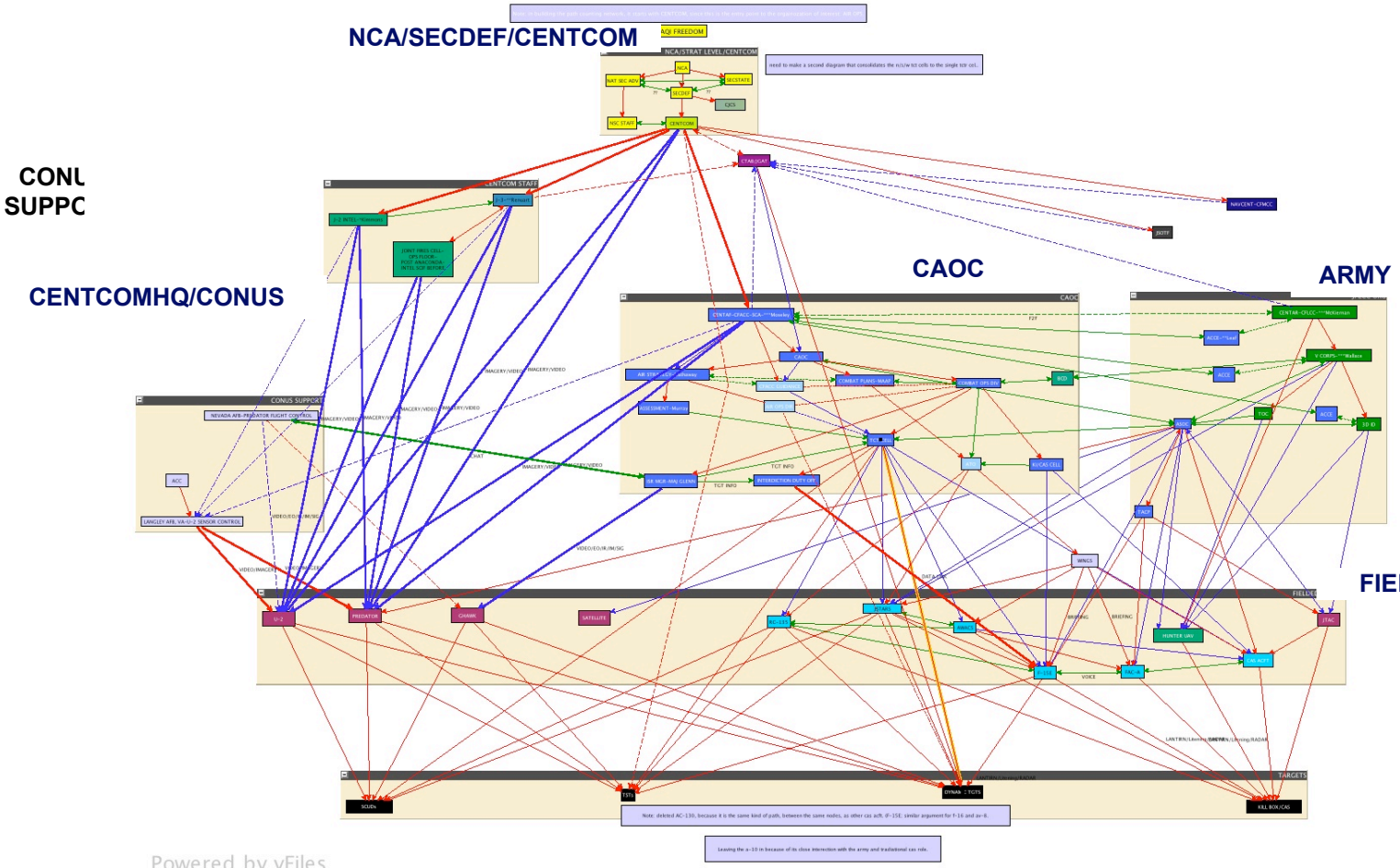
Combat Air Operations



1991-2003

2003: Iraqi Freedom

OIF: ~2003



Measuring the Architecture

- Ratio of lateral to vertical connections
- Number of paths through the system expresses as a ratio to the number of nodes (paths/node)
- Spectral and other network theoretic measures *(in progress)*
- *n.b.: numbers that follow are preliminary*

Initial Attempt at Measurement

CAMPAIGN	(V)	(L)	(LV)	L/V	**LV/V**	(L+LV)/ V	(L+1/2LV)/ (V+1.2LV)	**LN(PATHS/ NODE)**
DESERT STORM	62	21	24	0.34	**0.39**	0.73	0.45	**11.59**
KOSOVO	37	17	35	0.46	**0.95**	1.41	0.63	**10.51**
AFGHANISTAN	71	40	19	0.56	**0.27**	0.83	0.61	**13.56**
IRAQ-II	74	30	43	0.41	**0.58**	0.99	0.54	**11.30**

Note: preliminary data

Insights/Observations

- **Doctrinal organization was never used**
  - **Different organization in each case**
  - **IT enables more choices, more options**
- **No significant *structural* change in air operations C2 enterprise since Desert Storm**
  - **No transformation yet--*at the operational level of enterprise***
- **Possible reasons**
  - **Externally imposed constraints (risk management)**
  - **Doctrinal assumptions about proper use and effectiveness of coercive force--inter-service tussle**
  - **Other forces driving acquisition programs**

Insights/Observations

- **Architectural measures:**
  - **V/L ratio may prove a good proxy measure for flexibility of an enterprise architecture, more work is necessary**
- **Possible that transformational change (and effects) are concentrated at the tactical level**
  - **The core proposition of NCW**
  - **Enabled by changed tactical rules (not operational level architecture)**
- **Potential emergence of a formal coordinating (integrating) layer between service components and Joint Force Commander**
- **Underappreciated:**
  - **Role of key actors/leaders**
  - ***Potential for manipulation of enterprise architecture and the strategic agenda of the enterprise--even in a military context***

Methodological and Analytical Challenges

- Abstraction and modeling may be a more effective than detailed, microscopic, analysis
- Modeling at a larger scale
  - Examination of architecture may be more informative than micro-level analysis
  - Properties of interest to senior leadership are here
  - Architecture places 'boundaries' or 'constraints' on potential enterprise dynamics, properties, actions at the micro-level
- Catch-22: macro-level modeling and analysis must be supported by a robust micro-level theory

Potential Benefits

- A tool to 'measure' progress toward transformation
- Deeper understanding of fundamental dynamics, mechanisms and driving forces in enterprise transformation
  - Highlight areas where management, senior executive attention have most impact
- Concepts and tools to enable design of flexible and adaptable enterprise-technical systems
  - Impact of organizational modularity on performance (Army)
  - Flexibility of programs to changing user requirements (spiral development)
  - Coordination boards

Operationalization

(a larger agenda)

- **Design:**
  - **Bi-directional causality between capability and structure**
  - **What are the limitations of lateral vs. vertical architectures?**
  - **When, where, do different architectures perform 'better'?**
  - **How do/can we design enterprises to preferentially grow lateral connections?**
- **Management:**
  - **Understanding conscious and unconscious forces that drive evolution of enterprise capabilities**
    - **For the specific case of combat air operations:**
  - **Is there an upper limit on what the CAOC can 'command'?**
- **For military operations in general: What architectures enable truly effective capability generation--not just maximization of air power's effectiveness and efficiency?**

Questions

Methodological and Analytical Challenge

"While on the Gulf War Air Power Survey, I started trying to count the informal and lateral links between people and organizations in theater and between theater and CONUS. I gave up because it was very difficult to count and the number was very high…very difficult to trace…these connections saved the formal organization … from collapse by providing timely information, analysis, and instructions."

--Dr. Mark D. Mandeles

C2 Analyst, Gulf War Air Power Survey