NET-CENTRIC CONVERSATIONS: THE UNIT OF WORK FOR NETWORK CENTRIC WARFARE AND NETWORK CENTRIC OPERATIONS

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ABSTRACT

Network-centric warfare and, increasingly, Joint operations, demand vastly increased interdependencies and relationships among net-centric participants to produce net-centric capabilities and increase mission effectiveness. A net-centric conversation (NCC) captures a set of organizing principles that encompass a formal description and management of net-centric relationships among participants, such as people, machines, weapons, and sensors, that produce such a net-centric capability.

The term "conversation" is used deliberately to capture both the essence of an NCC's ability to change and as the interactions among the participants. Each NCC is version controlled, ensuring that participants know of relevant changes in other participants, which in turn creates a basis of trust. Each NCC has agility metrics to quantify the shortest amount of time needed to change any participant, which enables value-driven portfolio management of NCCs. The Global Combat Support System – Air Force is already beginning to support NCCs.

BACKGROUND

The terms *network-centric warfare* (NCW) and *network-centric operations* (NCO) have become common over the last 5 years within DoD and worldwide. In this paper we will use the following descriptions, taken from the executive summary of the DoD report to Congress 2001.

> **Executive Summary of the DoD Report to Congress 2001**
>
> *NCW represents a powerful set of warfighting concepts and associated military capabilities that allow warfighters to take full advantage of all available information and bring all available assets to bear in a rapid and flexible manner.*
>
> ***The tenets of NCW are:***
>
> 1. *A robustly networked force improves information sharing.*
> 2. *Information sharing enhances the quality of information and shared situational awareness.*
> 3. *Shared situational awareness enables collaboration and self-synchronization, and enhances sustainability and speed of command.*
> 4. *These, in turn, dramatically increase mission effectiveness.*
>
> ***Network-centric Operations*** *provide a force with access to a new, previously unreachable region of the information domain. The ability to operate in this region provides warfighters with a new type of information advantage. This advantage is enabled by the dramatic improvements in information sharing made possible by networking. With this information advantage, a warfighting force can achieve dramatically improved shared situational awareness and knowledge.*

Network-centric warfare and network-centric operations (NCO) are based on the existence of a highly connected force capable of leveraging the interdependent relationships among sensors, shooters, and decision makers, all enabled by information technology. Net-centric capabilities (such as new "kill" or "supply" chains[1]) are generated by linking multiple weapons, sensors, and people either permanently or temporarily. These net-centric capabilities must support complex relationships. Traditional bilateral interface exchanges such as Interface Exchange Requirements and Interface

[1] A kill or supply chain links participants in a common activity. For example, a kill chain can include a targeter, an air space controller, and a pilot all working together to put an effect on a target. A supply chain includes the product company, distributor, shipping company, and retail stores working together to bring products to the consumer.

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Control Documents are insufficient to describe and manage complex net-centric capabilities. Since the DoD has no formal mechanism to describe and manage such relationships, it is difficult to maintain trust among participants, which slows adoption of NCO. The adoption of methods to allow system design, engineering and perhaps most important change management is key to supporting the DoD JV 2010 and JV 2020. Starting with Joint Vision 2010 and its successor, Joint Vision 2020, the Joint Chiefs of Staff (JCS) recognized the need for "information superiority" to retain the United States' warfighting advantage in the Information Age. This prompted the Assistant Secretary of Defense for Networks and Information Integration and the Defense Information Systems Agency to urge industry to produce systems that were "interoperable" at various levels. That guidance, in turn, led to the establishment of architectural frameworks and standards to assist in reaching the goal of interoperability. While interoperability is vital to facilitate Net Centric Operations starting with Operation Enduring Freedom made it clear that U.S. forces would carry the fight to our enemies in new ways. The dramatic success of the combined U.S. Special Operations Forces/Air Force and allies in Afghanistan highlighted a significant new requirement: that of interdependence. Forces from the individual Services would no longer operate alone; from very small groups to senior headquarters all operational units would be joint. Increasingly, the Services and their supporting branches will depend on each other for support in the form or transportation, intelligence, and even direct fires to accomplish their mission. The current Army Chief of Staff has frequently emphasized this in both public and private forums, and the Chairman of the JCS has echoed his statements.

The terms “network-centric” and “net-centric” are often used interchangeably and may lead to increased confusion as the concepts of NCW and NCO evolve. Here we use “network-centric” to mean the relationship of the platforms in the sensor network to the platforms in the engagement network. They are linked by an information infrastructure grid consisting of communications links and information systems.

As the concept of NCW and the corresponding operational concept of NCO become established we might expect organizational change to some extent. For example, NCO was integral in Afghanistan and in Iraq, both in the initial high-intensity stage of warfare and in the latter stages of stability operations. We must take into account a society’s/entity’s ability to change as information dominates the nature of relationships, and then we might expect to see greater acceptance of the concepts within the military establishments.

EXAMPLES OF NCO

NCW and NCO are based on the existence of a highly network-connected force capable of leveraging the relationships among sensors, shooters, and decision makers, all enabled by information technology (IT). Net-centric capabilities (such as new “kill” or “supply” chains) are generated by relating multiple weapons, sensors, and people to each other, either permanently or temporarily. These capabilities require the creation and management of transitive multilateral relationships. Traditional bilateral interface exchanges such as information exchange requirements and interface control documents are insufficient to describe and manage transitive, multilateral, net-centric capabilities. Since the DoD has no formal mechanism to describe and manage such relationships, it is difficult to maintain trust among participants, which slows adoption of NCO. Net-centric conversations (NCCs) and their organizing principles address this problem.

In the future, advances in IT will dramatically increase the number of interfaces, interrelationships, and interdependencies between NCO participants, including machines, civilians, and members of the military, whether U.S., allied, or coalition. Moreover, the Information Age allows these relationships to assume an increasingly ad hoc nature. It will no longer be one system, or even a system of systems, but rather the loose coupling of systems and the exchange of data that will allow combat power to be channeled and focused.

The first example of NCO (Figure 1) begins with a sensor: in this case a man on horseback passing the target to the airborne command post over the Global Information Grid. The airborne command post (ABCP) then evaluates the data and determines that additional data is required to engage the target. To gain the additional data the ABCP tasks another sensor: a naval jet fighter that provides the data to the ABCP via its on-board radar. The ABCP then tasks a bomber already in flight. The bomber, in turn,

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passes the data to its precision-guided munitions. Control of the munitions now returns to the original sensor, who becomes part of the command and control process.

The key point here is that this instance of a kill chain was neither anticipated nor specifically trained for. However, the general concept or "type" of net-centric capability certainly could have been anticipated, prepared for, and encoded as an NCC that captures the nature of cooperation and message exchange required to instantiate this type of interaction in the field during operations.

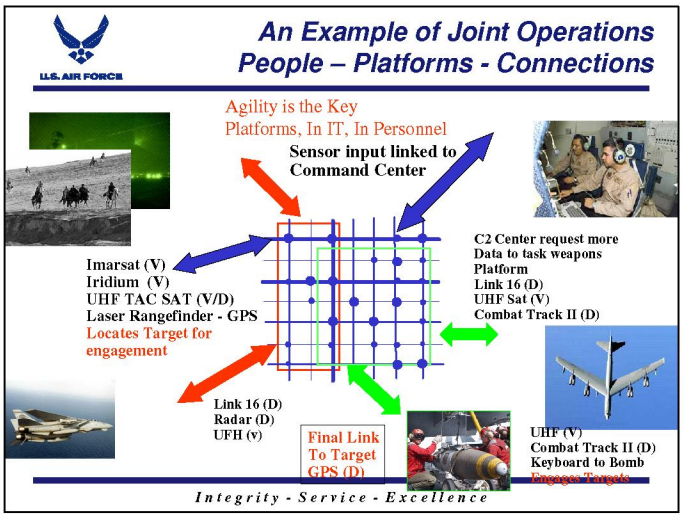

Figure 1 – Joint Operations Increase Interdependencies

Figure 2 illustrates the next example, which is taken from Western Iraq in 2005. Breaking down the radio stovepipes enabled data and information to be shared in ways never before experienced in large-scale conflict. The key technology was the Battlefield Universal Gateway Equipment. This combination of IT technologies permitted data from sensor and command and control platforms equipped with Link 16 to share data with weapons platforms equipped with the Enhanced Position Location Reporting System and to receive information from ground units equipped with several other radio systems. The key point is that stovepipe systems can be linked or loosely coupled, and that this coupling can produce significant combat power by sharing information.

While neither of these examples represents mature NCO, both provide insight as to what is possible when data is shared among people and systems in communities of interest (COIs). We must now develop a means to capture these new transitive multilateral relationships so that engineers can design and implement net-centric capabilities that are agile enough to respond to the highly interdependent and ad hoc nature of today's warfare.

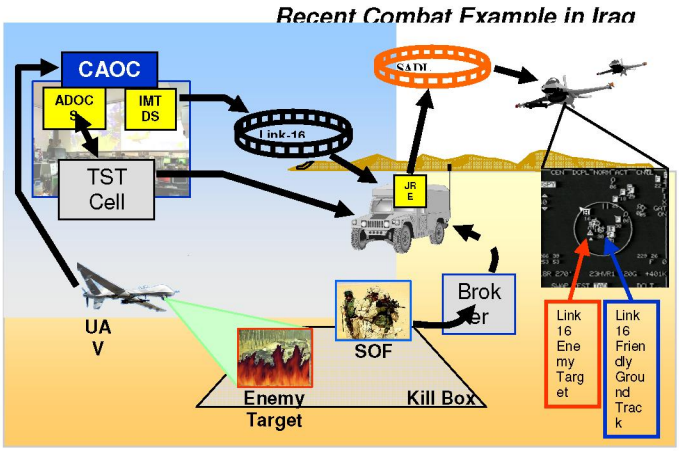

Figure 2 – Breaking Radio Stovepipes Increases Interdependencies

NET-CENTRIC CONVERSATIONS – INTRODUCTION

Existing stovepipe systems and bilateral tools and techniques make it difficult to construct a net-centric capability. In a typical notional example (Figure 3) we see that stovepipe systems expose services S1, S2, and S3, which exchange messages M1, M2, and M3 among themselves and ultimately with the analyst user U1. Moreover, the services are protected by security perimeters P1, P2, and P3. For this capability to retain operational integrity, none of the participants, including security perimeters, can change. The agreements are described in bilateral interface agreements 1–3, managed by separate program offices. Change, if it can happen at all, occurs very slowly, sometimes over a period of years.

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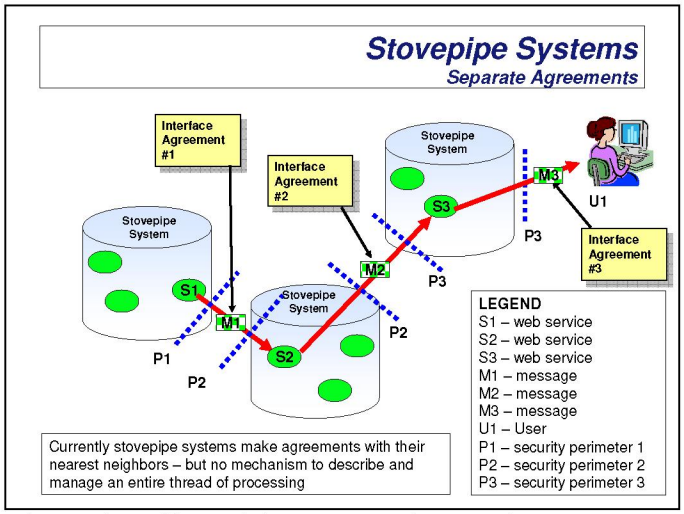

Figure 3 – Bilateral Agreements Are Inadequate

Figure 4 shows an alternative approach that records the transitive multi-party agreement in an NCC, in this case a single agreement, "Publish-01." This agreement can be encoded into metadata and used to analyze the future impact of proposed changes. The NCC allows change to happen in an orderly fashion, facilitates management of that change, and provides the basis for net-centric capabilities to evolve and improve over time without causing disruption to operations.

Our primary focus is on creating and managing relationships among the participants (sensors, shooters, decision makers, supporting machines and people) who use the network to exchange messages. We will not address the network itself (routers, bridges, pipes, etc.), except for the cases where a firewall or proxy would interfere with the exchange of messages. This distinction is important because the network itself should be largely unconstrained in how it delivers services. We simply assume the network service is highly available and has the ability to deliver messages. Further, individual systems with web technologies and messaging technologies such as an enterprise service bus (ESB) do not construct net-centric capabilities in and of themselves. They provide connection mechanisms, but the challenge involves describing, recording, and managing the relationships the DoD wants to create.

Moreover, key aspects of the NCC must be amenable to rapid change to make the NCC adaptable for use in specific situations in the field. In addition to traditional, acquisition-oriented major changes, such as upgrading a service, we will witness parametric changes that can be introduced in a matter of hours or minutes. The ability to accommodate management of both large and small changes, which includes allowing the field to make some structured changes, is what makes the NCC concept transformational.

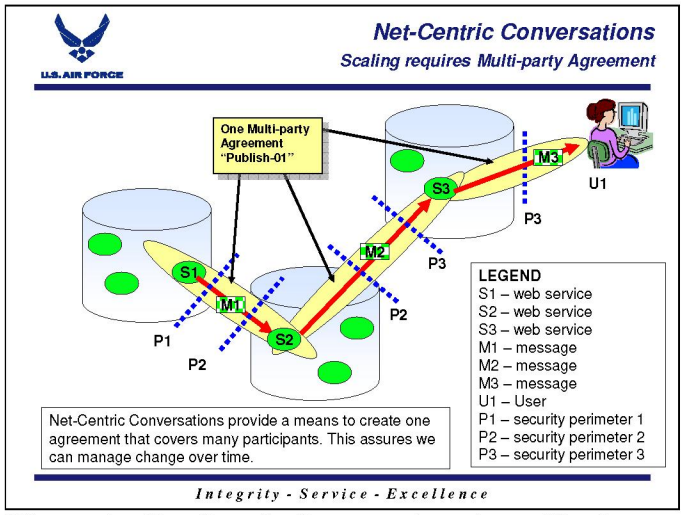

Figure 4 – Net-Centric Conversations Are a Single Agreement

NET-CENTRIC CONVERSATION – DEFINITION AND ORGANIZING PRINCIPLES

An NCC is a persistent multi-party agreement describing a set of relationships between sensors, shooters, decision makers, and other participants that create a net-centric capability. NCCs have five organizing principles:

1. An NCC is described, registered, and discoverable, and represents a persistent net-centric capability.
2. An NCC has both humans and machines as participants and is completely described by the set of possible message exchanges between them.
3. An NCC is associated with a set of net-centric key performance indicators (KPIs).
4. An NCC has an agility profile derived from the agility metrics of the participants and messages.
5. Portfolio management of NCCs reduces the complexity of the enterprise, and forms the basis of value-based evolution of the enterprise.

Principle #1

An NCC is described, registered, and discoverable, and represents the persistent net-centric capability.

NCC is a binding layer (see Figure 5) for the messages and mission services (warfighter and business capability) that in turn use enterprise services. In addition, the NCC describes critical roles for people, supporting doctrine, and procedures. The NCC is entered into an NCC registry so that impact analyses can examine any proposed changes.

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This impact analysis must support the examination of both low-level and high-level changes.

A typical scenario subject to impact analysis is a proposed change to a mission service, for example, to increase the functionality offered by that service. In a transitive multilateral situation many program offices will contribute services. The NCC impact analysis can alert all potentially affected program offices of a pending change that the group needs to discuss.

This scenario also highlights the critical importance of the stability of message structures. Whereas many individual mission services could change with no resulting impact on other participants, the same cannot be said of message structure. In the future message structures will be defined as XML schemas whose vocabulary will be well defined and explained by COI data panels. XML is flexible and can allow extensions, but changing existing structure or the vocabulary itself will have far-reaching effects.

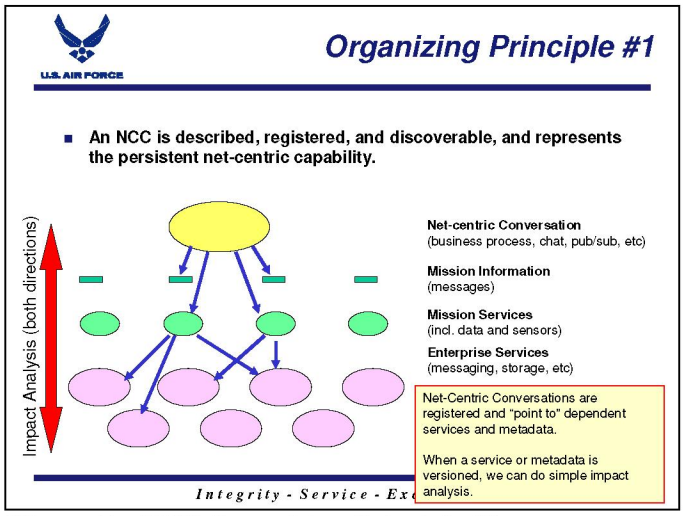

Figure 5 – NCC Organizing Principle #1

Principle #2

An NCC has both humans and machines as participants and is completely described by the set of possible message exchanges between them.

An NCC binds machines and users in a transitive multilateral agreement to produce a net-centric capability. As shown in the NCO examples above as well as in the notional scenario in Figure 6, the capability is enabled by the exchange of messages. We can go a step further and say that the possible message exchanges define the NCC and that this information is what is recorded in the NCC's entry in the NCC registry. We can of course associate supporting CONOPS and other ancillary materials to aid in the understanding and measurement of the NCC, but the message exchange is the center of the net-centric capability.

Figure 6 shows a sample entry in an NCC registry. Each NCC is registered to create a binding and change-controlled record of the participants and the KPIs used to measure the NCC. Each mention of a participant points to its entry in its own registry. For example, Service S1 is described in full in its Service Discovery.[2] The NCC registry then becomes a new, fifth type of Discovery that differs from the others in that it consists of a set of relationships among participants, but does not describe any individual participants in detail.

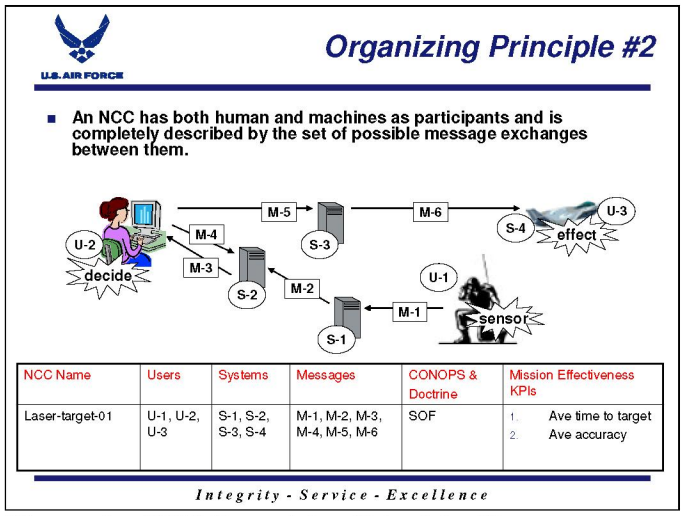

Figure 6 – NCC Organizing Principle #2

Principle #3

An NCC is associated with a set of net-centric KPIs.

Each NCC has an associated set of one or more KPIs. These KPIs must be expressed in terms of warfighter- and/or business-level measurements, as appropriate. This enables a portfolio manager to properly assess the contribution of the NCC to the value of the overall portfolio. Further, if the portfolio manager wants to improve the value (KPI) s/he can do so in an objective manner. This must be balanced against the cost of changing the NCC, as revealed by its agility profile (see principle #4).

[2] DISA NCES program prescribes four Discovery services (registries) – Services, Metadata, Content, and People – as part of its SOA Foundation (SOAF). We are proposing a fifth type of Discovery to maintain relationship links between all the other entries.

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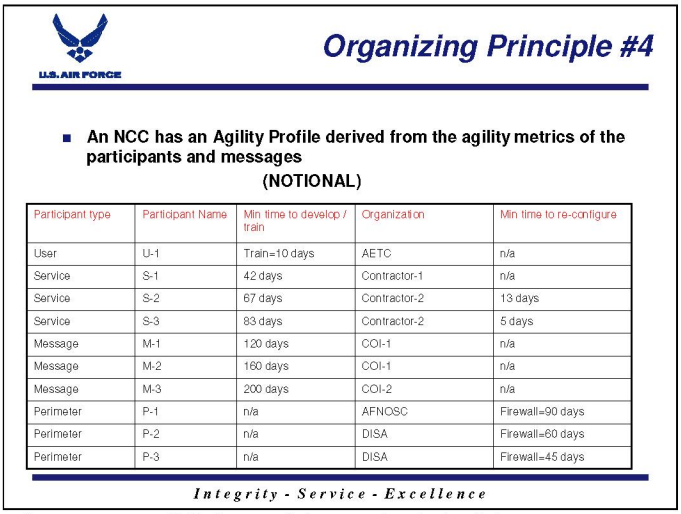
The warfighter- and/or business-level KPIs will be derived from a combination of human/machine observations (e.g., time to target, target assessment) as well as lower level IT infrastructure measurements (time for certain messages to arrive or be dispatched). These KPI derivations will generally be custom built, and represent a key asset in managing the NCC portfolio.

Principle #4

An NCC has an agility profile derived from the agility metrics of the participants and messages.

One of the defining measures needed for managing NCCs is a determination of the "minimum time to change (including configuration)" associated with participants (Figure 7). These individual measurements are rolled up into the minimum time to change any NCC. That minimum time depends strongly on the develop/deploy/configure processes employed by each participant's owning organization. By raising the visibility of the amount of time needed to change participants, we can focus policy and resources on high-priority "slow spots." Thus, NCC agility metrics will, for the first time, give us a summary view of how agile the enterprise is, which is a key performance metric for DoD transformation.

Agility has two aspects: that of the acquisition community and that of the operational community. The acquisition community constructs NCCs or pieces of NCCs that must be highly reliable and event driven (vice file transfer or database copy driven) and that include major acquisition-controlled systems as participants. The DoD must support both institutional pieces of an NCC, as well as support the operational edge of an NCC, by leveraging light-weight development and/or configuration changes. In both cases, NCC registries with impact analysis and agility metrics guide NCC evolution so that all participants remain informed and stability is maintained.



Participant type	Participant Name	Min time to develop / train	Organization	Min time to re-configure
User	U-1	Train=10 days	AETC	n/a
Service	S-1	42 days	Contractor-1	n/a
Service	S-2	67 days	Contractor-2	13 days
Service	S-3	83 days	Contractor-2	5 days
Message	M-1	120 days	COI-1	n/a
Message	M-2	160 days	COI-1	n/a
Message	M-3	200 days	COI-2	n/a
Perimeter	P-1	n/a	AFNOSC	Firewall=90 days
Perimeter	P-2	n/a	DISA	Firewall=60 days
Perimeter	P-3	n/a	DISA	Firewall=45 days

Figure 7 – NCC Organizing Principle #4

Principle #5

Portfolio management of NCCs reduces the complexity of the enterprise, and forms the basis of value-based evolution of the enterprise.

NCCs are managed with a combination of KPI performance metrics balanced against agility metrics, as shown in Figure 8. This additional transformation tool helps to rationalize the process of adding capability.

- Leadership (military and civilian) can understand the capability of an NCC because the capability is described in warfighter and/or business terms.
- Leadership can understand the performance of an NCC because the performance is measured in warfighter/business terms.
- Leadership can understand the minimum time to change an NCC because each NCC has an associated agility profile.
- Leadership can balance the need to improve KPIs against anticipated agility costs in an objective manner.

Leadership can also understand how NCCs relate to each other because NCCs can be assembled to yield compound NCCs. The set of all NCCs and their relationships to each other represents the "as-built" architecture of the enterprise, expressed in capability terms. This will focus leadership attention on integrated capability transformation and away from isolated systems or particular technologies.

Portfolio management of NCCs requires a social and organizational transformation to recognize that net-centric capabilities, including NCCs, require a rethinking of

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ownership. Currently, isolated programs of record (PORs) own capability. To support increasing Joint interdependencies we must be able to express these interdependencies as NCCs and establish the right level of ownership. This discussion goes beyond the scope of this paper, but the authors predict that high-level compound NCCs will be owned at the Joint level, and that the Office of Force Transformation will monitor agility metrics.

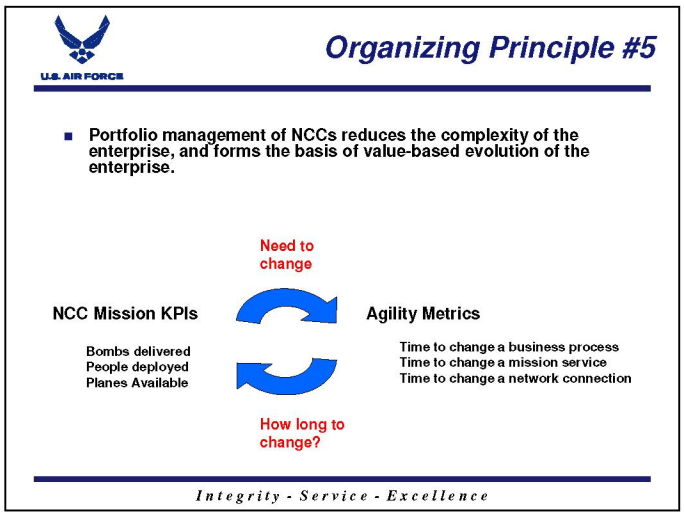

Figure 8 – NCC Organizing Principle #5

EXAMPLE FROM GCSS-AF

The Global Combat Support System – Air Force (GCSS-AF) is a National Security System that supplies the information system infrastructure to applications and services for Air Force operations support. GCSS-AF provides application, hosting, data, integration, and security services, as well as the Air Force Portal. Integration services include an ESB that allows applications and services to exchange messages. GCSS-AF is currently developing several NCCs in partnership with the programs, their systems and COIs that supply the mission services. The example below illustrates how GCSS-AF is assembling mission and enterprise services into an NCC to deliver a net-centric publish/subscribe capability.

Figure 9 shows a notional example of a simple personnel change notification. Publishing notifications of change is a key enabler of NCW that shares awareness among participants and increases self-synchronization. Publishing Service S-1 (personnel) sends a notification message to the ESB E-1 service on the NIPRNET (network-1) side of GCSS-AF. The notification takes the form of a publish message, M-1. The ESB E-1 then pushes Message M-1 to Subscribing Service S-2 (force readiness) on the ESB E-1 side, and also to Subscribing Service S-3 (warfighter) on the ESB E-3 (network-2) side via the cross-network service E-2.

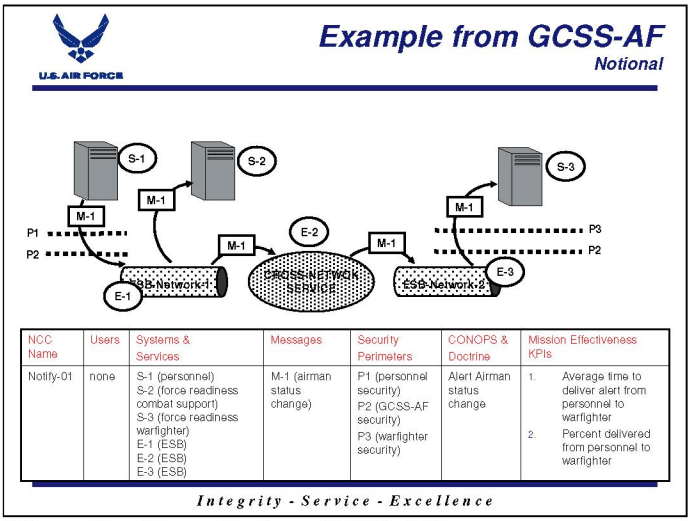

Figure 9 – Example from GCSS-AF

Even this very simple example (one publisher, two subscribers) involves ten participants: three services, two ESBs (network-1 and network-2), the cross-network service, the message payload schema/semantics, and three security perimeters. If any one of the participants must change, each of the remaining participants must be consulted beforehand. Each type of change must be coordinated, and is associated with different agility metrics. Table 1 continues the notional example.

Table 1 – Sample NCC Agility Metrics

Configure ESB when new subscribers are added	1 day[3]
Create SOA that permits easy substitution of services as long as interfaces are maintained	5 days
Change subscribing services if message payload semantics change	180 days
Change filters for cross-network services if message semantics change	6 months–1 year

These agility metrics are an important factor when evaluating proposed NCC changes to determine the shortest amount of time needed to make a version change. We can balance the value of the change against cost and time.

[3] This is an example where publish and subscribe connections are configured, not developed, and can support agility in the field.

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SUMMARY

NCC organizing principles enable us to build net-centric capabilities from transitive multilateral relationships among new and existing information systems and users and to measure them with KPIs. They also allow us to maintain version control across all participants in an NCC and to track agility metrics, which quantify the minimum time needed to change individual NCC capabilities and the enterprise as a whole. Understanding the overall agility of the enterprise is critical to successful transformation to net-centricity.

Bibliography:

1. " Network Centric Warfare - Leveraging Information Superiority" CCRP 1999/ 2000 first and second editions – Figure 1
2. Western Iraq paper presented at June CRP San Diego Calf 2006 – Figure 2

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