S&T Implications for Net Centric Operations

Jude E. Franklin, Ph. D.
TD, Command and Control
Raytheon Net Centric Systems
703-923-2218
703-923-2207-fax
978-902-5222-cell
6225 Brandon Avenue, Suite 230
Springfield, Virginia
22150-2519
Jude_E_Franklin@Raytheon.com

Abstract

The evolving environment for Net Centric Operations (NCO) is changing the requirements and capabilities that are needed for successful military and civil operations. This in turn is demanding science and technology developments of new enabling technologies with associated NCO capabilities. The Office of Naval Research (ONR) has studied these needs and has developed a Technical Taxonomy and associated shortfalls for Naval Net Centric Operations. This paper discusses that taxonomy and provides an examination of eight technology areas that are required to support five enabling functions necessary for Net Centric Operations. The taxonomy can be found on the ONR web site- http://www.onr.navy.mil/02/baa/expired/03_007/default.asp (Reference 1)

1.0 Introduction

For purposes of consistency, here is background on FORCEnet from the February, 2003 Naval Institute Proceedings (Reference 2). "ForceNet will enhance dramatically how the Navy acquires, shares, and capitalizes on information superiority to generate transformational combat effectiveness. It has its roots in the visionary work of the Chief of Naval Operations' Strategic Studies Group based in Newport, Rhode Island. After years of research and concept generation, the Strategic Studies Group defined ForceNet as "the operational construct and architectural framework for naval warfare in the information age that integrates warriors, sensors, networks, command and control, platforms, and weapons into a networked, distributed combat force that is scalable across all levels of conflict from seabed to space and sea to land." ForceNet implements the theory of network-centric warfare.

Developing ForceNet will involve designing and implementing a network architecture that includes standard joint protocols, common data packaging, seamless interoperability, and strengthened security. It requires identifying and prioritizing capability investments within and across joint, interagency, and international programs. Most importantly, it will emphasize people as the center of ForceNet development, so that technological advances support increasingly rapid and accurate decision making. "

"The goal of ForceNet is to arm our forces with superior knowledge, leading to increased combat power. In pursuit of this goal, ForceNet will provide a comprehensive network of sensors, analysis tools, and decision aids to support the full array of naval activities, from combat operations to logistics and personnel development. The focused, timely, and accurate data delivered by ForceNet will help leaders at every level by allowing them to draw on vast amounts of information and share the resultant understanding. This will increase the joint force's ability to synchronize activities throughout the battle space to achieve the greatest impact."

2.0 Discussion of the Technical Taxonomy

The Navy has developed a process for the selection of R&D to support Net Centric Operations evolution and transformation. The figure below shows the process that ONR has pursued to identify NCO critical operational capabilities and associated S&T. The process is driven from military operational capabilities. It then identifies functional capabilities and associated required enabling technologies. This process allows the operational capabilities to be prioritized, the functional capabilities to be prioritized and finally the S&T enablers can be prioritized. The process is iterative to ensure identification and convergence of technology enablers that will satisfy operational needs

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                        ┌─────────────────┐
                        │ • Platforms     │
                        │ • Sensors       │              ┌──────────────────────┐
┌─────────────────┐     │ • Weapons       │              │ Support Integrated   │
│ NCO Operational │────▶│ • CSS           │              │ Situation Awareness, │
│ Capabilities    │     │ • C4 Infrastructure │────────▶│ Decision Making, and │
└─────────────────┘     └─────────────────┘              │ Execution            │
        │                                                └──────────────────────┘
        ▼                                                          │
┌─────────────────┐                              ┌──────────────────────────┐
│ NCO Functional  │─────────────────────────────▶│ Provide Information       │
│ Capabilities    │                              │ When and Where Needed     │
└─────────────────┘                              │ and in an Appropriate Form│
        │        └───────────────────────────────┘                          │
        ▼                                         └──────────────────────────┘
┌─────────────────┐                                          │
│ NCO Technical   │      ┌──────────────┐      ┌──────────────────────┐
│ Capabilities    │─────▶│ Technology   │◀─────│ Essential Enabling   │
└─────────────────┘      │ Appraisal    │─────▶│ Technologies         │
                         └──────────────┘      └──────────────────────┘
                                │
                         ┌──────────────┐
                         │ S&T Needs    │
                         └──────────────┘
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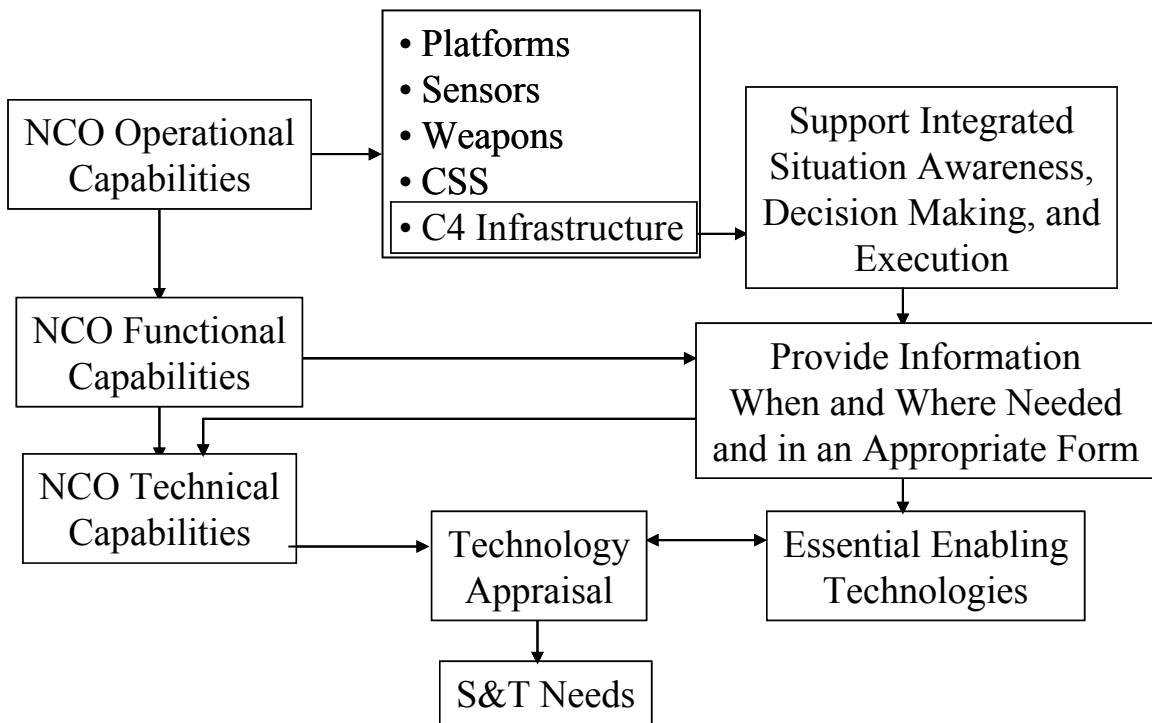
Figure 1. S&T investment Process for Net Centric Operations

Figure 2 shows the major operational capabilities that must be satisfied to support Naval Net Centric Operations. The major operational capabilities are

- Situational Awareness and Understanding
- Planning and Force Management
- Direction, Action, Synchronization and Control

These operational capabilities are the drivers that are used in the S&T process selection shown in the upper left-hand portion of Figure 1

Figure 2. "Operational Capabilities for Net Centric Operations"

The five NCO enabling functions to support FORCEnet are listed below:

1. Universal, seamless, robust communications, connectivity and network service management
2. Assured information integrity
3. Effective information processing, assessment, sharing/collaboration, presentation, and navigation
4. User focused information management and dissemination/communications
5. Empowered disadvantaged personnel and systems

These five areas provide the essence of what is needed to achieve the necessary operational levels and capabilities depicted in Figure 2. The next step was to identify the enabling technologies that are needed to achieve the five enabling functions listed above. There were eight enabling technologies identified as being key to achieving the five enabling functions for FORCEnet and NCO. In this way, the enabling technologies can be related directly to the NCO enabling functions and they can be benchmarked in quantifiable terms to determine the degree of satisfaction of the Navy's needs.

The eight enabling technology areas are listed below:

1. Reliable communications and infrastructure management
2. Information distribution management
3. Geographically distributed, computing infrastructure
4. Situation understanding
5. Automated adaptive dynamic planning
6. Human machine interface
7. Information assurance and information operations
8. Modeling and simulation

These eight enabling technology areas can be decomposed as shown below:

1. Reliable communications and infrastructure management
   - Data Transport and Transmission Systems/Data Links
   - Networking
   - Infrastructure and Computational Resource Management

2. Information distribution management
   - Interoperability Software for (for legacy networks)
   - Information Access and Delivery Software

3. Geographically distributed, computing infrastructure
   - Electronic Devices and Components (disadvantaged user and remote sensors
   - Adaptive Network Computing Management and Services
   - Power Sources (disadvantaged user, autonomous vehicles and remote sensors)

4. Situation Understanding
   - Information Integration Fusion and Correlation for current ISR systems, sensors and open sources
   - Computer Aided Inferencing and Reasoning
   - Autonomous Intelligent Vehicles and Platforms
   - Collaborative Environment
   - Pervasive Computing/Ubiquitous Computing
   - Remote Equipment Diagnostics
   - Augmented Reality

5. Automated Adaptive Dynamic Planning
   - Decision Support Systems
   - Cooperative Software Agents
   - Autonomous Intelligent Vehicles and Platforms
6. Human-Machine Interface (including disadvantaged users)
   - Visualization of Operational Situations and Plans
   - Explanation Agents
   - Alerting and Cueing Agents (for system monitoring and control)
   - Natural Language and Foreign Language Understanding
   - Hands-Free Human-System Interface
   - I/O in Stressing Environments (Noise, Motion, etc.) for Mobile Field Operators
   - Computer Aided Reasoning
   - Augmented Reality

7. Information Assurance and Information Operations

- Confidentiality
- Authentication
- Audit and Analysis of Network Activities
- Integrity
- Network Traffic Processing and Data Base Interaction Analysis
- Ensuring Trusted Systems
- Offensive Information Operations
- Computer Aided Reasoning/Pervasive Computing
- Detection of Covert Information

8. Modeling and Simulation
    - Situation Awareness
    - Course of Action Evaluation
    - Interoperability

The above process and identification of enablers is called the NCO Technical Taxonomy. The Technical Taxonomy, in this context, is a hierarchy of information technologies that support Net Centric Operations and FORCEnet. Each of the eight enabling technologies was examined to identify shortfalls that could prohibit successful Net Centric Operations. The document that can be found on the ONR web site (Reference 1) has over 108 footnotes that discuss potential limitations, ongoing R&D and possible solutions. The document lists over 200 S&T shortfalls. Feedback on this Technical Taxonomy is welcomed.

The following is an example of the Technical Taxonomy. Each section of the Technical Taxonomy describes an enabling technology area, such as decision support systems, that is shown below. There is a brief explanation about the meaning of the technology area (in this case decision support systems). The document then identifies limitations that need to be overcome to support Naval NCO. This particular example is from Section 5, the Automated Adaptive Planning portion and the first entry, Section 5.1 addresses Decision Support Systems. The actual paragraph numbers from the technical taxonomy are included as part of this example.

"5.1 Decision Support Systems

Automated intelligent machine capabilities to work with operators, machines and sources of information to produce and adjust planning in support of battle management execution, command and control, resource allocation and logistics.
5.1.1 Current systems are manpower intensive and cannot adjust to changing operational conditions in a timely manner.
5.1.2 There is little feedback and little support for the discovery process.
5.1.3 Unable to coordinate distributed planning processes that automatically adapt to a changing operational scenario with current systems.
5.1.4 Current real time systems do not interface very well with near real time planning systems and validated M&S systems.
5.1.5 There are a number of S&T issues including limitations on computing platforms to perform deterministic operations research optimization algorithms as well as the real-time access to resource states in optimizing or

dynamic repair of mission plans. Maintenance and resource allocation systems are typically unavailable to mission planners while performing alternative courses of action. Other issues are correlated to earlier sections of the technical taxonomy to include how mission planning data is transmitted or shared across platforms. In most cases, good metrics are required to determine operational success. "

The portion of the taxonomy shown above would contain footnotes that amplify descriptions and limitations. As another example, Information Distribution Management, Section 2, is addressed below. The taxonomy amplified the meaning of Information Distribution Management, identified functional shortfalls caused by technology limitations and then provided critical S&T needs.

- Network-Centric Vision Objective
    - Automatically provide the right information at the right time
    - Eliminate unnecessary distribution and delivery of information
    - Assist user in dealing with information from a wide variety and large number of sources
- Functionality Shortfalls Due to Technology Limitations
    - Information systems usually do not understand context of user needs
    - Users get little help dealing with information diverse needs
    - Tendency toward information overload
    - Inability to manage user subscription to information in near real time
    - Inability to merge information across semantic differences
    - Diverse presentation methods of information from diverse sources inhibits understanding and correlation

- Some Critical S&T Needs
    - Interoperability software
    - Information access and delivery software
    - Computer aided reasoning for task-oriented information dissemination
    - Automatic association and merger of information for unified presentation
    - Automated recognition and cueing for significant patterns of information
    - Adaptable viewers and Human-Machine Interfaces

The remainder of the NCO Technical Taxonomy addresses the other 6 enabling technology areas in a similar manner. Feedback is welcomed on the Technical Taxonomy

3.0 Summary and Conclusions

Net Centric Operations capabilities are a key ingredient to transformation. A Technical Taxonomy associated with Net Centric Operations has been developed to allow the NCO community to identify operational needs, associated functional capabilities, enabling technologies and potential shortfalls. This approach provides a common language and view that will assist the S&T community to address NCO investment and prioritization.

The S&T shortfalls that were identified by the Navy are very consistent with $&T thrusts as discussed at March, 2004 DARPATECH

4.0 References

1) ONR web site, http://www.onr.navy.mil/02/baa/expired/03_007/default.asp

2) Sea Power 21 Series—Part V "ForceNet: Turning Information into Power", Vice Admiral Richard W. Mayo, U.S. Navy, and Vice Admiral John Nathman, U.S. Navy *Proceedings*, February 2003