FORCEnet Science and Technology Needs with Potential Solutions

Presentation to ICCRTS
26-28 September, 2006
De Vere University Arms
CCRP # I-099

Jude E. Franklin, Ph. D.
TD, Raytheon NCS C2 Systems
Suite 1700
1100 Wilson BLVD
Arlington VA, 22209
703-284-4463
Jude_E_Franklin@Raytheon.com
Raytheon 06-051 TD Release
FORCEnet Operations
National Research Council of the National Academies FORCEnet Study Team

- Rich Ivanetich, IDA
- Bruce Wald, former Assoc TD, NRL
- Robert Brammer, NGIT
- Joseph Cipriano, LMIT
- Admiral Archie Clemins, Caribou Technologies
- Chip Elliott, BBN
- Joel Engel, Former IBM Fellow
- Jude Franklin, Raytheon
- John Hanley, IDA
- Kerrie Holley, IBM Global Services
- Ken Jordan, SAIC
- Otto Kessler, MITRE
- Jerry Krill, JHU APL
- Ann Miller, U. Missouri-Rolla
- RADM Bill Morris
- RADM Richard Nibe
- LTG. John Rhodes
- Daniel Siewiorek, CMU
- Ed Smith, Boeing
- Mike Zyda, USC
FORCEnet Information Infrastructure Capabilities

- Reliable wideband mobile communications
- Information management (including Common Operational Picture [COP])
- Situation awareness and understanding
- Persistent Intelligence Surveillance and Reconnaissance, ISR
- Information assurance
- Modeling and simulation
- Dynamic composability and collaboration
- Supporting the disadvantaged user-personnel, platform or sensor

http://www.nap.edu/catalog/11456.html

Blue, Orange are addressed in this paper
1. Provide robust, reliable communications to all nodes, based on the varying information requirements and capabilities of those nodes

2. Provide reliable, accurate and timely location, identity and status information on all friendly forces, units, activities and entities/individuals

3. Provide reliable, accurate and timely location, identification, tracking and engagement information on environmental, neutral and hostile elements, activities, events, sites, platforms and individuals

4. Store, catalogue and retrieve all information produced by any node on the network in a comprehensive, standard, repository so that the information is readily accessible to all nodes and compatible with the forms required by any nodes, within security restrictions

5. Process, sort, analyze, evaluate, and synthesize large amounts of disparate information while still providing direct access to raw data as required.

6. Provide each decision maker the ability to depict situational information in a tailorable, user-defined, shareable, primarily visual representation
7. Provide distributed groups of decision makers the ability to cooperate in the performance of common command and control activities by means of a collaborative work environment.

8. Automate lower-order command and control sub-processes and to use intelligent agents and automated decision aids to assist people in performing higher-order subprocesses, such as gaining situational awareness and devising concepts of operations.

9. Provide information assurance

10. Function in multiple security domains and multiple security levels within a domain and manage access dynamically

11. Interoperate with command and control systems of very different type and level of sophistication

12. Allow individual nodes to function while temporarily disconnected from the network

13. Automatically and adaptively monitor and manage the functioning of the command and control system to ensure effective and efficient operation and to diagnose problems and make repairs as needed.

14. Incorporate new capabilities into the system quickly without causing undue disruption to the performance of the system

15. Provide the decision makers the ability to make and implement good decisions quickly under conditions of uncertainty, friction, time, pressure, and other stresses
Information Management

Data Overload means Information Camouflaged

World War I: 30 wpm
Field Phone

World War II: 60 wpm
Radio

Vietnam: 100 wpm
SATCOM

Gulf War: 192,000 wpm
Networked Computers

War in 2010:
1.5 trillion wpm
Wideband Datalinks

We can transmit the entire Library of Congress each minute

wpm - words per minute

From General Buck Rogers Brief to NDIA
Information Management
Technical Challenges

- Trust
- Contamination
- Utility
- GIG Task, Push, Process and Use (TPPU) and Only Handle Information Once (OHIO)
- Metrics
- Pedigree
- Models to capture and share knowledge of phenomenology and sources to guide human interpretation
JOINT INTEGRATED AIR DEFENSE
Joint Theater Context - Information Management

JOINT INTEGRATED KILL CHAIN
Situation Awareness and Persistent ISR
Situational Awareness
Technical Challenges

- Inference engines
- Knowledge management
- Large scale relational and control frameworks
- Human-machine collaboration
- Cognitive modeling
- Dynamic “What If?” Analysis
Persistent ISR Technical Challenges

- Persistent sensing
- Pervasive sensing
- C2 of platforms and sensors to meet dynamic operational and tactical needs
- Dynamic planning and replanning of sensor modality and coverage
- Distributed autonomous networks
- Automation to support Net-Centric Warfare
- Dynamic netted sensors
Strike Netted Effects Network

Command and Control Center

LOAL MAV

F16

TOMAHAWK

JSOW

IRTTS
Information Assurance Technical Challenges

- Automated network analysis / monitoring
- Dynamic balancing of protection levels, including policy adaptation, with sharing needed to maintain mission effectiveness
- Trustworthiness of software systems
- Intrusion detection
- Identify insider threats
- Metrics
CHAIN – Part of the Solution for IA

Compartmented High Assurance Information Network (CHAIN)

Supports Homeland Defense Agency, Coalition and Joint Interoperability Information Assurance Requirements

Security Enhancements
- Designed to comply with DCID 6/3
- Context-sensitive content filtering
- Mandatory and discretionary access control
- Audit data collection and automatic analysis
- In-transit and at-rest data protection
Composability Technical Challenges

**Composeable Warfighting**

**Interoperable**
Across technologies and systems

**Composeable**
Systems, Organizations, Processes and Procedure

**Plug and Play**
Add, subtract platforms, sensors, weapons, warriors h/w, download s/w, reusable

**Distributed**
Ubiquitous, virtual sources, virtual systems, virtual spaces, virtual presence

**Adaptive**
To new missions, technologies, environments

**Sentient Applications**
Self-learning, context aware

**Secure**
I/O Protected, MLS, Tailorable

**Intuitive**
Low/no training, natural
Internet analogy – every Effector, Sensor, C2 & Platform has an IP address
FUTURE AIR DEFENSE TRANSFORMATION

INTEGRATED FIRE CONTROL

INTEGRATED KILL CHAIN
There are critical Science and Technology, S&T, capabilities – Key to FORCEnet and NEC success

The S&T issues must be aggressively understood and resolved

If we do not resolve these S&T issues, Net Enabled Capabilities and Net Centric Operations will not be successful
Backup
Prioritizing S&T
Recommendations-example

• Critical to Navy and no one else is working in this area
• Critical to the Navy but others are working this area
• Enhances performance but not required
• Near-term
• Mid-term
• Long-term
## S&T Sensitivity Table

<table>
<thead>
<tr>
<th>FORCEnet Information Infrastructure</th>
<th>Navy Priority</th>
<th>S&amp;T Experimentation</th>
<th>Ongoing ONR</th>
<th>Comments</th>
<th>Priority (scores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical to Navy and No One Else Working</td>
<td>N Partial Issue for ships and submarines</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical to Navy But Others Working</td>
<td>N Partial</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical to Navy But Others Working</td>
<td>N Partial</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enhanced Performance Fn II, Nice to Have but Not Required</td>
<td>N Partial</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 1. Communications

| (a) Links/Antenna | √ | N Partial |
| (b) QOS/Monitor | √ | N Partial |
| (c) Protocols/STD | √ | N Partial |
| (d) U.W. Communications | √ | L Partial |
| (e) Satellite Relay Alternative | √ | L |
| (f) Optical Communications Marine Layer | √ | L |
| (g) Apertures—Disadvantaged Users | √ | M ? |

### 2. Information Management

| (a) Ontology | √ | N Partial |
| (b) Information Services | √ | N Partial |
| (c) Sensor Resource Management | √ | M |
| (d) Distributed Fusion | √ | N Partial |
| (e) User Defined Visualization | √ | N |
| (f) Enterprise Monitor | √ | M |

### 3. Situation Awareness

| (a) Contextual Reasoning | √ | M Partial |
| (b) Knowledge Bases | √ | M Partial |
| (c) Interactive Hypothesis Management | √ | L ? |
| (d) Cognitive Interface | √ | I Partial |
### 4. Information Assurance

- **(a) Metrics/Monitoring**: √ M Partial
- **(b) Sharing enabler/Balance**: √ L
- **(c) Software Trustworthiness**: √ M √
- **(d) Power Sources**: √ M √

### 5. Modeling and Simulation

- **(a) Scaling**: √ M
- **(b) Systems Engineering**: √ M
- **(c) What If Analysis**: √ L

### 6. Composability/Collaboration

- **(a) Mission Management**: √ L
- **(b) Readiness Monitor**: √ M
- **(c) Manpower and Training**: √ L √
- **(d) Collaboration communications**: √ M Partial Automation in unreliable communications (4)

### 7. Disadvantaged Users

- **(a) HMI**: √ M Partial
- **(b) Customized Information**: √ M Partial
- **(c) Aperture Size/Weight**: √ M ? Small ships, U.W. - platforms H
- **(d) Power Sources**: √ M

### 8. Persistent ISR

- **(a) Automated Adaptive Sensor Control**: √ L Partial
- **(b) Manpower Reduction**: √ M Partial e.g., sonobuoys and UW
- **(c) Netted Sensors sensors/vehicles**: √ M Partial H

**NOTE:** N = Near term; M = Mid Term; L = Long Term; and H = High Priority. A list of acronyms is
High Priority FORCEnet S&T-

- 1.a. The capability in link and antenna technologies to provide increased data rates and beam agility.
- 2.d. Distributed, heterogeneous, real time level 1 data fusion.
- 2.e. User defined visualization and automation for decision support
- 1.b Insufficient quality of service and network monitoring, control, and reconfiguration to provide the necessary availability and latency for priority traffic.
- 7.c. The size and weight of antenna apertures too large for routine use by disadvantaged (especially dismounted) users.
- 8.c. Small, networked sensors for wide area, inexpensive alerting in difficult/denied areas.
- 2.a. Ontology consistency to enable automated machine collaboration across communities of interest.
- 2.b. Information services to enable management of information content/quality.
- 1.c. Necessary protocols in standard use to support the mobility, disruption, and information assurance robustness that will be needed in the future FORCEnet.
- 1.d. Reliable communications technologies to reach underwater vehicles at speed and depth.
S&T Recommendations

• Continue to develop prototypes that demonstrate solutions to the antenna blockage problem, such as wide-band multi-beam arrays, and alternative relays

• Aggressively seek technologies that will permit connecting to disadvantaged uses such as small vessels, marine vehicles, and dismounted marines
S&T Recommendations - 2

- MANET routing over multiple alternate paths
- QoS management and monitoring
- Network protection and recovery
- Information assurance
- Connectivity to dismounted units with smaller size and weight antenna apertures
- Small netted sensors for wide area, inexpensive alerting in difficult denied areas
- Information management in the naval context to permit full exploitation of network-centric enterprise services, increasing its investments in ontologies of naval operations, information services, distributed level 2 through 4 fusion, and user-defined visualization
- Investigate other shortfalls in long-term strategic investments
FEDERATED AIR DEFENSE

EACH SERVICE WITH OWN KILL CHAIN

FIRE CONTROL IS NOT INTEGRATED
TOMORROW’S NAVY AIR DEFENSE

OFFENSIVE POSTURE WITH MORE STRIKE
Communications and Networking Modeling and Simulation
Center of Excellence

Innovative Technologies:
Integrating a Simulated Communications Environment into man-in-the-loop and hardware-in-the-loop simulation and integration environments to accurately represent the effects of communications and networking protocols. Flexible design allows for use throughout all phases of system development and test.

Team Overview:
• “Center of Excellence” for tactical communications and networking Modeling and Simulation
• Over $1M in hardware and software to support modeling and simulation activities

Strengths:
• Advanced networking protocol prototyping and development
• Communication system performance evaluation and analysis
• 2-D and 3-D visualization and animation
• Integration of communication effects in distributed simulation environments
• Development of HLA compliant models

Rapid Prototyping:

Directly porting protocol models from the simulation environment into target hardware to minimize risk in developing SCA compliant protocols.

Integrating detailed OPNET models into hardware test/integration environments supports early evaluation of protocol performance.
Communications Technical Challenges

- Communication links and apertures
- Network quality of service
- Resource management
- Automated networking in a dynamic, mobile environment
The Process: Cosite System Design Flow

1. Define Comm Requirements
   - Comm Links with Cosited Range
   - Comm SWAP
   - Safety of Flight

2. Perform Platform Antenna Installation Surveys
3. Perform H/W Alternatives Surveys
4. Characterize H/W
5. Perform Platform External Coupling/Cosite Surveys
6. Perform Platform Internal EMI Surveys
7. Cosite Test Plan
8. Formulate Cosite Design Alternatives
   - Antenna Types/Locations
   - Filters
   - Cancellers
9. Generate Models
   - Cosite Models
   - Link Analysis Models
10. Evaluate Cosite Design Alternative Using Models
11. Select Cosite Design Alternative For Evaluation
12. Evaluate Model Results vs Requirements
    - Fail
    - Pass
13. Final Antenna Selections and Locations
    - Verify Installed Cosite Performance
14. Cosite Test Plan
15. Cosite Test Procedures
16. Cosite Test Reports
17. Subsystem Specifications
18. Cosite Design Document

Final Antenna Selections and Locations
- Verify Installed Cosite Performance
M&S provides a Solution for Communications

Blocked Frequencies

Useable Frequencies

Isolation

140dB

Intermod Product

Collocated Transmitters ("Boomers")

Intermod Products Created by the Two Boomers

Receiver Sensitivity

Band of Operation by Victim

Victim Receiver
Disadvantaged Users Technical Challenges

- Weight and space
- Information overload
- Limited communications and processing
- Limited power sources
Part of the Solution

★ Warfighter’s life is better
- More communications capability in a small package
- 1 piece of gear does the work of many
- Robust waveforms → get the message through
- Reduces “blue on blue” events

★ Warfighter is more effective
- Provides more information → voice, data and situational awareness
- Connects to local and wide area networks
- Puts powerful sensors at soldier’s disposal
- Supports urban warfighting operations through networking