Science and Technology to Support FORCEnet

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Presentation for DoD OASD NII CCRTS

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Report Documentation Page

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Members of S&T Panel

- Chip Elliott, BBN
- Joel Engel, Consultant, IBM Fellow
- Jude Franklin, Raytheon
- Ken Jordan, SAIC
- Otto Kessler, MITRE
- Jerry Krill, JHU APL
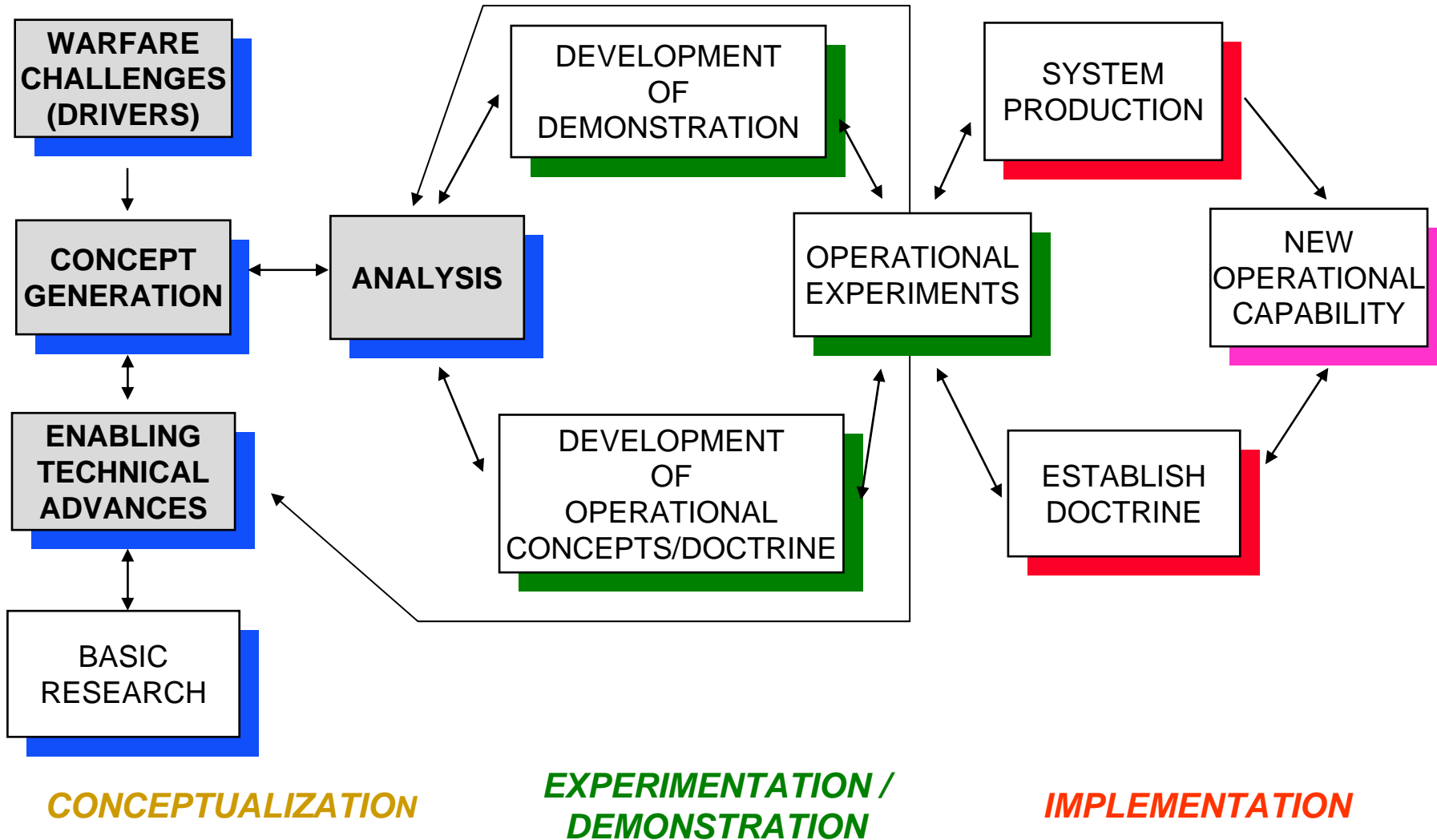- Dan Siewiorek, CMU
- Mike Zyda, NPS

FORCEnet S&T Study Process

- **Original terms of reference did not address S&T**
- **Team identified some holes derived from a quick look at the Mike Frankel GIG Brief**
- **Reviewed ONR Net Centric Operations Technical Taxonomy**
- **Study started in September, 2003**
- **S&T Conclusions were drafted in 2004**
- **A lot has happened since the study was completed, eg**
  - **Joint Functional Concepts and Capabilities**
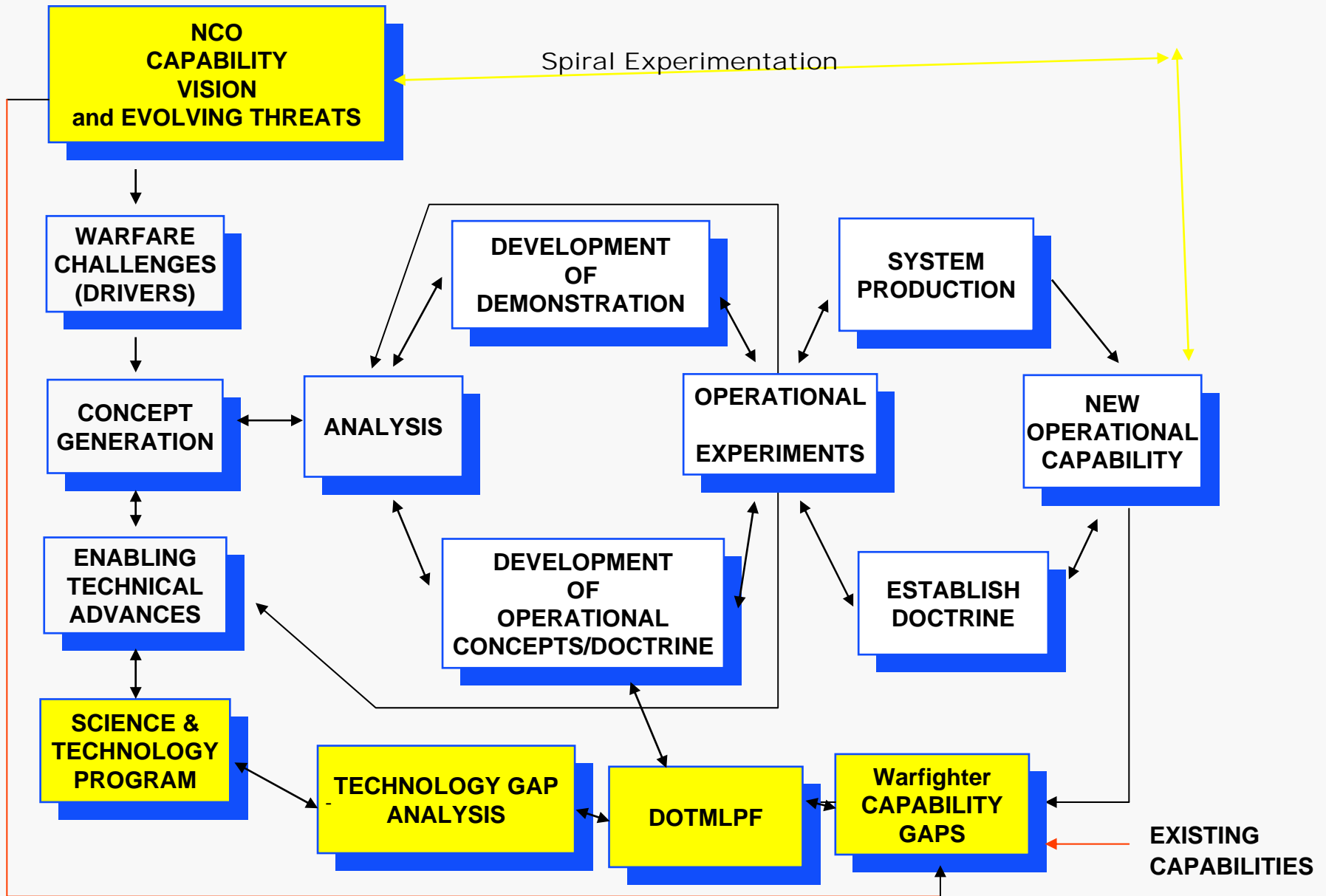 - **CNO FORCEnet 2005 document-required FORCEnet Capabilities**

Outline of the FORCEnet S&T Chapter

- **Overview and Background**
- **Process for Determining FORCEnet Capabilities**
- **Identify Eight FORCEnet Technology Related Capabilities**
- **Technical Capabilities, S&T Findings and Recommendations**
- **Summary of Functional Capabilities and Challenges**
- **Enabling Technologies Resulting from the GIG**
  - **FORCEnet Implications of the GIG**
  - **ONR S&T Program**
- **Summary Technology Findings and Recommendations**
- **High Priority S&T Recommendations**

Notional Innovation Process

WARFARE CHALLENGES (DRIVERS)

CONCEPT GENERATION

ENABLING TECHNICAL ADVANCES

BASIC RESEARCH

ANALYSIS

DEVELOPMENT OF DEMONSTRATION

DEVELOPMENT OF OPERATIONAL CONCEPTS/DOCTRINE

OPERATIONAL EXPERIMENTS

SYSTEM PRODUCTION

ESTABLISH DOCTRINE

NEW OPERATIONAL CAPABILITY

CONCEPTUALIZATION

EXPERIMENTATION / DEMONSTRATION

IMPLEMENTATION

Adm R. J. Natter, "Sea Trial Innovation Enabler for a Transformed Fleet" NIP, Nov 2003

Notional Process for Identifying Technology Gaps

**Adapted from Admiral Natter presentation**

8 Critical FORCEnet Information Infrastructure Functional Capabilities*

- **Reliable wideband mobile communications**

- **Information management**

- **Situation awareness and understanding**

- **Information assurance**

- **Modeling and simulation**

- **Dynamic composability and collaboration**

- **Support of disadvantaged user-personnel, platform or sensor**

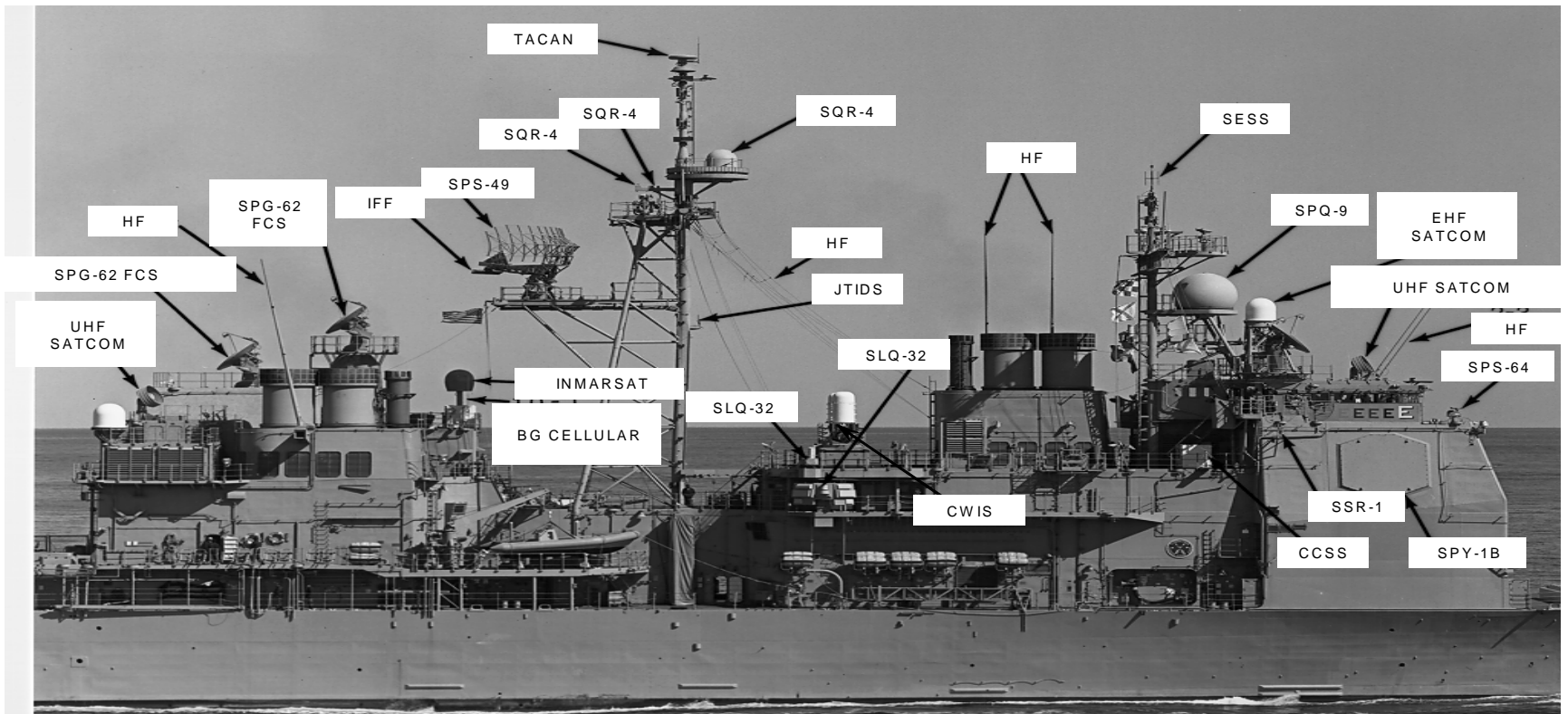- **Persistent intelligence, surveillance, and reconnaissance**

- **For each of the above Sections**
  - **Overview**
  - **Technical challenges**
  - **S&T Perspective**
    - **Findings**
    - **Recommendations**

  *Decision Making is contained in many of the capabilities

Notional Future Net Centric Environment for FORCEnet
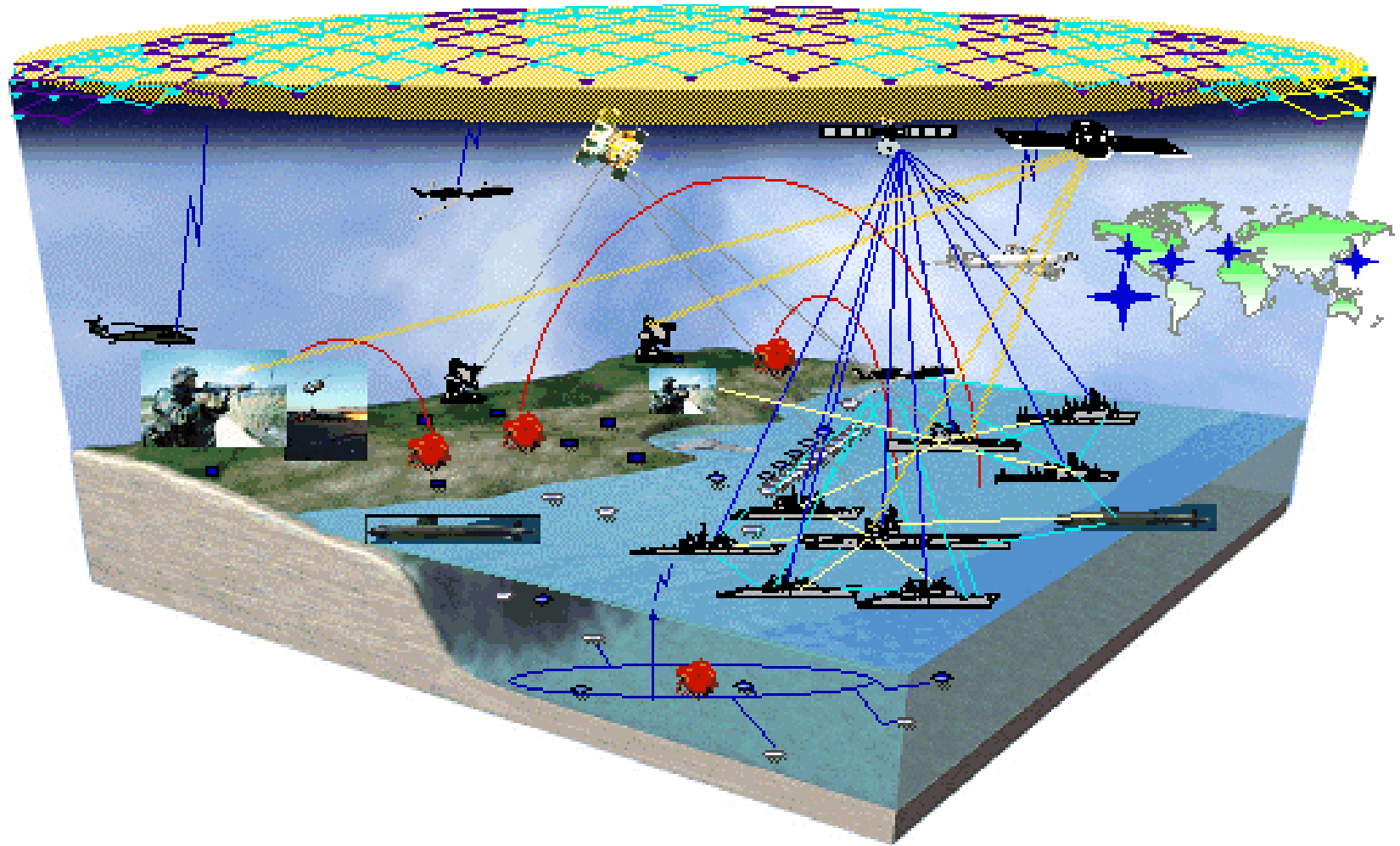
Example of Antenna Layout on Typical Ship

Technology Gaps-Reliable Wideband Mobile Communications Findings

- 1.a. The capability in link and antenna technologies to provide increased data rates and beam agility.

- 1.b. Insufficient quality of service and network monitoring, control, and reconfiguration to provide the necessary availability and latency for priority traffic.

- 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.

- 1.e. Shared, robust, reliable, multi-beam apertures satellite relay alternatives to support communications on the move and adaptive networks.

- 1.f. Reliable high speed communications, including optical, in the marine layer.

- 1.g. Improved antenna aperture technology for use by disadvantaged users and platforms/sensors.

Reliable Wideband Mobile Communications Recommendations

The committee recommends that ONR monitor technology availability, and, as appropriate, invest to sustain investigations that:

- 1.a.   Develop the applicability of optical frequencies for high data rate communications from satellite or airborne platforms to surface ships. Although the future Transformational Communications System holds promise for achieving as much as 100 Mb/s to ships at Ka-band, research into optical communications could provide a hedge for a need for higher data rates in the future.
- 1.b.   Provide automated monitoring and control for FORCEnet links and networks
- 1.c.   Explore the solution space for network approaches for FORCEnet mobility, disruption, and security using modeling and simulation and experimental approaches, and should particularly consider applications, such as the Littoral Combat Ship, as points of departure for this effort.

Knowledge Management
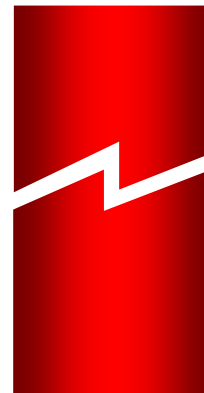
Data Overload means _Information Camouflaged_

1.5 trillion wpm

We can transmit the entire

Library of Congress each minute

192,000 wpm

30 wpm   60 wpm   100 wpm

wpm - words per minute

Technology Gaps-Information Management Findings

Insufficient technology exists, for reliable support of Naval warfighting capability, including limited understanding of the information management issues (accessing, processing, dissemination, presentation) which must be implemented with distributed functionality in network-centric environments. In particular, these current technology gaps include:

- 2.a.   Ontology consistency to enable automated machine collaboration *between* communities of interest.
- 2.b.   Information services to enable management of information content/quality and storage.
- 2.c.   Automated sensor resource management, coupled to dynamic tactical needs and military operational needs.
- 2.d.   Distributed, heterogeneous, real time level 1 data fusion.
- 2.e.   User defined visualization and automation for decision support.
- 2.f.   Enterprise monitoring and control to give the user feedback concerning information processes; in terms of performance, expected latency, flow and quality
- *2.g Management and storage of data and information*

Information Management Recommendations

The committee recommends that ONR monitor technology availability, and, as appropriate, invest to sustain investigations that:

- 2.a.   Develop technology for distributed real time processing and heterogeneous fusion
- 2.b.   Develop technology for automated resource allocation driven by current operational situation understanding
- 2.c.   Identify and formulate ontology frameworks for consistent data usage across the network enterprise
- 2.d.   Identify and implement information services that assure consistent IM processes across the network enterprise

Technology Gaps-Situational Awareness and Understanding Findings

- **Technology to provide automated situation and threat awareness is currently not available. In particular, these current technology gaps include:**

- **3.a.   Contextual reasoning regarding problems having scale and uncertainty of battlespace issues**

- **3.b.   Knowledge bases and tools to capture and represent diverse battlespace expertise *and to avoid information overload***

- **3.c. Interactive human-machine hypothesis management**

- **3.d. Visualization and Cognitive interfaces**

Situational Awareness and Understanding Recommendations

The committee recommends that ONR monitor technology availability, and, as appropriate, invest to sustain investigations that:

- 3.a. Advance an inferencing techniques necessary to relate objects and events to their environment and to units, activities, and behaviors.
- 3.b. Develop a relational and control framework for managing a broad range of knowledge representations, hypotheses, assertions, etc.
- 3.c. Develop automated techniques for information capture, representation, authoring, and validation.
- 3.d. Integrate human and machine capabilities for hypothesis management—balancing machine capability for handling numerical scale problems with human ability for intuition.

Technology Gaps-Information Assurance Findings

- **Inadequate technology exists to provide the necessary level of information assurance to support the FORCEnet vision. The network need for sharing information must be balanced with traditional information assurance roles involved in protecting information. This challenge is made more difficult under conditions requiring trusted information exchange across multiple independent levels of security and coalition partners. In particular, these current technology gaps include**

- **4.a.   Metrics and automated network analysis/monitoring of network reliability and security capable of scaling to network-centric needs and the demands of multilevel security and failure prediction.**

- **4.b.   Dynamic balancing of protection levels, including policy adaptation, with sharing needed to maintain mission effectiveness.**

- **4.c.   Trustworthiness of software systems and associated information in network-centric operations.**

- **4.d.   The ability to conduct intrusion detection and to identify insider threats**

Information Assurance Recommendations

The committee recommends that ONR monitor technology availability, and, as appropriate, invest to sustain investigations that:

- 4.a.   Identify improved information assurance metrics.
- 4.b.   Develop automated real time network-centric systems analysis to identify and predict *and fix* information systems failures.
- 4.c. Develop improved techniques to achieve *Information exchange with* multiple levels of information security.

Technology Gaps-Modeling and Simulation Findings

The present state of modeling and simulation does not scale to FORCEnet needs. In particular, these current technology gaps include:

- 5.a.   Scaling of models and simulations to large numbers of sensors, platforms, and users.

- 5.b.   Systems engineering, including means to checkout large scale network-centric systems prior to deployment (i.e. ability to model life cycle design, test, and validation).

- 5.c.   Robust "What If?" analysis to support tradeoffs among network-centric system configurations as a function of mission/threat environment, performance, and reliability.

Modeling and Simulation Recommendations

- **The committee recommends that the Office of Naval Research should monitor and sustain investigation, as appropriate, in the following areas in coordination with other relevant research and development activities across the Defense Department, industry, academia and the commercial sector:**

  - **5.a.   Develop modeling and simulation to support large scale systems engineering**
  - **5.b.   Develop Adversarial analysis models and simulations**

Dynamic Composability

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
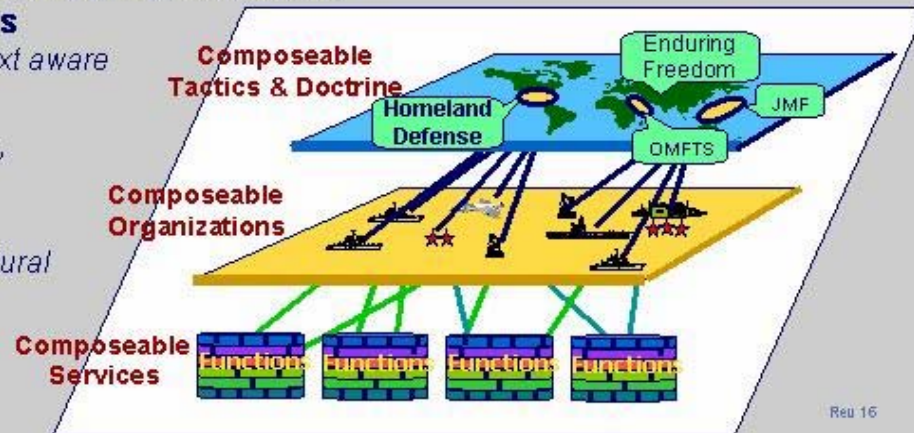
Sentient Applications
Self-learning, context aware

Secure
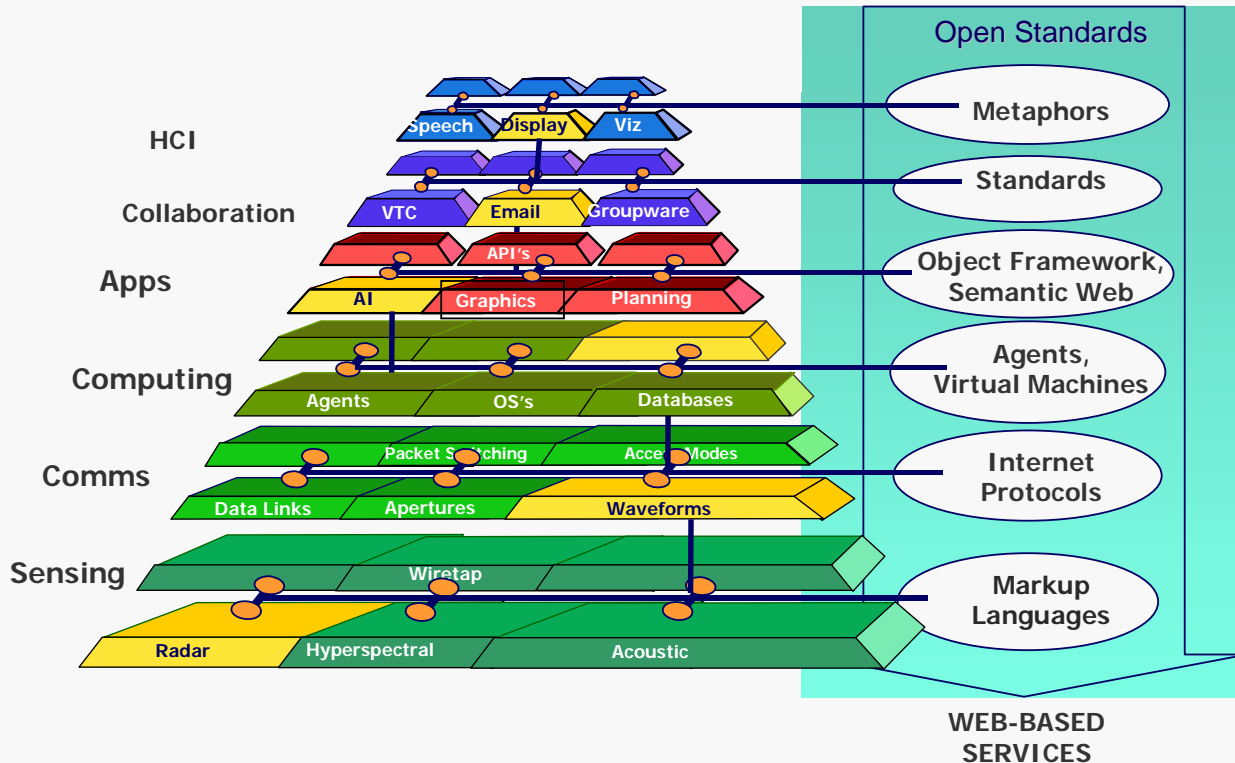*I/O Protected, MLS, Tailorable*

Intuitive
Low/no training, natural

Composeable Tactics & Doctrine

Enduring Freedom
Homeland Defense
JMF
OMFTS

Composeable Organizations

Composeable Services

Function Function Function Function

Reu 16

Dynamic Composability

Requirements for "Composeable" C4ISR

SPAWAR Government Reference Architecture version 1.0 2 April, 2003

Rev 16

Technology Gaps-Dynamic Composability Findings

- Today's technology does not support dynamic composability on the fly. A number of essential elements must be addressed to achieve the FORCEnet vision of mission composable capability while maintaining campaign level control, required for coordination of forces. In particular, these current technology gaps include:

  - **6.a. The complexity of managing mission composability in a way that assures integrated resource allocation to meet dynamic mission goals and achieve desired campaign outcomes.**

  - **6.b. A 'readiness' monitor that confirms the state of the entire FORCEnet enterprise (core plus communities of interest, across all enterprise layers) in any given configuration, for all users.**

  - **6.c. Manpower and training programs to teach and utilize *automated* composed functionality.**

  - **6.d. Tools to support automated means to facilitate collaboration between people and/or machines and to include planning/replanning functions.**

Dynamic Composability Recommendations

- **The committee recommends that ONR in concert with CFFC, NNWC, NWDC and appropriate laboratory organizations commit to a long term co-evolutionary process, which involves laboratory and field experiments, to evolve the required technical components with naval tactics and procedures and personnel implications*. The committee recommends that the Office of Naval Research should monitor and sustain investigation, as appropriate, in the following areas in coordination with other relevant research and development activities across the Defense Department, industry, academia and the commercial sector:**

  - **6.a.   Sustain investigation of complex resource management (allocation and coordination) issues.**

  - **6.b.   Sustain investigation of automated collaboration tools necessary to facilitate interactions and problem solving between humans, between machines, and between humans and machines (the effort should also address issues associated with the variable reliability of the naval communications).**

  *See notes section

Technology Gaps-Disadvantaged User Findings

- **The state of technology to support disadvantaged users (small boats, dismounted marines, etc.) is deficient. Depending on operational conditions, unique needs may exist for communications, information representation, and human machine interfaces. Beyond issues cited in other sections, these current technology gaps include:**

  - **7.a. The human machine interface—today's hand held displays are difficult to read are distracting, and head gear is bulky and also distracting.**

  - **7.b. Custom representation of information to meet difficult operating conditions*.**

  - **7.c. The size and weight of antenna apertures too large for routine use by disadvantaged (especially dismounted) users.**

  - **7.d. Power sources too heavy and bulky for rapid mobile use by individuals.**

* Dylan Schmorrow's DARPA program is Warfighter Information Intake Under Stress.   It was previously called AugCog or Augmented Cognition

Disadvantaged User Recommendations

The committee recommends that the Office of Naval Research should monitor and sustain investigation, as appropriate, in the following areas in coordination with other relevant research and development activities across the Defense Department, industry, academia and the commercial sector:

- **7.a.   Develop the minimum essential situation awareness for dismounted troops in a way that is least distracting.**
- **7.b.   Develop lightweight, high density power sources and improvements in power consumption in coordination with DARPA and the Army.**

Technology Gaps-Persistent ISR Findings

- For network-centric operations traditional intelligence, surveillance, and reconnaissance sensing (national and theatre, platform-based coverage) will need to be augmented by organic tactical sensors for responsive coverage of areas which difficult to monitor, or for which access is denied. In particular, these current technology gaps include:

- 8.a.   Automation for coordinated usage of multiple sensors, adaptive sensor control, and more robust sensing modalities.

- 8.b.   Automation to drastically reduce manpower requirements and reverse the ratio of humans per sensor from a positive number to a fractional number—this will become especially important with the likely proliferation of small sensors for wide area coverage of difficult areas.

- 8.c.   Small, networked sensors for wide area, inexpensive alerting in difficult/denied areas.

REUTERS/Caren Firouz

Persistent ISR Recommendations

The committee recommends that the Office of Naval Research should monitor and sustain investigation, as appropriate, in the following areas in coordination with other relevant research and development activities across the Defense Department, industry, academia and the commercial sector:

- 8.a. Develop a netted sensor technology for wide area alerting of asymmetric targets/activity.
- 8.b. Develop an automated sensor management to adjudicate sensing needs across mission goals, and for sensing responsiveness to dynamic battlespace needs.
- 8.c. Develop machine to machine collaboration for remote operations.

Process Recommendations

The committee recommends that ONR develop a FORCEnet Information technology roadmap and associated program

Perform sensitivity analyses to evaluate alternatives

Provide cost-benefit analyses

Assess COTS applicability

Identify opportunities for leveraging/incentivizing industry, academia, and other service participation

Sensitivity Analysis should address

- 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

- Impact

  - Near term, Mid term, Long term

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.

Back-ups

FORCEnet- A Functional Concept for the 21st Century- CNO, 2005-Required Capabilities

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**

FORCEnet- A Functional Concept for the 21st Century- CNO, 2005-Required Capabilities

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**

CECOM Fusion Technology Needs- 2005

Image Fusion

• Color Image Metrics

• FLIR, Image Intensification, Shortwave Infrared (SWIR)

• Visible/NIR/LWIR sensor fusion methods and metrics

Sensor Fusion

• Automated deployable Warrior Extended Battlespace Sensors (WEBS) (employs seismic, acoustic, thermal <u>magnetics and EM Olfaction</u> sensors and communication networks)

Aided Target Recognition (ATR)

• Generation and validation of system imagery for use in ATR algorithm and evaluation

• Algorithm development for single color sensors, multi-band sensors, hyperspectral sensor

• Simple, efficient moving target indication algorithms

• Change detection-Phenomenology studies for single and multisensor and hyperspectral images

• Improvements to ATR algorithms using battlefield network, GPS and digital map information

• Multi spectral aided target recognition algorithms with emphasis on dual band.

• Lightweight, compact, low power computing for on-board processing of high definition imagery in near real-time.