CODE 31

SCIENCE AND TECHNOLOGY STRATEGIC PLAN
2012

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Foreword

This Strategic Plan represents my vision and goals in support of Chief of Naval Research's Science and Technology (S&T) investment strategy, in particular for Information Dominance, to be responsive to Naval capability needs and empower Warfighters with the best technology driven solutions – both today and in the future.

To achieve these objectives, we have worked closely with the Fleet, Fleet Forces Command, OPNAV, PEOs and other relevant Naval Information Dominance Enterprise stakeholders to correctly identify technological needs. To address these needs, we have assembled a portfolio of S&T efforts ranging from Basic Research -- which provides insight into the "Art of the Possible", to Advanced Technology -- which provides prototypes that the Warfighter can exercise to assess its utility.

We seek to make sure everyone, both in and outside of the Office of Naval Research (ONR), has a common understanding of how we are approaching Information Dominance through a common framework. The Plan is structured to provide the reader with a clear understanding of our mission, the principles of S&T management, and a comprehensive discussion of what we mean by Information Dominance in the context of S&T.

Finally, the Plan contains a description about the importance of Fleet Experimentation venues, Limited Technology Experiments (LTE) and the need to emphasize Speed to Fleet research activity in order to satisfy the Warfighter's immediate capability needs, uncover significant issues, discover remaining challenges, and pursue opportunities for future research. The Code 31 Strategic Plan includes an Appendix (distributed separately) with full details on our Future Naval Capability (FNC), Innovative Naval Prototype (INP) and Discovery & Invention (D&I) programs.

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Deputy Chief of Naval Research
Command, Control, Communications, Intelligence,
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Introduction

This Strategic Plan describes how the C4ISR Department's (ONR Code 31) vision, mission, philosophy, structure, and processes support the execution of scientific research efforts that will enable future operational concepts of the Navy and the Marine Corps. The priorities of the Chief of Naval Research (CNR) and the C4ISR Department Head are reflected in the shape of the Code 31 investment portfolio described in this document. The principles for S&T management outlined below are intended to drive the development of technologies that enable new discoveries as well as develop and demonstrate high-payoff, game-changing capabilities. These capabilities will ensure that the Fleet/Force retains a significant advantage over potential adversaries within the Information Dominance domain. Information-based warfare will be fundamentally transformed from today's paradigm, illustrated in Figure 1. Today, data resides in mission specific networks, sensors and communication architectures. Information requirements are tied to "a" mission or mission phase where information for prosecution is generated and held for each mission in separate networks.

Figure 1. Future Information-Based Warfare

The future Information Dominance domain, shown in Figure 2, will consist of Combat, C2, Communication, Surveillance, etc. capabilities containing a number of parts, each with its role, operating in a distributed cloud, information and computing environment. A distributed cloud environment for processing the "big data" exchange requirements of future warfare missions will provide the following benefits:

- Resource pooling - different physical and virtual resources dynamically assigned and reassigned according to warfighter demands
- Rapid elasticity – data sharing capabilities that can be dynamically and elastically provisioned
- Measured service – resources are automatically controlled and optimized

We must achieve a "dynamic" environment where information processing, understanding, analysis, decision-making and execution are fully integrated into a warfighting system. Sensors will be autonomously controlled sources of data; agile, flexible communications links will provide the rapid data sharing required to process sensor data in the context of the battlespace, and appropriately distribute the results; and platforms will provide the means by which sensors are distributed and reallocated in the battlespace for the purpose of collecting data for understanding the battlespace, and with weapons to execute missions in an integrated, seamless kill chain.

Figure 2. Future Information-Based Warfare

Vision

Provide capabilities to enable the Warfighter to take immediate, appropriate action at any time against any desired enemy, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's intent.

Mission

ONR Code 31 executes S&T programs that focus on experimental and theoretical research and technology development in the areas of C4ISR & Combat Systems with relevance across near-, mid-, and far-term applications. To accomplish this we must:

- Seek visionary game-changing capabilities that enable Information Dominance for Naval forces of the future
- Mature and transition S&T advances in communications, electronics (including electronic warfare), sensing (radar, electro-optic/infrared), information processing and autonomous decision making to improve existing and future warfighting capabilities
- Pursue broad discovery and invention investments in order to maintain a leading edge ability to rapidly deliver disruptive technological capabilities to Naval forces in areas still unknown in order to anticipate and counter potential technology surprise and deliver overwhelming warfighting capability based on Information Dominance.

Principles for S&T Management

The primary drivers for all Naval S&T development are the current and anticipated future technology gaps and warfare requirements. The three Principles identified here determine how we develop and execute the focus of current and anticipated S&T investments.

1. Engage Operational Community to Identify Future Technology Needs

We must maintain insight into warfighter operations, TTPs, CONOPS, etc., in order to properly identify future technology needs and set the tone for prioritizing Naval technology gaps as well as in planning a balanced portfolio between near and far term investments.

2. Provide the Warfighter with Mission Focused Capabilities Enabled by S&T

Warfighter capabilities must be judged against mission effectiveness. Whether driven by a revolutionary new capability or an improvement to current capabilities, technology enhancements to Naval systems must be directly linked and evaluated against a defined warfighting mission gap in order to support major combat operations and lesser contingency capabilities in Joint environments. To accomplish this we must develop the best S&T to address identified and anticipated threats and then transition it to Naval systems in the shortest time. Anticipating future Naval needs must be based on a thorough understanding of the process of maturation of technologies and its impact on development of future threats. To prevent technological surprise, we must be prepared to overcome all critical technical barriers (e.g., risk, opportunity) and ensure technologies developed are affordable and meet defined capability requirements. Correctly identifying future technology needs is reliant upon a robust Basic Research program in order to better understand the art of the possible. We must focus on new concepts and opportunities evolving in the U.S. and international S&T community, maturation of the resulting technologies, and the development of prototypes.

3. Empower Decision-Making at the Highest Feasible Level of Expertise

Code 31's professional workforce is staffed with experts who know the "state of the art" within the scientific community. We should empower them with the capability to make decisions concerning the proper scientific portfolio planning and development process. ONR science officers constantly maintain communication across relevant S&T communities and are, therefore, in the best position to properly prioritize opportunities and to optimize Code 31's portfolio. The decision making process within the department ensures that proper resources are aligned to the highest prioritized opportunities/needs.

What is ID and why does the Warfighter need it?

Information Dominance is the ability to acquire, process, understand, and interpret massive amounts of data (intelligence, sensor, open source, etc.), while protecting and processing it and simultaneously controlling the information resources and pictures of our adversaries in order to obtain decisive competitive advantage across the range of naval missions and levels of warfare. Achieving Information Dominance implies freedom of action to maneuver and act – conduct offensive and defensive actions, kinetically and non-kinetically -- at the intersection of maritime, information and cyberspace domains. The Navy's concept for ID and decision superiority encompasses the following elements:

- Information power applied as the prime operational instrument;
- Information advantage overmatch in decision-making; and
- Global enterprise net-centric operations.

Strategic drivers for ID include the following:

- Potential adversaries are investing in advanced technologies that will challenge our advantages in the information domain.
- Nation states and non-state actors seek to degrade our command and control and surveillance capabilities, networks and computer systems.
- Ubiquitous technology enables our opponents to rapidly develop and field threats.

In order to achieve this, information must be available to any commander executing his mission, regardless of the source of that information relative to warfare mission (ASW, MIO, AAW, etc.), level of command (operational, tactical, platform) or the stage of operations (planning, assessment, execution) as illustrated in Figure 3.

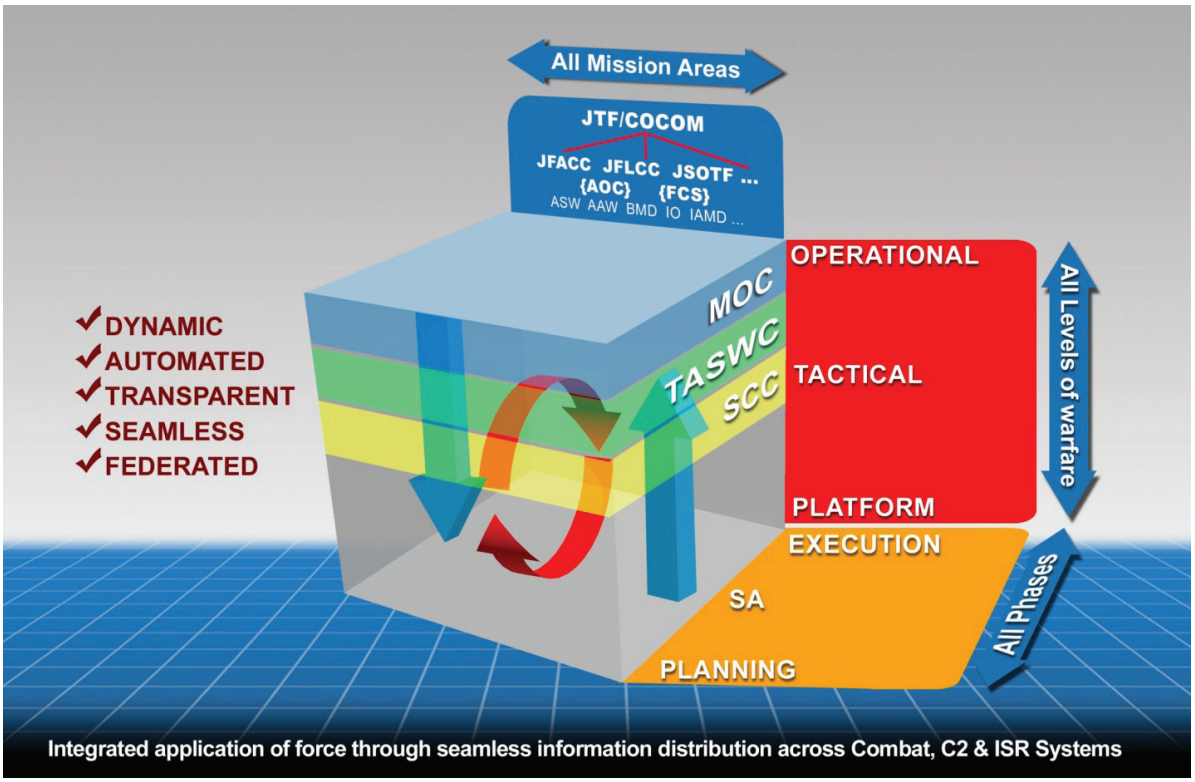


Figure 3. Integrated Application of Force Across Combat, C2 & ISR Systems

How does S&T impact ID?

Information Dominance consists of systems, architectures and analyses that gather and analyze data in order to develop an understanding of the battlespace and support decision-making and operations across diverse mission areas. Code 31's role in ID does not encompass solutions for capability gaps across the entire doctrine, organization, training, materiel, leadership and education, personnel and facilities (DOTMLPF). Rather, it is concerned with the "materiel" aspects – in conjunction with the objectives and constraints on these material solutions that are driven by the current and anticipated/projected threats as well as CONOPS, TTPs, and remainder of the DOTMLPF aspects. The key technical thrusts of ID are shown in Figure 4. The fundamental problem/issue that S&T must address is the Big Data problem with errors (contradiction, incompleteness, uncertainty, etc.). This problem will only become more complex and difficult in the future as new sensors come online, new technologies enable access to such data as COMINT internals, and more open source data is brought into the analysis process.

How will Code 31 enable ID for the Navy and Marine Corps?

To support enhanced naval capabilities with regard to ID and to develop the necessary technologies to implement them, the C4ISR department investment portfolio is organized to execute S&T programs in the following 5 research thrusts as illustrated in Figure 4:

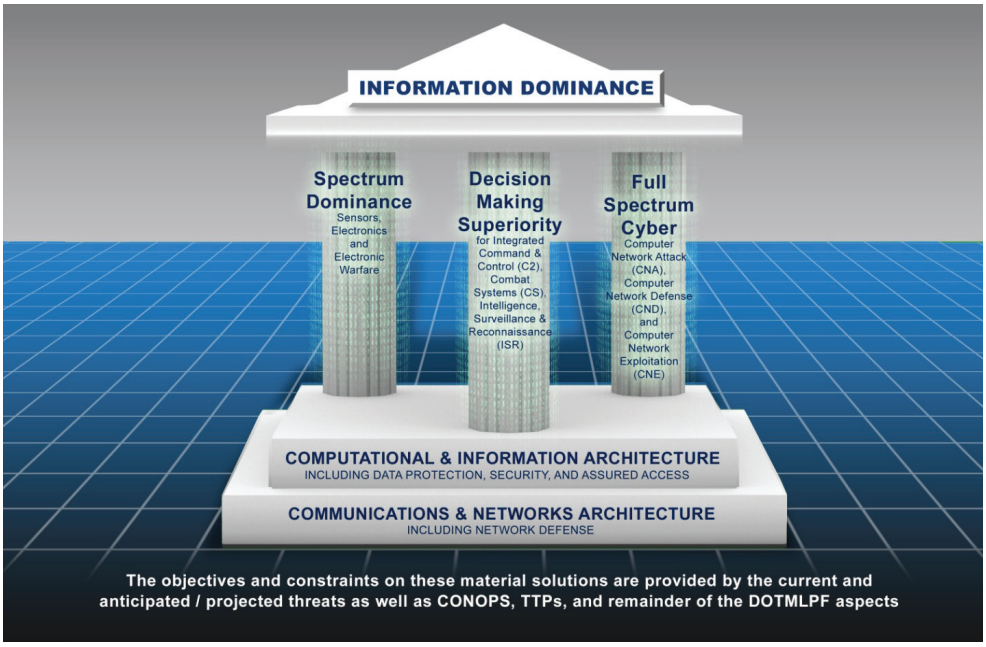


Figure 4. ONR Information Dominance Construct

Communications and Networks Architecture

- Dynamic, scalable tactical communication networks
- High-performance, low-cost communication solutions
- SATCOM denial mitigation
- Precision time and navigation

Computational and Information Architecture

- Open source, open architecture, service-oriented architecture and cloud computing
- C2/CS/ISR integration
- Machine reasoning and intelligence architectures

Spectrum Dominance

- Understanding the environment through sensing
- Control of the opponent's battlespace picture through control of the spectrum
- Electronic protection via networking and robust sensors

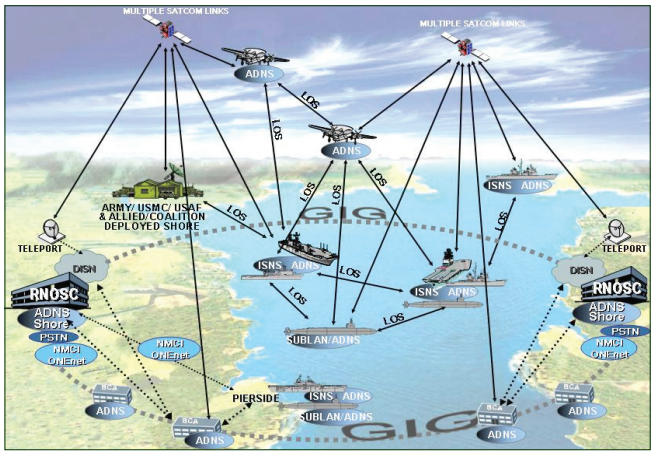
Full Spectrum Cyber

- Computer network defense
- Computer network attack
- Computer network exploitation

Decision Making Superiority for Integrated C2, ISR and Combat Systems

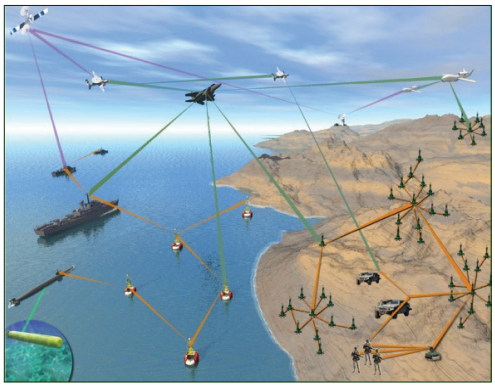
- Machine reasoning and intelligence
- Decision making in support of distributed mission-focused autonomy for control of large information networks (ISR)
- Information exploitation and decision making in support of mission kill chain execution
- Data error management

Communications and Networks Architecture



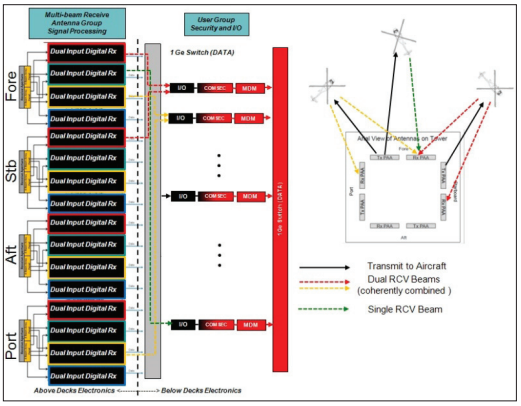
The overarching objective for this area is to develop high throughput, dynamic wireless communications and networks technologies critical to robust naval communications for widely dispersed mobile air, land, surface and submerged platforms in support of mission performance. These platforms are often size, weight and power (SWaP) limited, and operate under constraints of cluttered RF spectrum, harsh electro-magnetic interference (EMI) and Beyond Line Of Sight (BLOS) conditions. The technical payoff is increased network data rates, interoperability across heterogeneous radios, dynamic bandwidth management, and greater mobile network connectivity. The operational payoff is that Warfighters - coalition and allied forces - from the operational command to the tactical edge have the near real-time access to information, knowledge and decision-making necessary to perform their tasks. Emphasis is on tactical edge communications and networks to fully realize net-centric warfare concepts, bridging the gap between the Global Information Grid (GIG) and the 'disadvantaged user' (e.g., small-deck combatants, submarines, unmanned vehicles, distributed sensors and ground units, in Disrupted, Disconnected, Intermittent and Limited bandwidth (D-DIL) environments). See Figure 5 for the Communications and Networks S&T Roadmap.

Dynamic Scalable Tactical Communication Networks



Networks that facilitate distributed operations require the ability to automatically adapt to environment and/or adversarial changes while providing re-tasking and related adaptive behavior in order to securely distribute critical C4ISR information that improves Warfighter situational awareness, decision making, and shortens the kill chain at the tactical edge. Technologies are being developed that provide for network auto-configuration and continuous adaptation protocols to enable rapid, transparent platform network membership/departure without interrupting information flows, while minimizing human intervention.

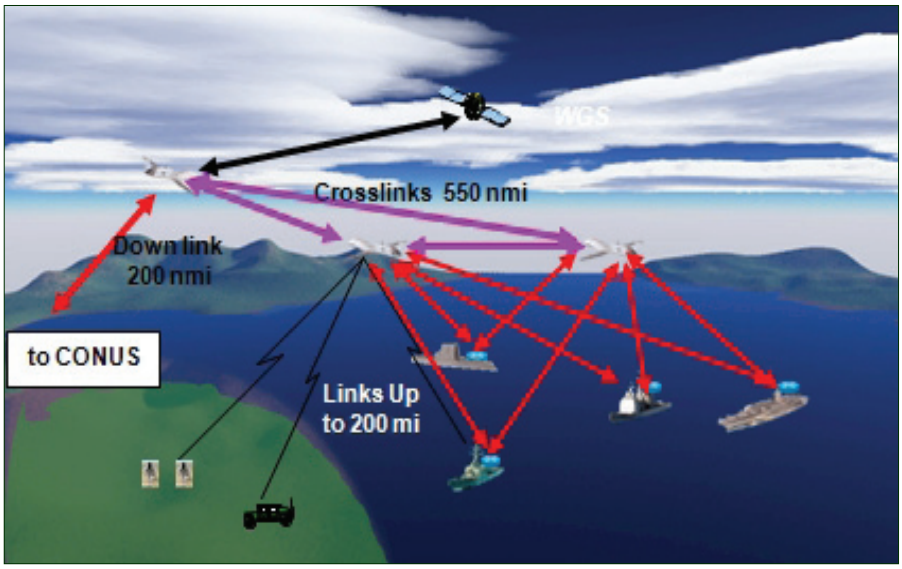
High Performance, Low Cost Communication Solutions



The C4ISR department executes technology development efforts that facilitate the implementation of low cost communications systems in support of improved littoral awareness for Naval forces using new high band networking waveforms and high mobility requirements that necessitate the use of multi-beam phased arrays and open radio architectures. These efforts will facilitate cost reduction and improve the performance of wideband RF data systems operated aboard ships and make them suitable for use in networking applications. Technology programs are focused on low cost phased arrays and low cost programmable radio solutions that are modular and can be distributed over the shipboard topside and connected to below-decks signal processing units using fiber. In addition, small, light antenna systems are being developed for small UxVs and other space/weight limited platforms.

SATCOM Denial Mitigation

This capability will be achieved through the development of new, open radio architecture, new system level components, and the integration of these items with low cost phased arrays into a high bandwidth networking infrastructure that is resistant to interference and can support all tactical activities. An alternate concept that could be pursued is the use of low cost, adaptable, ultra-wideband arrays in space that can reduce phased array sensitivity in the direction of threat jammers, place nulls over specific jammers, and frequency tune over very large frequency ranges to prevent barrage jamming.



Precision Time and Navigation

The technologies underlying Precision Time and Navigation are reliant on a level of precision not found in most other technologies. It requires an understanding not just of the fundamental physics involved in high-precision frequency or time measurements, but also all of the engineering factors that go into building a system that delivers that high precision in the real world. Precision navigation and timekeeping are essential for many modem naval and maritime systems, and it is essential that navigation and timekeeping services be made available to platforms and weapons at the highest level of accuracy and with the highest possible confidence at an affordable cost. Lack of precise navigation and timekeeping technologies may jeopardize the success of military operations. Code 31's Navigation and Timekeeping Program seeks new and innovative navigation technologies that will provide more accurate, reliable, maintainable and affordable systems for Naval air, surface, subsurface and ground platforms and forces. In the past six years, this department has been conducting a series of S&T projects in the following three technology areas: GPS Anti-Jam Technology, Precision Time and Time Transfer Technology and Non-GPS Navigation Technology. The C4ISR Department will continue to develop technologies that drive transformational improvements in accuracy and sensitivity of navigation, timekeeping and sensing based on coherent quantum phenomena.

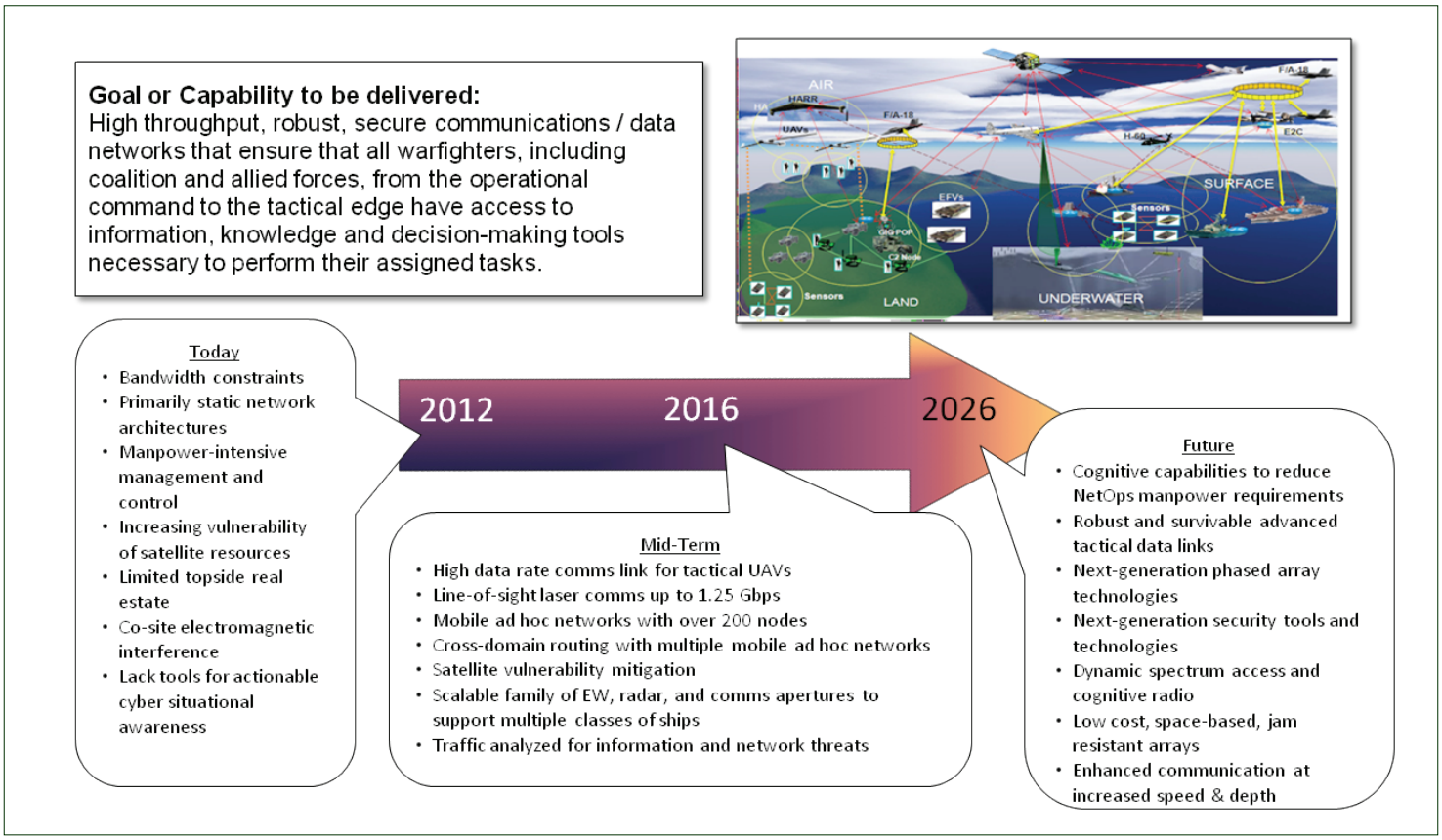


Figure 5. Communications & Networks Roadmap

Computational and Information Architecture

A service oriented architecture (SOA) in a cloud environment is the core for new technologies that use various computational techniques to create building blocks for analysis, reasoning, learning and machine intelligence. New computational architectures are needed to provide Warfighters the ability to analyze very large, diverse databases and thereby be more agile in response to changing adversary tactics and threats. See Figure 7 for the Computational and Informational Architecture S&T Roadmap.

Open Source, Open Architecture, SOA and Cloud Computing

Machine virtualization, cloud computing, and big data analytics are promising technologies for reducing costs while creating more agile/flexible solutions. The Navy has unique applications and services for Navy-specific systems as well as the challenge of operating them from ships. The shipboard environment is characterized by disrupted, disconnected, intermittent, and limited connectivity. Consequently, afloat users will need more services and data hosted locally to ensure that critical functions are sustained in this environment under Anti-Access, Area Denial (A2AD) conditions. Interoperability between those services in the tactical environment and the larger enterprise requires an open, modular, technology-agnostic architecture that (1) defines distinct service boundaries; (2) establishes open interfaces across these service boundaries; (3) implements security mechanisms within each layer of the software/hardware stack; and (4) establishes a Navy service broker that manages end-to-end capabilities across any service/organizational seams.

The Navy must develop S&T in support of mission focused, net-centric capabilities that are intended to enable the fleet to be more adaptive to changing mission needs and more agile in response to changing adversary tactics and threats. The core S&T being addressed will demonstrate how a distributed enterprise can be based on:

- SOA and cloud computing ;
- Shared plans/tasks data model; and
- Distributed data services that are implemented to provide effective support to C2ISR operations in an A2AD and D-DIL environment.

Figure 6 illustrates the data-driven, computational environment needed to provide the right set of functional capabilities required to support operations in their respective areas as well as common needs among all of the communities.

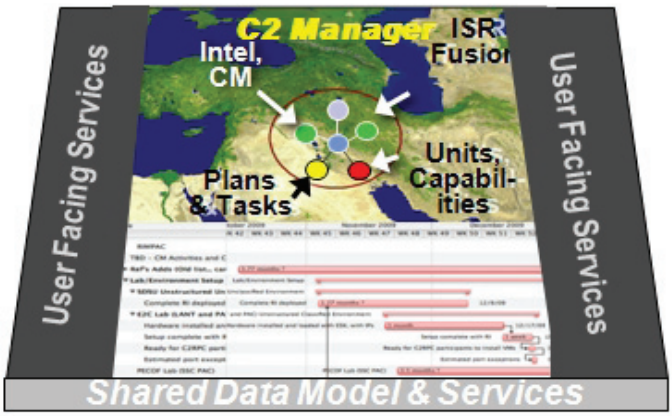
Key concepts essential to the success of this effort will include the design, development and implementation of:

- Common enterprise computing hardware and software infrastructure to align Navy data and information products and needs with Joint and other Service components capabilities;
- SOA and cloud computing techniques to decouple applications from infrastructure;
- Data strategy that incorporates a shared plans/tasks data model and enables shared data access/exchange among the various Naval/DoD communities; and
- Disciplined experimentation practices to validate technical capabilities and to co-evolve tactics, techniques and procedures and technology maturation via Limited Operational Experiments.

Figure 6. Data-Driven Functional Capabilities Enhanced by Cloud Computing using SOA

Command and Control / Combat Systems / ISR Integration

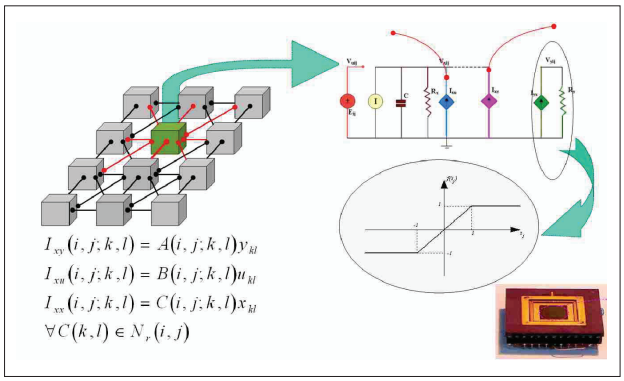
Achieving CNO and OPNAV N2N6 goals for "Information Dominance" requires rapid/effective integration of Joint and USN sensors, combat systems, C2 systems, ISR systems and tactical platforms that automate the movement of data between deterministic CS, non-deterministic C2 systems and their relevant sensors. Analysis conducted by ONR Code 31 over the past 7 years reveals that success against a near-peer regional competitor in all warfare areas requires rapid composition of force and movement of data across the force, regardless of its source, to any decision maker requiring the data. However, data movement between systems and platforms remains largely a manual process primarily using voice that does not effectively counter the threat. Automating movement of data between deterministic and non-deterministic systems or even between a platform LAN and the broader Force WAN requires establishing



quality of service and information assurance mechanisms enforced through service level agreements implemented in the technologies developed and fielded by multiple PEOs. Code 31 is developing and refining technologies and experimentation projects that enable multiple PEO collaboration and establish consistent data handling mechanisms, metrics and technology pull to overcome critical cross-PEO gaps, thus achieving CNO's ID objectives. To be successful, Code 31's S&T portfolio in the near to mid-term in this area centers around a broad effort to integrate the many disparate independent CS, C2, and ISR systems into a common information environment / architecture that is modular and based on open standards. The goal is to enable automation of analysis of large amounts of data, reduce manpower requirements, and provide technical solutions and direction to related acquisition programs. This will become increasingly crucial as more autonomous systems are introduced at the tactical level, thereby greatly increasing the amount of control and data analysis needed for orchestration and integration across the joint force with greatly reduced manpower.

As alluded to above, the real issue is all about the data, not whether one is engaged with CS, C2 or ISR systems. Any Warfighter working a task or mission must have access to appropriate data or analytic results regardless of its source, level of operation (strategic, operational or tactical) or when collected in the operation (planning, situation awareness, execution). To enable this capability, a cloud environment is being assessed. Such a data/computational environment can, in fact, enable the focus to be on the data. Thus, execution of a warfare mission becomes a series of activities and services drawing on this data rich environment to accomplish its goal. Initially, each Warfighter accomplishes his/her task via the data which he/she has to access. Clearly the longer term objective is to automate/autonomize more and more of the processing and analysis aspects of these mission execution tasks to enable the Warfighter to focus on decision making and execution. This aspect of Information Dominance will be discussed further in the Information and Decision Making Space section later in this document.

Machine Reasoning and Intelligence Architectures



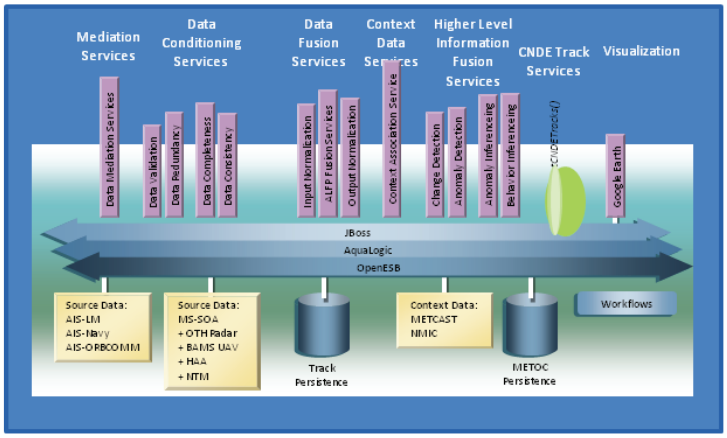
A final aspect of Computational and Information Architecture concerns the computational hardware. Currently, digital computations totally dominate the hardware aspects due to the success of digital computers for large, precision modeling and engineering problems. This has greatly diminished support of alternate computational architectures.

On the other hand, autonomy and decision making involve assessing the relevance of large amounts of highly disparate data with errors of uncertainty, incompleteness, contradiction and imprecision and the implications of integration on our understanding of the dynamic battlespace. Development of intelligent, autonomous architectures that respond to commander's intent, operate in a highly dynamical and ill-understood environment, and support autonomous collection and assessment of battlespace information may well require alternatives to traditional digital computing.

Certainly, Cellular Nonlinear Network (CNN) technology, with tightly coupled nodes, has proven to be extremely effective in image and video analysis with greatly reduced SWaP. Are there analog architectures that are similarly effective for decision making in these data environments?

This is not to say that emphasis should only be placed on analog computing, but objectives must include the ability to handle information environments noted above with low SWaP if it is to address the needs of decision making (autonomy) in both command and control environments, as well as unmanned platform environments, whether it be digital, analog, or quantum based.

Goal or Capability to be delivered:
New technologies that use various computational techniques to create building blocks of intelligence (e.g., reasoning, planning, learning, knowledge bases, and intelligent architectures) to set the foundation for enabling net-centric capabilities that are intended to provide warfighters the ability to be more adaptive to changing mission needs and more agile in response to changing adversary tactics and threats within the Information Space.



Today
- Numerous heterogeneous databases
- Inputs filtered to limit display confusion
- Manpower-intensive information management & control
- Digital computer technology
- Proprietary data types
- Highly limited data exchange & sharing

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Mid-Term
- Improved SOA-based interoperability (SOAP, common ontologies)
- Enhanced and accurate decision-making
- Dramatic C2 improvement for the Warfighter (C2/CS LTE)
- Automatically organize and align disparate data sources
- Intelligent data ingestion for many classes of data such as SIGINT, IMINT, MOVINT, etc.

Future
- Data focused information systems connect decision makers to knowledge that they need
- Access to all relevant Nat'l, theater, maritime DBs
- Increased access and shared awareness of relevant data, activities and enterprise status among tactical forces
- Autonomous mission focused sensing systems
- Enhanced machine reasoning and intelligence

Figure 7. Computational Environment Roadmap

Spectrum Dominance

Spectrum Dominance (SD) includes efforts that focus on electronics, sensors, and electronic warfare and employing them to understand and shape the battlespace, as well as to disrupt the adversary's ability to do the same, as illustrated in Figure 8. Over the last two decades significant advances have been in RF and millimeter wave electronics technology (power amplifiers, tunable filters, low noise amplifiers, antennas, analog to digital converters, circulators, etc.) that can enable major capability improvements in radar and EW across these spectra, including W-band. S&T is currently developing prototype systems which will provide the future Navy with coverage across all parts of the spectrum with useful atmospheric transmission. During this time major advances have also been made in electro-optic (visible and infrared) electronics (lasers, focal plane arrays, etc.) which have enabled major advances in active and passive sensors for both surveillance and EW. While electro-optic technology has previously found more applications for aircraft, that is now changing with its application to threats from anti-ship missiles.

However, continued future dominance will require broader bandwidths and more capable functionality to create new operational advantages and to maintain current ones in the face of increasingly diverse and sophisticated threats. Spectrum dominance in the future will require addressing the terahertz electromagnetic (EM) spectrum also. This bandwidth expansion will also drive continuing challenges in engineering trade-offs in power, dynamic range, efficiency, SWaP and sensor processing. The end goal of SD is to achieve maximum control of the entire EM spectrum, thus providing the capability to deny, deceive, disrupt, degrade, or destroy the full spectrum of globally emerging hostile communication systems, sensors, and weapons systems dependant on the EM spectrum. It also ensures that friendly systems can function in a dense noise and false signal environment intended for disruption. See Figure 9 for the Spectrum Dominance S&T Roadmap.

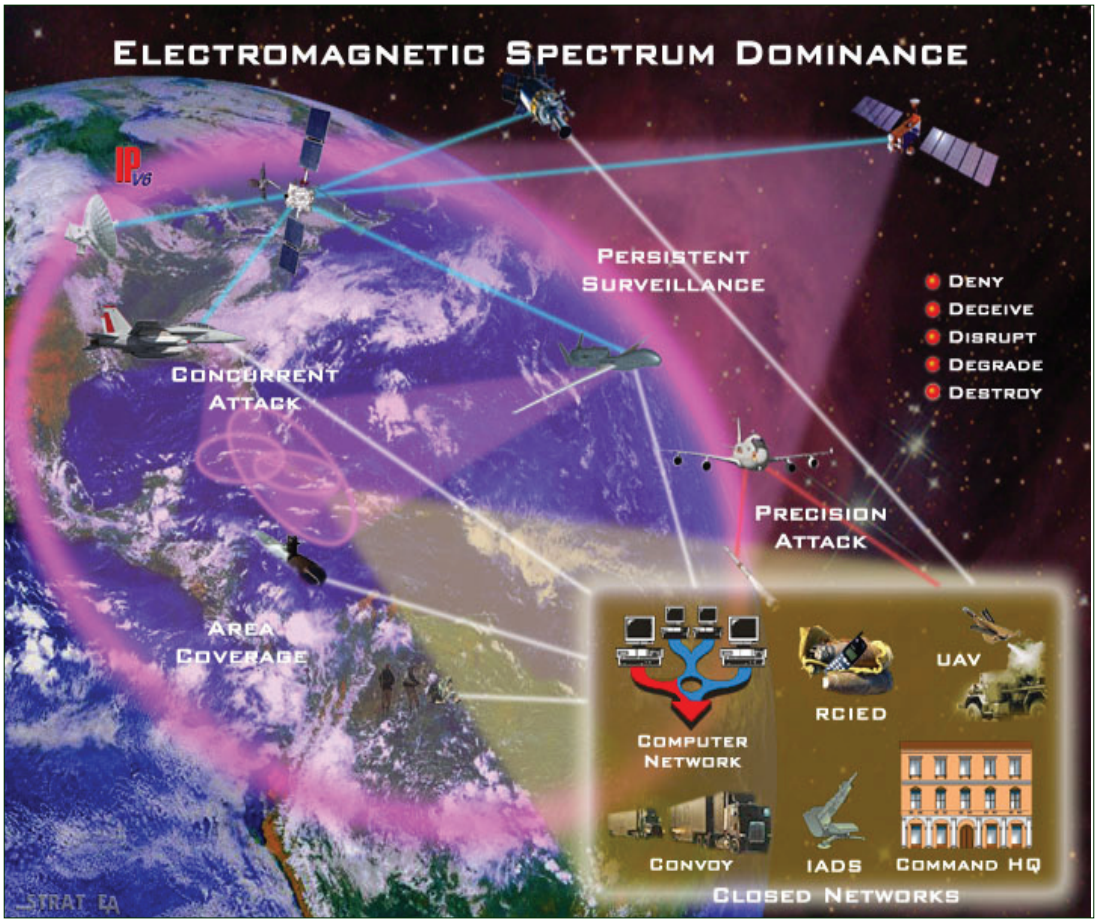
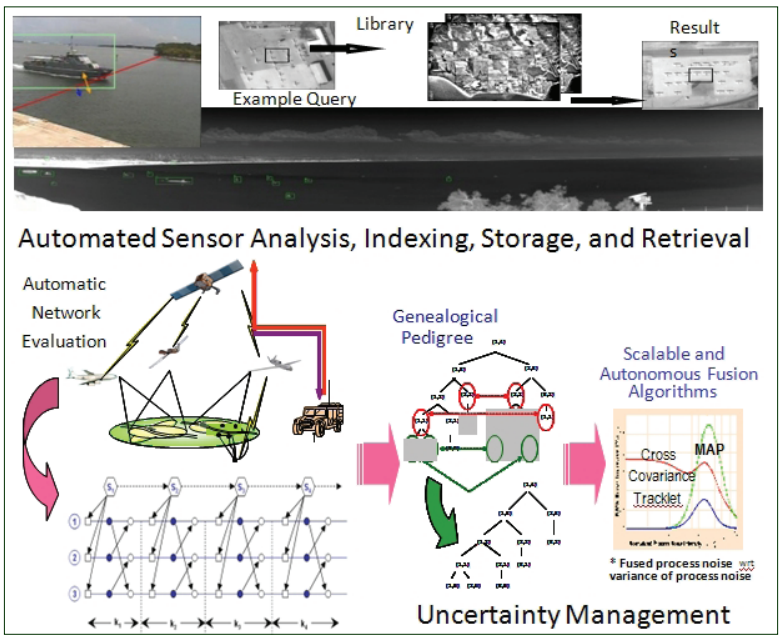


Figure 8. Spectrum Dominance Concept Overview

Understanding the Environment through Sensing

The C4ISR Department is developing the next generation of EM sensors including: (1) affordable radars with improved performance (e.g., extended area operations, extended threat sets, operability in harsh and noisy environments) and fully automated operations (e.g., classification, identification), (2) a range of affordable, compact, and reliable EO/IR imaging sensors for use on Navy and Marine Corps air, sea, land, and undersea platforms in order to perform wide-area surveillance, and long-range target detection and identification, and (3) passive EW capabilities to enable detection, classification and identification for conventional, unknown, and complex signals and emissions. The department is also developing algorithms and services for sensor management that can optimize the value of information that is produced by the sensors in the context of the mission. The networking of these sensors is critical in the current dense and complex EM environment.



Control of the Opponent's Battlespace Picture through Control of the Spectrum

ONR 31 is also developing the next generation of active and passive Electronic Warfare (EW) technologies and techniques for both centralized and networked on/off-board capabilities to counter emerging threats to Naval platforms by hostile surveillance and weapon sensors (both active and passive). The objective is to develop effective countermeasures to deny/deceive threat sensors. EM spectrum control will be achieved through a networked, integrated, and distributed surveillance and EW system-of-systems that provides the necessary increase in non-kinetic capacity and capability to meet emerging sea-based defense needs.

Electronic Protection via Networking and Robust Sensors

In addition, ONR 31 is developing next generation distributed sensing techniques (e.g., cooperative networked radar) to ensure robust situational awareness that is immune to interference and denial, and provides battlespace ID with improved accuracy. In general, Electronic Protection (EP) is provided by greatly increasing the degrees of freedom that are available to address intentional and unintentional EM interference. Key enablers to achieve this capability will be provided by developing technologies that improve sensitivity via active aperture technology and dynamic range improvements. The use of open architectures will enable relatively inexpensive upgrades to processing and hardware as new techniques and capabilities are developed. Technologies developed and matured under these efforts will validate the concepts and controls needed to use real-time networks to coordinate multiple radars, EW systems and other assets that are distributed across the battlespace to provide EM spectrum control over wide geographical areas.

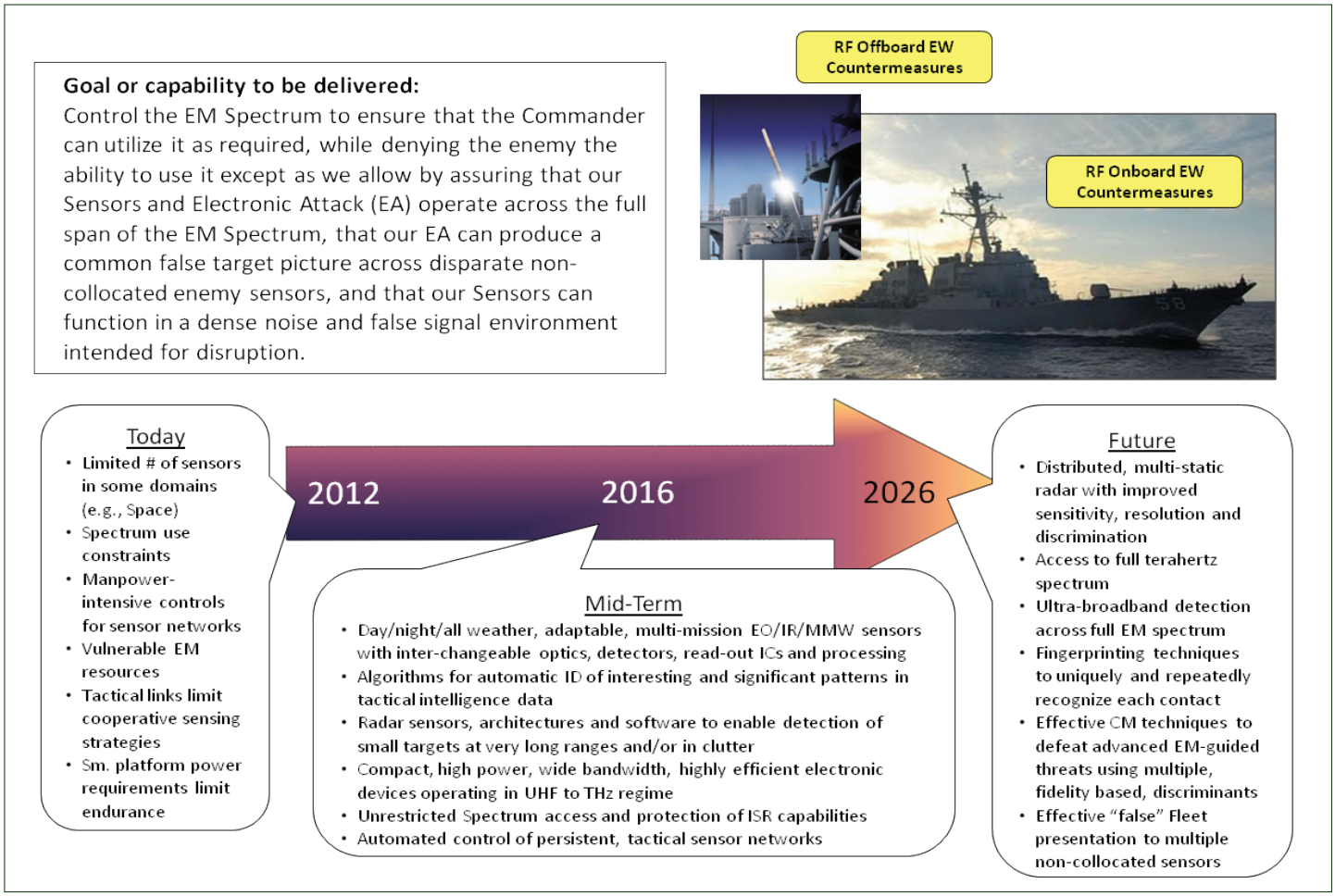
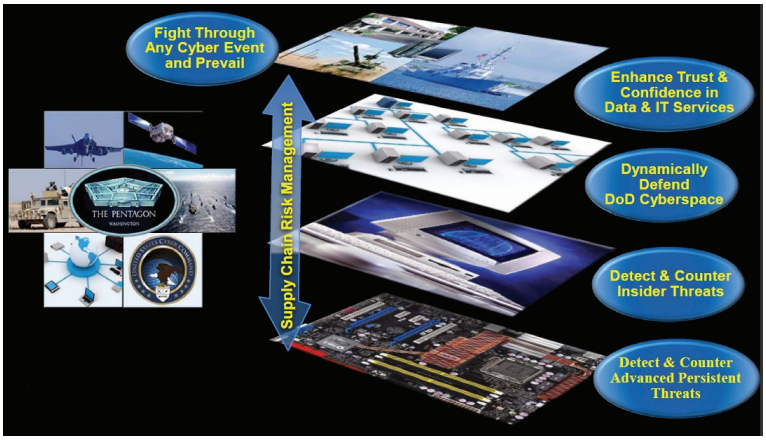


Figure 9. Spectrum Dominance Roadmap

Full Spectrum Cyber

Full Spectrum Cyber operations are used primarily to disrupt, disable, degrade or deceive an enemy's command and control, thus crippling the enemy's ability to make effective and timely decisions, while simultaneously providing protection for our networks and data as well as assured, validated access to this data by our Warfighters. The threats on our networks and our adversary's ability to disrupt our operations are increasing exponentially. Our current technologies are failing to keep pace as currently configured. We need new ways to frame the problems on our networks and look for new means to exercise command and control over our own networked assets, as well as those of our adversaries. Code 31's technology development strategy in this area takes a comprehensive, top-down system level approach to the problem of defending Navy networks. The approach focuses on enabling technologies that can be integrated into a single system rather than a series of disparate research efforts that are traditionally difficult to integrate into a single system. This can be accomplished by investigating new technologies within the framework of on overall goal system that enables the Navy to move away from the traditional concepts of patch management and computer resource management, thus allowing the Warfighter to focus on the real threats rather than spending an inordinate amount of time on configuration management. See Figure 10 for the Full Spectrum Cyber Roadmap.

Computer Network Defense



To achieve full spectrum dominance, our forces must create a layered defense across the C4ISR enterprise enhanced through global and enclave situational awareness with the capability to rapidly characterize, attribute and respond to attacks. To that end, Code 31 is developing technologies that enable tools to assess software and protocols to determine the inherent vulnerabilities of the software and analyze code for behavior characteristics to support remediation. Protocols will be developed by first identifying existing deficiencies in the protocol suite – then assessing the availability of new and emerging communications and security protocols. The newly designed protocols will be simulated and emulated to ensure that they provide: a) the appropriate levels of security for the data they are carrying; b) the appropriate quality-of-service mechanisms; and c) meet throughput and reliability parameters required to mission and security-critical functionality. One key aspect to be considered is to ensure that the protocols function correctly and efficiently over heterogeneous networks. This includes networks ranging from high-bandwidth, low-latency and low bit-error rate links to narrowband, and variable latency mission-critical links.

To address the ever-evolving threats to our networks, Code 31 is developing new event detection technology that will be designed to be dynamically reconfigurable and located throughout the network – providing enhanced anomaly detection capabilities and robust security features to aid in heightening network threat awareness by providing network information back to a decision support system. The event detection technology will provide local processing capabilities that include data analysis, fusion and correlation in order to provide processing at the point of attack as well as to provide near real-time detection and remediation actions. These local capabilities are supported by automated capabilities that are based on near real-time decision support to address cyber activities as they occur/unfold in the network.

Finally, significant international activity in the general area of quantum information science and specifically in free-space quantum teleportation for secure key distribution has occurred. Free-space teleportation is absolutely critical for the Navy where free-space communications is the only means of connectivity between elements of the battleforce and upper echelon commands. This is also a research area receiving increased ONR support.

Computer Network Attack

Cyber warfare is as real as warfare in the physical world demanding a strong offense, robust defense, and skilled Warfighters with an offensive mindset. Our maritime forces must be equipped with the most advanced technology to use cyber power to affect the world, physical and virtual. Code 31 is developing technologies that enable the capability to disrupt, deny, or degrade adversary information systems. Our S&T efforts will develop the capability to control adversarial communications and networks and protect our own, thereby crippling the enemy's ability to direct an organized defense while preserving effective command and control of our forces. Due to the CLASSIFIED nature of the activity is this area, the majority of ONR 31's technology development portfolio cannot be discussed in this document.

Computer Network Exploitation

To ensure friendly forces are dominant in the area of Computer Network Exploitation, we must develop a Common Operational Security Decision System to enhance the Warfighter's decision making process. Code 31 will develop technologies that enable operations and intelligence collection capabilities conducted through the use of computer networks that gather data from target or adversary automated information systems or networks. Technology development efforts will focus on aggregating and analyzing sensor data in order to provide network defense watch-standers with the best possible information to support their decision making process. Key focus efforts will include visualization technologies capable of: a) presenting vast amounts of data in a user friendly and actionable format; b) aggregation of network traffic from numerous sensors in order to detect events of interest in near real-time; and c) control and management of various security-critical network components.

In summary, we must provide cyber/security situational awareness to support cyber-physical and computer network operations, enable the Warfighter to understand and quantify the security posture of the network to support mission planning and mission outcome and provide a capability to dynamically control network security components to address changing network threat environments. Due to the CLASSIFIED nature of the activity is this area, the majority of ONR 31's technology development portfolio cannot be discussed in this document.

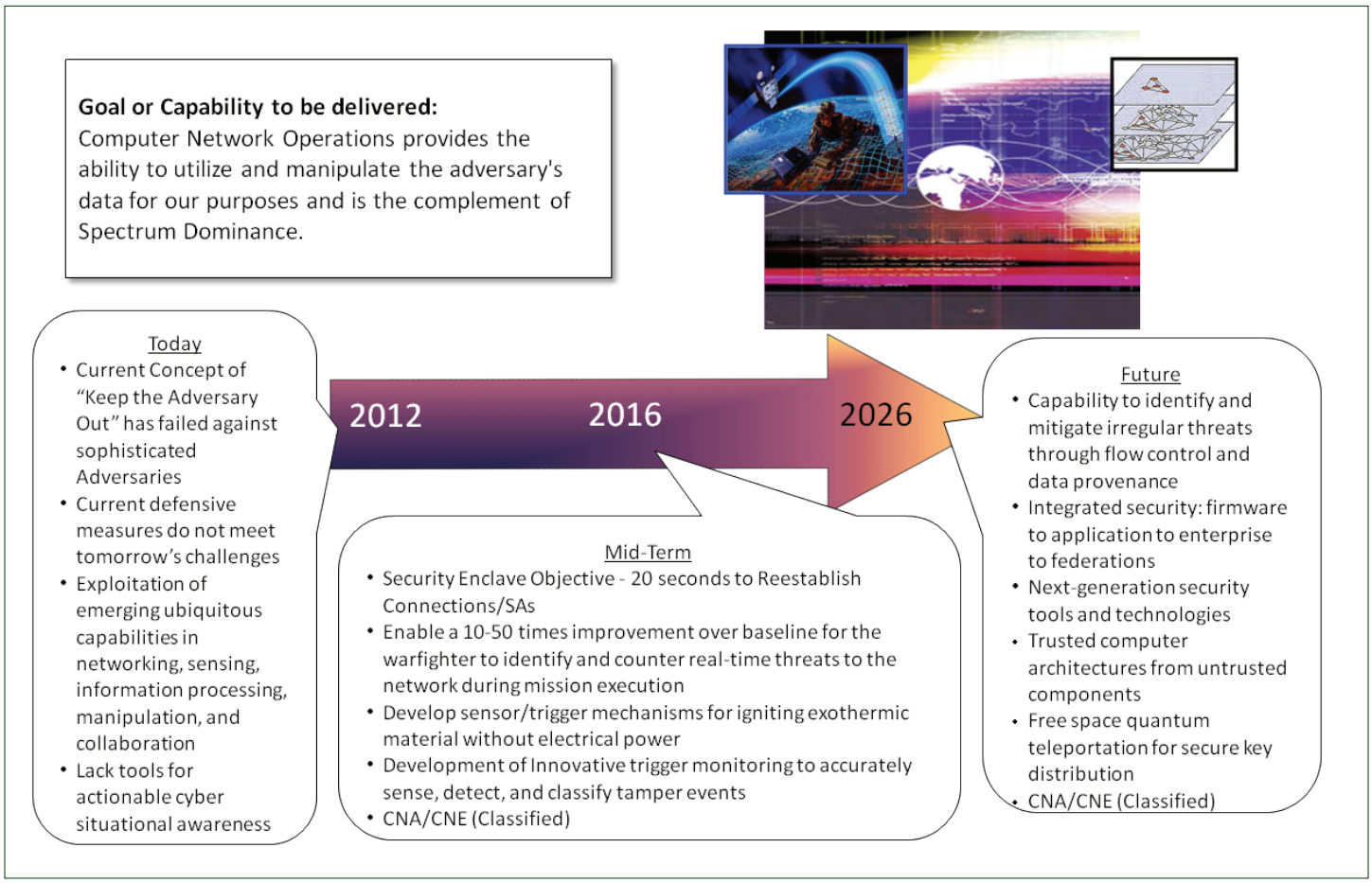


Figure 10. Full Spectrum Cyber Roadmap

Decision Making Superiority for Integrated C2, ISR and Combat Systems

ONR Code 31 has supported a broad effort to integrate the many disparate, independent CS, C2, and ISR systems into a common, data-focused information environment / architecture that is modular and based on open standards. The goals are: to achieve a higher level of "data transparency" through a cloud environment; reduce manpower requirements; reduce large number of errors inherent in manual processing systems; and provide technical solutions and direction to related acquisition programs. Figure 11 is a representative construct for a Decision Making Superiority architecture. The portion from the Application Interoperability Frameworks and below is largely the information and computational architecture, while the section above that is where the warfighter realizes Decision Making Superiority for C2, CS, and ISR. It consists of sets of services for the various aspects (information, C2, IO, etc.) that are the foundation for execution of the kill chain for any given warfare area seamlessly. This is the heart and brains of Information Dominance

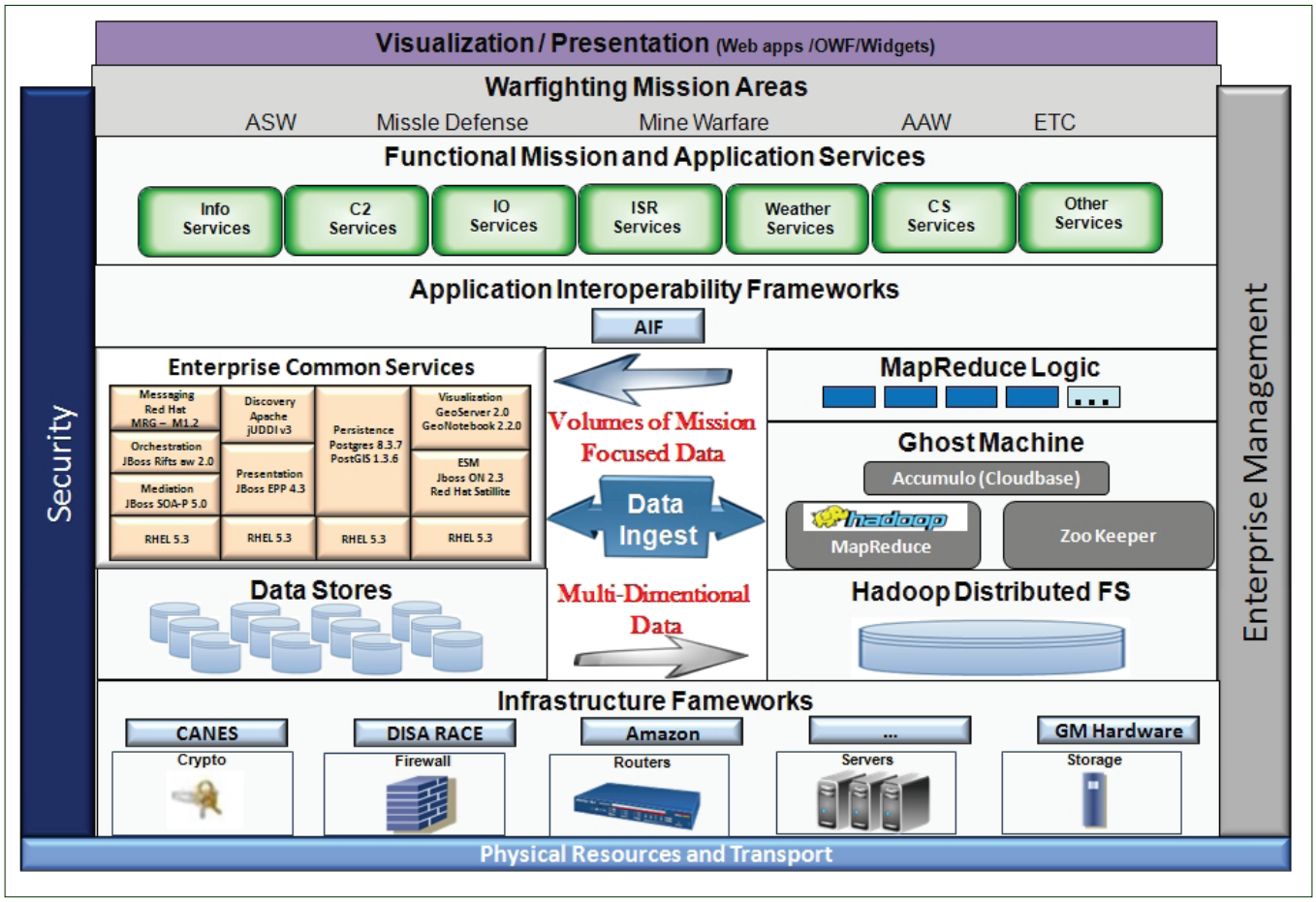


Figure 11. C2-CS-ISR Information Reference Architecture Framework

The goals for this area are to develop technology enhancements that enable the understanding, integration, analysis and assessment of extremely large, highly disparate information/data sources with errors in uncertainty, incompleteness, imprecision, and contradiction. Capabilities enabled will provide continuous and automatic integration of all information from all sources into battlespace threat and courses of action analysis and assessment. Consequently, Naval forces will be able to rapidly and accurately understand the battlespace in the context of their missions and execute them in a timely manner. This will assure that automatic, continuous analyses of intelligence, surveillance and open source information have, at all times, optimized the possible courses of action based on commanders' intent. To achieve this, advances are required in machine reasoning and intelligence (autonomy) as it enables autonomous control of large information gathering sensor networks and intelligence, as well as analyses of large disparate data/information sets.

Decision Making Superiority for Integrated C2, ISR and Combat Systems

Machine Reasoning and Intelligence

This area is the fundamental capability for machines to reason about information, assess their current world knowledge (model) against available information, identify inconsistencies relative to new data/information, adjust its world model, and test these new hypotheses. This capability is fundamental to advances to higher levels of autonomy. (Note that autonomy is about decision making and only has meaning or specification in conjunction with an objective - whether that is control of a vehicle or object or sensor, or analysis and assessment of large data sets.) Clearly, critical underlying issues include efficient, effective representations of entities, activities, events, relationships (i.e., connections such as family, phone calls, emails, meetings, etc.), networks, complex models, etc. Many of these quantities are dynamic in nature, which is a requirement of any concept for realizing machine reasoning and intelligence.
Digital computers can certainly simulate the underlying models for such a capability; this is a very active area of research today. A critical issue is SWaP and latency. Can these reasoning strategies be better implemented in alternate architectural constructs? How does the "computational architecture" and data representation interact or get intertwined? Can a "data driven" dynamic "computational" architecture lead to lower latency and error management? This is clearly a very complex issue which will require a long-term perspective.

Decision Making in Support of Distributed Mission-Focused Autonomy for Control of Large Information Networks (ISR)

UxVs enable Naval forces to take humans out of harm's way and enable missions that are impractical for humans such as long-term persistence. While remote controlled UxVs support such objectives, they are manpower intensive. As a next step in the evolution of autonomy, rule-based systems can support simple environments and relatively simple missions, but are still too brittle for complex, uncertain, unstructured environments and complex missions. A further level in the evolution of autonomy is the ability of the autonomous control to at least recognize when its world model does not agree with its own sensor data, and only then request human support. This certainly reduces manpower. The next capability level will require "computers" to comprehend their environments and relevant aspects of the battlespace in the context of the commander's intent / objectives. This will enable robust systems in unstructured and uncertain environments, including the presence of threats, dynamic changes and "open world" models with large numbers of types of objects/entities that are not all known in advance. Achieving this capability level is truly a long-term objective and requires major advances in machine reasoning and intelligence.

Information Exploitation and Decision Making in Support of Mission Kill Chain Execution

As the new surveillance systems in the Naval forces come on line and technology enables the automated assessment of broader unstructured material (open source, HUMINT, phone internals, etc.), the Warfighter will become inundated with data: a state of information deluge vice information dominance. Currently this area is advancing relatively fast as funds to deal with current requirements have enabled the maturation and fielding of "low hanging fruit". These applications, like rule-based autonomy, can handle, generally, relatively well-structured tactical issues. These have seen significant success in current tactical conflicts. On the other hand, as the diversity and magnitude of information increases along with the dynamics and complexity of the battlespace, new strategies / methodologies / technologies will be required. This is

particularly true in understanding the broad battlespace and its evolution over time vice the more structured information need of near-term tactical operations. This requires a higher level of machine reasoning and intelligence just as discussed in the autonomous control of surveillance resources. In fact, both of these areas (Decision Making in Support of Distributed Mission-focused Autonomy for Control of Large Information Networks and Information Exploitation and Decision Making in Support of Mission Kill Chain Execution) require similar advances in machine reasoning and intelligence such as representations of entities, events, relationships, etc., and the ability to process and integrate large amounts of highly disparate data with errors.

Data Error Management

As has been mentioned a number of times, dealing with, managing, and developing a solid mathematical foundation for errors of uncertainty, incompleteness, imprecision, and contradiction are critical. We must have a solid framework that can provide confidence levels to results of the integration of large sets of highly disparate data. We must also be able to rapidly assess upon which data to focus efforts for improved quality in order to more rapidly improve our confidence level of the over-all result.

See Figure 12 for the Decision Making Superiority for Integrated C2, ISR and Combat Systems S&T Roadmap.

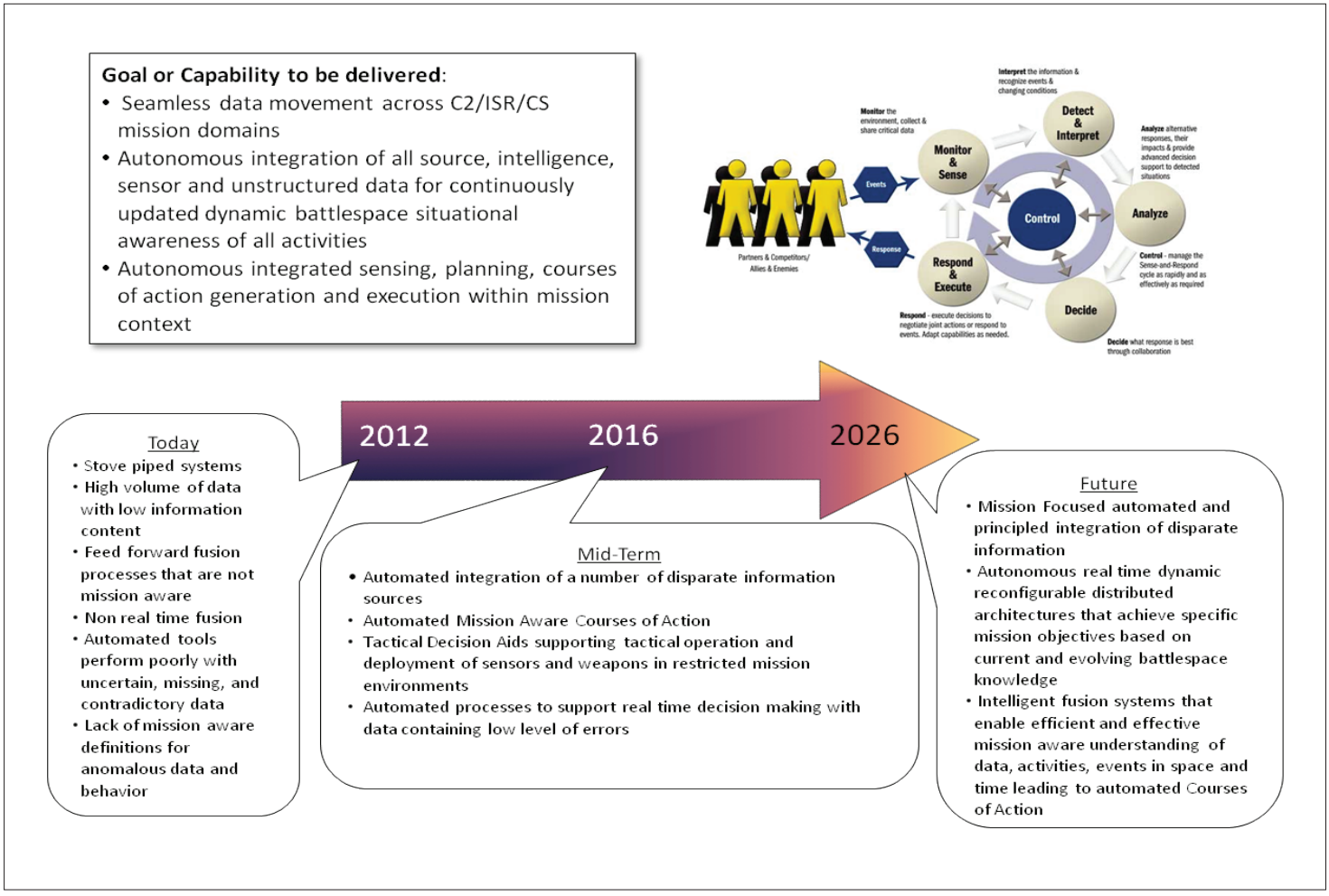
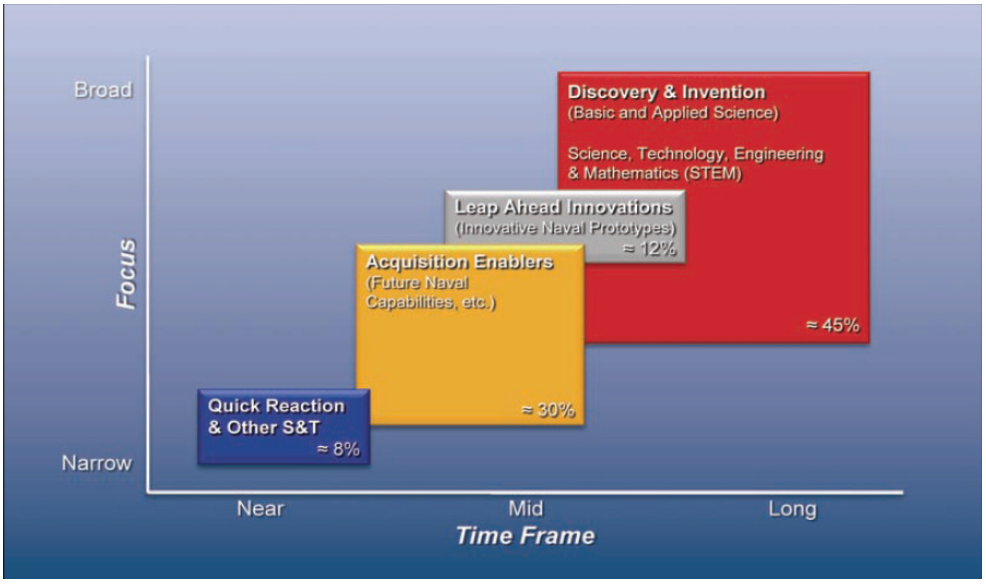


Figure 12. Decision Making Superiority for Integrated C2, ISR and Combat Systems Roadmap

Code 31 Science & Technology Process

Code 31's portfolio follows the established, approved S&T process, with the exception of an added Limited Technology Experimentation (LTE) component, closely engaging PEOs and OPNAV, in developing technology that provides both knowledge and products that contribute to near-to-long-term DoN strategic goals. Key components of the investment portfolio are designed to support the Navy S&T Strategic Plan and work to meet current and emerging Warfighter needs and deliver future Force capabilities in the following research categories: Discovery and Invention (D&I) (6.1 and early 6.2); Leap Ahead Innovations / Innovative Naval Prototypes (INP) (6.3); Acquisition Enablers / Future Naval Capabilities (FNC) (late 6.2/6.3); and Quick Reaction. (Figure A-1



In addition, Code 31 develops and executes projects in several special categories: Speed to Fleet (S2F) (6.4); Small Business Innovative Research (SBIR) (6.7); Multi-Disciplinary University Research (MURI) (6.2); Limited Technology Experiments (LTE) (6.4/6.3); and other Fleet Experimentation (FLEX) (e.g., Trident Warrior, Valiant Shield, RIMPAC, Northern Edge, etc.), as well as projects funded from external sources such as OSD and DARPA.

Figure A-1. ONR S&T Investment Portfolio (as of FY11)

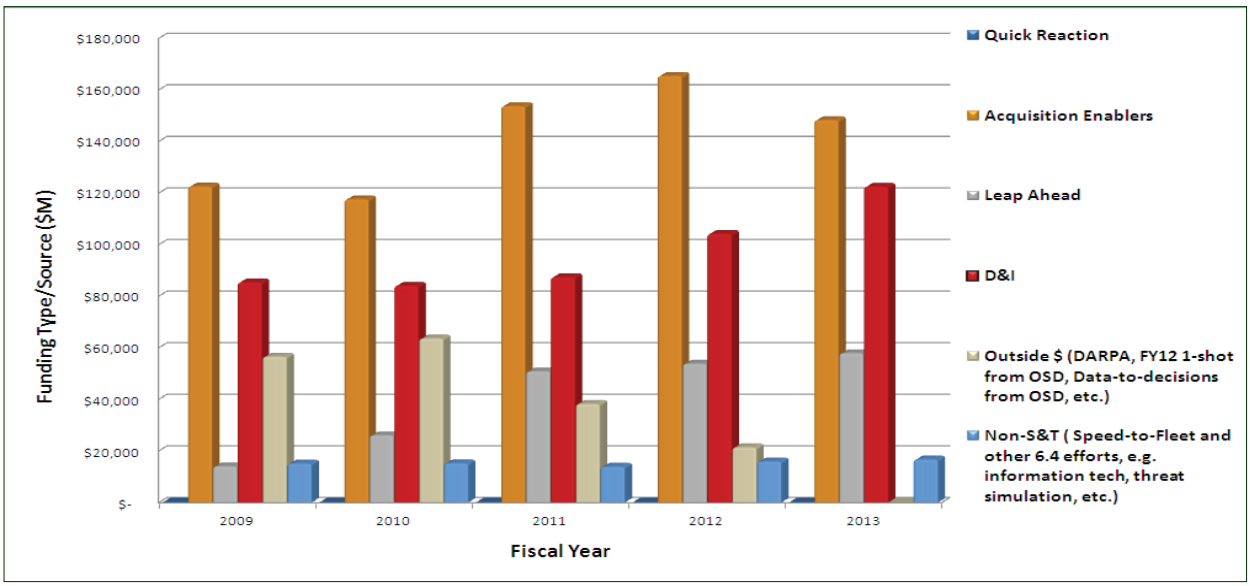


Figure A-2. Code 31 S&T Investment Portfolio (FY09 – FY13)

Discovery and Invention (D&I)

Basic and Applied Research

With a broad focus covering a long time span from 5-20 years, D&I investments concentrate on Basic and Applied Research – primarily at universities, with potential Naval relevance and technology opportunities required for advanced capabilities for future Warfighters. As noted earlier, the D&I program is largely the result of the individual program manager's and program officer's analysis of research and technology opportunities. It is generally the highest risk, highest payoff component of the portfolio. Code 31's D&I portfolio covers RF electronics, EO/IR sensor technology and processing, radar and radar processing, electronic warfare, precision time and navigation, communications and networks, information technology, nanoelectronics, information assurance, automated image and video processing, autonomy, machine reasoning and intelligence, quantum information science and operations research.

Innovative Naval Prototypes (INP)

Leap Ahead Innovations

Code 31 very actively seeks new technology investments that are potentially "game-changing" and "disruptive" in nature. Programs in this category may, for reasons of high risk or radical departure from established requirements and concepts of operation, be unlikely to survive without top leadership endorsement, which, unlike FNCs, are initially too high-risk for a firm transition commitment from the acquisition community. However, this willingness to accept higher risk often produces exceptionally higher payoffs for the Warfighter. For this reason, the INP programs are approved by the Navy S&T Corporate Board (VCNO, ACMC and ASN RDA).

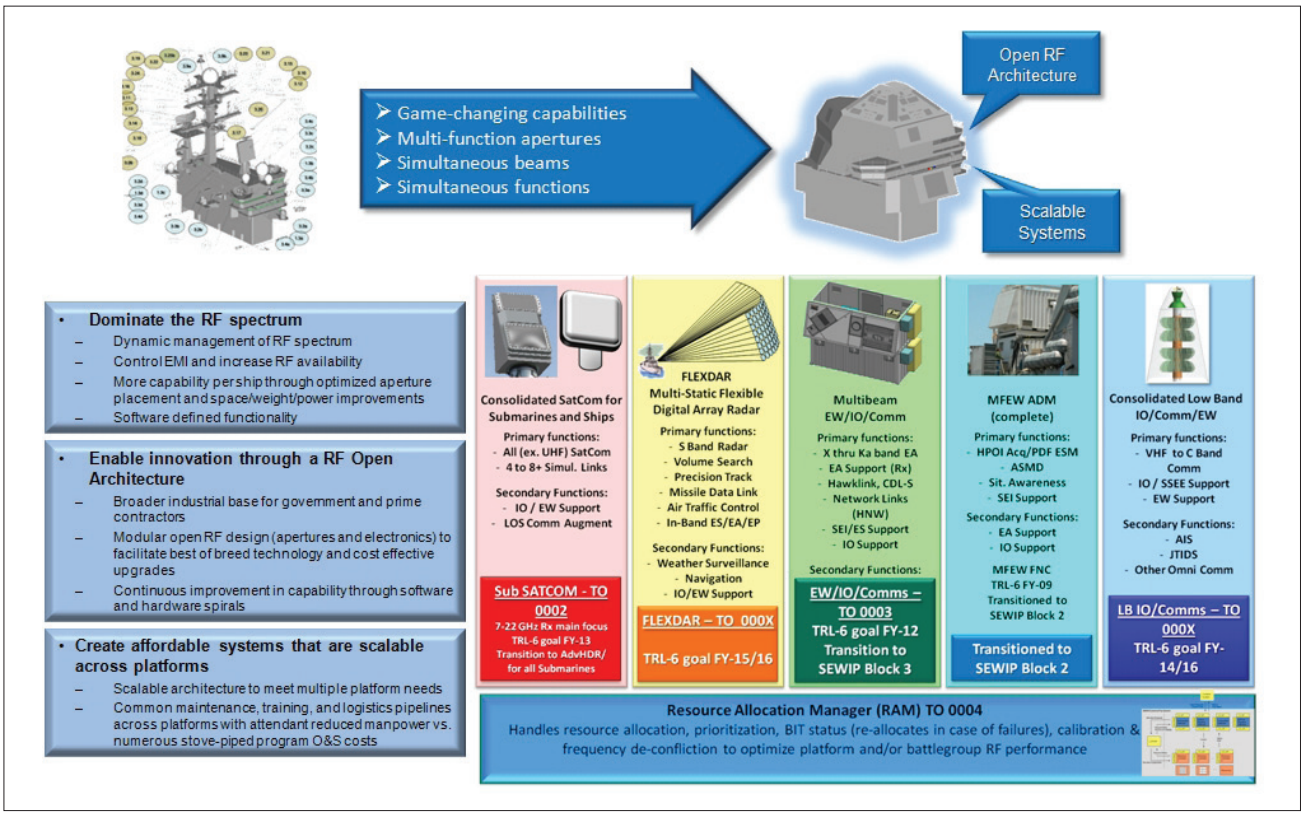
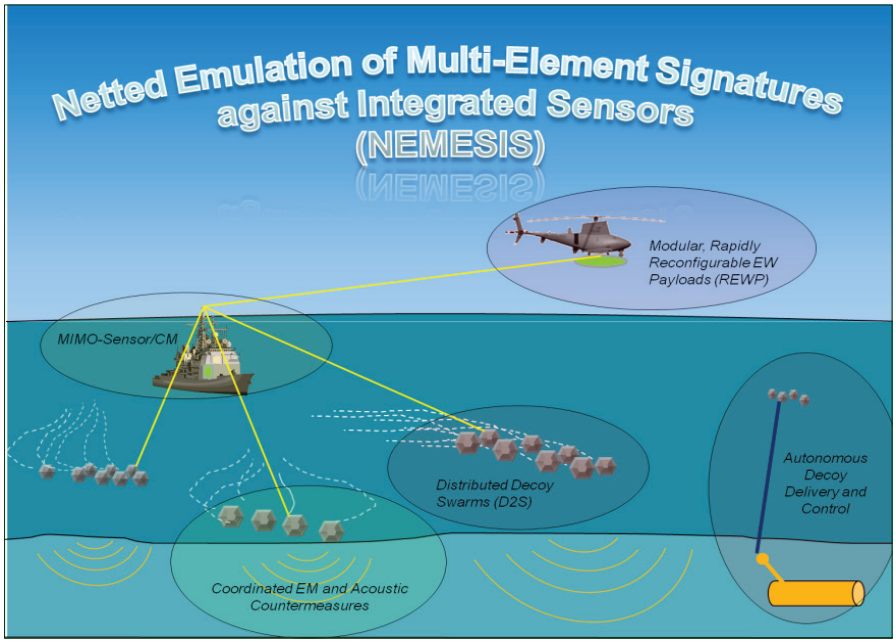


Figure A-3. Integrated Topside Innovative Naval Prototype

A significant current investment of this type is the INP for Integrated Topside (InToP) (Figure A-3). InToP will deliver game changing capabilities for operating in the electromagnetic spectrum through the use of multi-function apertures in an open RF architecture providing multiple simultaneous beams that individually do different functions (EW, Comms, IO, etc.) The current program (Figure A-3) is focused on Multibeam EW/IO/Comms; Consolidated SatCom for Ships and Submarines; Consolidated Low Band Comms and Information Operations; and Flexible Multi-channel Digital Array Radar (FLEXDAR). The Integrated Topside INP provides continuous spectrum coverage from the upper VLF band through Q band. The result is a set of agile apertures that can be reprogrammed on the fly to meet the Commander's current battlespace needs. A second investment in the area, planned to begin in FY14, is designed to use networked sensors to deceive threat surveillance sensors.



Future Naval Capabilities (FNC)

Acquisition Enablers

As technology development matures in the D&I program or from outside sources, the focus of FNC efforts are to provide enabling capabilities (ECs) to fill gaps in OPNAV and MCCDC requirements. FNC research delivers component technologies that transition at a mature readiness level in a 3 to 5 years time horizon into existing or newly established programs of record (POR). The FNC process is well established and governed by Integrated Process Teams (IPT), a Technology Oversight Group (TOG), and TOG Working Groups (TOG WG). It consists of nine pillars: FORCEnet, Sea Shield, Sea Strike, Expeditionary Maneuver Warfare, Sea Basing, Capable Manpower, Enterprise and Platform Enabler, Power and Energy, and Force Health Protection. Code 31 has proposed a number of successful ECs in the FORCEnet, Sea Shield, Sea Strike, Expeditionary Maneuver Warfare, and Enterprise and Platform Enabler FNCs.

Quick Reaction (QR) and Other

Quick Reaction includes efforts funded from ONR TechSolutions, Navy and Marine Corps Experimentation, one-third of the Marine Corps BA 6.3 funds, Rapid Technology Transition (RTT), Science Advisor program, responses to Urgent Universal Needs Statements and high-priority demands from the Fleet and a percentage of SwampWorks efforts. These are off-the-shelf technology projects responsive to the immediate needs identified by the Fleet, operating forces or Naval leadership with a 12 to 24 month time horizon. Examples of completed QR efforts sponsored by Code 31 are: Medusa and Graywing -- initiatives that developed and delivered counter-sensor capabilities; and Static Discharge, an initiative that developed an EW response to a Pacific Command requirement for F/A-18 aircraft protection.

Limited Technology Experimentation (LTE)

Code 31 frequently uses laboratory-based operational experimentation to test new technology prototypes working hand-in-hand with relevant PEOs to ensure their perceived issues and risks relative to technology transition are specifically addressed. In these LTEs, technology, CONOPS and TTPs are co-evolved and validated. Select candidate technologies are chosen to support specific experimentation with the goal of thoroughly understanding technology capabilities and limitations. Current and planned efforts below illustrate the philosophy and goals driving Code 31 experimentation plans. In FY10 and FY11 Code 31 sponsored a set of LTEs to develop the capability to automate generic sharing of information across combat systems and SOA-based C2 systems with emphasis on Missile Defense. This experiment (Figure A-4) was executed with full participation of PEO Integrated Warfare Systems (IWS) and PEO C4I to ensure the experimentation directly addressed the critical risks and issues to ensure rapid transition of this S&T to the Advanced Capability Build (ACB) POR and the Afloat Core Services (ACS) POR. It also addressed issues related to information assurance and latency requirements for CS and those required to demonstrate machine-to-machine transfer of general information between CS and C2 systems to through a single, general gateway (Figure A-5) rather than the current, approximately 30 point-to-point specific connections which are manpower intensive and for which security is difficult. In addition, joint experimentation involving Navy, Air Force, and Army demonstrated automated and continuous air battlespace de-confliction utilizing this framework. This enables rapid Naval fire support, as well as direct machine-to-machine information transfer for joint targeting. The USAF has adapted the ONR-developed Federation Framework and gateway technologies into their open architectural builds for future Air Operations Center and Tactical Operations Center C4ISR capabilities.

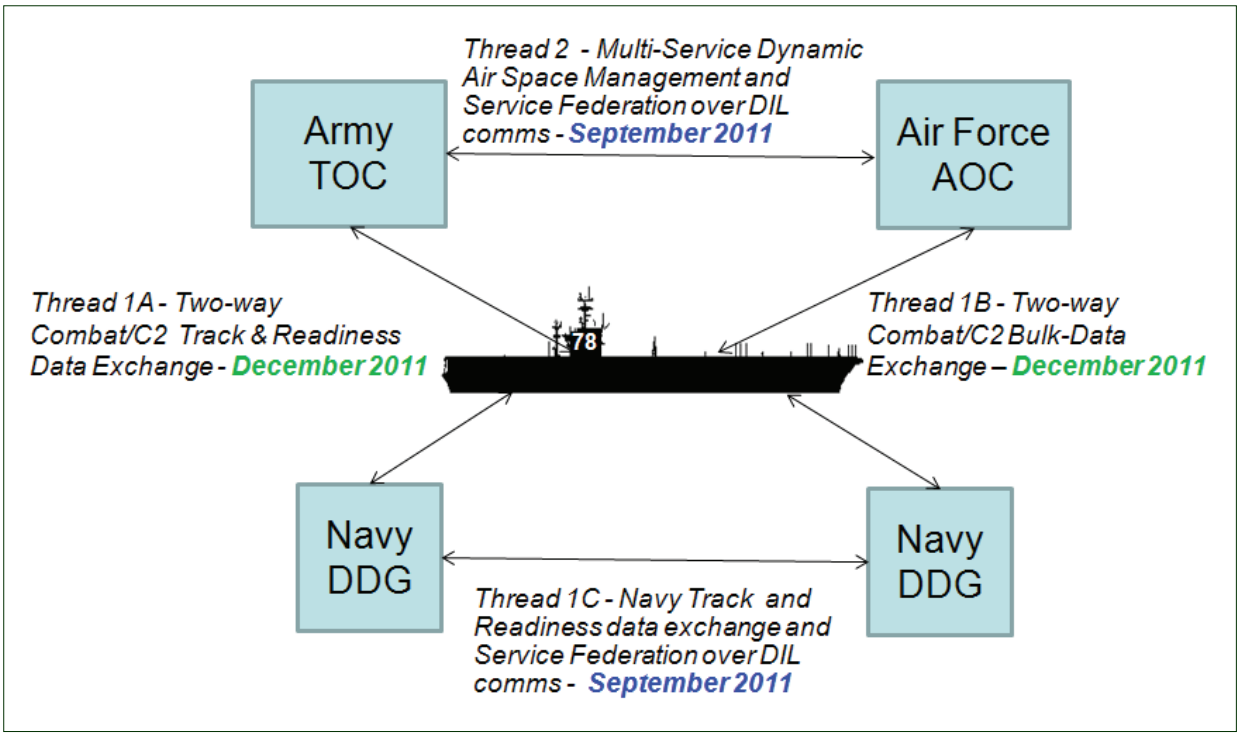


Figure A-4. C2 to Combat Systems Information Transfer LTE

The gateway will transition to Navy ships on both the Combat System and C2 networks beginning in FY13 and the Federation Framework will become a part of Afloat Core Services beginning in FY14.

For FY12, ONR Code 31 is planning to sponsor a Multi-Service LTE focused on Common UxV control and operation within the Anti-Access Area-Denial (A2AD) joint battlespace. The LTE will examine technologies and concepts related to common UxV control services, UxV discovery services, UxV control hand-off, UxV data exfiltration, machine-to-machine integration of critical mission information, and appropriate data models to support these concepts/capabilities. This event will expand upon several of the main ONR prototyping areas of the 2010/11 LTEs, including Applications Interoperability Framework (AIF) /Force Discovery Service (FDS) / Federation Framework, across operational networks, Information Management Services, Dynamic Air Space Management (DASM) Services and the Universal Gateway (Figure A-3) that provides transparency and security of data and services across disparate networks.

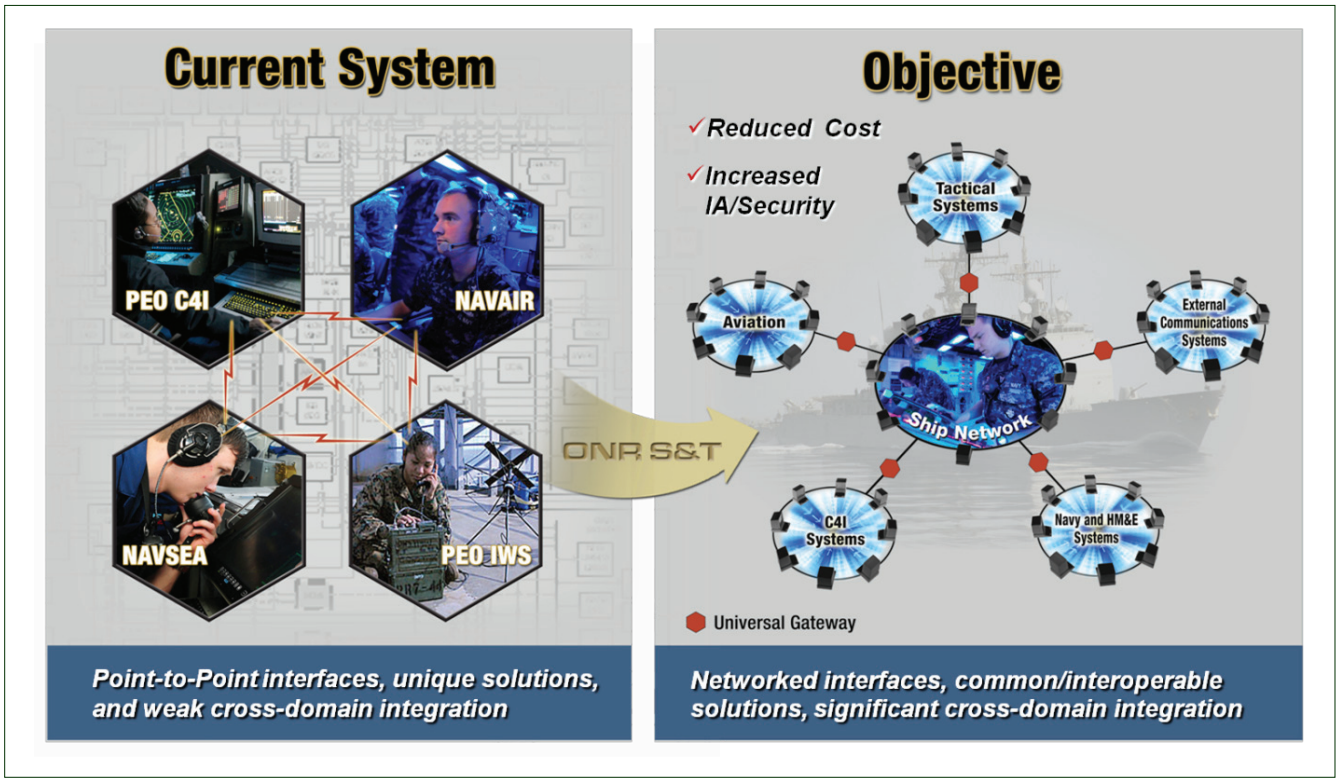


Figure A-5. Universal Gateway

Fleet Experimentation (FLEX)

Code 31 leverages the Navy's FLEX experimentation campaign designed to facilitate a wide variety of perspectives and competencies to test concepts, CONOPs, processes, tactics, techniques, procedures, hypotheses or technologies - all driven toward improving warfighter capabilities. Matured technologies and prototypes are exercised in Fleet Exercises such as Trident Warrior, RIMPAC, Valiant Shield, Neptune Scissors, and Northern Edge, etc. This provides the fleet the opportunity to assess the contribution of these prototypes in real Fleet Exercises to warfighting capabilities and investigate how they can lead to new CONOPs and TTPs. Below are a few examples of recent Fleet experimentation efforts:

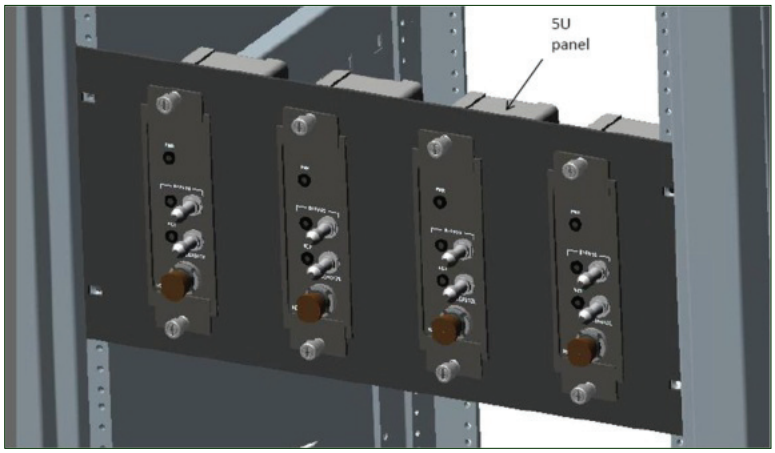
- ONR C4ISR Department program officers participated in Rim of the Pacific (RIMPAC) 2010 and 2012 exercises by experimenting with and demonstrating the capabilities of the Transportable EW Module (TEWM) system, including the capability to coordinate multiple TEWM systems. TEWM is a multi-role EW system capable of detecting and countering a variety of threats. ONR EW technologies, particularly TEWM, will continue to support RIMPAC exercises which occur every 2 years through the demonstration of new and advanced EW capabilities. The ONR C4ISR Department has and will continue to provide EW technologies to the fleet to be tested in other relevant FLEX venues such as Exercises Northern Edge (NE) and Neptune Scissors (NS).

- Experimental products, such as the highly successful Command and Control Rapid Prototyping Continuum (C2RPC) capability, have recently been used to provide improved situational awareness at the C6F Maritime Operations Center (MOC) in Terminal Fury 2011 and 2012. C2RPC is a Code 31 developed, agile development platform designed for deploying operational C2 capabilities to the Fleet. Component technologies Open Track Manager (OTM) and Tactical Halo were developed variously under ONR Future Naval Capability projects FNT-FY07-01, FNT-FY08-06, and FNT-FY09-04. OTM is based on ONR XCOP and includes additional data exchange and analysis technologies. The Tactical Halo is built on IntellEx to ingest, analyze and display Fleet readiness and other operational data. C2RPC is currently deployed to COMPACFLT, COMSIXTHFLEET and COMFIFTHFLEET and supports both operational exercises and real world operations. Continuous Fleet engagement and responsive agile development have been the hallmarks of this highly successful ONR S&T program.

- The ONR C4ISR Department has also supported operational missions such as Commander Naval Forces Africa (NAVAF) African Maritime Law Enforcement Partnership through the deployment of a rapid development capability called Rough Monkey (FY-2011) and Rough Rhino (FY-2012). The "Rough" experimental ISR systems were installed in Navy Research Laboratory VXS-1 P-3 Orion aircraft, US and host nation vessels, and multiple maritime operational centers to provide a comprehensive Maritime Domain Awareness (MDA) capability for Light, Grey and Dark targets. The system is being developed to automate multi-source sensor operations, integrate advanced sensor processing, distribute a common picture, and databases all tactical information for post mission law enforcement prosecution. The "Rough" rapid development capability has been requested again to participate in future operations by Commander, Naval Forces Africa and multiple host nations for additional support to counter narcotics, human trafficking, illegal fishing, and piracy operations.

Speed to Fleet (S2F)

S2F is a concept to use 6.4 Budget Activity funding to accelerate insertion of maturing technologies (TRL-6) into the Fleet to address critical naval needs – providing initial advanced capability to the Warfighter while simultaneously and in parallel working through the acquisition process to address DOTMLPF issues. Fleet evaluations through extended user evaluations of prototypes provide valuable lessons and direct feedback to the S&T and acquisition communities. Additionally this process enables the Fleet to develop, test, and refine CONOPS and evaluate integration with existing warfighting capabilities. . Below are some examples of recent S2F efforts:



- ONR 31 is currently developing a new low cost, multi-beam, phased array-based open radio architecture for Ku-band Common Data Link (CDL) which will give the Navy the ability to support multiple ISR and networking data links aboard surface platforms, a capability that does not currently exist. This architecture requires a communications security (COMSEC) cryptographic end unit that is low cost and is compatible with an open radio architecture in order to secure these data links. The "Phased Array COMSEC" S2F effort is developing this cryptographic end unit in the FY13-14 timeframe to address this need. The cryptographic end unit that is being developed will support emerging networking capabilities in the fleet and will also be compatible with legacy CDL systems at data transmission rates up to 274 Mbps.

- ONR 31 is currently developing an active-passive dual imaging IR sensor (AP-DIS) comprising an active shortwave/passive midwave imager with common receiver optic and focal plane. The readout unit will provide high-speed gating for laser backscatter reduction and haze penetration, and range-to-target information, facilitating improved target identification and selection through range-resolved imagery of swarm engagements against littoral clutter. The AP-DIS Speed-to-Fleet effort (FY12) will provide incorporation of active imaging algorithms for image clean-up, available under a joint US/UK program, and the fully marinized integration of the AP-DIS sensor to the NATO Sea Sparrow Director System. As the last part of the Speed-to-Fleet the integrated AP-DIS sensor will undergo sea trials in order to support transition to acquisition at TRL 7.

Technology Roadmapping

The management of technology in order to benefit Warfighters requires effective processes and systems to be put in place to ensure that the proper mix of technological resources are applied and aligned with capability needs, now and in the future.

Code 31 has developed a Technology Roadmapping methodology that provides an excellent visualization tool for organizing, correlating, assessing and storing information for:

- Evaluating the status of S&T development programs for application to Naval warfighting required capabilities
- Assisting in the examination of program execution options that contribute to an integrated development and acquisition strategy for warfighting capability evolution; and
- Aiding the development of a budget defense rationale by illustrating linkages among Navy and other DoD research programs, acquisition programs and requirements.

The Roadmapping tool selected by Code 31 uses a COTS product, Milestones Professional, to generate electronic Roadmaps that both graphically depict S&T investment opportunities for trade-off analysis (i.e., down selecting alternatives for continued development and technology maturation) – and provides a unique clickable database for access to extensive details about ONR S&T (D&I, FNC and other efforts). It is effectively an Electronic War Room.

Two current S&T Roadmaps of particular significance produced by Code 31 are:

- RF Systems for Naval Platforms / Integrated Topside (InTop) -- emphasizes the core Solid State Electronics efforts (e.g., wavelength scaled array, High Power Amps / Microwave MMICs, Power DACs, ADCs, Channelizers / Tunable Filters and other semiconductor technology). (Figure A-6)
- Information Dominance -- a comprehensive look at those technologies required and under development to enable the Navy's ID vision with specific emphasis on C4ISR in these areas: Communications and Networks; Computational Environment Architecture; Computer Network Operations; Information Space for Integrated C2, ISR and Combat Systems Decision Making; and Spectrum Dominance.

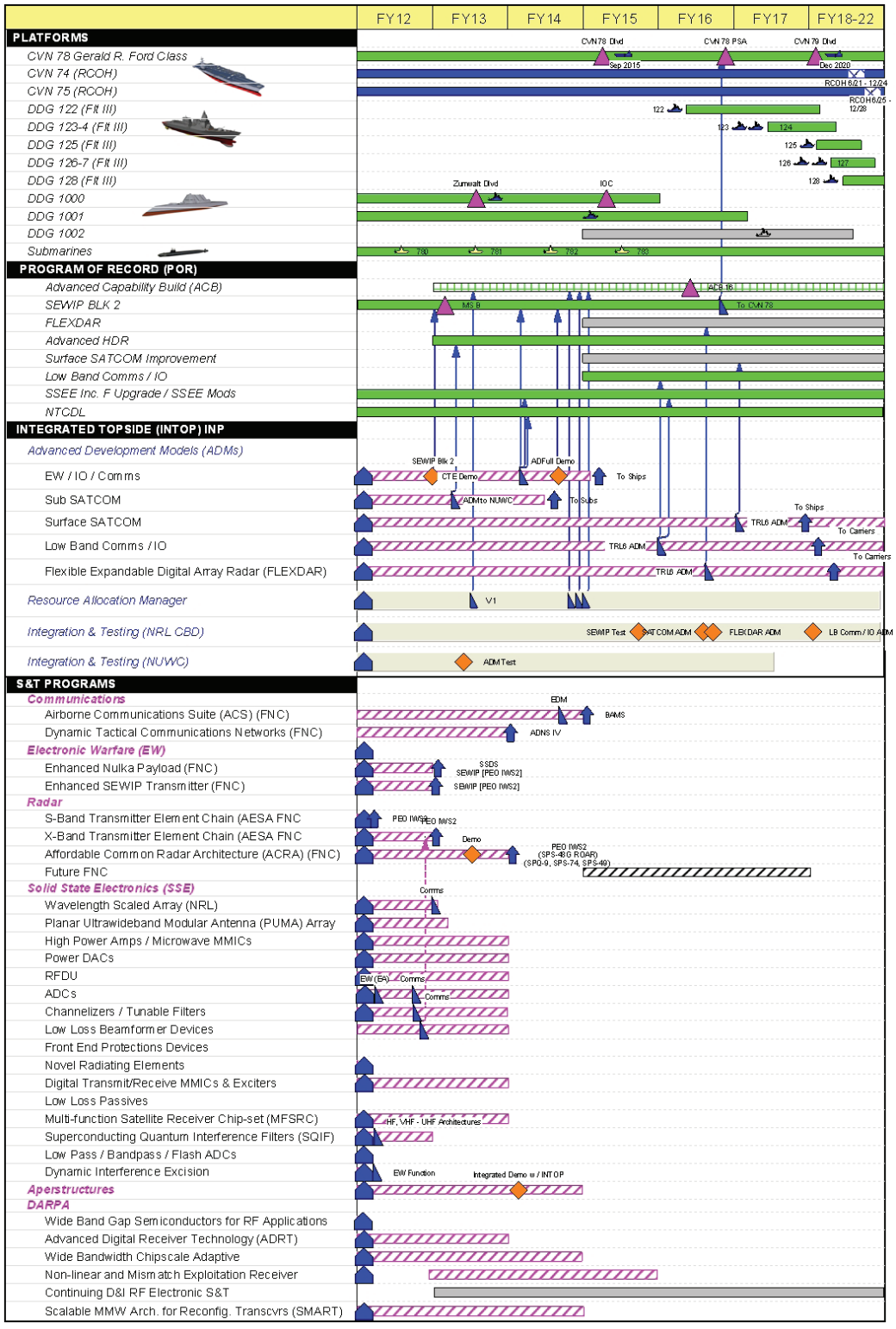


Figure A-6. Integrated Topside S&T Roadmap

C4ISR Department Organization

Division 311: Mathematics, Computers and Information Research

Director: Dr. Wen Masters

This division sponsors basic research, applied research, and advanced technology development efforts in mathematics, computer and information sciences that address Naval and Department of Defense needs in computation, information processing, information operation, information assurance and cyber security, decision tools, and command and control with specific focus on enabling Information Dominance in network centric environment. Specific research areas are:

- Intelligent & Autonomous Systems
- Systems Theory
- Applied & Computational Analysis
- Computational Decision-Making
- Command & Control (C2)
- Information Integration
- Assured Computing
- Resource Optimization
- FORCEnet S&T

Division 312: Electronics, Sensors and Network Research

Director: Dr. Michael Pollock

This division conducts an integrated research program into technologies that enable new and innovative uses of the electromagnetic spectrum in support of Navy and Marine Corps needs. Specific applied programs include research in the areas of surface and aerospace surveillance, communications, electronic combat, and navigation. All these areas are supported by a broad research program in electronics, focused on reducing the cost weight and size of transmit and receive systems. Specific research areas are:

- Atomic and Molecular
- Navigation
- Communications & Networking
- Electronic Devices & Applications
- Electronic Combat
- Surface/Aerospace Surveillance
- Multifunction Systems
- Sea Shields/Sea Strike S&T

Division 313: Applications and Transitions

Director: VACANT

This division coordinates the transition of technologically superior systems and equipment that will enhance warfighting capabilities to C4ISR, electronic warfare, air and missile defense, and precision timekeeping and navigation acquisition programs. It also ensures that applied research and advanced technologies are aligned with current and future naval capability gaps. Specific areas of execution are:

- FNC Execution Oversight
- FNC Transition Agreements
- Technology Roadmapping
- FNC Business Plan
- GWOT/AT/FP
- USCG Liaison

Acronyms

ADM	Advanced Development Model
AFRL	Air Force Research Laboratory
AIS	Automated Information Systems
AOC	Air Operations Center
ASMD	Anti-Ship Missile Defense
ASW	Anti-Submarine Warfare
BLOS	Beyond Line-Of-Sight
C2	Command and Control
C2RPC	Command and Control Rapid Prototype Continuum
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CANES	Consolidated Afloat Network and Enterprise Services
CDL	Common Data Link
CND	Computer Network Defense
CNO	Computer Network Operations
CNR	Chief of Naval Research
COI	Community of Interest
Comms	Communications
CONOPS	Concept of Operations
COTS	Commercial Off-The-Shelf
CS	Combat Systems
D&I	Discovery and Invention
DoN	Department of the Navy
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities
EA	Electronic Attack
EM	Electromagnetic
EMI	Electromagnetic Interference
EP	Electronic Protect
ES	Electronic Support
EW	Electronic Warfare
FLEXDAR	Flexible Digital Array Radar
FNC	Future Naval Capabilities
GIG	**Global Information Grid**
HNW	High band Networking Waveform
HPOI	High Probability of Intercept
ID	Information Dominance
IO	Information Operations
INP	Innovative Naval Prototype
InToP	Integrated Topside
ISR	Intelligence, Surveillance and Reconnaissance
IWS	Integrated Warfare System
JCREW	Joint Counter Radio-Controlled IED Electronic Warfare
JTIDS	Joint Tactical I D System
LAN	Local Area Network
LOE	Limited Operational Experiments
LOS	Line Of Sight
LTE	Limited Technology Experiment
MCCDC	Marine Corps Combat Development Command
MFEW	Multi-Function Electronic Warfare
NetOps	Network Operations
ONR	Office of Naval Research
OPNAV	Chief of Naval Operations
OTH	Over-The-Horizon
PDF	Precision Direction Finding
PEO	Program Executive Office
POR	Program of Record
QoS	Quality of Service
RTT	Rapid Technology Transition
RF	Radio Frequency
Rx	Receive
S&T	Science and Technology
S2F	Speed2Fleet
SatCom	Satellite Communications
SEI	Specific Emitter Identification
SEWIP	Surface Electronic Warfare Improvement Program
SSEE	Surface Ship Exploitation Equipment
SOA	Service Oriented Architecture
SWaP	Size, Weight and Power
TOC	Tactical Operations Center
TRL	Transition Readiness Level
TTA	Technology Transition Agreement
TTP	Tactics, Techniques & Procedures
TX	Transmit
UHF	Ultra High Frequency
UIIC	Uncertain, Incomplete, Imprecise and Contradictory
UxV	Uninhabited Vehicle (Air, Surface, Underwater, Space, Ground)
VHF	Very High Frequency
WAN	Wide Area Network

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