U.S. NAVY INFORMATION DOMINANCE

Science & Technology Objectives

2014

VISION:

A U.S. NAVY FULLY OPTIMIZED FOR INFORMATION-AGE OPERATIONS; A FORCE CAPABLE OF TECHNOLOGIC AGILITY AND ADAPTATION THAT DELIVERS CAPABILITY APACE OR AHEAD OF ANY ADVERSARY.

FOREWORD

In 2009 the CNO directed the Navy to position itself for pre-eminence in the fields of Intelligence, Cyber Warfare, Command and Control, Electronic Warfare and Battlespace and Knowledge Management; to man, train and equip a U.S. Navy that is agile and dominant in the Information Age operating environs. This mandate was the driving force behind the creation of a new Navy warfare discipline called Information Dominance. OPNAV N2/N6 is evolving and delivering information dominance through the core capabilities of Assured Command and Control, Battlespace Awareness and Integrated Fires; however, many challenges remain.

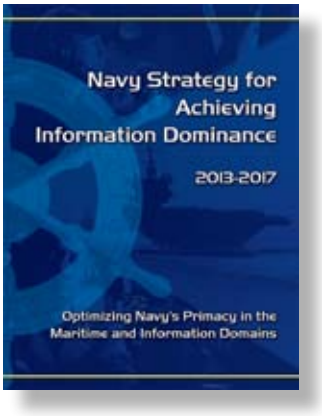
A rapidly-leveling technologic playing field and fiscal challenges increasingly stand to erode the Navy advantage in many areas integral to information dominance. Growing threats in cyberspace and the electromagnetic spectrum (EMS) could soon challenge long-held U.S. Navy advantages within selected areas of the maritime battlespace. We can no longer fall back on mass of force or spending as a resolution path; we can no longer afford inefficiencies incurred with stove-piped networks, systems and processes. We must pursue open solutions that convey agility and rapid adaptation. We must pursue technology and approaches that enable us to think and fight smarter, faster and better than our adversaries at every level.

To confront and overcome the challenges presented by the current and future technologic and security landscapes, it is necessary to set forth our priorities as defined by technologic development and investment so that all Information Dominance stakeholders know where we are headed and how they can most effectively pitch in.

In order to realize the full promise and potential of Information Dominance, this document is drafted, under the aegis of the Information Dominance S&T Cross Functional Team, to codify and operationalize a set of technology objectives that will aid in aligning and synchronizing efforts, investments and resources across our "enterprise" to meet the CNO's demand signal and evolve information dominance as a force-multiplier and Navy warfare area of expertise.

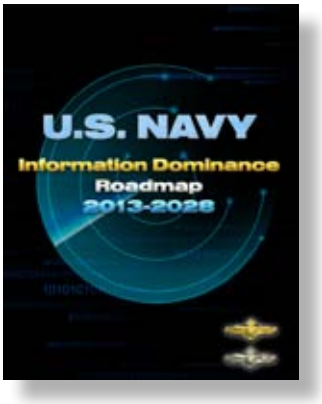
Ted N. Branch
Vice Admiral, U.S. Navy
Deputy Chief of Naval Operations
for Information Dominance

EXECUTIVE SUMMARY



The CNO has charged N2/N6 with delivering Information Dominance capabilities via the tenets of Assured C2, Battlespace Awareness and Integrated Fires. The documents that provide this demand signal are the *Navy Strategy for Achieving Information Dominance (2013–2017)* and the *U.S. Navy Information Dominance Roadmap (2013–2028)*.

This S&T objective document is aligned with key ID tenets and intended to inform technologic investment necessary to realize the goals and objectives set forth in related strategy. To that end, it is also intended to serve as a platform for engagement and discussion with the Naval Research Enterprise, other government partners, industry and academia to most effectively channel intellectual and financial capital to meet CNO intent.



The backbone of this document is formed by the following eleven Information Dominance Technology Focus Areas.

- Information Transport and Infrastructure
- Information Security and Assurance
- Advanced Sensing
- Data Integration and Decision Support
- Enhanced Targeting and Fire Control
- Electromagnetic Spectrum Operations
- Non-Kinetic Fires
- Positioning, Navigation and Timing
- Autonomy
- Human-Systems Interface
- Environmental Battlespace Awareness

Under these Focus Areas, 47 sub-component Technology Objectives are defined.

We in the Information Dominance stakeholder community will work together to operationalize these objectives and grow U.S. Navy advantage in every warfighting and operational domain.

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BALTIC SEA
Ships from various nations in the Baltic region and the U.S. 6th Fleet command and control ship USS Mount Whitney begin the underway phase of Baltic Operations 2014. Baltic Operations is an annual, multinational exercise to enhance maritime capabilities and interoperability, and to support regional stability. (Navy photo by MC3 Luis R. Chavez Jr.)

INTRODUCTION

IMPERATIVE

There is arguably no other warfare discipline so critically tethered to the technology landscape and development tempo than Information Dominance. Technologic and fiscal challenges stand to level the playing field for myriad adversaries and could soon present the United States with an array of technologic challengers and peers in areas where we have traditionally enjoyed sustained advantage and superiority.

Against such challenging technologic and fiscal terrain it is imperative that we as Information Dominance providers and stakeholders codify, converge on and operationalize a set of technology objectives. This convergence is necessary to align and synchronize efforts, investments and resources to sustain and evolve Information Dominance as a Navy warfare area of expertise.

INTENT

This document is intended to articulate the desired operational capabilities and related technologies necessary to fully realize Information Dominance warfighting effects. This document is also intended to be used as a vehicle for engaging the Naval Research Enterprise (NRE), industry and academia to align efforts and optimize Information Dominance-related technology investments.

VISION

A U.S. Navy fully optimized for Information-Age operations; a force capable of technologic agility and adaptation that delivers capability apace or ahead of any adversary.

FIRST PRINCIPLES

To secure this vision the following First Principles are to be stressed and applied wherever and whenever possible in the pursuit of technologic investment and development associated with the objectives defined in this document:

Design in Change

- Plug and play capabilities wherever possible
- Open and scalable architectures are a first resort
- Stove-piped, point solutions are a last resort
- Payloads over platforms
- Software-reprogrammable payloads over static hardware modules
- Modularity as preferred path to capability

Interoperability is King

- Connectivity within a larger capability is a given
- Plan to interoperate, including the EM spectrum
- Data: share and share alike

Optimize Scarce Human Resources while Maintaining Speed of Operations

- Use machines for what machines are good at so people can focus on what only people can do
- Use local pre-processing, sorting, and classification, autonomy and cross-cueing
- Collect, process and exploit in real-time

Design for Easy Use (assume very little training)

- Reduce complexity
- Build systems as if no manual comes in the box
- Optimize and fine tune the human interface

Form Factor Matters

- Smaller is better than bigger
- The less power consumption the better
- Unmanned beats manned

To be Connected is to be Dependent and Vulnerable

- Harden for resilience
- Build for agility
- Assume there is a threat and secure accordingly

ALIGNMENT

This content of this document is primarily aligned to the *U.S. Navy Strategy for Achieving Information Dominance (2013–2017)* and *U.S. Navy Information Dominance Roadmap (2013–2028)*.

METHODOLOGY

This document was drafted under the aegis of the Information Dominance Science and Technology Cross Functional Team—a cross-cutting Navy body with representatives from OPNAV, the Fleet and major U.S. Navy system acquisition commands. The Technology Focus Areas and component Technology Objectives contained herein are the result of the efforts of 10 teams (an eleventh Focus Area was added at the recommendation of one of the teams), each dedicated to a particular Technology Focus Area and led by an N2/N6 Action Officer most closely familiar with the capabilities and programs addressed by those areas. The resulting Technology Objectives were vetted by OPNAV N2/N6 and ID S&T CFT stakeholders for validity and veracity.

GLENDALE, Calif.
CNO Adm. Jonathan Greenert is briefed on a conceptual operations center tailored to meet the technology needs of the modern warfighting era. (Navy photo by MCC Peter D. Lawlor)

STRAITS OF FLORIDA
Aerostat is launched and tethered for the first time off of Joint High Speed Vessel USNS Spearhead (JHSV 1) during experimentation conducted by U.S. Fourth Fleet and Navy Warfare Development Command (NWDC). (Navy photo by Lt. Jessica Crownover)

DOCUMENT STRUCTURE AND READER INSTRUCTIONS

This document is structured principally along 11 Technology Focus Areas. Under each focus area a set of related and sub-component technology objectives have been articulated. These objectives are anchored in the challenges to achieving Information Dominance that are believed best addressed by technology acquisition and/or development. Focus Area Descriptions are uniformly composed of the following three sections: Focus Area definition, Investment Focus, and Intent.

Under each Focus Area, related technology objectives are expressed and are uniformly constructed as follows: objective identifier and title; a statement of "what" type of technologies are desired; and lastly, associated attributes of the desired technologies bound by the objective.

In the left margin a ready-reference topic identifier is provided for the reader.

In the right margin, alongside each objective, a graphic reference is provided depicting the relation of the objective to the Information Dominance Roadmap.

An exemplar of Focus Area and Objective structure is presented below:

Example Focus Area: Positioning, Navigation and Timing

What is it — *Focus Area Description: Positioning, Navigation and Timing (PNT) capabilities provide position and precise time references to surface, sub-surface, air and space-borne assets, enabling safety of navigation, communications and assured command and control.*

Investment Focus — *Technology investments in this area are focused on hardening and modernizing existing GPS-dependent PNT capabilities; developing GPS-independent PNT solutions; and miniaturized and scalable PNT solutions.*

Intent — *Our intent is to equip the Navy with a range of capabilities that convey robust, assured positioning, navigation and timing under any and all operational conditions and physical environments.*

Objective Ready-Reference Topic: Protected/Hardened PNT

Technology Objectives:

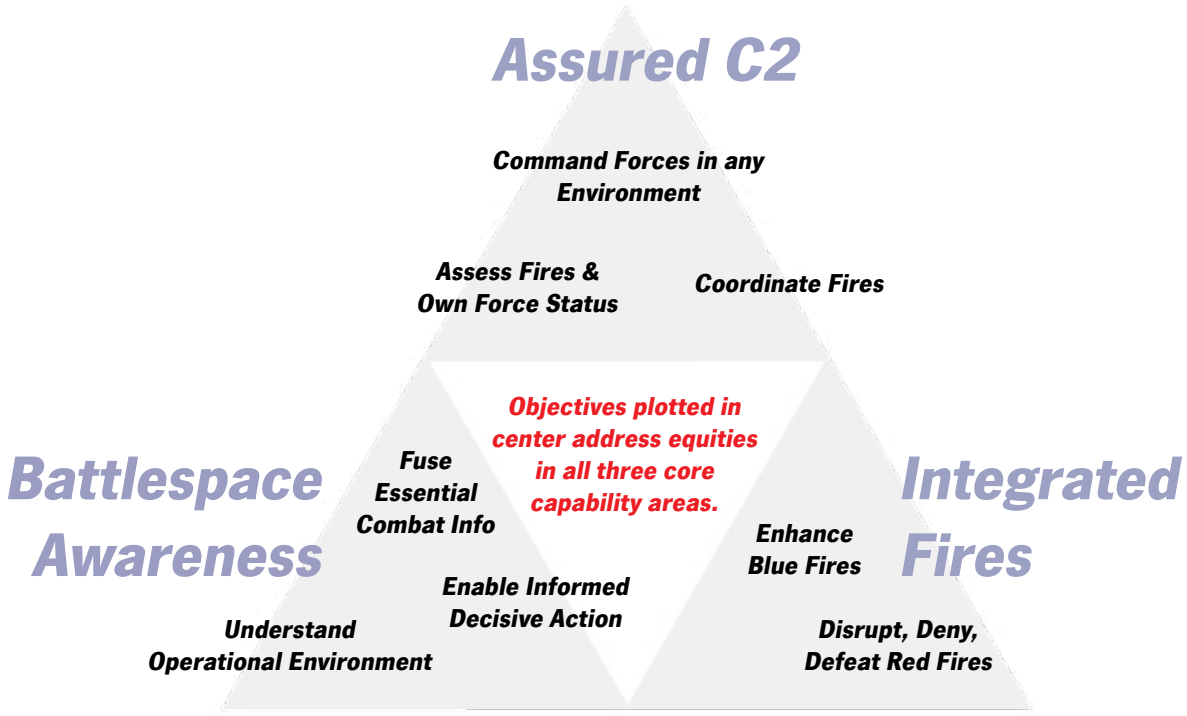
Objective Identifier — ID-PNT-STO -01: Protected GPS-dependent PNT Capabilities.

Develop what — Develop technologies that counter threats to and protect conventional GPS-dependent positioning, navigation and timing capabilities.

Attributes — These technologies should enable assured GPS-based PNT operation under contested, degraded and complex operational conditions ...

Objective in relation to ID Core Capabilities

The figure below provides a graphic representation of Information Dominance Core Capabilities and Roadmap; it is intended to provide the reader an ID-focused operational context to which the following technology objectives can be keyed. Reference graphics in the right margins and in the Appendix 2 graphic are based on this schema:



Information Dominance Roadmap Reference (with Roadmap Major Section References)

REVISION AND MAINTENANCE

This document will be reviewed and revised under the auspices and governance of the ID S&T CFT on an annual basis. All inquiries or comments related to this document should be directed to: OPNAV N2/N6FX, (703) 695-8360; brett.vaughan@navy.mil.

INFORMATION DOMINANCE TECHNOLOGY FOCUS AREAS AND OBJECTIVES

INFORMATION TRANSPORT & INFRASTRUCTURE (ITI)

Focus Area Description: The Navy must securely move, manage, and maintain an increasingly large and diverse array of mission-critical data at the rapid pace needed to support effective tactical, operational, and strategic decision-making at sea and ashore. Technology investments in this area focus on dynamic and agile routing capabilities; enterprise-level grid awareness and management; tactical network control; communications diversity and satellite communications resilience. Our intent is to posture Navy forces to enter into all operational environments securely connected to the grid, communicating at will with their mission partners, and deriving the decisive warfighting benefits associated with having continuous access to relevant data and analytics under any and all threat conditions, from permissive to contested to denied.

ITI Technology Objectives:

Connectivity

ID-ITI-STO-01: Assured Connectivity and Access in all Operating Environments

Develop/leverage technologies that provide the volume, veracity and velocity of information required for uninterrupted operations in any and all environmental and operational conditions. These technologies should ensure the exchange of high-priority mission critical information, as determined by the warfighter, in all operational domains and especially in any dynamic and bandwidth-constrained Anti-Access Area Denial (A2AD) environment across manned and unmanned systems and unattended sensors. These technologies are needed to facilitate assured SATCOM access, protection and resiliency and provide quality of service, traffic management, scalability, and robustness to meet unique Fleet challenges not found in the commercial environment to include: topology and bandwidth changes based upon adversary actions; desire to use the same network for critical and non-critical applications; a mix of various radio waveforms and technologies; multiple security domains providing information exchange (NIPR, SIPR, JWICS, etc); continuity of operations in LOS and BLOS A2AD environment. In the context of SATCOM and space-based service provision, especially under A2AD conditions, responsive access to space and resilient satellite architectures should be viewed as key force multipliers.

Network Awareness

ID-ITI-STO-02: Persistent Network Awareness and Control

Develop/leverage technologies that generate acute awareness of network health and operating status and the ability to pro-actively control and direct network assets. These technologies should support Navy's ability to monitor, collaborate, plan, and reconfigure enterprise systems in a timely and robust manner. These technologies should: integrate all elements of the network into an open architecture using common standards and

PACIFIC OCEAN
The littoral combat ship USS Independence (LCS 2) demonstrates its maneuvering capabilities in the Pacific Ocean off the coast of San Diego. (Navy photo by MC2 Daniel M. Young)

protocols among manned and unmanned systems, unattended sensors, and across all domains (air, afloat, ashore, undersea, and space); convey centralized control of each network element with access to status and performance data that will facilitate global network status aggregation at the Regional Network Operation and Security Centers, while allowing situational awareness (SA) reporting up the Chain of Command. This capability should also enable seamless synchronization with emerging DoD/Joint initiatives; visibility into the infrastructure of end-to-end information flows; and standardization of Information Assurance (IA).

Communications

ID-ITI-STO-03: Bandwidth-efficient Communication Capabilities

Develop/leverage technologies that provide communication solutions that convey bandwidth agility and efficiency far beyond current capabilities. These technologies should address the linkages between Navy C4ISR applications/systems using network resources to support warfighting functions among manned and unmanned systems, unattended sensors, and across all domains (air, afloat, ashore, undersea, and space). Capabilities should provide a comprehensive load-shedding strategy to achieve a "warfighting C2" thinline in an A2AD environment. Capabilities should convey increased throughput for a given sector of the RF spectrum; reduce channel spacing; increase channelization; reduce transmission power requirements and provide low-probability of intercept and counter-measure-resistant qualities.

INFORMATION SECURITY AND INFORMATION ASSURANCE (ISA)

Focus Area Description: The Navy is heavily reliant on the operational employment of networked Information Technologies (IT). These technologies, while powerful, are growing increasingly vulnerable due to such factors as the rapid, global proliferation of relatively low-cost, dual-use, commercial solutions and supply chains, and the desire on the parts of several state and non-state actors to use those solutions in a manner that threatens the security of Navy's information architecture and the strategic interests of the United States. Technology investments in this area focus on finding innovative and cost-effective ways to mitigate those vulnerabilities through such measures as Identity and Access Management (IDAM); Attribute-Based Access Controls (ABAC); Trusted Data Format (TDF) tagging; the use of real-time, automated information guards to manage the provision of access to tagged data across multiple security domains; and the employment of modernized cryptographic devices and algorithms to encrypt data at rest and data in motion. Our intent is to make data security and authentication a given; constant, seamless and transparent to the Navy warfighter.

ISA Technology Objectives:

Network Access

ID-ISA-STO-01: Assured Access and Transparent Identification and Authentication across the Network

Develop/leverage technologies that convey seamless, transparent and comprehensive identity assurance and data authentication. These technologies should provide the ability to identify, authenticate individuals, groups, and entities and allow access to services and information while preventing access by or disruption from unauthorized individuals, groups, or entities. These technologies should utilize Intelligence Community Metadata Standard for Information Security Marking (IC-ISM) data tagging as instructed by Department of Defense (DoD) Directive 8320.02, stating that "data assets shall be made visible by creating and associating metadata including discovery metadata, for each asset." These technologies should also secure information with appropriate access controls as determined by operational need and acceptable level of security risk.

Network Defense

ID-ISA-STO-02: Nimble and Proactive Network Defense Posture against Advanced Persistent Threats

Develop/leverage technologies that detect and eradicate advanced persistent threats, well-organized and heavily-resourced cyber-attacks that access and exfiltrate information from Navy systems. These technologies should provide the ability to maneuver within the physical and cyberspace realms to influence and secure technology infrastructures and the data within them. Provide the ability to recognize and defeat non-kinetically delivered attacks whether lethal or non-lethal from anywhere in the environment. These technologies should minimize resource usage and embrace automation go beyond traditional "scanning and cleaning" to combat such attack vectors as: (1) polymorphism (i.e. code altered from its recognized signature), (2) stealth, (3) regeneration and (4) disabling of anti-malware applications.

Insider Threat Mitigation

ID-ISA-STO-03: Detection, Prevention and Reporting of Data Exfiltration to Counter the Insider Threat

Develop/leverage technologies that provide full inspection of encrypted traffic, embedded data, and compressed files—all forms for which exfiltrated data may be in to bypass detection by currently deployed data loss prevention (DLP) solutions. Control systems and auxiliary devices, such as printers, scanners and fax machines, should also be considered as they are potential conduits for malicious insiders.

Network Resiliency

ID-ISA-STO-04: Resiliency Under Cyber Attack

Develop/leverage technologies and/or mechanisms which provide continued mission operations in the event of a disruptive cyber-attack and returning to normal mission operations once the attack has been addressed/resolved. These technologies must convey/provide ability to: (1) identify critical mission-supported information and technology assets, (2) implement controls to protect such assets from harm, (3) implement controls to sustain the ability of those assets to operate under stress and recover from disruptive events, (4) develop processes to maintain and repeatedly carry out the protection and sustainment activities, and (5) develop appropriate measures to drive these activities.

Improved Data Auditing

ID-ISA-STO-05: Improved Information Audit & Forensics

Develop/leverage technologies that improve current audit capabilities for increased forensics effectiveness. These technologies should enable advance auditing by: (1) including more information at a user level (i.e. keystrokes and tracking website visits and file transfers), (2) protecting audits from unauthorized access, modification and deletion, (3) synchronize logs across all network operations centers (NOCs) with respect to timestamps, and (4) provide an alternative audit capability in the event of a failure of the primary audit capability.

Cloud Security

ID-ISA-STO-06: Cloud Computing Security & Assurance

Develop technologies for cloud security to address data confidentiality, integrity, and availability (CIA). These technologies should address security for cloud infrastructure that goes beyond traditional cryptography and allow for computing operations without the need to decrypt the data.

Our intent is to make data security and authentication a given; constant, seamless and transparent to the Navy warfighter.

ADVANCED SENSING (AVS)

Focus Area Description: The Navy will employ diverse, persistent, and robustly networked sensors to achieve sufficient battlespace awareness in support of operational planning, tactical execution, and operational assessment. Technology investments in this area are focused on advanced multi-role/multi-function sensor development; increased autonomy in sensor operation and sensor data processing; adaptive sensor netting, pre-processing of sensor data; innovative sensor deployment; bandwidth and energy efficient sensors; improved strategic/operational/tactical sensor coordination and collaboration; dynamic sensor tasking and management; and technologies that enable/improve maritime-unique collection and exploitation capabilities, especially where space-based ISR systems are concerned. Our intent is to increase awareness and understanding of the battlespace and the disposition and intent of our adversaries through diverse and dynamic sensing and streamlined processing of sensor data.

AVS Technology Objectives:

Improved Sensing

ID-AVS-STO-01: Improved and Persistent Sensing and Awareness of the Battlespace

Develop/leverage technologies to increase capability and capacity in sensor collection and processing performance across multiple spectral bands in all operational domains. These technologies should enable/convey: multi-spectral/function within a single sensor; platform agnostic; persistent over operationally-relevant time spans (i.e. mission-defined); potential for sensor operation under limited/restricted bandwidth conditions; assured autonomous sensor performance; resilience and graceful degradation through environmental and adversarial interference.

Sensor Netting

ID-AVS-STO-02: Optimized Sensor Netting & Synchronization

Develop/leverage technologies to increase sensor coordination/collaboration (i.e. cross-cueing and fusion) and dynamic employment/operation in netted environments. These technologies should enable/convey: a high-degree of intelligent and autonomous interoperability across multiple sensors, platforms, domains, and operational/intelligence centers; improve mission effectiveness/execution through collective performance when compared to singular/stand-alone operation.

PATUXENT RIVER, Md.
Rear Adm. Matthew Klunder, chief of naval research, talks with an airship pilot during an orientation flight aboard the Navy's MZ-3A. The MZ-3A, assigned to Scientific Development Squadron (VXS) 1 of the Military Support Division at the Naval Research Laboratory, is an advanced flying laboratory used to evaluate affordable sensor payloads and provide support for other related science and technology projects for the naval research enterprise. (Navy photo by John F. Williams)

DATA INTEGRATION AND DECISION SUPPORT (DDS)

Focus Area Description: Effective decision-making is predicated on the ability to rapidly and confidently move from data to options to informed decisions. This technology area focuses on the ability to discover and collect data from multiple sources, fuse it, and make it available to all relevant users in the right form, resulting in better and faster decisions in any environment, including in the presence of Anti-Access/Area Denial (A2AD) threats. Technology investments in this area will focus on universal data discovery and access, automated data fusion and integration, improved display and visualization, advanced analytics, user-centric designs, trend analysis, prediction tools, and targeting tools. Our intent is to create a National-to-Tactical data framework that reduces the discovery and analytic burden on personnel and fosters a comprehensive and penetrating knowledge of the operating environment and an expansive range of options for the commander such that the blue decision cycle consistently operates inside that of the adversary, resulting in decision overmatch over red.

DDS Technology Objectives:

Data Discovery & Access

ID-DDS-STO-01: Enhanced Data Discovery and Access

Develop/leverage technologies that transparently discover, distill, and transform raw data into actionable information in any operationally degraded/denied environment. These technologies should provide the ability to discover, select and distill information that provides meaning and value to reduce the cycle time and manpower requirements for analysis of large data sets. These technologies should enhance collection, processing, exploitation, and dissemination and fusion capabilities, enabling decentralized semi-autonomous analysis that produces and/or converts information into actionable intelligence. These technologies should seamlessly traverse security domains, data domains, and diverse semantics to provide data based on mission needs and access profiles. These technologies should extend explicit mission-focused data needs to predict additional and supporting data needs. Technologies should integrate with automated adaptable work flows to dynamically adjust to new data, mission requirements and adversary capabilities.

Data Analytics

ID-DDS-STO-02: Advanced Analytics and Tools

Develop/leverage automated and adaptive technologies to continuously and dynamically integrate diverse data across multiple dimensions and quickly and accurately assess impact and risk of proposed allocation, assignment, apportionment changes to efficiently project and sustain logistically ready forces. Technologies should apply, extend, and explore patterns for data fusion, recognition of known and unknown entities and events, prediction of events, and formation and assessment of options responsive to mission objectives. Technologies must assess data omissions, correctness, usability, errors, and duplication in the context of mission focus. Technologies must provide continuous visibility into reasoning processes, pedigree, provenance, product quality and usability, and data trends. These technologies should provide the information

infrastructure that takes all-source information and dynamically organizes formats, disseminates, and presents information to decision makers for Courses of Action (COA) development, selection, and implementation. As a part of the infrastructure, these technologies provide the decision support tools that dynamically assess and reassess the effects of the actions taken and provide new COAs.

Data Visualization

ID-DDS-STO-03: Advanced Data Display and Visualization

Develop/leverage advanced data display and visualization technologies that increase cognitive understanding of complex data sets, reduce analysis time and accelerate decisions. Technologies should facilitate display of multi-dimensional data, data with multiple attributes, generate animated visualizations, permit visual queries of data sets by manipulating data displays, enable temporal analysis, project/transform data into different spatial domains and dynamically link data visualization to real-time databases.

Decision-making

ID-DDS-STO-04: Mission and Operations Architecture for Improved Decisions

Develop/leverage mission and operations planning aids to enable commanders and staffs at all levels to make informed decisions, solve complex problems, and ultimately accomplish assigned missions. These technologies should use analytic and dynamic visualization techniques to integrate geospatial C2, navigation, and tactical data into useable planning products throughout the "Plan-Brief-Execute-Assess" planning cycle structure. Implementing a common collaborative planning capability across the operational to tactical levels of war will improve alignment of effort, improve utilization of multi-mission platforms, determine where and when to operate, and provide a common planning picture from the Commander Task Force down to individual ships, submarines, and large deck ships. These planning aids will enable staffs to plan across all warfare domains, optimizing employment based on Commander's intent, scheme of maneuver, weapons employment, sensor performance, and environmental factors.

Data Management

ID-DDS-STO-05: Management of Sensor Overload

Develop/leverage an integrated warfare system to better support surface and undersea decision-makers with improved sensor employment, conversion of large volumes of sensor level data into tactical understanding, and improved integration of time-critical sensor level understanding into command and control processes to counter threats and maximize tactical opportunities. These technologies should convey next-generation set of data-centric, intuitive and easy to operate tools that will facilitate a "Data to Knowledge; Knowledge to Action" information process that supports time-critical missions across the full range of military

operations. Technologies should make the data machine interpretable, and deliver it to the operator in a timely, relevant display vice through data discovery. Technologies should employ "best-of-breed or best-of-technology" tools from development of improved human-sensor interfaces and sensor employment strategies to integration of sensor understanding into standardized planning processes.

ENHANCED TARGETING AND FIRE CONTROL (ETF)

Focus Area Description: The Navy must continually seek targeting and fire control capabilities that enable increased speed, accuracy, range, and lethality of maritime-related weapons against evolving threats. Technology investments in this area will focus on net-enabled weapons and data links that share fire control data even in a denied environment; integrated C4ISR and combat sensors that automate and improve combat identification and target accuracy; integrated manned and unmanned systems to counter adversary ISR&T; and automated battle management aids and dynamic weapons coordination to optimize target/weapon pairings and support seamless, real-time C2. Our intent is to deliver technology that increases precision of targeting and fire control solutions to enhance the effectiveness of Navy fires, ensure the most efficient use of weapons, and prevent collateral damage.

ETF Technology Objectives:

Net-Enabled Weapons

ID-ETF-STO-01: Net-Enabled Weapons

Develop/leverage technologies that improve communication between weapons, shooters, and third party targeting assets and enable effective Command and Control of Net-enabled Weapons (NEW). These technologies should enable: collaborative/coordinated engagement through transmitting/receiving targeting information, Battle Damage Indication/Battle Damage Assessment (BDI/BDA), and weapon health and status information in contested/degraded and complex operational environments. Technologies should integrate across all mission areas to include both surface/ground and airborne targets; facilitate single and multi-sensor data; should utilize Advanced Sensor integration and automated Battle Management Aids to prosecute engagements and optimize sensor resources.

Combat ID

ID-ETF-STO-02: Improved Combat Identification

Develop/leverage technologies that increase multi-spectral integration and processing performance and enable fusion among forward-deployed, dissimilar tactical manned and unmanned platforms sufficient for targeting and fire control under the most stressing operationally-relevant threat scenarios. These technologies should enable: multi-spectral/function integration/fusion in a single platform, sharing of CID, RADAR, ESM data to produce high-fidelity real-time fused data; integration of off-board/NTM data with on-board sensor data; resilience to jamming and other counters

to blue spectrum exploitation. Explore technologies that utilize innovative phenomena in conjunction with or as a follow-on to legacy technologies, as the basis for long range, wide-area non-cooperative Combat Identification. Technologies should enable data and information ingest from platforms participating on non-interoperable tactical line-of-sight networks; disassembly and re-compilation of data into a single piece of actionable information suitable for dissemination in near-real time and real-time. These solutions should include a common implementation across all relevant platforms/ sensors and a common set of software applications that can perform the localized fusion functions across the following missions: Offensive Anti-Surface Warfare, Integrated Air and Missile Defense, Anti-Submarine Warfare, and Ballistic Missile Defense.

Battle Management Aids (Air Warfare)

ID-ETF-STO-03: Automated Battle Management Aids (ABMA)

Develop/leverage technologies to improve mission planning and near real-time/real-time decision-making in support of Air Warfare. Technologies shoul enable independent and cooperative integrated fires; facilitate selection and execution of kill chains (weapons and employment modes) against multiple and disparate targets and types of targets. Mission planning capabilities must also account for greater complexities associated with Integrated Fire Control engagements, related sensor and weapon (shooter) positioning requirements. Technologies should enable modeling of all variables in the battlespace, including red capabilities; blue capabilities, status and weapons effectiveness; neutrals, and non-combatants in order to make near-real time recommendations to the war fighter focused on optimizing the battle problem and future events in the campaign. ABMA should include Joint and Coalition assets across the AOR in order to optimize resources throughout the battlespace and consider assets that may become available in the near-term that could influence current options and decision recommendations.

The Navy must continually seek targeting and fire control capabilities that enable increased speed, accuracy, range, and lethality of maritime-related weapons against evolving threats.

ELECTROMAGNETIC SPECTRUM OPERATIONS (ESO)

Focus Area Description: The Navy will develop an exceptional awareness of the EMS to enable the means to aggressively maneuver through, visualize, protect and control the spectrum at any time and place of our choosing. Technology investments in this area will focus on pervasive sensing, measuring, mapping, predictive modeling and visualization, and overall spectrum agility. Our intent is to operationalize the EMS; to deliver technology that allows the Navy to maintain freedom of action, increase survivability and seize the initiative across the full range of the EMS.

ESO Technology Objectives:

EMS Sensing & Awareness

ID-ESO-STO-01: Acute Spectrum Sensing and Awareness

Develop/leverage technologies for pervasive EMS sensing, measuring, mapping, management and performance prediction in real-time, enabling an EMS common operational picture for SA on friendly, neutral, adversary signatures and Electromagnetic Interference. Technologies should address: cancellation of "own platform" and off-board RF generators/jammers; autonomous classification and identification of maritime and airborne targets; improved SNR/noise floor; ultra-band real-time spectrum sensing/management and the capability to receive near-real time system software updates in order to maintain war fighting relevancy. Candidate technologies should consider novel chip designs, RF over fiber, optical cancellation, photonics, material science, and low-temperature superconducting technologies and technologies that enable EMS sensor data transfer and fusion into a common picture.

EMS Maneuver

ID-ESO-STO-02: Increased Survivability and Maneuverability

Develop/leverage technologies to enable spectrum agility and dynamic resource allocation and maneuverability of EMS solutions to emerging red force capability, waveforms and signal technology. Key technologies will: advance common shipboard Combat/EW/Cyber RF architecture and common interface/environmental input from all-source sensors to enable decision-making; enable rapid tech refresh and integration of next generation EW/Cyber radars and capabilities and seamless integration of emerging non-kinetic effects with existing Navy Fire Controls Systems; contribute to rapid decision-making and development of rational ROE from all-source electromagnetic spectrum sensing. Technologies should consider/exhibit the following attributes: modularity and scalability across broad ranges of ship classes; re-use of common software applications/functions/interfaces; common interfaces to allow external EMS networked data from other platforms, afloat and ashore: vessels, aircraft, unmanned platforms, and shore sites; spectral/frequency/waveform diversity; cancellation of on-board and off-board RF generators/jammers; dynamic emitter development and integration.

EMS Signature Control

ID-ESO-STO-03: EMS Signature Control

Develop/leverage technologies that increase Navy abilities to manage and control blue force EMS signature—from quiet/silent to deceptive operations in order to increase survivability and operational advantage. Technologies should increase bandwidth/sensitivity, improve SNR/noise floor, ultra-band real-time spectrum sensing and management, and spectral/frequency/waveform diversity. Key technologies include novel chip designs, RF over fiber, optical cancellation, photonics, material science, and low temperature superconducting technologies.

Non-Kinetic Fires (NKF)

Focus Area Description: These offensive measures leverage the EMS and the "wired" network to deliver weapons, either in information content or sheer energy. These weapons include offensive cyberspace operations (OCO), jamming, and the use of directed energy weapons, any of which can be extremely subtle or as destructive as kinetic fires. Technology investments in this area are focused on electronic attack, directed energy capabilities, and RF-enabled cyber incursion and the characterization of the military effects of each. Our intent is to drive toward fully characterized non-kinetic alternatives to Navy commanders to reap the benefits of effectively combining kinetic and non-kinetic fires.

NKF Technology Objectives:

Non-Kinetic Targeting & Engagement

ID-NKF-STO-01: Non-Kinetic Targeting and Engagement

Develop/leverage technologies to assert the Navy's non-kinetic capability to dynamically target, engage and execute integrated fires and seamlessly integrate emerging non-kinetic effects with existing U.S. Navy Fire Controls Systems. These technologies should: afford the opportunity to leverage existing tactical sensors, communications, electronic signatures and electronic attack systems; provide high-fidelity target characterization and BDA; enable the complete integration of both kinetic and non-kinetic effects into a singular Fire Control system.

Non-Kinetic Op Aids

ID-NKF-STO-02: Non-Kinetic Operational Aids/Modeling/Planning

Develop/leverage technologies that enhance and expand options for all phases of the blue kill chain and assist operational planners with near-real time modeling and planning of non-kinetic fires, independent of and in conjunction with kinetic fires missions. These technologies should enable: organic and non-organic non-kinetic fires modeling simulation; planners to harmonize missions (U.S., joint and coalition) that involve both non-kinetic and kinetic fires; prediction and assessment of combined kinetic/non-kinetic effects.

Develop/leverage technologies that provide services/capabilities for system test and evaluation of non-kinetic effects (OCO, EA, DE, etc.) across all domains. These technologies should focus on validation of performance

when integrated with fires from any combat system in either actual or simulated environments. They should allow for access to any test range (SESEF, AUTEC, Virtual Cyber Ranges, Joint IO, etc.), computer aided simulation (Fleet Synthetic Training (FST)) to enable full end-to-end integration of fires, or other hardware design tools.

Develop/leverage technologies to enable a networked, end-to-end tool suite that allows operators to understand all aspects and conditions of the non-kinetic effect. These operational aids must tap/have access to all datasets that can affect or influence kinetic effects and visually display these interactions to the operator. Technologies developed should also address comprehensive inventory, impact, readiness, vulnerability, and collateral damage of kinetic vs. non-kinetics and well as combined kinetic and non-kinetic options.

NK-Enabled Counter C4ISR

ID-NKF-STO-03: Non-Kinetic Counter C4ISR

Develop family of long duration decoys for surface ships to pace the current and future threats. Decoys must be rapidly recoverable and/or reloadable at sea. They should be able to produce various characteristics to defeat current/future threats and emergent seekers.

Develop/leverage technologies that provide non-kinetic counter-sensor capabilities for deployment and operation on surface combatants, fixed and rotary wing aircraft and eventually submarines. These technologies should be effective against adversary Electro-Optical/Infra-Red (EO/IR) sensors carried by airborne platforms up to and including High Altitude Long Endurance/Medium Altitude Long Endurance (HALE/MALE) Unmanned Aerial Vehicles (UAV). These solutions should provide a wide spectrum of effective non-kinetic jamming in the infrared and visible portion of the spectrum.

Develop/leverage technologies that will support and increase defensive electronic countermeasures, reduce risk, and improve offensive electronic attack. These technologies should significantly enhance the survivability of the EA platform and improve the probability of weapons on target.

NK Attack

ID-NKF-STO-04: Non-Kinetic Attack

Develop/leverage technologies that enhance non-kinetic fire missions (including cyber payloads) capabilities and effectiveness and enable the Commander to sequence and synchronize the employment of EMS with traditional force employment. Key technologies should enable: EA nodes (air, surface, and ground) to effectively communicate and collaboratively synchronize (temporally and spatially) to efficiently engage targets in the electromagnetic spectrum; existing infrastructure

re-use, frequency extension and wider instantaneous bandwidth technologies that support low SWAP solutions for smaller platforms.

Develop/leverage non-kinetic means to modify, disrupt, and destroy adversarial information/kill chain infrastructure capabilities and neutralize or destroy adversarial combat capability in the EMS. These technologies should increase frequency agility, increase detection range (sensitivity), increase power output, increase directivity, increase geo-location accuracy, and minimize electromagnetic interference to blue forces. The technologies should decrease development time, increase effectiveness and reduce deployment time for cyber payloads.

POSITIONING, NAVIGATION AND TIMING (PNT)

Focus Area Description: Positioning, Navigation and Timing (PNT) capabilities provide common and precise position and time references to surface, sub-surface, air and space-borne assets, enabling safety of navigation, communications, command and control, combat and weapon systems. Technology investments in this area are focused on hardening and modernizing existing GPS-dependent PNT capabilities, developing GPS-independent PNT solutions; and miniaturized and scalable PNT solutions. Our intent is to equip the Navy with a range of capabilities that convey robust, assured positioning, navigation and timing under any and all operational conditions and physical environments.

PNT Technology Objectives:

Protected PNT

ID-PNT-STO-01: Protected GPS-dependent PNT Capabilities
Develop/leverage technologies that counter threats to and protect conventional GPS-dependent positioning, navigation and timing capabilities. These technologies should enable assured GPS-based PNT operation under contested, degraded and complex operational conditions and challenging physical environments within scope of the most stressing and relevant high-priority threat estimations.

Alternative PNT

ID-PNT-STO-02: GPS-independent PNT Solutions
Develop/leverage technologies and integration algorithms that provide alternatives to existing GPS-dependent PNT capabilities (such as fiber optic time transfer, chip-scale atomic clocks (CSAC), and optical clocks, as well as navigation by celestial or eLoran means). These added capabilities should sustain operation in conditions and physical environments represented by the most stressing and relevant high-priority threat estimations. They must also interoperate with and complement the existing suite of GPS-based PNT capabilities and be capable of sustained accuracy over required operationally-relevant time spans.

Dynamic PNT

ID-PNT-STO-03: Miniaturized and Scalable PNT Solutions

Develop/leverage technologies that provide a range of solutions for miniaturized and scalable PNT capabilities. These technologies should be capable of deployment and operation on small-unit manned /unmanned platforms such as unmanned undersea vehicles, small unmanned aerial vehicles and small surface combatants. These solutions should reduce size, weight and power while delivering sustained, operationally-relevant PNT accuracies.

PNT Diversity

ID-PNT-STO-04: Diverse Sensor Applications

Develop/leverage multi-sensor integrations and algorithms that complement existing navigation sensor limitations to provide continuous PNT service during operations with limited navigation information and when sensor or environmental degradation occurs.

PNT Decision Aids

ID-PNT-STO-05: Navigation Decision Aids

Develop/leverage and validate modeling and simulation to improve common navigation decision aids to enhance voyage and route planning, facilitate automated navigation, and provide enduring support for operational command and control.

ATLANTIC OCEAN A sonar technician monitors sonar tracking in the combat information center aboard USS Jason Dunham (DDG 109) operating in the U.S. 2nd Fleet area of responsibility. (Navy photo by MC3 Derek Paumen)

AUTONOMY (ATY)

Focus Area Description: Autonomous capabilities incorporated into systems (platforms, networks, etc.) to enable individual unit and collaborative/networked operations across all domain and multiple mission sets to provide a highly survivable, self-organizing, adaptive mission capability that cannot be easily defeated by the loss of individual platforms and/or sensors. Autonomy includes location and nature of processing, exploitation, and storage of information to enhance operations and conserve bandwidth. Technology investments in this area are focused on unmanned system navigation, unmanned system mission execution (individual and networked), unmanned system sensor operation, intelligent autonomous networks and systems, and improved machine intelligence. Our intent is to equip Navy platforms, networks, and systems with mission-appropriate levels of autonomy in order to optimize performance across a variety of missions at acceptable risk and cost.

ATY Technology Objectives:

UXS Maneuver

ID-ATY-STO-01: Autonomous Unmanned Vehicle Navigation & Maneuver

Develop/leverage technologies to conduct real-time, flexible UXV navigation and maneuver in response to unanticipated events/features. These technologies should enable/convey: locational awareness and accuracy; sensing of the operating environment; intelligent path-finding and re-routing, collision and threat avoidance; optimizing mission-related profiles (i.e. collection plan); launch and recovery and contingency management based on vehicle health and status. Technologies should also factor cost-effective sensors and algorithms to significantly enhance autonomous UxS operation. Areas of focus include self-localization, operation in adverse environments, obstacle detection and avoidance, terrain mobility, sea-state assessment, wave-detection/mitigation strategies, and tip-over prevention.

STRAITS OF FLORIDA
During an experimentation conducted by U.S. Fourth Fleet and Navy Warfare Development Command (NWDC), the BAT Unmanned Aircraft System flies over the Joint High Speed Vessel USNS Spearhead (JHSV 1) during its maiden flight off of a U.S. Navy vessel. (Navy photo by Lt. Jessica Crownover)

Data Processing

ID-ATY-STO-02: High-order Autonomous Operations, Networking, and Data Processing

Develop/leverage technologies that convey highly capable autonomous processing of sensor data on-board as well as off-board both manned and unmanned platforms. These technologies should enable/convey: an increased range of sensor data transport options and efficiencies (i.e. reduced bandwidth); improved data exploitation in terms of intelligent data triage (on-board); streamlined analytic workload management (on- and off-board); and increased exploitation quality (on- and off-board); securely store and transmit classified information. Technologies should consider: encryption key zero-ization in the event of platform loss by incorporating innovative zero-ization trigger mechanisms.

Unmanned System C2

ID-ATY-STO-03: Assured Unmanned System Command and Control

Develop/leverage technologies that ensure UXV mission accomplishment given limited or intermittent communications environment, provide situational awareness as well as minimize operator staffing. These technologies should enable/convey: prioritizing information transfer based on communications constraints; facilitating supervisory control despite limited information; mission planning tools; dynamic reconfiguration of UXV assets; automated sensor discovery and UXV autonomous behaviors to maximize UXV-to-operator staffing.

Manned-Unmanned Synchronization

ID-ATY-STO-04: Reliable and Efficient Unmanned-to-Manned Synchronized Operations

Develop/leverage technologies that enable collaborative planning and synchronized operations between unmanned and manned platforms. These technologies should convey/enable: cross-domain, cross-service control of UXV platforms and sensors; integrated mission planning tools; safe, predictable UXV behaviors for space management; UXVs to intelligently and autonomously respond to manned platform operations without supervisory intervention; and automated load balancing across UXV platforms. Technologies should also consider machine learning of red and blue tactics for optimal, autonomous responses.

UXS Power & Energy

ID-ATY-STO-05: Reliable and Durable Power Sources for Unmanned Systems

Develop/leverage technologies that enable the power demands of long-duration, high-efficiency UXS operations with particular emphasis on undersea UXS power requirements. These technologies should be adaptable to existing UXV platforms and should enable/convey: increased power density; autonomous power generation or charging; improved charging times; improved storage safety on Naval platforms; power monitoring and management based on mission profiles; and predictive power performance for mission planning and adaptive re-planning.

HUMAN-SYSTEMS INTERFACE (HSI)

Focus Area Description: Enhance Navy understanding of the physiological and cognitive characteristics that define and shape human interaction with technology at the individual and collective level and optimize system use in an operational context. This includes understanding how data and information are best delivered to the system and how it is best consumed by the user. Technology investments in this area include improved user-centric system design, enhanced user interface, adaptive training and simulation, improved training-to-field knowledge retention and improved performance assessment. Our intent is to optimize the human-machine interface for each component and system to increase operational effectiveness and reduce total ownership costs.

HSI Technology Objectives:

System Design

ID-HSI-STO-01: User-centric System Design

Design, develop/leverage systems to capitalize on the cognitive and physiological characteristics that define and shape human interaction with technology at the individual and collective level. Develop technologies that focus on sensory and cognitive characteristics including attention, information processing, and decision-making. Optimize system use in an operational context, including mission-based workflows between warfighters and across systems. Develop technologies that apply existing RDT&E experience to focus system design on how a system will be operated by users to accomplish Navy missions, as well as how it will be installed, trained, and maintained. Support the translation of system performance requirements (KPPs) into warfighting capability requirements, as evaluated during operational testing with users. This design philosophy and associated technologies should improve user effectiveness by reducing errors, speeding task completion, and facilitating the gathering, processing, and communication of information and decisions.

Knowledge Retention

ID-HSI-STO-02: Improved Knowledge Retention from Training to Operations

Develop/leverage concepts and technologies for adaptive, synthetic, mission-based simulation and training environments, to improve the coherence and retention of classroom and operational training at the individual, team, multi-system, and integrated warfare levels. Develop technologies that convey/enable: a common immersive simulation engine for use across the DoN/DoD; a scientifically-based process and guidelines for developing adaptive training systems; processes to rapidly develop and deploy training for the rapidly-evolving computing environment; and processes to determine the best training delivery method for a given level of learning (Bloom, Harrow, Krathwell, etc). These processes and guidelines could then be used to develop governing issuances to ensure all DoN/DoD training is of a consistent high quality.

Cognition

ID-HSI-STO-03: Improved Cognition in Complex Operating Environs

Develop/leverage concepts and technologies to help users manage the increasing informational load associated with complex operating environments and maximize decision efficiency. Technologies should enable/improve identification of cognitive aids (such as multi-mode data presentation) and training methods that enhance Battlespace Awareness and decision making in these environments. Technologies should improve user ability to identify, isolate, and interpret operationally significant data, patterns, trends, and anomalies and minimize the negative impact of known biases and other errors in information processing.

Manned-Unmanned Load Balancing

ID-HSI-STO-04: Optimized Load Balancing of Manned & Unmanned Roles & Capabilities

Develop/leverage technologies that apply existing RDT&E experience during system design to optimize task and role allocation to operators vs. automation (typically still under some level of human supervisory control). Evaluate program of record systems to identify manual user processes that could be partially or sometimes fully automated, while maintaining user insight into the progress, decisions, and rules applied by that automation. Identify opportunities to use automation to reduce cognitive workload, freeing users to achieve greater overall operational effectiveness, and potentially producing savings in reduced manning.

Adaptive Training

ID-HSI-STO-05: Adaptive Training Systems

Develop/leverage adaptive training interventions whose content can be tailored to an individual learner's aptitudes, learning preferences, or styles prior to training and that can be adjusted, either in real time or at the end of a training session, to reflect the learner's on-task performance. These technologies should convey/enable robust adaptive training software which is seamlessly integrated in operational warfare afloat and shore-based systems and provide a means to measure and track the impact of adaptive training on actual operator performance. These technologies should increase effectiveness and efficiency of decision-making processes by reducing time required for information search and communication prior to reaching a decision.

Simulation

ID-HSI-STO-06: Simulation Toolset for Analysis of Mission, Personnel and Systems

Develop/leverage technologies to assess and compare early platform designs and manpower allocations, by identifying platform systems response to a significant number of realistic deployments and operating conditions, and identify how well the allocated manpower supports ship and mission requirements. These technologies should convey/enable reporting on the manpower and training impacts of technology introduction; the effectiveness of proposed crew complements to operate and maintain

the platform/system under a wide variety of realistic scenarios; and the effectiveness of manpower reduction features incorporated into a design. These tools should simulate the design and manpower interactions to determine the trade spaces and cost commitments required for a given platform design and manning compliment. The analysis tools should provide Navy decision-makers with the information required to balance system and manning performance and optimize total life-cycle costs early in the acquisition process, when substantive changes can be implemented cost-effectively.

Virtual Training

ID-HSI-STO-07: Virtual Training Platforms

Develop/leverage training technologies to alleviate unique system baseline training requirements and create new systems by improving the current methods to teach multiple baselines. Technologies should convey/enable development of instructional strategies, performance measurement/assessment systems, and fidelity identification tools for mixed simulation/stimulation training environments. These technologies should improve synthetic onboard training technologies for use in command centers, CIC/CDCs, vehicle trainers, etc for training in communication-denied or degraded environments.

ENVIRONMENTAL BATTLESPACE AWARENESS (EBA)

Focus Area Description: Environmental Battlespace Awareness (EBA) capabilities provide knowledge of the current and predictive physical environment and its impact on naval operations from the bottom of the oceans to space. Technology investments in this area are focused on efficiently and effectively collecting environmental data, improving numerical weather and ocean modeling, developing and improving tactical decision aides that describe environmental impacts, and decision management tools that fuse operational information, intelligence and system performance information in a predicted environment to support optimal decision-making: asset allocation, weapons and sensor performance, route selection, and execution timelines to maximize warfighter advantage. Our intent is to equip the Navy with a range of capabilities that sense, analyze and predict the impact of the physical environment across the spectrum of naval operations.

U.S. 5TH FLEET AREA OF RESPONSIBILITY
Aerographer's Mates assigned to the Naval Oceanography Mine Warfare Center at Stennis Space Center, Miss., stand by as an unmanned underwater vehicle leaves the surface to search for mines as part of a training exercise during an International Mine Countermeasures Exercise (IMCMEX) 2013. (Navy photo by MC1 Gary Keens)

EBA Technology Objectives:

Environmental Sensing

ID-EBA-STO-01: In-situ Environmental Sensing Capabilities

Develop/leverage manned and unmanned technologies that provide comprehensive sensing of the air and ocean physical environment. These technologies should seamlessly combine manned and unmanned means to efficiently and effectively collect data from the bottom of the ocean to space and deliver the data to a repository for timely use in environmental databases and predictive models. Collection capabilities should not be limited to dedicated platforms, but should leverage every opportunity to execute environmental collection as a secondary, passive capability.

Environmental Prediction

ID-EBA-STO-02: Advanced Numerical Environmental Prediction Capabilities

Develop/leverage technologies that effectively and efficiently predict the state of the future physical environment across the tactical to strategic spectrum covering time periods of one hour out to the decadal timescale and capturing phenomena with spatial resolutions ranging from the sub-one kilometer micro/meso-scale to the global scale. These technologies should be able to operate in a fully coupled air-ocean-ice mode that covers the entire globe and leverage probabilistic techniques to provide a realistic prediction of the most probable future climate. These probabilistic predictions should be of sufficient fidelity to identify regional changes as well as major global impacts such as changes in polar ice coverage and sea level rise.

Sensor Performance Prediction

ID-EBA-STO-03: Sensor Performance Prediction Capabilities

Develop/leverage technologies that provide a robust predictive capability of a sensor or suite of sensors performance in a given environment. These technologies should leverage the timeliest data and databases through global reach-back to national data repositories and be able to operate in a stand-alone mode in a communications denied environment. Predictions should be available in a tactically-relevant timeframe and available in a GIS-enabled format for inclusion in a wide variety of tactical and operational command and control systems.

Environment-based Decision-making

ID-EBA-STO-04: Force Allocation and Employment

Develop/leverage technologies for decision management tools that quantify risk and opportunity at strategic, operational and tactical levels. These technologies should fuse operational force, intelligence, environmental and system performance information to provide optimized Courses of Action (COAs) in support of force disposition and utilization such as asset allocation, weapons and sensor performance, route selection, and execution timelines to maximize warfighter advantage. Final products should be available in a GIS-enabled format for inclusion in a wide variety of tactical and operational command and control systems and the user should have the ability to interrogate the source data as meta-data or GIS layers.

APPENDIX 1: TECHNOLOGY FOCUS AREAS AND OBJECTIVES LISTING BY TITLE (SHORT)

Information Transport and Infrastructure
- ITI-STO-01: Assured Connectivity and Access
- ITI-STO-02: Persistent Network Awareness and Control
- ITI-STO-03: Bandwidth-efficient Communication Capabilities

Information Security and Assurance
- ISA-STO-01: Assured Access and Transparent Identification and Authentication
- ISA-STO-02: Nimble and Proactive Network Defense
- ISA-STO-03: Detection, Prevention, and Reporting of Data Exfiltration
- ISA-STO-04: Resiliency Under Cyber Attack
- ISA-STO-05: Improved Information Audit and Forensics
- ISA-STO-06: Cloud Computing Security and Assurance

Advanced Sensing
- AVS-STO-01: Improved and Persistent Sensing and Awareness of the Battlespace
- AVS-STO-02: Optimized Sensor Netting and Synchronization

Data Integration and Decision Support
- DDS-STO-01: Enhanced Data Discovery and Access
- DDS-STO-02: Advanced Analytics and Tools
- DDS-STO-03: Advanced Data Display and Visualization
- DDS-STO-04: Mission and Operations Architecture for Improved Decisions
- DDS-STO-05: Management of Sensor Overload

Enhanced Targeting and Fire Control
- ETF-STO-01: Net-enabled Weapons
- ETF-STO-02: Improved Combat Identification
- ETF-STO-03: Automated Battle Management Aids

Electromagnetic Spectrum Operations
- ESO-STO-01: Acute Spectrum Sensing and Awareness
- ESO-STO-02: Increased Survivability and Maneuverability
- ESO-STO-03: EMS Signature Control

Non-Kinetic Fires
- NKF-STO-01: Non-Kinetic Targeting and Engagement
- NKF-STO-02: Non-Kinetic Operational Aids, Modeling and Planning
- NKF-STO-03: Non-Kinetic Counter-C4ISR
- NKF-STO-04: Non-Kinetic Attack

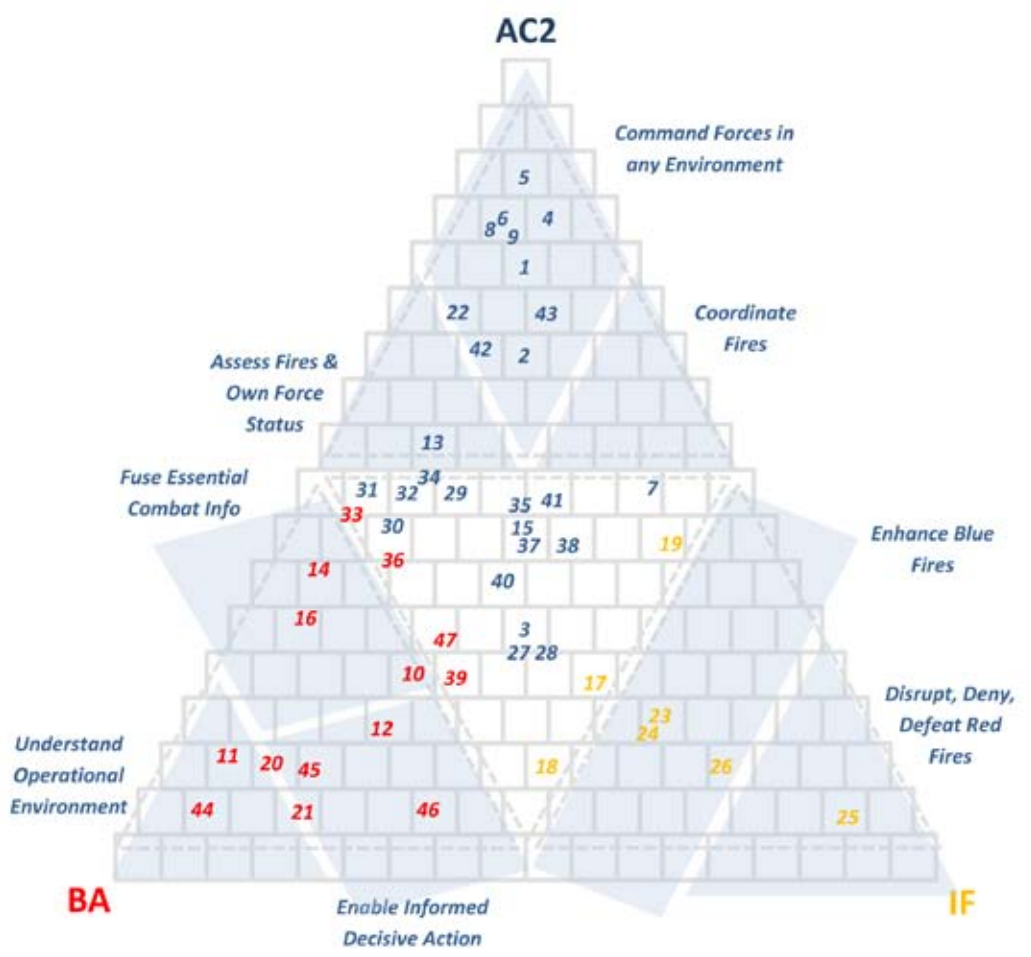
Positioning, Navigation and Timing
- PNT-STO-01: Protected GPS-dependent PNT Capabilities
- PNT-STO-02: GPS-independent PNT Solutions
- PNT-STO-03: Miniaturized and Scalable PNT Solutions
- PNT-STO-04: Diverse Sensor Applications
- PNT-STO-05: Navigation Decision Aids

Autonomy
- ATY-STO-01: Autonomous Unmanned Vehicle Navigation and Maneuver
- ATY-STO-02: High-order Autonomous Operations, Networking and Data Processing
- ATY-STO-03: Assured Unmanned System Command and Control
- ATY-STO-04: Reliable and Efficient Unmanned-to-Manned Synchronized Operations
- ATY-STO-05: Reliable and Durable Power Sources for Unmanned Systems

Human-Systems Interface
- HSI-STO-01: User-centric System Design
- HSI-STO-02: Improved Knowledge Retention from Training to Operations
- HSI-STO-03: Improved Cognition in Complex Operating Environs
- HSI-STO-04: Optimized Load Balancing of Manned & Unmanned Roles & Capabilities
- HSI-STO-05: Adaptive Training Systems
- HSI-STO-06: Simulation Toolset for Analysis of Mission, Personnel & Systems
- HSI-STO-07: Virtual Training Platforms

Environmental Battlespace Awareness
- EBA-STO-01: In-situ Environmental Sensing Capabilities
- EBA-STO-02: Advanced Numerical Environmental Prediction Capabilities
- EBA-STO-03: Sensor Performance Prediction Capabilities
- EBA-STO-04: Force Allocation and Employment

APPENDIX 2: SUMMARY GRAPHIC
INFORMATION DOMINANCE TECHNOLOGY OBJECTIVES IN RELATION TO THE U.S. NAVY INFORMATION DOMINANCE ROADMAP 2013–2028



1. ITI-STO-01
2. ITI-STO-02
3. ITI-STO-03
4. ISA-STO-01
5. ISA-STO-02
6. ISA-STO-03
7. ISA-STO-04
8. ISA-STO-05
9. ISA-STO-06
10. AVS-STO-01
11. AVS-STO-02
12. DDS-STO-01
13. DDS-STO-02
14. DDS-STO-03
15. DDS-STO-04
16. DDS-STO-05
17. ETF-STO-01
18. ETF-STO-02
19. ETF-STO-03
20. ESO-STO-01
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22. ESO-STO-03
23. NKF-STO-01
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27. PNT-STO-01
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43. HSI-STO-07
44. EBA-STO-01
45. EBA-STO-02
46. EBA-STO-03
47. EBA-STO-04


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