Science & Technology Objectives

Naval Aviation Enterprise

2014


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Naval Aviation Enterprise
Science and Technology Objectives
2014

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NAVAL AVIATION ENTERPRISE SCIENCE AND TECHNOLOGY OBJECTIVES

The Naval Aviation Enterprise (NAE) conducts research across broad areas of technology to provide the best solutions to meet current, emerging, and future warfighter needs at the right time and lowest cost. The Science and Technology (S&T) portfolio ensures near-term warfighting needs are addressed without detracting from the pursuit of mid- to far-term evolutionary and revolutionary capabilities. The distribution and balance among these research areas are critical to ensure the vitality and relevance of the NAE S&T efforts.

The NAE has identified near- (0-5 years), mid- (5-10 years) and far-term (10 years and out) S&T objectives (STOs) with quantifiable metrics for identified capability gaps that ensure these critical efforts align with established requirements. These objectives are the baseline for guiding, identifying, aligning, and synchronizing S&T efforts throughout the Enterprise. They represent a broad strategy that provides focused direction for the future while retaining flexibility to meet current and emerging needs/challenges.

The NAE S&T community, in collaboration with other services within the Department of Defense (DoD), federal agencies, academia and industry produce detailed, leveraged wherever possible, development strategies that support strategic objectives with measureable results. The STOs provide consolidated Naval Aviation strategic S&T guidance as a first step in taking the state-of-the-art and transforming it into the state-of-the-possible to ensure that our warfighters maintain the technological advantage.

The DoD is in a period of reduced resources where plan-to-budget is the Commander's Guidance for the foreseeable future. The identification and pursuit of science within the NAE focuses on efforts to ensure the S&T community is well positioned to assist leadership by providing options of varying complexity, utility, and cost to address the current and future threat. The Office of Naval Research's (ONR) establishment of the Sea Based Aviation (SBA) National Naval Responsibility in 2011 clearly delineates that operating in and around a

sea base, presents a different and unique set of challenges requiring critical technologies, talent (skill sets) and resources not addressed by the other services. Sec 219 (the Naval Innovative Science and Engineering program) initially authorized by the 2009 National Defense Authorization Act provides essential discretionary funding to support in-house research to fill critical technology gaps identified by the STO roadmaps. A focus of Sec 219 is developing and mentoring the skilled researchers and engineers of the future. This funding is essential not only to conducting the necessary basic and applied research, but also to supporting program of record transition demonstrations to prove the functionality and affordability of these next generation technologies to the requirements/resource and acquisition sponsors. Sec 219 plays a major role in ensuring that the vitality of the naval in-house laboratories are not only maintained but strategically grown in critical new emerging areas to support the development, maturation, and transition of high risk research and critical technologies. As our workforce continues to age, attrite, and retire, it is essential to develop and train the future researchers and engineers in traditional as well as emerging areas.

The NAE STOs are reviewed on a biennial basis, updated, refined, merged, and redirected as necessary. This is the fifth edition of the NAE STO document. It incorporates lessons learned and insights gained through STO roadmapping. It has shifted focus as needed while merging similar areas.

The NAE Chief Technology Officer/Organization and the entire NAE S&T team of lead technologists and scientists provide clearly articulated input to guide S&T investments, made by ONR and others on the NAE's behalf, toward the best capabilities to address current and future warfighting needs.

DR. JAMES B. SHEEHY
NAE Chief Technology Officer


NAVAL AVIATION
NAE
ENTERPRISE

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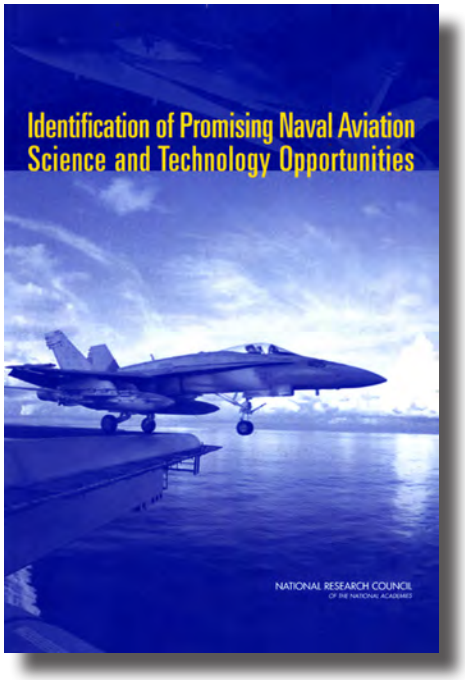

The Naval Studies Board of the National Research Council published a study in 2006 entitled "Identification of Promising Naval Aviation Science and Technology Opportunities." The report stated that "the committee was asked to recommend S&T opportunities to the Office of Naval Research (ONR) that could support future Naval Aviation capabilities and address any capability gaps. However, they were not presented with any vision, strategy or implementation plans by the Naval Air Systems Command (NAVAIR) or ONR regarding the role of Naval Aviation in satisfying the goals of Naval Sea Power 21. Future capabilities that might be deployed were not identified, nor were existing capability gaps discussed at any length." The report went on to say, "Naval Aviation badly needs a clearly stated vision and strategic plan to focus its future. Moreover, NAVAIR and the Office of the Chief of Naval Operations (OPNAV) have the primary responsibilities for creating a Naval Aviation strategic S&T plan that identifies needed capabilities and the technology developments that can, over time, provide those capabilities. ONR…must be an essential partner with NAVAIR in developing a Naval Aviation strategic S&T plan."

In 2007, the NAE Board of Directors directed a study to address S&T process shortfalls identified by the Naval Studies Board report. The study recommended that an enterprise-level Chief Technology Officer (CTO) position be created. On 24 August of 2007, the NAE CTO organization was chartered to include NAVAIR; Program Executive Offices (PEOs) and Program Managers, Air (PMAs); and the Naval Air Warfare Centers (NAWCs) both Aircraft and Weapons Divisions. The CTO was assigned the responsibilities to oversee all NAE S&T programs and projects; produce S&T objectives linked to warfighter capability gaps; produce S&T objective technology development plans (roadmaps); increase stakeholder visibility into S&T investments; increase transition success of S&T products; and monitor the health of the S&T portfolio and progress toward delivery of capabilities through the use of approved metrics and processes.

In response to these tasks, the NAE CTO organization, in collaboration with naval S&T stakeholders, has identified S&T objectives every two years since 2006. This is the fifth edition of the STO document.

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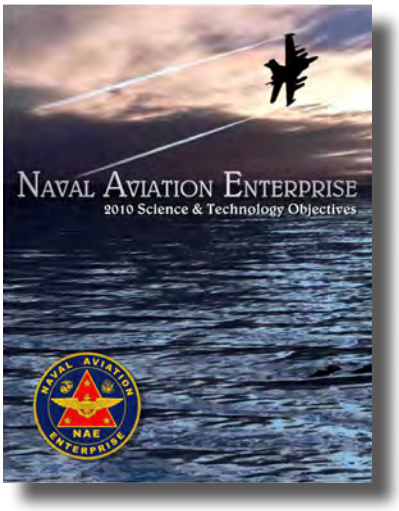

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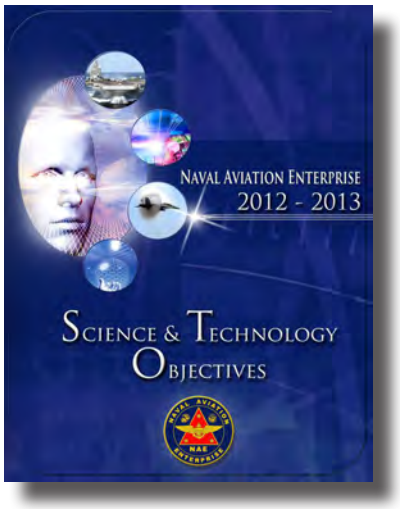


2012

S&T OBJECTIVES

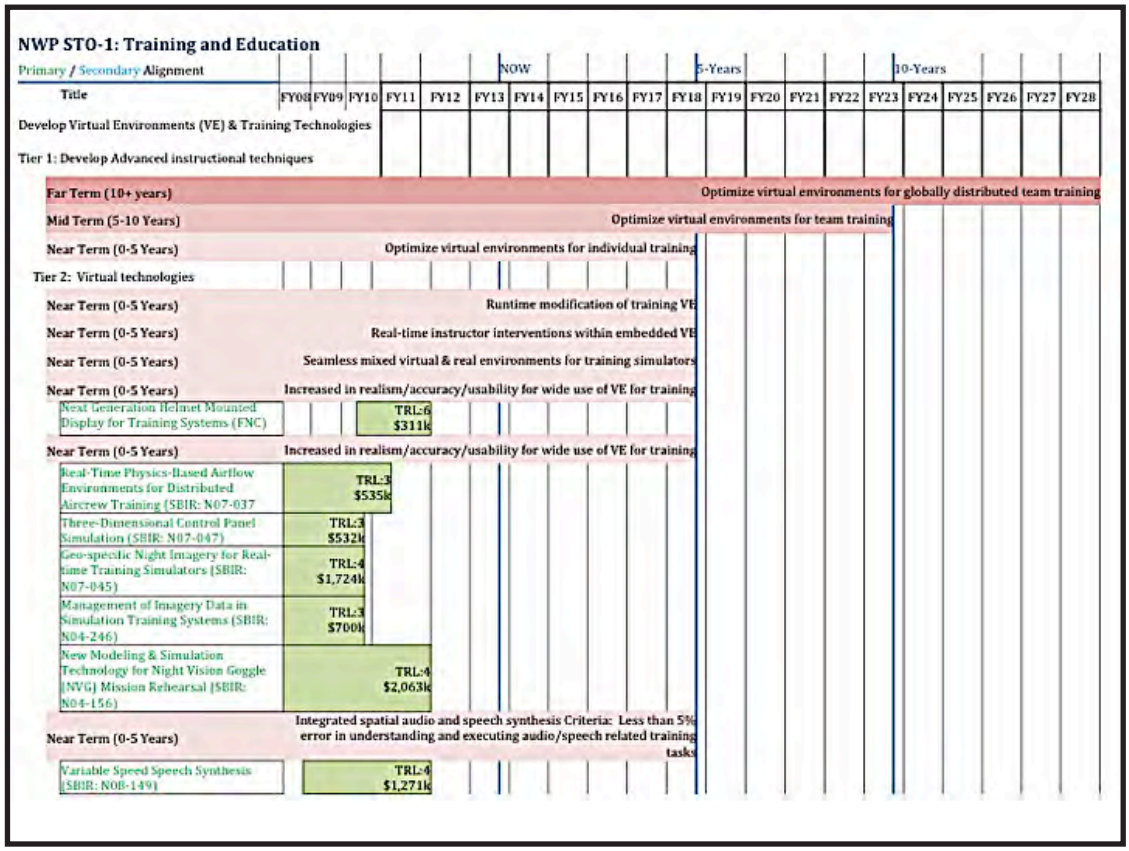
The 2014 S&T Objectives were developed in collaboration with the NAE stakeholders: the Fleet; OPNAV; Headquarters Marine Corps; NAVAIR to include the PEOs; PEO (Aircraft Carriers); and ONR. These objectives align S&T efforts throughout the Enterprise.

The 2014 STO Document provides a framework to align current NAE S&T investments to Naval Aviation missions and projected future capability needs. Alignment provides investigators, stakeholders and sponsors with context and options to identify potential future S&T investments. The framework permits the NAE to more effectively communicate the S&T portfolio's current value and future opportunities to senior decision-makers, key stakeholders, partners, customers, and performers. This document serves as a foundation for the mission area NAE S&T roadmaps.

Alignment. The STOs provide a structure to align S&T programs to organizational objectives and associate projects with specific capability areas allowing stakeholders a better understanding of where NAE S&T investments are being made and why. Tracking progress of the ongoing technical work/research in a particular capability area combined with the STO roadmaps, shows the current state of technology development and whether current investments will mitigate a known gap. The STO and STO roadmaps illustrate the balance between near-, mid-, and long-term technology development targeting current Fleet needs while developing

solutions for future capabilities. Interdependencies where multiple projects may be individually contributing to a part of a single capability solution are highlighted.

Alignment of the projects to STOs illustrates the comprehensive plan for using S&T investment to close or mitigate a capability gap. STO tracking can be used to identify where additional investment is warranted; provides a basis for determining the health of S&T funding in a particular mission area (i.e., current investment is either adequate or insufficient for gap closure); and serves as a tool for evaluating the potential merit/context of new S&T projects.



Analysis. STO roadmaps are a fundamental tool for analyzing and managing the S&T portfolio. These roadmaps provide insight into the current state of technology development, the targeted technology goal, and current and needed investment required to close a gap. This provides investigators, stakeholders and sponsors with an informational basis to guide future investment decisions.

Investigators from the Navy, Marine Corps, other Services, industry or academia can see where similar work is being performed and identify opportunities for potential collaborative/leveraged efforts. This also informs the larger community of ongoing work which minimizes duplication, increases focus, and enhances communication between the NAE scientific

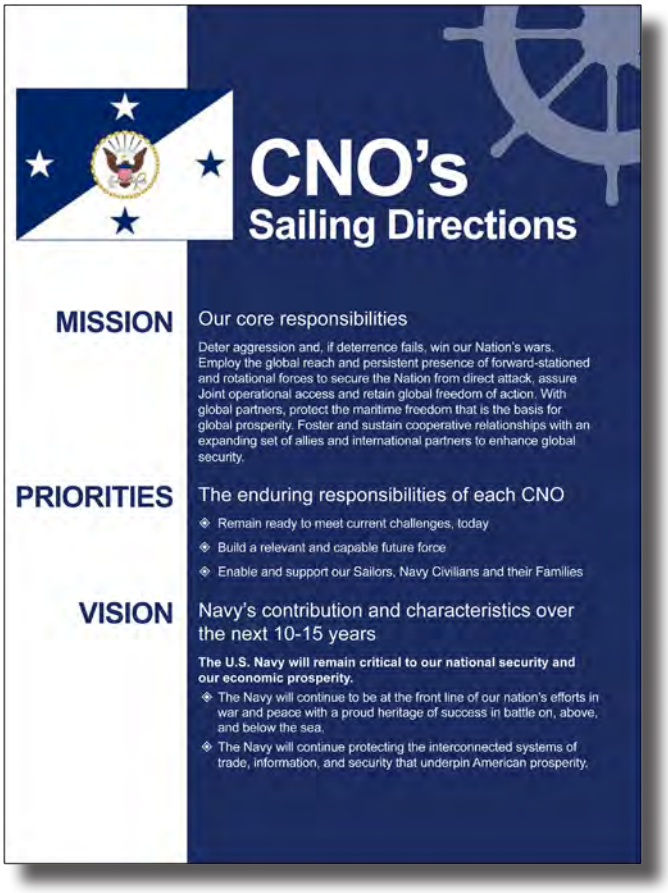
communities. The goal is to ensure each dollar of S&T funding is invested in the best way possible to coordinate and support critical steps to achieve the best solution.

This document enables stakeholders to better understand the contribution of an S&T project in addressing a particular gap within a specific time frame and see the complete suite of projects/technology options that support a program/mission area when considering endorsement and transition. This information allows stakeholders to make informed decisions weighing multiple technology programs/options against the constrained resource environment.

The STOs provide a means of showing external S&T funding from ONR, Defense Advanced Research Projects Agency (DARPA), and other S&T sources in context, illustrating how a project fits within a body of work instead of a technical vacuum. The stakeholders can be assured the project has been vetted, fully coordinated with existing work, and integrated into a complete plan to close a gap. This approach places the NAE projects in better standing when evaluated in the competitive funding constrained S&T environment.

VALUE OF A BALANCED PORTFOLIO

The Chief of Naval Operations' Sailing Directions state that we will "remain ready to meet current challenges, today" while building "a relevant and capable future force" using "new technologies and operating concepts to sharpen our warfighting advantage against evolving threats" to provide rapid, relevant solutions to urgent fleet needs, while reducing risks associated with the implementation of new technologies into an increasingly complex battlespace.



The NAE S&T portfolio balances near-, with the pursuit of mid- and long-term, revolutionary technologies tied to future capabilities. The distribution and balance between basic research and rapid response to Fleet/Forces needs is critical to ensuring the NAE

S&T portfolio remains healthy and relevant, and addresses documented needs and requirements. Pursuit of future game-changing capabilities requires investments in high-risk, high-payoff technologies with varying time frames necessitating a focused array of basic research projects to support critical components of the NAE S&T portfolio.

EMPHASIS AREAS

The 2014 STO Document does not prioritize areas of technology investment. The STOs do address specific emphasis areas identified by Navy and Marine Corps leadership and presents associated roadmaps to provide users the information necessary to make better decisions within any capability area. The solutions across all of the NAE STOs must take specific emphasis areas into account that include:

Creating Integrated Warfighting Capabilities

By Vice Admiral David Dunaway, U.S. Navy

To meet increasing demands with decreasing budgets, 'integration and interoperability' become words for the Navy to to live by.

The United States has the greatest navy in the world. Free passage over the high seas is largely due to substantial taxpayer investment and the blood, sweat, and tears of extraordinary sailors and Marines. In the face of decreasing budgets, rapidly evolving threats, and a shift in national defense strategy that demands more than ever from our naval forces, it's imperative that every dollar spent increases warfighting capability.

I believe that a view of the outcomes really helps us understand where best to invest resources. With a fixed Department of Defense budget, the only way we will afford our future without stripping away force structure is to consistently deliver integrated warfighting capabilities (networked platforms, sensors, and weapons that can operate seamlessly in a systems-of-systems [SoS] environment) to create desired mission-level effects.

This concept of integrated warfighting capabilities (IWC) is often referred to as "integration and interoperability" or I&I. This makes perfect sense, because integration and interoperability are fundamental components of the IWC end state. IWC encompasses the combined

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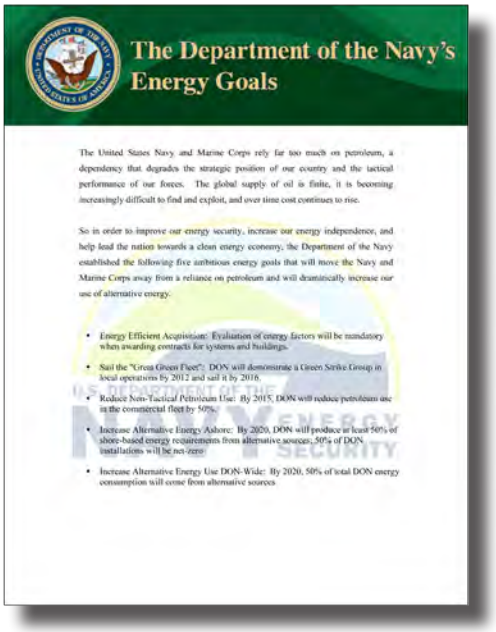
Integration and Interoperability. With a fixed Department of Defense budget, the only way to afford the future without stripping away force structure is to consistently deliver integrated warfighting capabilities (IWC) to create desired mission-level effects that are integrated and interoperable. IWC encompasses the combined interaction of people, equipment, and training into a system architecture. The effects can be kinetic or non-kinetic. These capabilities must be available at adequate speed and capacity, as well as be affordable, in order to dominate the battlespace. A recent update to the Defense Acquisition Guidance emphasizes the importance of considering systems-of-systems in the development of individual systems: "From the Joint Capabilities Integration and Development System (JCIDS) Capabilities-Based Assessment (CBA) through sustainment activities," it is important to recognize how the system influences system requirements. Limited funding, dynamic threats, disruptive technologies, and operational needs call for a corresponding methodology to address the interaction of platforms, weapons, sensors, and networks that form mission-area kill chains in a system-of-systems construct. The Navy must balance platforms, sensors, and weapons development and deliver a corresponding, comprehensive, capabilities-based focus and methodology.

Maturing this focus improves integration and interoperability, speeds rapid response and irregular-warfare solutions, and reduces life-cycle development and support costs, making it possible for our naval forces to deter threats, fight and win.

Reduction of Total Ownership Cost. A declining Total Obligation Authority impacts the ability of the Navy and Marine Corps to acquire new/additional capabilities while maintaining legacy assets ultimately meeting force structure and readiness targets. Despite a reduction in flight hours, aircraft and manpower, the overall costs to Naval Aviation continue to increase at a pace that erodes Naval Aviation's buying power. This in turn exacerbates maintaining aging aircraft and equipment functionality up to and beyond their intended service lives. Controlling rising acquisition, operational and sustainment costs is critical to maintaining and modernizing the fleet. The current challenges with recapitalization and modernization highlight the importance of developing new systems that are affordable, reliable, and sustainable. Production and maintenance with a focus on cost effectiveness and long-term in-service performance will be required in order to ensure readiness of the Naval Aviation forces.

Scientific and technological innovations will be a critical component of reducing and controlling total ownership costs (TOC). Consideration should be given to common or standardized solutions capable of reducing costs while providing technological improvement.

Energy Efficiency. The Secretary of the Navy outlined the Navy and Marine Corps' energy goals in 2009. These goals include incorporating consideration of lifetime system energy costs in Navy and Marine Corps contracts; creating a Green Strike Group by 2012 composed of nuclear vessels and ships powered by biofuels and deploying that fleet by 2016; reducing petroleum use in the Navy Department's 50,000 commercial vehicle fleet by 50 percent by 2015; producing at least half of shore-based energy requirements from renewable sources; and, ensuring that at least 40 percent of the Navy's total energy consumption comes from alternative sources by 2020. As a result ONR has designated power and energy as a naval S&T focus area, and has identified objectives in the areas of energy security, efficient power and energy systems, and high energy pulsed power. Similarly, the 2014 NAE STOs include a specific objective for improvements in energy conservation, flexibility and security.


The Department of the Navy's Energy Goals

The United States Navy and Marine Corps rely far too much on petroleum, a dependency that degrades the strategic position of our country and the tactical performance of our forces. The global supply of oil is finite, it is becoming increasingly difficult to find and exploit, and over time cost continues to rise.

So in order to improve our energy security, increase our energy independence, and help lead the nation towards a clean energy economy, the Department of the Navy established the following five ambitious energy goals that will move the Navy and Marine Corps away from a reliance on petroleum and will dramatically increase our use of alternative energy.

- Energy Efficient Acquisition: Evaluation of energy factors will be mandatory when awarding contracts for systems and buildings.
- Sail the "Great Green Fleet": DON will demonstrate a Green Strike Group in local operations by 2012 and sail it by 2016.
- Reduce Non-Tactical Petroleum Use: By 2015, DON will reduce petroleum use in the commercial fleet by 50%.
- Increase Alternative Energy Ashore: By 2020, DON will produce at least 50% of shore-based energy requirements from alternative sources. 50% of DON installations will be net-zero.
- Increase Alternative Energy Use DON-Wide: By 2020, 50% of total DON energy consumption will come from alternative sources.

NAE SCIENCE AND TECHNOLOGY OBJECTIVES

FORCE PROTECTION (FP)

Vision: Protect naval assets and provide increased survivability across the full spectrum of conflict. This capability includes those measures the force needs to remain viable and functional to protect itself from the effects of enemy activities.

FP STO-1: Platform Survivability

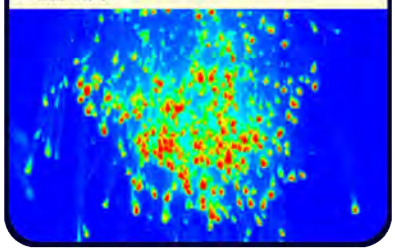
Advances in threat technology have resulted in improved detection and targeting sensors, weapon capabilities and kinematics, and other capabilities that place joint and coalition air and carrier forces within the threat envelope.

Develop technologies that improve survivability of naval platforms in current and emerging threat environments. Increase the defensive capabilities of joint and coalition platforms against advanced current and emerging threats, including both airborne and surface-based threats (small boats, swimmers, etc.). Platform survivability includes the ability to avoid detection/tracking (susceptibility), withstand both kinetic and non-kinetic effects (vulnerability) through protective means; and to reconfigure subsequent to battle damage. Low observable signature (radio frequency (RF), electro-optic/infrared (EO/IR), acoustic), warning, and countermeasure technologies include the development of soft- and hard-kill laser countermeasures, high power/high efficiency optical amplifiers/switches, hostile fire indication and cueing systems, advanced electronic warfare/RF countermeasure technologies, advanced kinetic hard-kill defensive systems and low maintenance tactical paints. Vulnerability reduction technologies include lightweight conformal armor for aircraft, improved self-sealing and/or hydrodynamic ram resistant fuel systems, and adaptable flight control systems.

Nanoparticles for Mid-Infrared Heat Source

The proliferation of lethal Man Portable Air Defense Systems are the leading threat to assault and assault support rotary and tilt-rotor aircraft. These tactically launched surface-to-air missiles typically use infrared seekers for guidance. Pyrophoric decoys are critical components in aircraft self-protection and are used by all services. The Navy is investigating pyrophoric nanoparticles as a decoy material.

Nanoparticles have the benefit of a dimensionally small non-uniform particle distribution leading to high surface area for rapid and even oxidation, with the desired spectral radiance in the mid-infrared. The technology will provide an environmentally friendly process using inexpensive, recyclable base materials.



FP STO-2: Mine and Improvised Explosive Device (IED) Detection and Neutralization

Joint and coalition forces must be able to safely maneuver from blue water to land in order to perform their missions.

Develop technologies to improve capabilities to locate and neutralize mines and IEDs in areas where joint forces must operate. Capabilities include intelligence, surveillance and reconnaissance, preparation of the battlefield, and engagement abilities. Research areas include (from ship and air): deep and shallow water mine detection, classification, localization, identification and neutralization in all environments (sea state, water clarity, hard/soft or rocky bottom conditions, etc.); and beach mine and IED detection, identification and neutralization.

FP STO-3: Electronic Protection

Advances in airborne threat jamming systems, including the incorporation of digital radio frequency memory technology, require advanced counter-countermeasures for joint and coalition forces.

Develop technologies to improve joint and coalition air, land, and ship systems' resistance to friendly and adversary electronic attack (EA) and electromagnetic interference, including electromagnetic pulse, directed energy, and high power microwave.

Develop technologies that provide for netted collaboration between platforms to mitigate or alleviate adversary electromagnetic attacks.

FP STO-4: Surface Torpedo Detection and Neutralization

Joint and coalition forces must be able to safely maneuver in all operational waters up to and including the littoral zone in order to perform their mission.

Develop technologies to improve the abilities to detect, locate, identify, track/target and neutralize torpedoes in areas through which joint forces must operate.

Develop technologies to protect and provide increased survivability across the spectrum of conflict for U.S. aircraft carriers.

SURFACE WARFARE (SUW)

Vision: Project power within blue water and littoral zones to preserve open access to key shipping lanes. This capability includes all efforts taken to control the battlespace by warfare commanders. Efforts include strikes against high payoff and high value targets such as missile launching ships and other strike and power projection units throughout the theater, and actions to undermine the enemy's will/ability to fight.

SUW STO-1: Maritime Surveillance and Interdiction

Naval forces must maintain the ability to project power in blue water and littoral zones to preserve open access to key shipping lanes. Improved capability to detect, identify, track and determine intent of surface contacts and engage hostile vessels is required.

Tracking/identification capability is required for ship classes ranging from traditional surface combatants to small vessels with low radar cross section and thermal signatures. This capability is required in low and high density shipping traffic and during unintentional/intentional jamming scenarios.

MQ-8 Fire Scout UAS Radar Maritime and Overland Target Classification Aids

NAVAIR, in cooperation with industry partners, has developed a complete maritime classification suite that intelligently utilizes radar resources to provide automated ship and small craft classification, and feature aided tracking to the operator. This technology's goal is to dramatically reduce operator workload, improve mission performance and provide actionable intelligence in support of maritime intellegence, surveillance reconnaissance missions; potentially enabling a single air vehicle to triple its surveillance capability.

Develop technologies to detect, classify, identify and maintain persistent tracking of surface contacts (friendly, hostile, and neutral) in all weather conditions, across breaks in surveillance coverage during day and night operations, at standoff ranges sufficient to ensure the survivability of the targeting and/or weapon delivery platforms. This capability must endure modern hostile electronic attack and electronic surveillance capabilities. Develop technologies that provide timely, relevant and actionable intelligence that enables near-field situational awareness to counter planned and opportunistic hostile small vessel swarm attacks against naval surface forces operating in congested littoral areas.

Develop weapon technologies that can be employed from sanctuary with high probability of mission kill and low probability of collateral damage to support the engagement of surface

combatants, amphibious vehicles, and other high value assets in the most challenging scenarios. Endure hostile electronic attack, electronic surveillance, and defensive capabilities, to ensure rapid and/or simultaneous engagement of multiple fast small vessels executing a swarm attack.

UNDER SEA WARFARE (USW)

Vision: Establish battlespace dominance in the undersea domain to permit friendly forces to accomplish the full range of potential missions and deny opposing forces the effective use of undersea systems and weapons.

USW STO-1: Environmental Sensing, Assimilation and Tactical Decision Aids

As sensors and weapons are developed to pace the advances in the increasingly complex and variable USW battlespace, more comprehensive real-time environmental and target data is required. On-board tactical decision aids that rapidly assimilate the expanded data set are needed to decrease workload, optimize new sensor and weapon employment, and provide effective single and multi-platform, tactical employment options across all phases of undersea warfare.

Develop technologies that provide real-time comprehensive sensing of the undersea environment (air, ocean, and situational awareness of marine mammals) along with integrated on-board and off-board decision aids that rapidly assimilate data to produce information that can be used to optimize multi-sensor and weapons employment, and improve overall USW effectiveness.

Develop technologies that provide improved calibrated sensing and processing of target characteristics for USW intelligence purposes.

USW STO-2: Wide Area Search and Detection

Continued advances in submarine capability to avoid acoustic and non-acoustic detection increasingly challenge the ability of air anti-submarine warfare (ASW) platforms to cover tactically significant search areas in both deep and shallow water.

Develop effective aerial search and detection capabilities against threat submarines and unmanned undersea vehicles that facilitate covering large areas at high search rates in shallow to deep water with high probability of detection and low probability of false alarm/detection.

Develop methods to mitigate RF interference at all altitudes in littoral or adverse RF environments.

Develop technologies to enable automatic detection and discrimination of small targets (i.e. periscopes, unmanned undersea vehicles, etc.) from all altitudes and/or standoff ranges, and improve active/passive/multi-static (distributed netted sensors) identification algorithms to minimize false detections.

USW STO-3: Precision Localization/Identification/Attack

Continued advances in submarine capability to counter acoustic and non-acoustic sensors and weapons increasingly challenge the ability of air ASW platforms to rapidly localize, track, and deliver effective precision attacks. Stand-off or high-altitude flight profiles are required in littoral zones or hostile threat environments, but high-altitude littoral ASW capability is severely constrained by RF interference and RF jammers.

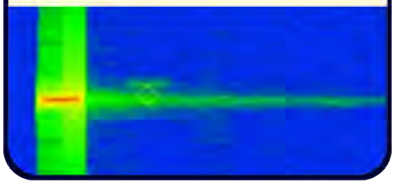
Develop technologies for rapid and sustained precision localization, tracking, and positive identification of threat submarines and unmanned undersea vehicles after initial air platform search sensor detection.

Develop an advanced, precision ASW weapon with high probability of kill for all-altitude attack of submerged targets at any operational depth.

Rapid Prototyping for Multi-static Signal Processing

The Multi-static Active Coherent (MAC) system will provide a wide area acoustic search capability to Maritime Patrol and Reconnaissance Aircraft (MPRA) with reduced false alarms and improved classification in challenging environments. It will improve MPRA effectiveness in the detection, localization, identification and tracking phases of the ASW kill chain.

With several MAC enhancements planned over the next several years, a rapid prototyping initiative has begun that will allow the ability to conduct in-house independent evaluations of new MAC capabilities. By developing a rapid prototyping capability for MAC systems, the value-added of different sonar algorithms and operating modes could be evaluated, before any significant investment is made. This will ensure that only the best algorithms are integrated into the platform and that these new technologies complement existing ones.



THEATER AIR AND MISSILE DEFENSE (TAMD)

Vision: Detect, track, target, and neutralize or destroy enemy aircraft and missiles in flight through a mixture of mutually supportive kinetic and non-kinetic assets.

TAMD STO-1: Anti-Air Warfare Performance

Air superiority requires the ability to engage manned or unmanned air platforms, potentially superior in number, prior to an enemy's ability to launch weapons at joint and coalition force combatants, ground stations/bases and surface vessels. Advances and proliferation of air-to-air threat technologies have resulted in improved threat air platforms (reduced radar cross section, enhanced sensors, improved command and control (C2) and situational awareness), threat weapon kinematics/sensitivity, and electronic attack/electronic protection capabilities

that pose a threat to joint and coalition air forces. It is imperative that sensors and weapons enable sufficient situational awareness and survivability to ensure that joint and coalition air forces can counter threats posed by enemy weapons/systems.

Develop weapon system technologies to neutralize or destroy advanced air platform threats outside of their projected detection and employment ranges in an electronic attack environment.

TAMD STO-2: Airborne Missile Defense

Advances in, and proliferation of, advanced land attack and anti-ship cruise missile threat technologies have resulted in an increased threat to joint and coalition forces.

Defense of joint and coalition forces requires the ability to detect and engage emerging missile threats to ensure the safety of our forces while minimizing the reliance on point defense systems (i.e. threats need to be successfully detected and engaged as far from the target as possible in a layered defense concept of operations).

Develop kinetic and non-kinetic weapon system technologies to neutralize or destroy emerging cruise missile threats at ranges that support a shoot-look-shoot versus a shoot-shoot strategy.

NOTE: Technologies addressing detecting, tracking, identifying, and targeting are addressed under the Information Dominance STOs. Note pertains to TAMD STO-1 and TAMD STO-2.

Low-Erosion and Affordable Nozzles for Advanced Air-to-Air Missiles

Reduced-signature, high-performance solid rocket motors operate in an oxidative environment produced by composite propellants, high propellant flame temperatures, and high motor operating pressures. This environment has a significant and adverse effect on the erosive-resistant properties of the nozzle liner material, particularly those in the critical throat region.

Researchers are investigating candidate nozzle material and design architectures to provide low-cost, low-eroding design solutions and establish a credible materials database to support analysis and testing. Thermal/structural analysis was conducted to evaluate the performance of four candidate technologies for dual-pulse, reduced smoke motor designs. The data will be used to improve calibration and increase the fidelity of the nozzle analytical models to support the design and analysis of the full-scale tactical nozzle design.

STRIKE OPERATIONS (STK)

Vision: Apply combined-arms naval combat power as part of a joint and coalition force to disrupt, divert, delay, destroy, suppress, neutralize, or seize military objectives. Strike operations incorporate and integrate multi-dimensional capabilities for power projection with various combinations of forces and platforms.

STK STO-1: Responsive Engagement

Rapid changes in operational conditions and enemy action result in a need for engagement in limited vulnerability windows. Timely awareness of these opportunities and the capability to prosecute multiple targets with organic assets is essential. Effective, responsive, precise fire in support of friendly forces in urban areas, day or night, and in all weather conditions, is essential to responsive engagement including close air support, strike coordination reconnaissance, and interdiction missions. These operations require a common and coherent picture of the battlefield.

Develop technologies that enable: persistent, precise, and responsive engagement day or night, and in all weather conditions; in denied or degraded communications/navigation (COMM/NAV) RF environments; in the presence of counter-measures and rough terrain environments; realization of optimal effects given target and engagement parameters; and a weapon's ability to select the right target and aim point for moving and/or time-urgent fixed targets. Deep magazines, weapon's time-of-flight inside the threat's ability to counter, and multi-engagement and interoperable weapons are needed; as well as technologies that allow intuitive, heads up target designation by the controller.

Handheld Capability for Precision Fires Image Software Suite

A Technology Transition Initiative was executed to develop and deploy an integrated software system, providing image, video and geographical capabilities on a handheld computer to allow dismounted personnel to verify targets and provide precision coordinates to air platforms within minutes.

The Precision Fires Image is the only truly dismounted controller capability to generate coordinates accurate enough for GPS guided weapons. Not only has this capability enabled the use of approximately 60 percent of the current precision weapons inventory in both Iraq and Afghanistan, but it is influencing future programs of record decisions. The project enabled the development of this paradigm breaking capability and went from concept to completely deployed and trained at formal service schools in less than two years.

NOTE: Technologies addressing detecting, tracking, identifying and targeting, as well as communications/global positioning system (GPS) denied or degraded environments, are addressed in the Information Dominance STOs.

STK STO-2: Engagement of Non-Time-Sensitive Targets

The ability to engage pre-planned and non-time-sensitive targets including mobile targets in an anti-access/area denial (A2/AD) environment increases the ability of joint and coalition forces to neutralize enemy threats. Improvements are required in the weapon's ability to guide to an accurate impact given uncertainty of target location provided by targeting assets.

Develop technologies to improve range, target recognition, combat identification, realization of optimal effects given target and engagement parameters, mission flexibility, weapon survivability, and interoperable weapon capabilities against pre-planned and non-time-sensitive targets.

These technologies must support employment of weapons with positive target identification in all-weather, day or night, and in denied or degraded COMM/NAV environments and rough terrain. This must also be true in the presence of cyber-attack and counter-measures.

NOTE: Technologies addressing detecting, tracking, identifying and targeting, as well as communications/GPS denied or degraded environments, are addressed in the Information Dominance STOs.

STK STO-3: Collaborative Unmanned Strike Capability

In suppression/destruction of enemy air defenses, strike, surface warfare, and other missions, future joint and coalition forces will encounter contested and denied environments that will necessitate the integration, collaboration, and coordination of manned and unmanned systems to enhance mission effectiveness. Attributes of unmanned systems extend the reach of manned platforms and allow portions of these missions to be completed without risk to humans while

providing gains in range, persistence, and maneuverability.

Develop technologies to enable collaborative unmanned strike capabilities against the full spectrum of potential threats and targets to enable a seamless integration into sea-based aviation operations. These include technologies that increase unmanned air systems (UAS) automation and autonomy such as, but not limited to, threat response, tactical planning, dynamic mission replanning, and mission/system-level problem detection, diagnosis, and reconfiguration. Enhance UAS integration and coordination with manned platforms via cockpit command and control with natural user interfaces, formation flight capabilities, and automated air-to-air refueling operations.

STK STO-4: Airborne Electronic Attack (EA)

Current naval airborne EA capability is well suited to earlier generation radars but requires improvement against advanced and emerging radar and communication technologies and techniques. Networked, collaborative EA across multiple security levels is necessary to effectively maneuver within the electromagnetic battlespace.

Develop airborne EA technologies that can effectively neutralize or destroy an enemy's effective use of the electromagnetic spectrum with both passive and active EA, directed energy or anti-radiation weapons.

Develop technologies that enable air, surface, and ground nodes to effectively communicate and collaborate to efficiently engage targets in the electromagnetic spectrum.

Develop technologies to deploy and deliver cyber effects.

Develop technologies to predict, and assess combined effects.

INTEGRATED LOGISTICS SUPPORT (ILS)

Vision: Sustain joint and coalition forces in the combat zone by arming, fueling, maintaining equipment, moving, supplying, manning, and providing personnel and health services.

ILS STO-1: Enhanced Logistical Support of Joint Assets

The ability of naval forces to generate and sustain combat readiness indefinitely, anywhere on the globe requires that materiels flow seamlessly from the industrial base to where it is ultimately used.

To position/pre-position assets in critical areas of the world, naval logistics capability must develop better models, planning tools and deployment

strategies to reduce cost and increase logistic capabilities that link customer demands with the supply chains.

Develop technologies that improve aerial delivery of both internal and external cargo to include automated handling systems.

Develop technologies that enable automatic, real-time, asset identification/tracking and sense/respond logistics in order to optimize effective throughput within and from the sea-base to ashore combat operations.

Develop intelligent planning aids that maximize the ability to provide just-in-time inventory and enable lean methodologies that minimize staged material.

ILS STO-2: Improved Maintenance Capability

Legacy aircraft must be able to sustain capability superiority longer than installed technologies remain relevant. Legacy systems and components rapidly face availability and maintainability challenges due to obsolescence as the industrial base terminates sustainment of replacement parts or as threat systems evolve. Current and future aircraft are increasingly complex and require advanced technologies to maintain the airframe, systems, and electronic suites.

Develop technologies that enable just-in-time/rapid manufacturing at sea to reduce asset down-time and sustain maximum combat readiness.

Automated Canopy Refurbishment

Scratches and crazing in aircraft canopies (transparencies) may render aircraft unready for flight. Canopies must be refurbished or replaced to return aircraft to ready for tasking status. The conventional manual process for refurbishing crazed or scratched transparencies relies upon the "touch" of a human artisan to polish out the deficiencies which could take from several hours to days of continuous polishing by two highly skilled technicians.

A robotic automated transparency refurbishment system for depot level repair was developed using commercial-off-the-shelf components. This system reduces the time and number of workers required to refurbish the aircraft and improves the quality of the final product by reducing variability in the process. The system is also expected to reduce the scrap rate while preserving the optical quality and life of the transparencies.

Develop automation tools that will reduce maintainer workload and turnaround time and enable the rapid integration of support equipment and maintenance practices.

Develop automated, networked logistic systems so that aircraft diagnostic systems interface with parts requisition chains.

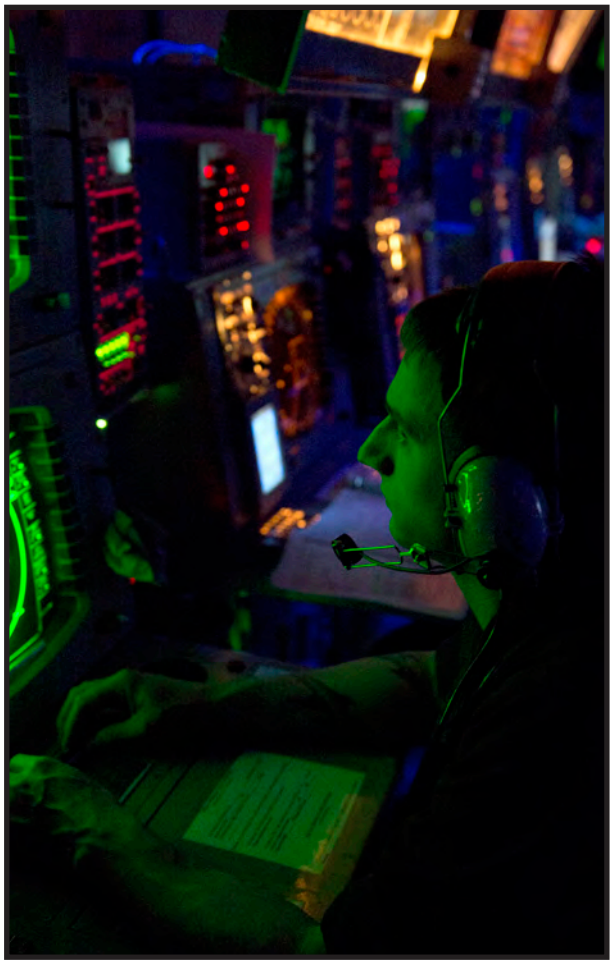
Develop technologies with improved built-in diagnostics that reduce false-removal rates and can-not-duplicate conditions.

INFORMATION DOMINANCE (ID)

Vision: Enable naval integrated fires through assured command and control and battlespace awareness. Deliver essential, timely combat information to naval commanders, deployed units, and weapon systems. Enable platforms to communicate freely and autonomously with other elements of the distributed architecture. Aviation capabilities will serve a critical role in the generation and seamless flow of actionable information to the warfighter across fault-tolerant, secure, adaptable/self-organizing, continuously available, interoperable networks to joint, coalition and civil/law enforcement agencies.

ASSURED COMMAND AND CONTROL

ID STO-1: Command and Control



Joint and coalition forces must have the ability to task, process, exploit, and disseminate information to/from the appropriate entity within the force with enough fidelity to be acted upon in a timely manner. With multiple sensors providing more information, operators must assimilate an increasing volume of data and information. All relevant and available information must be filtered, organized, and coalesced to enable timely, informed decisions in order to manage, control, and manipulate the battlespace.

Develop technologies to enable rapid, accurate decision making to ensure efficient battle management. Desired technologies include intelligent agents or decision aids for rapid and reliable threat/intent determination, distributed and decentralized weapons/sensor coordination and control, and improved mission planning.

ID STO-2: Communications and Networks

Dynamic, flexible and resilient communication and networking capabilities are core to achieving the Navy's vision for information dominance and advancing Naval Aviation abilities to coordinate, command and control widely dispersed aviation assets, as well as connect aviation assets to elements in other domains. Key to this, for Naval Aviation, is automated machine-to-machine collaboration.

To fully realize the vision of automated collaboration at the machine-to-machine level, combat platforms require a seamless, scalable, interoperable architecture that ensures secure and timely distribution of information to manage the efficient employment of sensors, platforms, weapons and networks. Naval, joint and coalition forces must be interoperable to enable distributed maneuver and execute responsive, persistent, lethal and adaptive full-spectrum operations.

Develop reliable and robust networking technologies that enable early entry and sustained communication beyond line-of-sight.

Develop technologies to improve, manage, and optimize aircraft, ship, and expeditionary aviation combat element communications and network connectivity performance (speed and range) throughout the battlespace in the most challenging scenarios, adapted to electronic attack, surveillance, and protection.

ID STO-3: Navigation and Geolocation

Joint and coalition forces are dependent on precision navigation and timekeeping to assure operational maneuver and weapons employment in all environments and with the highest possible confidence. Evolving threats create the need for sustainable and adaptive technologies capable of ensuring precision navigation in RF degraded and denied environments.

Develop technologies to improve GPS related precision and robustness in an Denied-Disconnected Intermittent Limited bandwidth domain.

Develop organic navigational capabilities (i.e., inertial, celestial, earth magnetic, EO/IR, LIDAR, RF, etc.) that are independent of outside signals.

ID STO-4: Computing, Processing, and Architectures

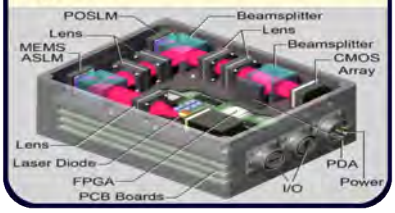
Joint and coalition forces are collecting and utilizing vast amounts of data and information from on- and off-board sources. The real-time use of collected digital data and resultant information drives the need for flexible, advanced computing and software architectures, increased storage capacity, and improved processing speed without an increase in space, weight, and power (SWAP).

Develop technologies that increase real-time availability of information derived from collected digital data including flexible computing, software architectures, and increased storage capacity with SWAP suitable to the Naval Aviation environment.

Optical Correlator for Real-Time Pattern Recognition Applications

The Real-Time Holographic Optical Correlator is based on a novel design which combines the shift-invariant Fourier transform correlator with a high-speed MEMS-based technology for fast retrieval and processing of target templates for real-time automatic target recognition applications.

When compared to current and future automatic target recognition technologies, the novel correlator design will overcome the limited digital processing capability and heat generation constraints enabling the comparison of each image against thousands of target templates at processing speeds beyond current digital processors. The system will also provide the ability to perform online adaptive learning when encountering new targets.



ID STO-5: Cyber Defense, Information Assurance (IA), and Network Protection

Naval forces operate jointly with North Atlantic Treaty Organization (NATO), allied, coalition, and homeland security forces using information networks, each of which has varying security requirements. There is not only a need to assure secure information sharing among a mix of forces and security levels, but also a need to defend that information against the adversaries cyber operations.

Develop technologies that facilitate rapid and secure information storage and sharing (down to the platform level) across multi-level security in joint and coalition operations during intermittent/limited connectivity, and in restricted and hostile environments. These technologies will holistically assure information through proactive defensive measures that are not limited to conventional areas such as multi-level security, real-time automated information guards and response, cross domain solutions, inter-domain authentication, encryption, intrusion detection, prevention, and response. These solutions will assimilate technology areas with architectures and implementations that simultaneously ensure IA, and network defense as well as anti-tamper.

BATTLESPACE AWARENESS

ID STO-6: Intelligence, Surveillance, Reconnaissance and Targeting

The ability to detect and maintain constant, enduring contact with a potential target increases understanding, enables a faster decision cycle at all levels of command, and supports the application of effects to achieve desired outcomes. The ability to provide persistent, flexible, scalable, common, accurate, and timely, tactical collection and actionable situational awareness is required to meet the information requirements of joint and coalition forces.

Develop technologies to conduct persistent surveillance, automatically integrate sea, ground, space, and air sensors in theater and confidently identify friendly, neutral and hostile contacts while collaboratively tracking and localizing potential targets at standoff ranges. Provide real-time targeting data and battle damage assessment to joint and coalition forces with sufficient accuracy and confidence to prosecute targets as required.

Develop technologies for improved combat classification and identification to enable engagement decisions at longer ranges while reducing fratricide, improving battlefield coordination and deconfliction, solving rules of engagement criteria, and avoiding engagement of non-hostile targets.

Develop technologies that provide complete situational awareness of the electromagnetic spectrum through improved electronic surveillance to detect, intercept, identify, and locate/localize sources of intentional and unintentional radiated electromagnetic energy for the immediate threat recognition, targeting, planning and conducting future operations. Surveillance across the electromagnetic spectrum is required to support missions such as electronic attack, protection and other tactical employment of forces that can be used to produce full spectrum signal, communication and electronic intelligence.

INTEGRATED FIRES

NOTE: STOs that contribute to disrupting/denying/defeating red fires are described in Force Protection and Theater Air and Missile Defense. STOs that contribute to enhancing blue fires are located in Strike Operations and Theater Air and Missile Defense.

ENTERPRISE AND PLATFORM ENABLERS (EPE)

Vision: Leverage existing and emerging technologies to enhance and achieve operational capabilities and readiness across multiple warfare areas, providing cost savings and increased operational effectiveness.

EPE STO-1: Enterprise Enablers

Enterprise enablers provide the technology base with options that affect and maintain critical U.S. S&T capabilities that develop the next generation S&T workforce. The portfolio, by design, has a broad focus and applicability across multiple platforms and systems. Pervasive research areas such as modeling and simulation, computation, manufacturing, test and evaluation capabilities, and advanced instrumentation should be considered as key elements of this objective with additional emphasis on vital enablers such as increased durability, commonality, standardization and affordability. Workforce development activities that improve the capacity of the NAE laboratory to recruit and retain personnel with needed scientific and engineering expertise are a key element of this objective.

Develop skills and new technologies to enable the NAE to sustain legacy systems and produce future systems designed to provide affordable, long range, persistent, flexible and responsive capabilities that assist and strengthen U.S. forces, allies and partners.

EPE STO-2: Fixed Wing Platform Enablers

Provide the fixed wing technology base with options that affect and maintain critical U.S. S&T capabilities. The portfolio has a broad focus and applicability across multiple manned and unmanned fixed-wing aircraft, systems and subsystems.

Develop technologies to improve aerodynamic efficiencies; decrease aircraft empty weight; increase speed, range and payload capability; advance material development and structural protection; and improve durability. Pervasive research areas such as advanced propulsion, power and thermal management, propulsion/airframe integration, reduced EO/IR, RF, and acoustic signature, advanced flight control/algorithms, advanced material development, and overall systems integration should be considered as key elements of this objective.

EPE STO-3: Vertical Lift Platform Enablers

Provide the vertical lift technology base with options that affect and maintain critical U.S. S&T capabilities. The portfolio has a broad focus and applicability across multiple manned and unmanned vertical lift aircraft and subsystems.

Develop technologies to improve: lift and rotor performance; aeromechanical stability; handling qualities/flight control management systems; engine and drive train performance; increase speed, range and payload capability; improve material development and structural protection; and improve durability; decrease aircraft empty weight.

Develop technologies required to increase tactical effectiveness and survivability in all weather.

EPE STO-4: Weapon Enablers

Weapon enablers provide the technology base with options that affect and maintain critical U.S. S&T capabilities. The portfolio has a broad focus and applicability across kinetic and non-kinetic weapons and mission areas.

Develop technologies to improve kinetic weapon lethality and insensitivity without size or weight penalties.

Develop technologies to increase range, responsiveness and flexibility of employment (all environments, multi-mission/effect, ease of use), and reduce size, weight, procurement and total ownership costs of kinetic weapons while maintaining or improving lethality effects.

Develop improved anti-tamper technologies to prevent adversary exploitation of key weapon technologies.

Develop technologies to reduce physical stressors/impact on personnel in weapons assembly, disassembly and handling while maintaining or increasing throughput.

Develop technologies to reduce time and/or cost of weapons integration, maintenance and test.

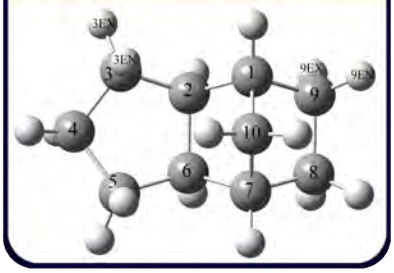
Develop technologies to reduce the environmental impact of materials used in energetics or in the manufacturing of energetics, and to improve the reliability of weapons.

Develop technologies enabling non-kinetic weapons employment on naval aircraft delivering variable effects (disrupt through destroy) at the speed of light with deep magazine capability.

Characterization of the High-Temperature Decomposition Products of JP-10

JP-10 is the highest energy density hydrocarbon fuel suitable for shipboard environments. Exploiting its chemical kinetics mechanisms is necessary for optimal design of weapon and platform propulsion systems.

Existing propulsion system designs relied heavily on empirical data, testing and surrogate fuel models; however, researchers have recently developed a highly accurate JP-10 chemical kinetics model to enable the optimization of new propulsion system designs. The primary effort resulted in a validated detailed mechanism, nearly 1000 species and more than 10,000 reaction steps, able to model pyrolysis and oxidation of JP-10 to predict ignition delay, heat release, species concentrations and combustion behavior for ramjet, scramjet and turbojet applications.



EPE STO-5: Energy Conservation, Flexibility and Security

Support overall naval energy goals to increase energy security and use of energy efficient non-petroleum based fuels while reducing green-house gas emissions and tactical petroleum consumption. The volatility of energy costs, dependence on foreign oil sources, and the carbon footprint of energy consumption puts the Navy in a vulnerable position.

To reduce this vulnerability the Navy and Marine Corps must transform energy supply, demand and security. Technology areas to address these goals include more efficient engines, decreased aircraft drag, power and thermal management integration, optimized mission planning, alternative fuels, training efficiencies and increased simulator usage.

Develop technologies to enable legacy, emerging and future systems to operate more efficiently, consume less energy with the ability to utilize alternative fuel and power sources.

Develop fuel efficient technologies and methodologies to increase maritime operational energy security, maintain operational flexibility, support forward presence and reduce the carbon footprint while reducing the risk associated with an extended energy supply line.

Develop advanced and/or renewable power generation technologies and high density power storage capabilities.

EPE STO-6: Aircraft/Ship Integration

Aircraft operations at sea are inherently dangerous, costly and labor intensive. Operating within the maritime environment imposes unique demands and limitations upon sea-based aircraft (i.e., fixed wing and rotary wing aircraft, both manned and unmanned) which need specific technology solutions to ensure their continued success and warfare integration. Aircraft carriers and air-capable ships (e.g., amphibious ships, guided missile cruisers and destroyers) must support aircraft during pre- and post-flight deck operations, launch, mission execution, recovery and maintenance. Aircraft/ship integration must be able to support all aircraft operations and maintenance to safely achieve required sortie rates and operational availability.

Develop technologies that mitigate the negative effects of the dynamic interface between aircraft, aircraft carriers and air-capable ships; automate and increase efficiencies in launch, recovery and deck operations; and improve structural materials and coatings to withstand high loadings, corrosion, and high temperatures.

Develop technologies that increase performance of aircraft launch and recovery equipment to meet higher energy requirements of future aircraft.

Develop technologies that enhance aircraft design and maintainability for shipboard space constraints and improve flying qualities and performance while conducting sea-based operations.

Develop technologies that enhance aircraft carrier, air-capable ship and aircraft design to improve human-machine interface; improve shipboard air wing sustainment support infrastructure; reduce, simplify and improve robustness of maintenance actions and procedures; reduce hazardous materials without compromising structural protection performance; and enable interoperability with legacy and future logistic systems.

SYSTEM SAFETY, AVAILABILITY AND AFFORDABILITY ENABLERS (SSAA)

Vision: Use advanced technologies to improve safety, reduce cost and improve reliability of naval operations and platforms.

SSAA STO-1: System Safety and Availability

Ensure that safety, consistent with mission requirements, is designed into systems, subsystems, equipment, facilities and their interfaces. Improvements in inspection techniques, maintenance procedures, processes and materials and health management technologies can enhance long term mission performance, system safety, and platform availability.

Develop technologies to achieve acceptable risk of mishap, within the constraints of operational effectiveness, time, and cost, throughout all phases of the system life cycle.

Develop, integrate and transition technologies to improve system safety, increase platform availability, extend useable service life, and reduce maintenance actions.

Develop and implement methods and technologies including condition based maintenance, prognosis, and health management that can predict, identify and provide solutions to address safety risks and manage system life.

Develop remote/teleoperation or automation technologies to remove sailors or marines from hazardous or hostile environments.

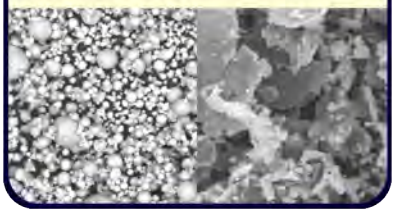
Develop technologies that enable Naval Aviation to better comply with environmental regulations at reduced cost.

Develop technologies to improve maintenance tools and processes to increase robustness and service life of repaired components.

The Mechanism of Corrosion Protection Provided by Metal-Rich Coating Systems

Hexavalent chromium compounds have long been used to prevent corrosion, but they are carcinogens and a major source of exposure to hazardous chemicals. Metal-rich coatings are one option for reducing or eliminating the use of hexavalent chromium compounds.

Navy researchers are working to understand the effects of metal-rich coatings on aerospace substrates. The electrochemical and physical properties of magnesium, zinc, and other metal-rich primers are being assessed using DC and AC electrochemical techniques, scanning electron microscope/energy dispersive analysis of X-rays, X-ray diffraction and DC conductivity in an effort to establish the mechanisms of protection provided by the coatings. This information will be used to develop new concepts in corrosion protection without the use of hexavalent chromium compounds.



SSAA STO-2: Total Ownership Cost (TOC)

The increasing TOC of naval platforms threatens the ability to recapitalize the aging in-service systems and acquire new systems in sufficient quantities to maintain required force structure.

Total ownership cost includes development, acquisition, operations and support (O&S), manpower, training, and disposal. Technology advances that reduce development costs (e.g. modeling and simulation) and target acquisition costs (e.g. manufacturing) are needed as well as those that target O&S cost by reducing the maintenance burden through increases in reliability (e.g. solid state or direct drive), maintainability (innovative corrosion protection), availability (e.g. maintenance turnaround time and inventory optimization), and reliance upon virtual vice live training.

Develop and demonstrate manufacturing process and technology improvements to reduce acquisition and sustainment costs in component/subsystem/system production (e.g. direct digital manufacturing of metallic aircraft components).

Develop procedures and systems to take advantage of advances in condition based maintenance that promise to decrease maintenance costs and improve availability of aviation systems.

Develop and improve industrial base processes and capability investments to cut maintenance costs and turnaround times (innovative analysis and approaches for evaluation and repair of aging materials and parts).

Develop advanced materials and processes for metallic and composite structures such as coatings, sealants, non-destructive inspection and structural repair.

NAVAL WARFIGHTER PERFORMANCE (NWP)

Vision: Sustain warfighter performance and enhance decision making through optimized training, protection, system integration, health management/monitoring, and combat casualty care technologies.

NWP STO-1: Training and Education

Increasing mission complexity and security requirements, frequency of asymmetric warfare, high live/range exercise costs, growth in operational demands and fleet response plans require: new metrics-driven processes; high fidelity training environments; more realistic constructive and semi-automated forces; incorporating multiple media; and empirically linked training and readiness competencies. This will enable informed training pipeline decisions and improve operator and maintainer combat readiness, qualifications and proficiency while reducing training life-cycle cost drivers.

Develop education and training technologies and strategies to cost-effectively maximize transfer of knowledge from the classroom and trainer to the operational environment. Technologies and strategies incorporated may include adaptive training; intelligent tutoring systems design; improved medical modeling and simulation; establishment of standards, modalities, and prototypes for the integration of virtual assets into live asset training displays; improved semi-autonomous force modeling and design; virtual environments supporting high asset count evolutions and participants in multiple warfare domains; game-based training; development and assessment of distributed team competencies; and mobile training technologies.

NWP STO-2: Human Systems Design and Decision Support

Excessive operator workload in a non-optimized data rich environment degrades effectiveness, results in extended decision timelines with potential for increased human error and injury. Defining human performance and

training requirements early in the design and development process can mitigate these and a myriad of other problems.

Through the effective use of human performance modeling and assessment, develop technologies to improve: human systems design to reduce manned and unmanned operator workload; decision-making; model processes related to situational awareness; and mitigate stress (physiological and psychological) and injury risk; and improve our understanding of human social and cultural behavioral processes to yield improved decision making. Crewmember knowledge, skills, abilities, personality characteristics, experiential requirements, and workload targets will be quantitatively assessed. These methodologies will provide a means for more effective decisions in the context of system and platform design, manpower requirements, design tradeoffs, mission sustainability, and warfighter effectiveness.

NWP STO-3: Warfighter Health, Survivability and Protection

The majority of current technologies were designed as standalone systems that do not efficiently integrate, nor adequately protect or enhance survivability of the individual warfighter. Legacy systems were not developed to accommodate the current expanded anthropometric range, support extended operations, or minimize repetitive loading resulting in musculoskeletal pain and injury, which leads to cognitive (e.g., distraction) and physiological fatigue, reduced endurance, and decreased mission effectiveness. As the emphasis shifts to asymmetric warfare, life support systems must support non-traditional missions and provide protection against multiple environmental and physiologic stressors.

Develop state-of-the-art life support technologies and personal protective equipment to optimize warfighter performance, effectiveness, safety, and survival.

Prediction and Prevention of Musculoskeletal and Blast Injury during Naval Operations

A collaborative multidisciplinary program was conducted to obtain validation data and develop a probabilistic human head/brain/spine injury prediction model, funded by ONR Code 34. This can be used to predict the occurrence of spinal injury from aircraft crash and ejection, low back pain, and mild traumatic brain injury. The model and an interactive hazard assessment tool can be used to provide design criteria for personal protection equipment based directly on human injury tolerance rather than inferred from manikin response.

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ACRONYMS

A2/AD	Anti-Access/Area Denial
ASW	Anti-Submarine Warfare
AVN	Aviation
C2	Command and Control
COMM/NAV	Communications/Navigation
CTO	Chief Technology Officer
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
DRFM	Digital Radio Frequency Memory
EA	Electronic Attack
EO/IR	Electro-Optic/Infrared
EPE	Enterprise Platform Enablers
FP	Force Protection
GPS	Global Positioning System
IA	Information Assurance
IED	Improvised Explosive Device
ILS	Integrated Logistics Support
ID	Information Dominance
IWC	Integrated Warfighting Capabilities
JCIDS	Joint Capabilities Integration and Development System
MAC	Multi-static Active Coherent
MPRA	Maritime Patrol and Reconnaissance Aricr aft
NAE	Naval Aviation Enterprise
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAWC	Naval Air Warfare Center
NWP	Naval Warfighter Performance
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations
O&S	Operations and Support
PEO	Program Executive Office
PMA	Program Manager, Air
RF	Radio Frequency
SBA	Sea Based Aviation
SSAA	System Safety, Availability and Affordability
S&T	Science and Technology
STK	Strike Operations
STO	Science and Technology Objective
SUW	Surface Warfare
SWAP	Space, Weight and Power
TAMD	Theater Air and Missile Defense
TOC	Total Ownership Cost
UAS	Unmanned Air System
USMC	United States Marine Corps
USW	Under Sea Warfare

APPENDIX A

Alignment of NAE STOs to Marine Corps S&T Aviation (AVN) STOs

The USMC leadership publishes an S&T Plan and its own STOs to provide guidance to the Marine Corps. The NAE and Marine Corps aviation are dependent upon each other for leveraging S&T investment and coordinate as appropriate for development efforts of mutual Navy and Marine Corps benefit.

AVN STO-1: Collaborative networking

NAE STO: ID STO-2, Communications and Networks

AVN STO-2: Advanced electronic warfare (EW) systems

NAE STO: STK STO-4, Airborne Electronic Attack

AVN STO-3: Sand and dust-penetrating radar, providing precision (landing quality) navigation video in brownout and dust-out visibility conditions

NAE STOs: ID STO-3, Navigation and Geolocation and SSAA STO-1, System Safety and Availability

AVN STO-4: Command and control (C2) data fusion and networking

NAE STOs: ID STO-1, Command and Control (C2) and ID STO-2, Communications and Networks

AVN STO-5: Standardized force tracking system

NAE STO: ID STO-6: Intelligence, Surveillance, Reconnaissance and Targeting

AVN STO-6: Group 4 (Tier III) unmanned aircraft systems (UAS)

NAE STO: STK STO-3, Collaborative Unmanned Strike Capability; ID STO-6: Intelligence, Surveillance, Reconnaissance and Targeting; and ID STO-4: Computing, Processing, and Architectures

AVN STO-7: Advanced multi-function EW transceiver

NAE STO: STK STO-4, Airborne Electronic Attack

AVN STO-8: Ground based C2 and surveillance systems

NAE STO: ID STO-2, Communications and Networks

AVN STO-9: Advanced laser systems suitable for countermeasure, sensor, and attack applications

NAE STOs: STK STO-1, Responsive Engagement and STK STO-2, Engagement of Non-Time Urgent Targets

AVN STO-10: Scalable, light weight, interference cancellation system and adaptive/cognitive radio technologies for both co-situated RF emitters and RF saturated environments to eliminate VHF, UHF, SATCOM RF interference between multiple radio and electronic attack systems

NAE STOs: ID STO-2, Communications and Networks; ID STO-4: Computing, Processing, and Architectures; and ID STO-5: Cyber Defense- Information Assurance (IA) and Network Protection

AVN STO-11: Net-enabled weapons

NAE STOs: STK STO-1, Responsive engagement; STK STO-2, Engagement of Non-Time Urgent Targets, STK STO-4, Airborne Electronic Attack; EPE STO-4: Weapon Enablers; and ID STO-2, Communications and Networks

AVN STO-12: Cargo UAS

NAE STOs: ILS STO-1: Enhanced Logistical Support of Joint Assets and ID STO-1, Command and Control (C2)

AVN STO-13: UAS Universal Ground Control Station (UGCS)

NAE STOs: ID STO-1, Command and Control (C2); ID STO-2, Communications and Networks; and ID STO-3, Navigation and Geolocation

VN STO-14: Active kinetic and non-kinetic aircraft self-protection

NAE STOs: FP STO-1, Platform Survivability; FP STO-3, Electronic Protection; and TAMD STO-2: Airborne Missile Defense

AAVN STO-15: Radio frequency (RF) countermeasure, decoy, and expendables systems

NAE STOs: FP STO-1, Platform Survivability and FP STO-3, Electronic Protection

AVN STO-16: Advanced rotor/prop technologies for performance across wider envelope

NAE STOs: EPE STO-1, Enterprise Enablers and EPE STO-3, Vertical Lift Platform Enablers

AVN STO-17: Small form factor, lightweight expeditionary ordnance for fixed and rotary wing aircraft

NAE STOs: EPE STO-1, Enterprise Enablers; EPE STO-2, Fixed Wing Platform Enablers; EPE STO-3, Vertical Lift Platform Enablers; EPE STO-4, Weapon Enablers

AVN STO-18: Low collateral damage/low energetic weapons

NAE STOs: EPE STO-4, Weapon Enablers and STK STO-1, Responsive Engagement

AVN STO-19: Cost effective mass memory (terabytes)

NAE STOs: ID STO-4: Computing, Processing, and Architectures

AVN STO-20: Distributed networking of aviation simulators

NAE STOs: ID STO-4: Computing, Processing, and Architectures and NWP STO-1, Training and Education

AVN STO-21: Multi-function, low-drag VHF, UHF, and SATCOM (broadband) antenna

NAE STOs: FP STO-1, Platform Survivability and ID STO-2, Communications and Networks

AVN STO-22: Composite materials in expeditionary environments

NAE STOs: EPE STO-1, Enterprise Enablers and ILS STO-2, Improved Maintenance Capability

AVN STO-23: Lightweight De-ice/Anti-ice capability for aircraft

NAE STOs: EPE STO-1, Enterprise Enablers and FP STO-1, Platform Survivability

AVN STO-24: Variable-speed air refueling drogue

NAE STOs: EPE STO-1, Enterprise Enablers; EPE STO-2, Fixed Wing Platform Enablers; and EPE STO-3, Vertical Lift Platform Enablers

AVN STO-25: Aviation technologies that increase the capacity of aviation assets

NAE STOs: FP STO-1, Platform Survivability; EPE STO-3, Vertical Lift Platform Enablers; and ILS STO-1: Enhanced Logistical Support of Joint Assets

APPENDIX B

Photograph Acknowledgements

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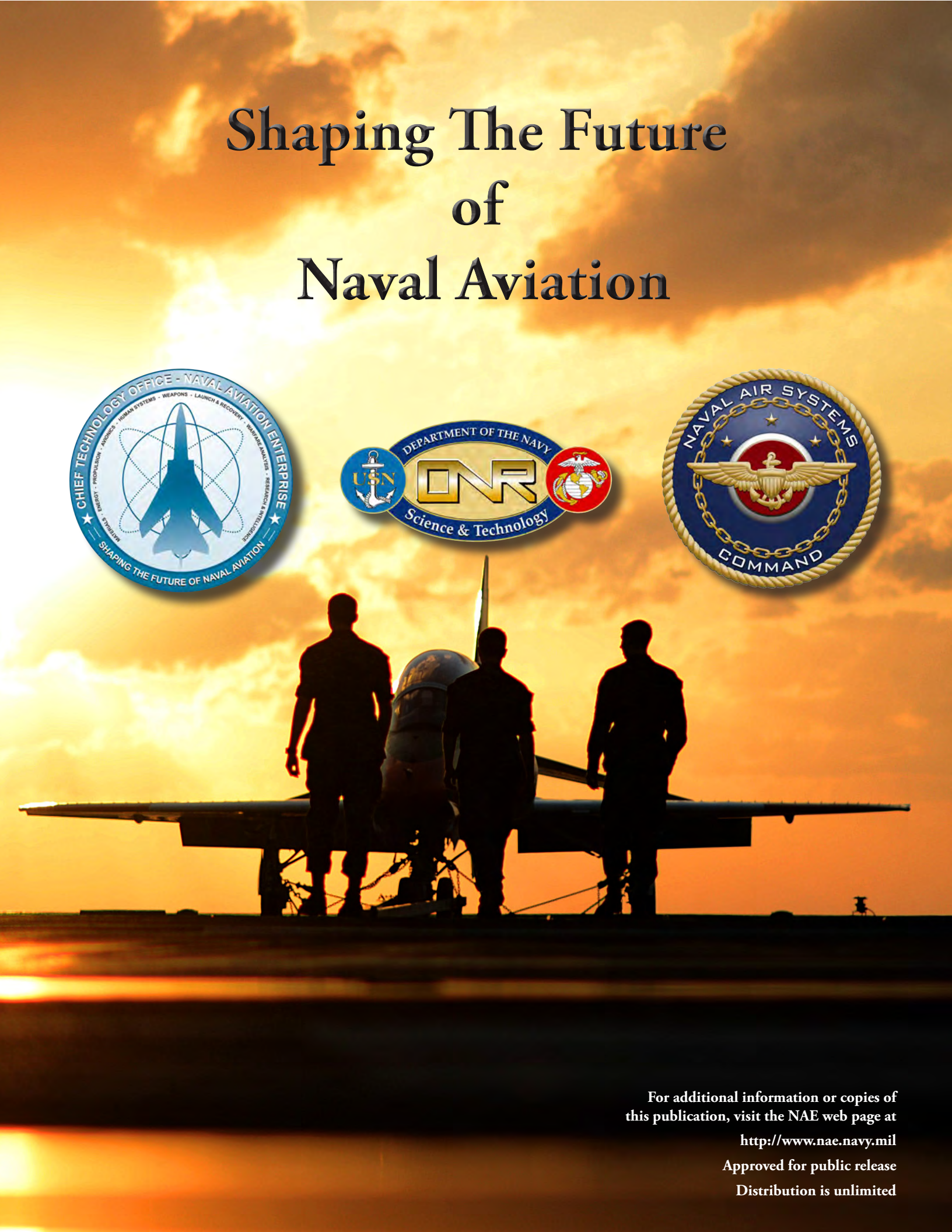

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