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PMW/A170

CORE AVIONICS MASTER PLAN

CAMP

2012

Aviate

Navigate

Communicate

Network

Survive

Endorsement and Distribution

PMA209, Air Combat Electronics, hereby promulgates the 2012 Core Avionics Master Plan (CAMP 2012). This document is co-sponsored by PMA209 and PMA272, Advanced Tactical Aircraft Protection Systems. PMW/A170, Communications Office (including Air Navigation Warfare), PMA213, Air Traffic Management Systems and PMA281, Strike Planning and Execution Systems, also contributed relevant avionics system information. It presents recommended practices, roadmaps and detailed explanations of evolving avionics-enabled capabilities designed to provide platform managers with situational awareness that can help them build effective Flight Plans and efficient budget submission strategies.

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Core Avionics Master Plan

Executive Summary

Objective. A significant portion of Naval Aviation's forces future tactical advantages will be achieved through innovative improvements to digital information processing and networked exchanges enabled by avionics. Given the current fiscal environment, it is more critical than ever to maximize such warfighting capability gains by reducing the costs of fielding and sustaining these systems. The 2012 Core Avionics Master Plan (CAMP) is promulgated by PMA209, Air Combat Electronics, in support of the Naval Aviation Enterprise (NAE) mission – ***"Advance and sustain Naval Aviation warfighting capabilities at an affordable cost… today and in the future**."* It is co-sponsored by participating commodity management program offices, including: PMA213, Air Traffic Management Systems; and PMA272, Advanced Tactical Aircraft Protection Systems. PMW/A170, Communications Office (including Air Navigation Warfare), and PMA281, Strike Planning and Execution Systems, also contributed relevant avionics system information. The CAMP presents recommended practices across requirements, resourcing and acquisition management that promote affordability through leveraging, economy of scale, expansion of benefits across multiple users through commonality, faster delivery of new or enhanced warfighting capabilities through open architectures, improved sustainment and reduced logistics footprint in support of expeditionary operations. Appendices to this document include capability evolution roadmaps that portray the progressive enhancement of avionics systems warfighting contributions over time. Operational and programmatic compliance mandates are referenced for Navy and Marine Corps program managers to use in tailoring their platform Flight Plans.

Core Avionics. Core avionics encompass those systems that provide the core set of functionalities that are fundamental to aviation. Their contributions can be organized into the following capability areas:

- Information Management – planning, processing, encryption, display
- Information Exchange – voice, data, imagery, video, tactical networks
- Navigation – position, velocity, altitude, attitude and time (en-route and approach)
- Cooperative Surveillance and Combat Identification – battle-space management
- Flight Safety – collision/terrain avoidance, parameter recording, health monitoring
- Self Protection – threat sensors and defensive countermeasures

Recommended Practices. Naval Aviation development, procurement and sustainment resources are becoming increasingly limited. Resources spent on duplicative system development efforts, independent modernization of unique solutions and redundant logistics infrastructures reduce the overall warfighting capability that can be provided to the Combatant Commanders. Stove-piped uniqueness of systems with like functionalities results in competition between platforms for funds to cover the same incremental improvements. Expeditionary forces need to reduce deployment footprints to remain agile and increase cross-platform interoperability. Commodity-based program offices, requirements officers and resource managers have been purposefully established across the NAE to capture efficiencies by optimizing centralized management and commonality in product solutions. Recommended best practices described in this document are intended to achieve efficiencies across the three principal NAE management arenas. Each of the recommended processes is built upon existing formal instruction guidance or policy.

Requirements:

- Use the USN Naval Aviation Requirements Group (NARG) and USMC Operational Advisory Group (OAG) processes to identify and prioritize core avionics requirements according to collective need and benefits.
- Where possible, leverage existing Service or Joint capability documents to accelerate formal requirement establishment.
- Use commodity capability evolution roadmaps and platform flight plans to align the timing of pursuit and integration of avionics-based capabilities across platforms.
- Define requirements in terms of warfighting capabilities necessary to accomplish a platform mission in support of Combatant Commander strategic objectives.

Resourcing:

- Use road-mapping processes to conduct cross-platform and commodity office exchanges to enable collective resourcing for broader benefits.
- Ensure issues with application across multiple platforms are coordinated with commodity program offices, OPNAV N98 and HQMC APW73.
- Utilize alternative avionics resourcing opportunities between Program Objective Memorandum (POM) budget cycles, including:
    - Logistics Engineering Change Proposals (LECPs)
    - Value Engineering Change Proposals (VECPs)
    - Mid-year reprogramming
    - Supplemental funding

Acquisition:

- Prominently factor commonality, standardization, interoperability, supportability and affordability during development of new capability solutions or enhancements.
- Leverage established solution development, maturity and lessons learned. Coordinate deliberate convergence toward common products/families of systems.
- During program baseline assessments, use the NAVAIR Commonality Opportunity Review Process (CORP) process to analyze alternative solution logistics footprints, modernization costs and sustainment life cycle cost and support impacts. Base assessments on the impacts to the entire Enterprise rather than to just the individual platform.
- Employ Open Systems Architecture (OSA) in hardware and software designs. Adhere to collective interoperability standards and protocols in order to control future modification costs. Design future platforms and evolve current platform processing architectures toward a FACE (Future Airborne Capabilities Environment) Open Application Interface configuration that allows systems and software to be integrated without requiring full mission profile regression testing.

- Ensure that Performance-Based Acquisition and Logistics (PBA, PBL) contracts can effectively and affordably leverage common product upgrade opportunities, whether they involve Government or other vendor Commercially Furnished Equipment. Work to eliminate unique interfaces and proprietary ownership.
- Consider using PMA209's government based Avionics Capability Integration Support Team (ACIST) as an alternative to the prime vendor for Lead System Integrator (LSI) activities involving avionics systems.
- Establish pro-active sustainment teams to anticipate and mitigate obsolescence and Diminishing Manufacturing Sources and Material Shortages (DMSMS) operational impacts and cost burdens.

Application and Utilization. CAMP 2012 is intended to be used as a tool by all platforms and other commodity capability providers across Naval Aviation. The recommended practices do not diminish Program Manager (PM) authority. It is understood that the efficiencies and benefits of commonality and centralized management do not always present the best acquisition strategy. Unique solutions should be pursued when there are operational imperatives that require immediate individual capability fielding, as determined by OPNAV and HQMC. They may also be appropriate if the single platform force level warfighting contribution gains justify the increased costs of independent life cycle sustainment, or the loss of potentially broader Enterprise benefits.

The roadmaps and accompanying narratives are intended to provide platform offices situational awareness of avionics enabled capability growth and expected time of maturity. The descriptions are high level, but should provide enough detail to enable the reader to determine relevance for their particular mission sets. In order to achieve these objectives, leaders across Naval Aviation requirements, resourcing and acquisition are strongly encouraged to employ the processes and strategies described in this document.

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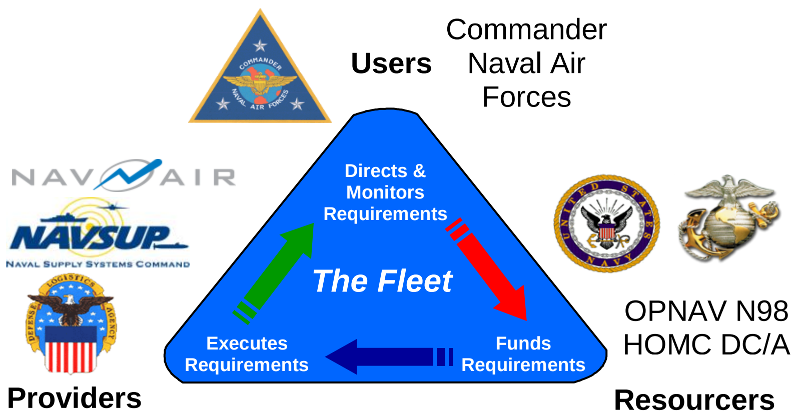
Core Avionics Master Plan

I. INTRODUCTION.

The 2012 Core Avionics Master Plan (CAMP) is promulgated by PMA209, Air Combat Electronics Program Manager (PM) for Naval Aviation, in support of the Naval Aviation Enterprise's (NAE) mission – ***"Advance and sustain Naval Aviation warfighting capabilities at an affordable cost… today and in the future."***. It is co-sponsored by participating commodity management program offices, including: PMA213, Air Traffic Management Systems; and PMA272, Advanced Tactical Aircraft Protection Systems. PMW/A170, Communications Office (including Air Navigation Warfare), and PMA281, Strike Planning and Execution Systems, also contributed relevant avionics system information.Managers are strongly encouraged to apply practices recommended in this plan during requirements generation, development of acquisition strategies, and preparation of resourcing requests.

The CAMP is designed to serve as a strategic planning tool to promote awareness of enhanced warfighting contributions enabled by evolving avionics systems. It identifies higher authority compliance mandates, systems inter-dependencies and advancing technological opportunities that program managers can leverage when developing their platform and weapons systems capability roadmaps or flight plans.

Naval Aviation Enterprise



NAE Leadership relationships.

II. OBJECTIVE.

Naval Aviation is at a crossroads with respect to affordability of technological advancements and capability evolution. Every possible efficiency must be achieved to maximize our ability to procure desired future force structure and simultaneously maintain current inventory operational readiness and relevance. Aircraft warfighting capability enhancements are increasingly dependent upon the platform's avionics architecture, which directly affects its ability to rapidly and affordably modify hardware and software. Platform interoperability is critical to enabling Naval Aviation forces to collaboratively perform Joint Operations in support of Combatant Commander objectives. With the high costs associated with modern software-driven digital systems, we can no longer afford to independently modify or logistically manage multiple unique systems that deliver similar functions. The 2012 Naval Aviation Vision's principles of platform Type/Model/Series (TMS) reduction should be applied down to the system level. Effective utilization of this document can help enable that transformational step.

III. AVIONICS.

A. <u>Core Avionics</u>. Core avionics include those electronic systems that provide functionalities in support of the fundamentals of flight (aviate, navigate, communicate), as well as flight safety, platform survivability, and information management in support of individual and collaborative mission accomplishment. When they have application across multiple platforms, avionics can be considered 'common' or 'commodity' systems. In this master plan, core avionics are divided into the following functional capability areas:

- Information Management – planning, processing, display
- Information Exchange – voice, data, imagery, video, tactical networks, encryption
- Navigation – position, velocity, altitude, attitude and time (en-route and approach)
- Cooperative Surveillance and Combat Identification – battle-space management
- Flight Safety – collision/terrain avoidance, parameter recording, health monitoring
- Self Protection – threat sensors and defensive countermeasures

B. <u>Unique Avionics</u>. Unique avionics include those systems that enable a capability that is specific to a particular platform. In some cases there are no other platforms that perform that mission task. In other cases these are solutions whose design factors are so unique that they could not be practically integrated into other aircraft, such as with the E-2 radar. Although CAMP 2012 is scoped to focus on core systems, many of the strategies and practices described in this plan can also be applied to unique systems. Unique avionics can be grouped into the following functional capability areas:

- Sensors – radars, radio frequency, infrared, optical, 'listening' systems
- Ordnance Controllers – weapons arming and release
- Offensive weapons systems – lasers, jammers
- Specialized data links – Intra-community Intel/Surveillance/Reconnaissance transceivers and wave forms, unmanned aircraft flight control signals
- Classified Systems

C. <u>Avionics Relevance</u>. Core avionics manage information, provide situational awareness and enable decision-making to execute all missions, whether they are training, transport or combat related. The following evolving avionics enabled capabilities will transform air warfare to meet Naval Aviation Vision 2030 goals.

- Inter-platform Digital Interoperability for Networked Warfare
- Secure Combat Identification (CID)
- Blue Force Situational Awareness (BFSA)
- Secure, GPS-based en-route, precision and non-precision approach navigation
- Unrestricted global access through foreign and domestic civil airspaces
- Multi-level, secure communications and information exchange
- Military Flight Operations Quality Assurance (MFOQA) for safety/proficiency
- Condition-Based Maintenance (CBM)

IV. RECOMMENDED PRACTICES.

With limited resources available to balance current and future readiness, Naval Aviation cannot afford to pay for independent development or separate and discrete modification of core avionics over every platform's life cycle. The Fleet cannot afford duplicative overhead costs of multiple unique systems that address a similar functionality. The acquisition workforce must work to capture overhead efficiencies that reduce their costs of doing business. The Secretary of Defense (SECDEF) and Chairman of the Joint Chiefs of Staff (CJCS) recently instituted a comprehensive revision of the requirements generation process and acquisition management instructions. In order to provide the greatest aviation system capabilities and warfighting benefits for the dollars available, this master plan presents recommended practices for each realm of the NAE triad.

A. <u>Requirements</u>. Requirements are capability needs identified (generated) by warfighters and formally documented using processes prescribed in CJCS Instruction 3170.01F, Joint Capability Integration and Development System (JCIDS). Solutions to satisfy requirements are developed, fielded and sustained by acquisition program managers. Funds to cover solutions development, fielding and sustainment are allocated by Navy OPNAV and Marine Corps Deputy Commandant, Aviation (DC/A), resource sponsors. When Fleet operators first identify specific mission capability gaps, they are not constrained by resource limitations. Fiscal realities are applied later during issue prioritization in the programming and budgeting phases of budget building. Leaders are encouraged to apply the following recommended requirements identification and documentation practices to promote efficient fielding and sustainment of capabilities enabled by core avionics.

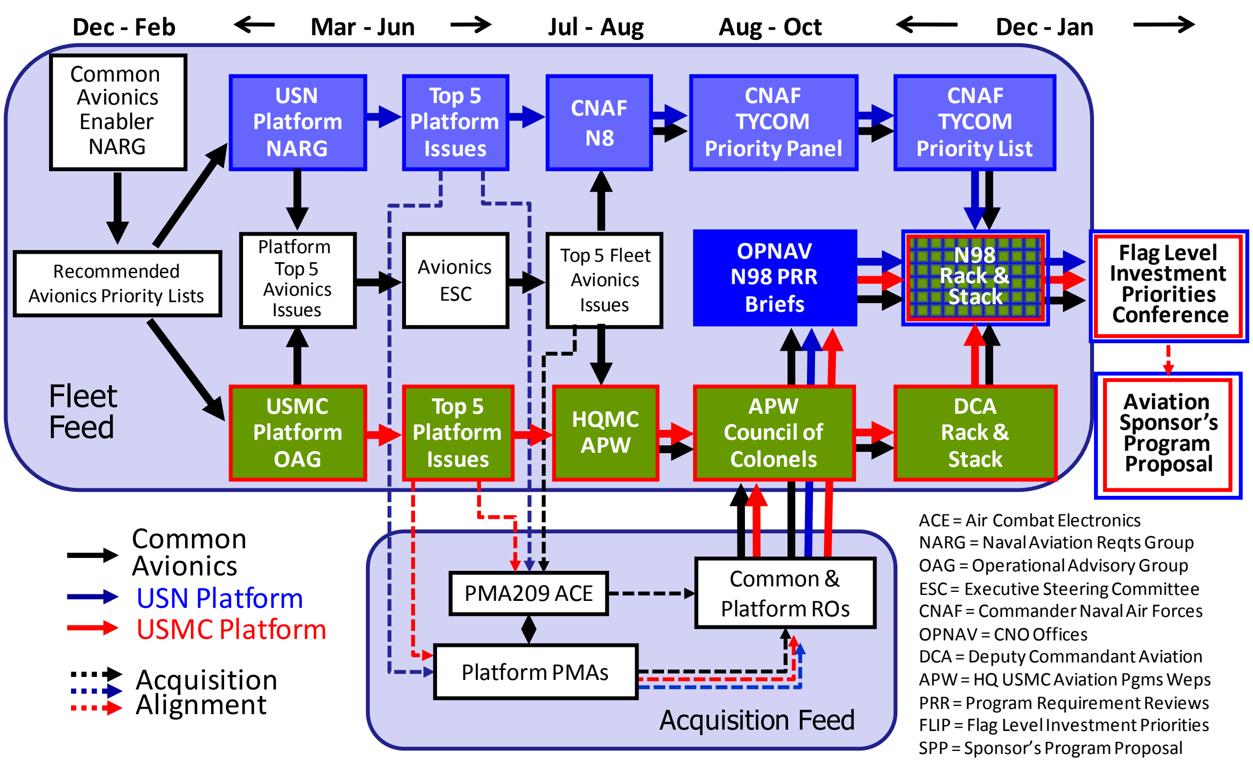
1. Use the USN Naval Aviation Requirements Group (NARG) and USMC Operational Advisory Group (OAG) processes to identify and prioritize core avionics requirements according to collective need and benefits. In response to the Fleet Forces Command (FFC) Requirements office call for more standardization in Fleet requirements identification, the aviation Type Commander (TYCOM), Naval Air Forces (CNAF), promulgated CNAF Instruction 3025.1. It establishes methodologies and guidance for aviation requirements identification and prioritization. This document was updated in December 2011. It outlines roles, responsibilities and processes for conducting NARG events, which replaced the former Navy OAGs. The Marine Corps continues to use the OAG process, but directly interfaces with the NARG process. The instruction establishes both Platform NARGs and Enabler NARGs.

Common Avionics, Cooperative Surveillance and Airborne Electronic Warfare Enabler NARGs are held prior to Platform NARG and OAG meetings. A Marine Corps Avionics Officer serves as the CNAF N8 Common Avionics Requirements Officer, and chairs the Common Avionics Enabler NARG and Executive Steering Committee (ESC) events. Platform community representatives are invited to the Enabler NARGs. They are briefed on avionics-enabled capability areas to help understand solution maturity, operational relevance and timing of applicable deadlines. They also collaboratively develop tailored recommended priority lists of commodity system enabled requirements.

Core Avionics Master Plan

Platform NARG and OAG attendees review the Enabler NARG recommended priority lists at their platform events and formally report concurrence or changes to the recommendations. Each Enabler NARG ESC then collates the Platform NARG and OAG responses and builds a collective (Enterprise-perspective) priority list that is presented to the TYCOM Priority Panel (TPP). The TPP uses those lists to generate the TYCOM Priority List (TPL), which is used to influence the Aviation Sponsor's Program Proposal (SPP) budget build. Marine Corps Platform OAG results are also provided to the Headquarters Marine Corps (HQMC) Aviation Weapons Systems Requirements Branch (APW) Council of Colonels, which prioritizes issues for budget consideration.

Platform community leaders are strongly encouraged to send experienced operators who are familiar with their mission sets to the Enabler NARG events. When possible, it is best if these same personnel are available to carry what they learn at the Enabler NARG event to the Platform NARG or OAG event. This allows avionics-enabled capability growth to be championed by a community member, rather than the commodity system managers. Except for safety systems, which are mandated by OPNAV and DoD instructions, there are no formal requirements to field avionics systems per se. The requirement comes in the form of the operational mission contribution that a platform performs with the capability enabled by the avionics. Therefore, all requirements for avionics must be sponsored by Fleet (platform) users. The Enabler NARG process provides a vehicle to align that sponsorship.



Core Avionics Issue Capture Process.

2. Where possible, leverage existing Service and Joint capability documents to accelerate formal requirement establishment. The JCIDS instruction lays out the procedures for analyzing identified capability deficiencies and formally documenting them in Initial Capability Documents (ICDs), Capability Development Documents (CDDs), and Capability Production Documents (CPDs). In the Marine Corps, capability needs can also be documented by Joint Urgent Operational Needs (JUONs) and Universal Needs Statements (UNSs) or Urgent UNS (UUNS). Joint Capability Documents (JCDs) are required to be established in order to initiate acquisition programs and apply resources to field and sustain solutions. There are few capabilities that have not already been outlined in JCDs in at least one of the military Services. Platform and commodity managers pursuing new programs or spiral upgrades are encouraged to leverage existing JCDs to accelerate program initiation. OPNAV N98 has personnel assigned to assist with review of existing JCDs, as well as development and staffing of new ones.

3. Use commodity evolution roadmaps to align the timing of pursuit and integration of avionics-based capabilities across platforms to enable collective resourcing and broader benefits. Requirements are generated when threats change, tactics change or new mission creates a capability gap. Avionics solutions can address many of those requirements. This document speaks to 'core' solutions that apply to most platforms. The roadmaps presented in the appendices of this document are divided into the core capability areas shown in Section III above. The timelines for activities in the capability sub-elements portray when enhancements are being developed and are expected to be mature, based upon technology growth and programmatic preparation time. Platform requirements officers and program managers are recommended to use these roadmaps to create their capability roadmaps and flight plans so that they may align with planned avionics capability enhancements as well as other platform initiatives to deliver broader collective benefits and improved interoperability across the enterprise.

4. Define requirements in terms of warfighting capabilities necessary to accomplish a platform mission in support of Combatant Commander strategic objectives. DoD leadership has outlined future warfighting capability objectives in Joint Vision 2020. The Navy Aviation Plan 2030 (NAvPlan) and Marine Corps Aviation Plan (Marine AvPlan) list more detailed objectives for Naval Aviation warfighting capabilities, including more detailed definition of future force structures. The ultimate customers for capabilities enabled by core avionics are not necessarily the platform communities, but the COCOMs who apply their mission sets in Joint operations. Clear explanation of the specific tactical application is essential in the budgeting prioritization process. Proposed issue costs are built upon programmatic aspects, but resource allocation prioritization decisions are primarily based upon criticality of operational capability gaps and warfighting benefits. For example: funds are not required to 'integrate SATCOM;' they are required to 'enable platform X to conduct over the horizon tactical information situational awareness exchanges in order to perform long range expeditionary operations in support of Joint Command and Control objectives.'

B. <u>Resourcing</u>. During the Programming phase of the Planning Programming Budgeting and Execution (PPBE) process, the OPNAV N98 and DC/A aviation resourcing offices host Program Requirements Reviews (PRRs) and Council of Colonels review for all platform and commodity program offices. Resource allocation decisions are based upon issue criticality, urgency of need (timing), depth of contributions to JCAs and affordability. Leaders are encouraged to apply the following recommended practices to support effective and affordable resourcing of core avionics enabled capabilities.

1. Use road-mapping processes to conduct cross-platform and commodity office exchanges during budget issue preparation. The commodity system roadmaps presented in the CAMP differ in format from platform roadmaps or flight plans. They characterize evolving states of maturity of core capability enablers; whereas flight plans represent time-phased strategies to budget for and incorporate mission capability enhancements. Each entry on the CAMP roadmaps is backed up with a descriptive paragraph in the appendix that provides enough detail for users to determine whether or not that element has operational relevance to their mission set. Since these roadmaps address core systems, most elements will have application to all aircraft. This enables multiple platforms to collaborate and collectively present packaged resource requests that deliver broad benefits. The collective approach is usually more cost effective than several stove-piped initiatives because redundant infrastructure elements are eliminated. Even more importantly, the issue gets stronger traction with collective advocacy versus when it is competed between independent presenters.

The Naval Aviation Center for Rotorcraft Advancement (NACRA) has been chartered by DC/A and Program Executive Office, Air ASW, Assault and Special Missions Programs [PEO(A)], to leverage Joint Service initiatives to streamline integration of capability enhancements. One of NACRA's functions is to facilitate alignment of standardized platform roadmap formats with commodity roadmaps to enable improved cross-talk and consistency in requirements issue characterization. They are also working to standardize vertical lift platform program office "Battle Rhythms" for building budget submits.

2. Ensure issues with application across multiple platforms are coordinated with commodity program offices, OPNAV N98 and HQMC APW73. The commodity program offices (PMA209 Air Combat Electronics, PMA281 Mission Planning and PMA272 Advanced Tactical Aircraft Protection) should be directly involved in platform preparation of issues that are enabled by their core systems. OPNAV N98 and DC/A POM serial guidance has encouraged platform managers to pursue such exchanges when preparing issue sheet budget requests for the PRRs and Council of Colonels. OPNAV N98 and APW-73 Requirements and Action Officers are directed to present rollups of commodity capability issues across the platforms. This enables the resource sponsors to understand the overall costs, efficiencies and benefits of commodity enabled capabilities as they apply across the NAE. Coordination of core capability issues with OPNAV N98 and APW73 allows individual platforms to leverage momentum of collective enterprise-level benefits and promotes interoperability. Resource sponsors understand that rolled-up issue representations show a higher cost, but the total cost is less than the sum of several independent solutions.

3. Leverage alternative avionics resourcing opportunities. A program office may not have a program element or funding stream to address emerging avionics component issues, particularly when they come in the post-production sustainment phase. With the pace of technology rolls and obsolescence with digital systems, issues pop up that cannot be addressed in a timely fashion using the PPBE process. Component issues usually do not successfully compete for internal resources against major platform-specific mission systems, weapons upgrades or airframe integrity sustainment issues. Components that are centrally managed are more likely to have active resources for modernization/improvements as they evolve because they can leverage research and development available in new platform funding lines. Independent platform appeals for resources to modernize in order to increase reliability, reduce sustainment costs or avoid obsolescence supportability train wrecks may be more challenged to achieve Returns on Investments (ROI) because the fixes will affect a smaller inventory or repair demand. Common systems have broader application of modernization or upgrade benefits. The following programs and processes offer alternative resourcing options.

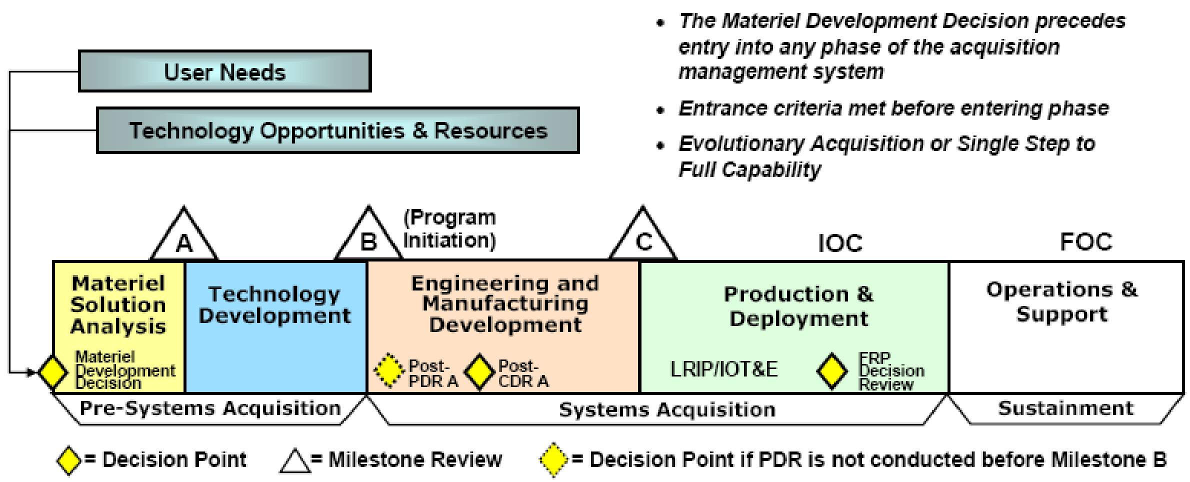
(a). Navy Supply Systems Command (NAVSUP) Logistics Engineering Change Proposal (LECP). The NAVSUP (formerly known as NAVICP) Weapons Systems Support (WSS) department provides support to common systems programs at NAVAIR. The NAVSUP Buy Our Spares Smart (BOSS III) program (NAVSUPINST 4105.1A) continually reviews candidate proposals to fix problematic repairable components. The program focuses on supply management cost reductions and seeks to achieve an aggregate ROI across all initiatives of two to one over seven years (five years after the new unit is fielded). If a submission is approved by the review board, NAVSUP Navy Working Capital Funds (NWCF) can be applied for both Non-Recurring Engineering (NRE) and procurement funding. (Visit https://www.navsup.navy.mil).

(b). DoD Value Engineering Change Proposal (VECP). Federal Acquisition Regulation (FAR) law and the DoD FAR Supplement prescribe Value Engineering clauses to be included in prime vendor contracts. FAR Section 52.248-1 outlines two alternatives in which the vendor or Government sources can fund product improvements to achieve savings or cost avoidances. The DoD 4245.8-H Value Engineering Handbook delineates proposal procedures and presents sharing ratios describing how savings are distributed between the vendor and the affected user program. Additional information is available at http://rtoc.ida.org/ve/ve.html.

(c). Mid-year reprogramming. PEO's analyze their program offices' funding execution throughout the year. Dynamics of acquisition management create opportunities to redirect resources to address emergent critical issues. Well-defined avionics solutions that address currently critical problems may compete for these resources if they are in a position for rapid funds obligation. Solicitations for candidate initiatives are usually promulgated through Engineering Class Desk channels.

(d). Supplemental Funding. Overseas Contingency Operations (OCO) operations erode equipment inventories and highlight poor component performance. The NAVAIR War Council reviews applications and allocates supplemental funds to address emergent Fleet war-fighting requirements and sustain a posture of combat readiness within the NAE. OCO funds are expected to end in fiscal year 2013 or 2014.

C. Acquisition. Acquisition management is performed by the "Provider" element of the NAE triad. NAVAIRSYSCOM develops, delivers and sustains system solutions for the Fleet users. DoD Transformation has driven significant revision of the DoD and Secretary of the Navy (SECNAV) 5000 series acquisition instructions. Policies and direction now more directly align with JCIDS processes to focus on support for the COCOMs. DoDI 5000.02 also presents a framework for Evolutionary Acquisition, which is described as the preferred strategy for rapid acquisition of mature technology for the user. PMs have ultimate responsibility for cradle to grave management of their weapons systems. Recommended practices presented in CAMP 2012 are built upon existing acquisition policies that support defined NAE objectives.



Defense Acquisition Management System, Dec 2008.

The following acquisition guidance covers processes and practices that support CAMP 2012 and Naval Aviation leadership objectives.

SECNAVINST 5000.2E (para. 2.4.6.5. Standardization and Commonality) states: "Common systems can provide efficiencies that include inherently greater interoperability, lower total ownership costs, improved human performance, consistent and integrated roadmaps for system evolution, and planned dual-use functions. Acquisition strategies shall identify common systems integrated into the acquisition program."

SECNAVINST 5000.2E (para. 5.4.1 Weapon System Analysis of Alternatives) states: "The cognizant program executive officer (PEO), SYSCOM commander and direct reporting program manager (DRPM), or ASN(RD&A), and Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC), but not the PM, shall have overall responsibility for the AoA which shall be conducted per the guidance provided in reference (a). The CNO and CMC, or designee, as supported by the analysis director, shall propose the AoA study guidance for pre-ACAT IC, IAC, II, III, IV programs and an AoA study plan for all pre-ACAT programs in coordination with an AoA integrated product team (IPT), under the overall guidance of the Acquisition Coordination Team (ACT) where established. Common systems shall be included as one of the alternatives when one may provide the needed capability."

SECNAVISNT 5000.2E (para. 6.1.9.2. Standardization and Commonality) states: "PMs shall seek and employ DON Enterprise-wide commonality to reduce the proliferation of non-standard parts, material and equipment within and across system designs. The process shall include the periodic evaluation of different items having similar capabilities, characteristics, and functions used in existing type, model, series and class designs to reduce the number of distinct items."

ASN RDA Memorandum (23Dec04. Horizontal Systems Engineering) states: "Cross-platform commonality is difficult to reconcile with requirements and schedules in our normal vertical management of acquisition programs. It becomes further complicated when we delegate decisions on modularity and families of systems to prime contractors, who will understandably optimize for their particular business models rather than ours." This memorandum established Executive Committees to "make recommendations and action assignments to develop architectures, roadmaps and implementation plans to increase commonality" and to "seek opportunities for Enterprise-wide commonality in hardware and software modules."

Leaders are encouraged to apply the following recommended practices to promote efficient acquisition and fielding of core avionics-enabled capabilities.

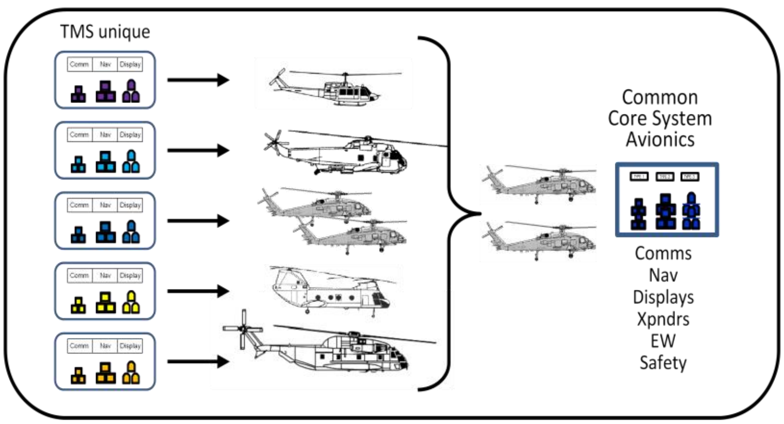
1. Prominently factor commonality, standardization, interoperability, supportability and affordability during development of new capability solutions or enhancements. Component commonality can enable the following benefits:

- Avoidance of duplicative research and development investments
- Avoidance of duplicative sustainment management and upgrade efforts
- Reduced acquisition staffing
- Economy of scale in procurement
- Increased competition by Industry interest (larger contracts)
- Fewer logistics tails and reduced logistics overhead
- Reduced spares requirements and smaller inventory footprints
- Increased applicability of upgrades and enhancements
- Increased interoperability

Program management and operational employment successes achieved with the ARC-210 radio and other common system solutions can be emulated across other core products. In early phases of system design or modification efforts, PMs should assess potential benefits and risks of developing a new system against tailored application of a known solution. Unique solutions may appear more attractive in the near term because they usually have fewer dependencies and allow more direct control of resources. However, unique solutions can also present significant modernization and sustainment challenges over the remaining life cycle when they have to be independently funded. There are compelling cases when a unique solution is appropriate. Justifications for decisions to proceed with unique solutions should be formally recorded for Milestone Decision Authority (MDA) approval in Acquisition Strategy (AS) and Acquisition Program Baseline (APB) documents.

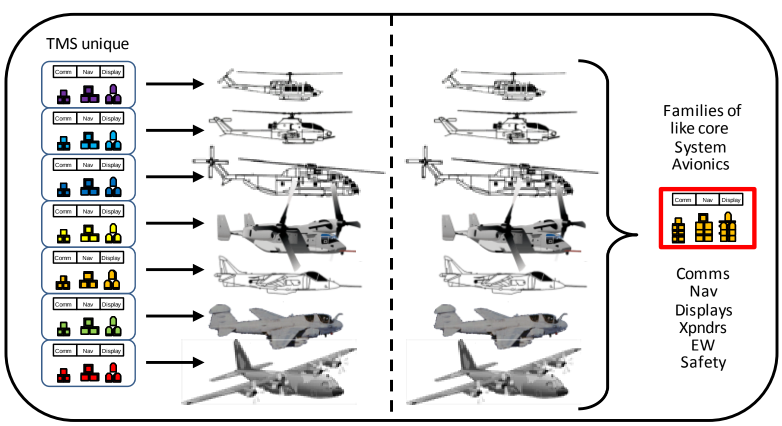
2. Leverage established solution development momentum, maturity or lessons learned. Coordinate deliberate convergence toward common products or families of systems. The DoD 5000 series directs that Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF) reviews will be conducted to determine if a capability gap can be addressed without a materiel solution. When a materiel solution is called for, it then directs that Commercial Off the Shelf (COTS) solutions be explored first. Similarly, existing military solutions should be reviewed for applicability before pursuing a new solution.

Benefits achieved with deliberate convergence (necking down) of Navy helicopter TMS came not only from eliminating several unique airframe sustainment infrastructures, but also from reductions of many unique component sustainment infrastructures. The cost avoidances achieved freed resources to enable more system-enabled capability integration. Additionally, even though the two remaining variants have different mission sets, they were purposefully designed to achieve efficiencies from commonality in their core avionics systems.



Navy Helicopter TMS neck-down efficiencies.

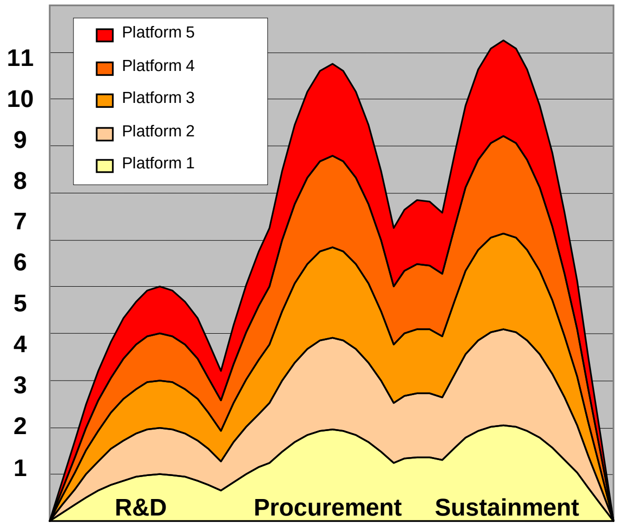
Similar efficiencies can be captured by applying these deliberate convergence principles at the system component level across other existing platforms.



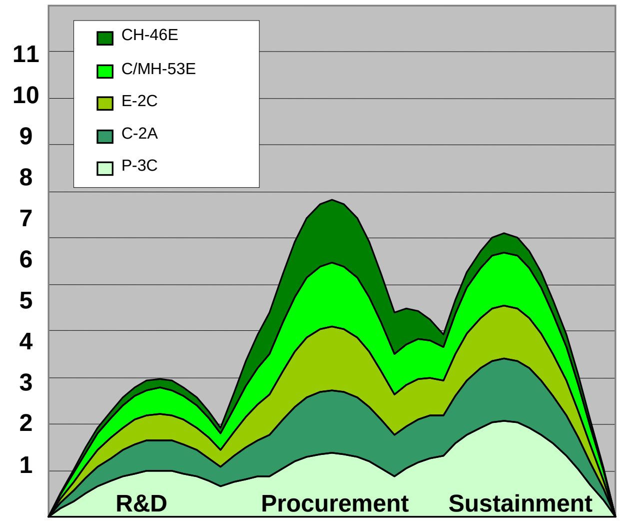
Potential USMC Assault Support deliberate convergence efficiencies.

The following graphic presents an example of resourcing efficiencies that have been achieved through centrally managed integration of Air Traffic Control interface systems.

Independent versus leveraged costs for integration of Air Traffic Control functionality.



Life-cycle costs ($M) for 5 platforms independently integrating Mode S



Actual life-cycle costs ($M) for 5 platforms leveraging centralized integration of Mode S

Established program modernization upgrades and capability enhancements should also leverage prior efforts or established solutions whenever practicable. The roadmaps presented in this document identify what evolutionary capability steps are already being developed in avionics enabling systems and when they are expected to be fielded. If the timing of those advancements can meet platform mission needs and modification schedules, existing momentum and funding can accelerate integration. PMA209 also serves as the Naval Aviation representative to the Joint Services Requirements Committee (JSRC), which is chartered to leverage accomplishments and promote commonality across the Services.

3. During program baseline assessments, use the NAVAIR Commonality Opportunity Review Process (CORP) process to analyze alternative solution logistics footprints, modernization costs and sustainment life cycle impacts across the full life cycle, and to the Enterprise rather than to the individual platform. NAVAIRINST 5000.25 (CORP) was established to maximize cost-wise resource allocation decisions across the NAE, as well as to promote interoperability and reduce deployment logistics footprints. CORP projects are executed by NAVAIR Program Office, Program Executive Officer (PEO) staff and Competency personnel using standardized procedures, templates and checklists that enable business case analyses and analysis of alternatives based upon factual data. The process enables quantitative assessment of common versus unique system costs and benefits over the life cycle and across the NAE. It is intended to be applied prior to requests for fiscal resources or program initiation. The CORP Handbook identifies process details, timelines, roles and responsibilities and deliverables.

4. Employ Open Systems Architecture (OSA) in hardware and software designs. Adhere to collective interoperability standards and protocols in order to control future modification costs. Design future platform and evolve current platform processing architectures toward an Open Application Interface configuration (FACE Future Airborne Capabilities Environment) that allows system software to be integrated without requiring full mission profile regression testing.

SECNAVINST 5000.2E. (para. 2.4.6.1. Strategy and para. 6.1.4. Open Architecture) states: "Naval open architecture precepts shall be applied across the Naval Enterprise as an integrated technical approach and used for all systems, including support systems, when developing an acquisition strategy."

Recent executive committee and task force analyses have identified platform architectural and software diversity as the most significant cost driver of Naval Aviation capability evolution. Software code modifications for single function integration, such as Mode S or Mode 5, are estimated to run into the tens of millions of dollars per platform, even if the host component was previously integrated with hooks to enable growth. Although Joint Technical Architecture (JTA) mandates are being complied with, some systems still have proprietary code or design issues that prevent leveraging upgrades developed for like systems. Truly open architecture should allow open interface with new technology, COTS products and Non-Developmental Item (NDI) solutions irrespective of the specific provider source. Commercial personal computing and telecommunications products have achieved this construct with operating system software and peripheral devices. NAVAIR program management can help drive this necessary shift in the aviation and avionics industry.

Interface with standardized protocols does not fully cover the "Open" part of the Open Architecture equation. Most of our platforms do not have computer architectures that are configured to allow rapid and reduced cost integration of new capabilities because all new software gets directly hosted by the main Operational Flight Profile (OFP) or operating system software. Constant changes to the core software to enable interface with new applications quickly saturates processing capacity. If the architecture is not structured to practically upgrade to more processing or memory storage capacity, the platform can reach a condition of functional obsolescence. The application interface point design can mitigate the capacity issue by separating application integration from the OFP core software. Many future capabilities will be integrated into platforms via software. The combined costs of required near term communications upgrades, datalink integrations, GPS waveforms and encryption corrections make the case for deliberate convergence to a common application interface management structure.

Both OPNAV and DC/A strongly endorse development and integration of FACE architectures in Naval Aviation platforms. A FACE construct (bypassing full OFP regression testing) can be achieved without replacing the current mission computer by using a modular or partitioned processing design, or distributed processing managed in other components, such as recorders, moving maps or even digital flight instruments and displays. Once the FACE architecture is in place, multiple users will be able to take advantage of centrally developed applications, more like the open applications library model currently employed in smart phones and personal computers.

In 2010, PMA209 led the establishment of a FACE consortium made up of industry representatives and military aviation stakeholders. Their job included development of common standards and protocols for the computing environment. In January 2012, the first FACE standard was published. This protocol will enable simpler, faster and more affordable integration of components and software enabled capabilities. Common standards will benefit platform capabilities by allowing more competition across industry, which brings down price and expands innovation across a broader provider base. It will also enable government entities to more directly provide and control capability enhancements. FACE standards should be used for new avionics developments and analyzed for feasibility during system modifications or upgrades.

5. Ensure that Performance-Based Acquisition and Logistics (PBA, PBL) contracts can effectively and affordably leverage common product upgrade opportunities, whether they involve Government or other vendor Commercially Furnished Equipment. Work to eliminate unique interfaces and proprietary ownership.

DoD Directive 5000.1 (E1.16) states: “To maximize competition, innovation, and interoperability, and to enable greater flexibility in capitalizing on commercial technologies to reduce costs, acquisition managers shall consider and use performance-based strategies for acquiring and sustaining products and services whenever feasible. For products, this includes all new procurements and major modifications and upgrades, as well as re-procurements of systems, subsystems, and spares that are procured beyond the initial production contract award.”

SECNAVINST 5000.2E (para. 2.4.7. Support Strategy) states: “PBL is the preferred support strategy and method of providing weapon system logistics support.”

In a performance-based acquisition or logistics construct, increased profit motivates the provider to improve performance and reduce cost. The vendor is empowered to implement engineering changes without waiting for Government offices to identify and provide (unplanned and un-programmed) resources. Sustainment strategies should utilize the best public and private sector management capabilities and incorporate effective government and industry partnering initiatives. Effective performance-based contracts require comprehensive planning using a full life cycle perspective. Unless properly structured, single point ownership of the weapon system may drive unique design work (or additional pass-through costs) when trying to upgrade core commodity systems, regardless of whether they are Commercially Furnished Equipment (CFE) or Government Furnished Equipment (GFE). Care should be taken to avoid a contractual situation where the government is charged a premium or is prohibited from capitalizing on common or commodity system upgrades. In any case, a Business Case Analysis (BCA) should be conducted to compare alternative product support strategies and determine the best value solution for the government. The DoD Product Support BCA Guidebook (issued April 2011) provides guidance for performing BCAs. The guidebook and additional supporting information can be found at http://www.acq.osd.mil/log/mr/library.html.

6. Consider using PMA209's government based Avionics Capability Integration Support Team (ACIST) as an alternative to prime vendor for Lead Systems Integrator (LSI) activities involving avionics. PMA209's ACIST program serves as the Lead Systems Integrator for Communications Navigation Surveillance / Air Traffic Management (CNS/ATM) functionalities. Their efforts have provided enhanced glass cockpit upgrades to fixed wing and rotary wing, Navy, Marine Corps and US Coast Guard aircraft. They heavily leverage prior efforts to significantly reduce costs of subsequent integrations. Their software re-use exceeds 90 percent, which promotes more commonality and interoperability between the platforms. They have also designed the civil functionality upgrades to enable provision of additional military operational capability benefits. While addressing current civil interoperability (global access) requirements, they have put the foundation/hooks in place for future requirements. Their products have overcome and eliminated proprietary issues, enabling faster and cheaper future modifications. Furthermore, their cockpit schemes are also being emulated as designs for next generation platform replacements.

7. Establish pro-active sustainment teams to forecast and mitigate obsolescence and Diminishing Manufacturing Sources and Material Shortages (DMSMS) operational impacts and cost burdens. The post-production sustainment phase of the weapon system life cycle can present some of the greatest challenges to the acquisition manager. Modification resources (APN-5) are more limited and their applications more restricted. Management reserves are discouraged, but performance, obsolescence and sustainability issues are often difficult to predict with enough detail to justify dedicated resource needs to comptrollers. Platform lives have been extended ten to fifteen years while living within the five-year 'sundown' stage, which prohibits integration of increasingly critical modification efforts. [Per ASN RDA Memorandum (09Aug06), the five year rule does not apply to modifications costing less than $100,000, or costing less than $1,000,000 for items that can be re-used again on another platform, or to safety systems. The rule can also be waived by ASN RDA.] Legacy platforms have established obsolescence funding lines or flexible sustainment accounts by demonstrating comprehensive knowledge of specific component issues.

SECNAV Memorandum (20Aug04) addresses DMSMS policies. Every NAVAIR program office has been directed to implement an Obsolescence Management Plan. Program managers are encouraged to establish sustainment teams that pro-actively identify avionics system performance degradation and address impending supply and support issues before they threaten to impact Fleet readiness. Supply and maintenance data systems provide detailed component and parts availability and performance data. Advance identification of parts that will no longer be available due to technical obsolescence and DMSMS issues allows teams to react and make timely component sustainment decisions (retain, redesign, replace, re-use, retire). Pro-active tracking can eliminate premium charges for retooling or limited production procurements. Often distributors will have stockpiles of discontinued items that will support component repair through the remaining life cycle. NSWC Keyport has extensive experience with analyzing component obsolescence at the piece-part level. They can determine what percentage of parts will reach an obsolescence status in the near, mid and longer term, and perform comprehensive distributorship searches. Post-production common avionics are managed by PMA209's Fleet Avionics Systems Support Team (FASST) staff.

DoD 4140.1-R, Section C 3.6, Supply Chain Material Management (23May03) requires each DoD component to develop a process to proactively manage DMSMS throughout the system life-cycle. SECNAVINST 5000.2E provides DoN guidance for management of DMSMS and establishes NAVAIRSYSCOM DMSMS policy, procedures and responsibilities. It states, “PMs shall manage obsolescence at the piece part level for all active microelectronics, unless otherwise supported by a business case analysis. Performance Based Logistics (PBL) agreements shall address mitigation of DMSMS risk to their program and the government.” The NAVAIR DMSMS instruction (NAVAIRINST 4790.35) directs every program office to implement a proactive DMSMS program plan. The purpose of the program is to mitigate the impact on total ownership cost and schedule, enhance the interchangeability, reliability and availability of parts; and promote synergy across NAVAIR programs through collaborative sharing and teaming on DMSMS solutions, information, processes, tools and practices. The DMSMS program should incorporate or consist of a DMSMS Management Plan, a DMSMS Management Team, DMSMS data, and participation in the NAVIAR DMSMS Working Group. Program managers are encouraged to establish DMSMS teams that pro-actively identify avionics system performance degradation and address impending supply and support issues before they threaten to impact Fleet readiness.

Supply and maintenance data systems along with DMSMS predictive tools provide detailed component and parts availability and performance data. Advance identification of parts that will no longer be available due to technical obsolescence and DMSMS issues allows teams to react and make timely component sustainment decisions (retain, redesign, replace, re-use, retire) and chose the most cost-effective solutions. Pro-active tracking can eliminate premium charges for retooling or limited production procurements. Often distributors will have stockpiles of discontinued items that will support component repair through the remaining life cycle. Within PMA209, the FASST staff personnel have extensive experience with analyzing component obsolescence at the piece-part level. FASST can train teams within other IPTs how to establish a proactive DMSMS approach and determine what percentage of parts will reach an obsolescence status in the near, mid and longer term, and perform comprehensive distributorship searches. AIR-6.7.1.6 provides policy and process guidance and can provide tailored guidance and training to help establish proactive DMSMS plans and processes.

D. Best Practices Application. The recommended practices presented in CAMP 2012 are not intended to override guidance or policy governing the three NAE arenas. They prescribe a strategic blending of existing guidance to achieve Enterprise objectives. The NAE itself was designed to facilitate improved communication and success across the disciplines in support of the aviation warfighter. CAMP 2012 strives to promote awareness across those disciplines so that core avionics system solutions can more effectively support the warfighter.

V. ROADMAPS.

The CAMP 2012 appendices include roadmaps showing time-phased core avionics-enabled capability evolution over the next ten years. They are intended to promote awareness of avionics technology and solution maturity. Some functional aspects overlap across multiple roadmaps. Each appendix includes a background section that explains what systems and functionalities are covered in that capability area, along with descriptions of current capability baselines and future desired capability states. Amplifying paragraphs are presented in sequence with each entry on the roadmap elements timeline. They address funded program of record capability enhancement activities, gaps that are not yet being funded (but are recommended to be pursued to reach the desired end state), and related advance research and engineering activities that are expected to transition to programs of record or enhance existing capabilities. The Introduction appendix further explains the methodology and convention of the roadmap entries.

The roadmaps are intended to be used as planning tools to frame discussions between acquisition managers, Fleet requirements officers and resourcing requirements and action officers. Amplifications provided in the appendices are top level and fairly generic. Platform managers are encouraged to understand the capability enhancements that are represented, determine if they are applicable to their warfighting mission set, and then use the time-phasing to build those pursuits into their Flight Plans.

Roadmaps and Appendices Introduction

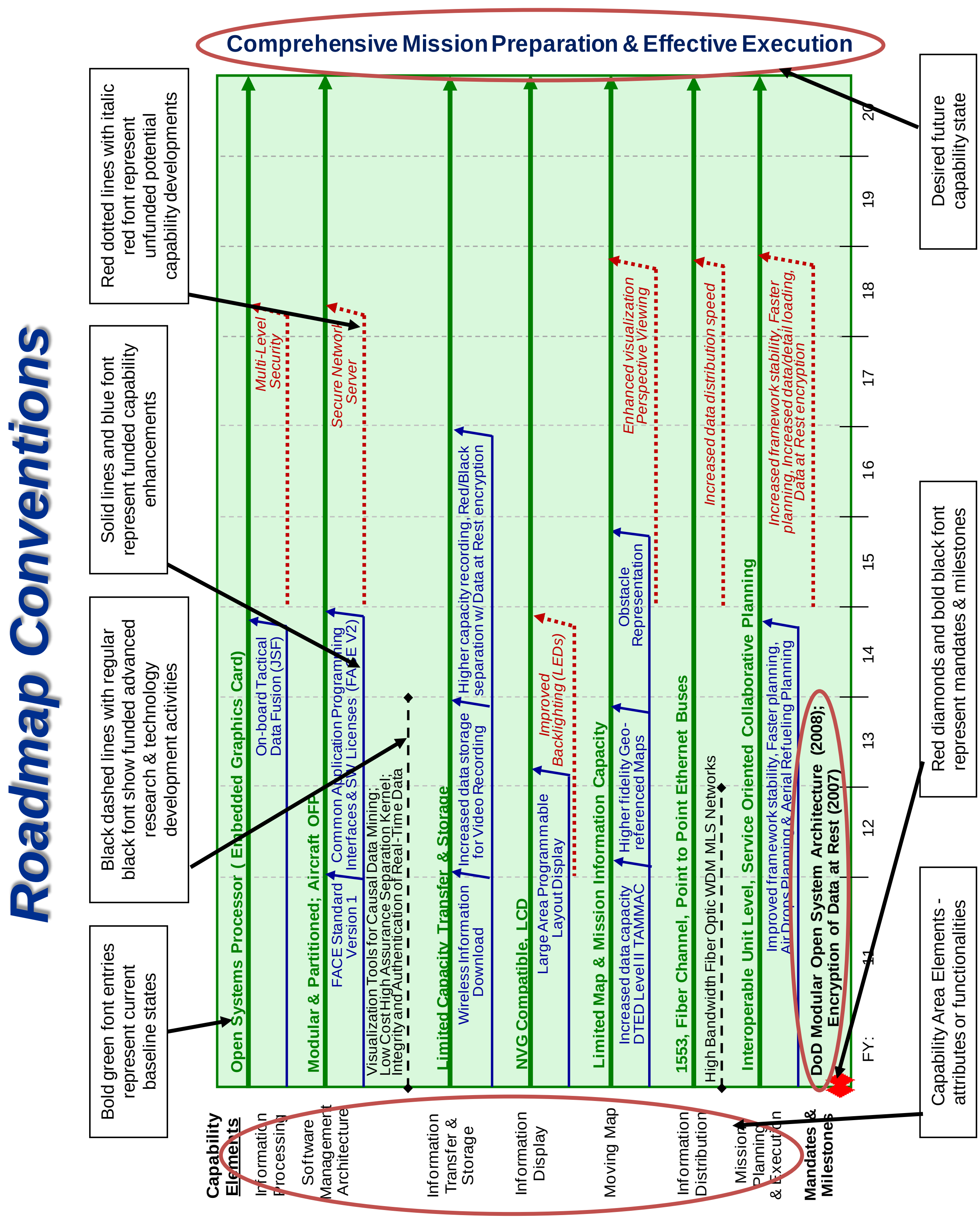
Core Avionics Scope: The following Roadmaps and accompanying amplifying material provide insight into the evolution of enabling systems within each of the six Capability Areas: Information Management, Information Exchange, Navigation, Cooperative Surveillance, Flight Safety Systems and Self Protection. Some avionics applications cross over multiple Capability Areas.

Roadmap Format: The vertical entry on the right side of each roadmap describes the desired future (ten year) capability end state. Capability elements are listed down the left margin. The roadmap timeline begins with FY09 to capture recent developmental efforts and capability transitions. The legend outlines conventions used to identify capability entry status. Different line styles and fonts have been used to facilitate interpretation of black and white copies. Bold green lines and bold green font entries represent current baseline capabilities. Solid blue lines and regular blue font represent funded developmental programs (new or modified systems) that will deliver additional capability, and identify projected first availability of that capability. Red dotted lines and italicized red font specify needed capabilities that are not currently funded for development or integration, and the estimated times that such capabilities should be fielded to support achievement of the desired end state. Most of these begin in 2015, which is the next opportunity for new start funding. Black dashed lines with diamond ends depict starts and finishes of advanced research initiatives that will contribute to technology maturation in support of programmed or potential acquisition pursuits. At the bottom of each roadmap, red diamonds and bold black font signify associated mandates (or policy) and capability state milestones. Amplifying material is organized to follow entries from the top left, across each capability element baseline, down to the bottom right of the roadmap.

Appendix Format: Each appendix begins with a scope statement for the capability area. It presents a graphic depicting the elements associated with that area, the enablers that support those elements, intended evolutionary enhancements, and desired resultant warfighting capabilities. The graphic is accompanied by a description of the overall baseline to objective transition strategy, and then a list of guidance, mandates and milestones relevant to that area. The remainder of each appendix is dedicated to descriptions of each roadmap entry as they flow left to right through each capability element. Each sub-section starts with the scope of that element, followed by a current capability state baseline description, then advance research and technology development efforts, and then funded enhancements and potential enhancement pursuit descriptions.

Utilization: Requirements and Program Management offices are provided this information to assist with development of platform Flight Plans and budget requests. As a strategic planning tool, this document describes core avionics evolution in terms of warfighting capability. Programmatic acquisition and technical detail is limited. Amplifying material is intended to provide the reviewer enough information to determine whether a capability or mandate is applicable to their weapon system or community mission set. Platform managers should then pursue additional detail to assess whether the described enhancement supports a legitimate warfighting requirement for them, and if the timing of solution maturity can effectively support their platform evolution.

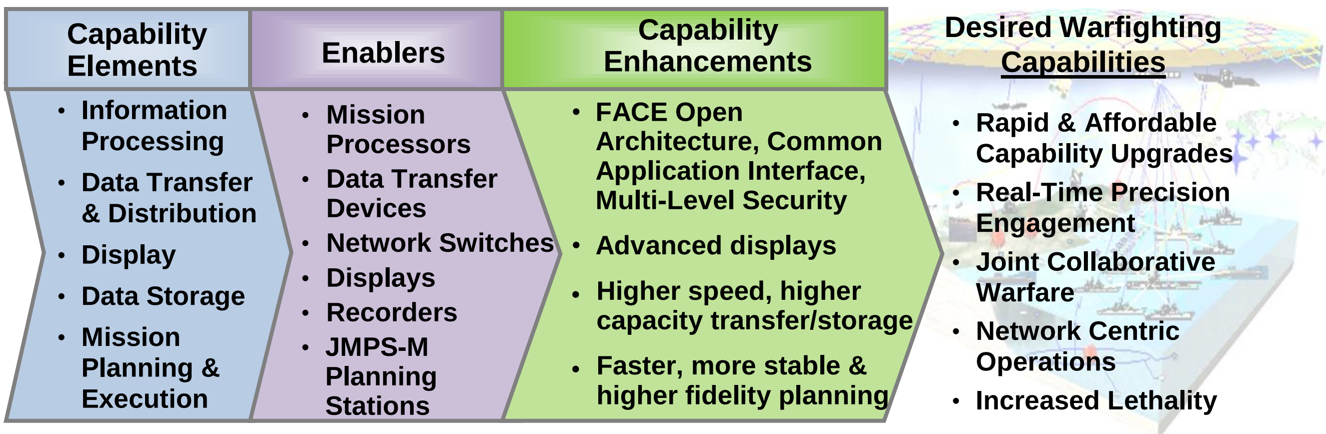
Roadmap Conventions



Appendix A-1
Information Management

Scope: The Information Management capability area includes equipment used to prepare, upload, display, manage, internally distribute, store, process, and download data used in planning and executing the mission. It addresses both off-board preflight and on-aircraft in-flight systems.

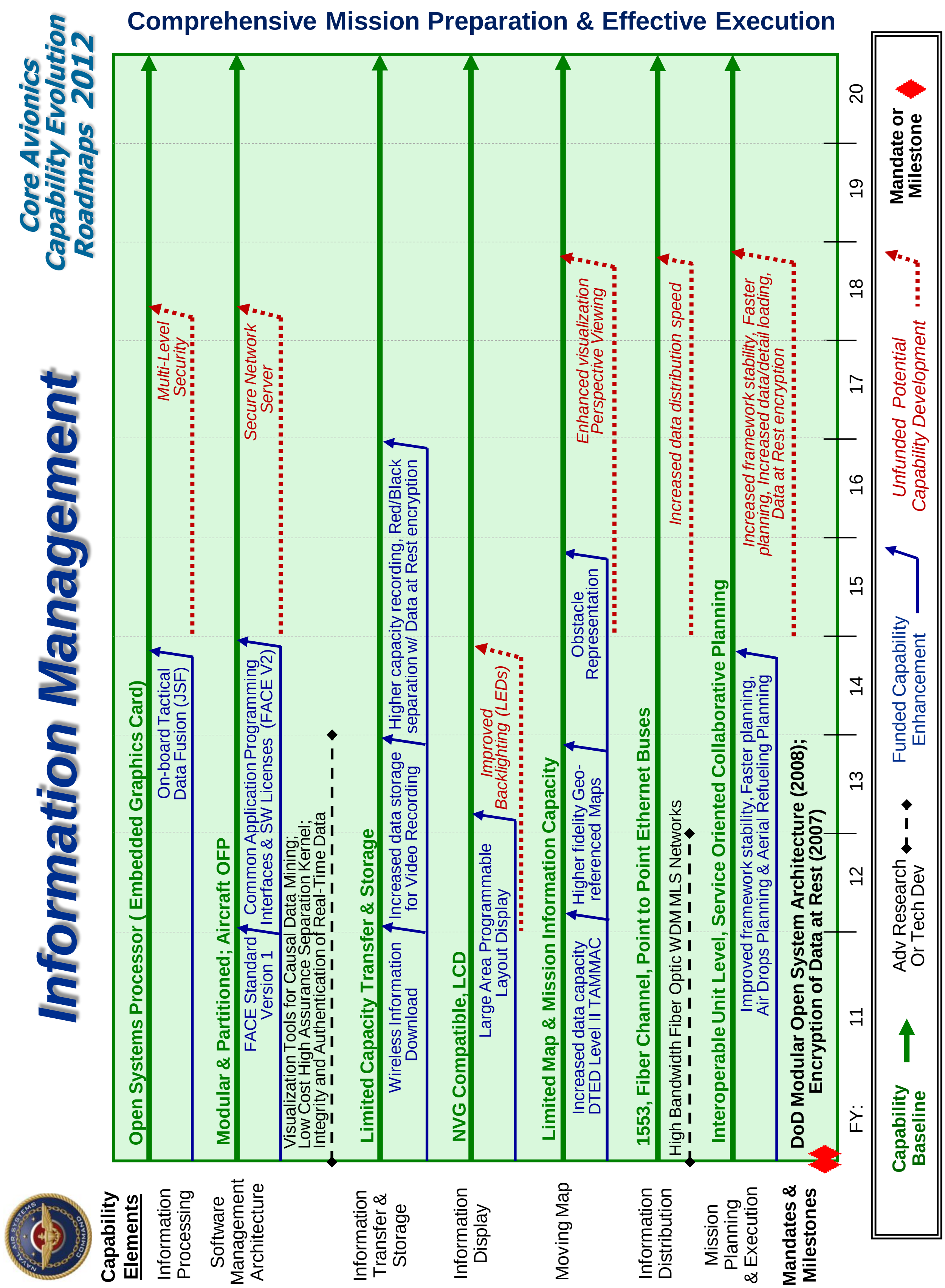
Capability Evolution:



Objective: Comprehensive Mission Preparation & Effective Execution

Baseline Enhancement Objectives and Transition Strategy.

Current Information Management avionics automate and accelerate complex manual processes of preflight planning, in-flight execution and post-flight debriefing. DoD and Naval leadership have called for a transformation that supports application of forces on the enemy in a much more timely, flexible, precise and persistent manner. Incorporation of modern Modular open architecture and standardized interface processing architectures will speed up and reduce the cost of integrating valuable warfighting utilities. Compartmentalization will simplify management of multiple levels of data security. Higher resolution and larger displays will afford more effective portrayal of the increased volume of tactical information available to the warfighter (including powerful situational awareness tools such as reconfigurable tactical picture layouts for faster interpretation and picture in picture streaming video). Modern media solid state information transfer media will address material and operational obsolescence issues. Increased digital data storage capacity, faster transfer rates and data format improvements will simplify post-mission playback and enable more thorough operational assessment for follow-on planning. Mission Planning tools have transitioned from independent platform applications to a common planning environment. Faster preflight data entry will improve agility and readiness. Modern processing architecture will greatly increase the amount and detail of data that can be entered. Capability evolution in Information Management avionics will provide FORCEnet information flow that enables Naval Aviation to achieve objectives in the following Joint Capability Areas: Engagement, Command and Control, Net-Centric Operations (NCO), and Battlespace Awareness.


Core Avionics Capability Evolution Roadmaps 2012
Information Management
Comprehensive Mission Preparation & Effective Execution
Capability Elements
Information Processing
Software Management Architecture
Information Transfer & Storage
Information Display
Moving Map
Information Distribution
Mission Planning & Execution
Mandates & Milestones
FY: 11 12 13 14 15 16 17 18 19 20
Open Systems Processor (Embedded Graphics Card)
On-board Tactical Data Fusion (JSF)
Multi-Level Security
Modular & Partitioned; Aircraft OFP
FACE Standard Version 1
Common Application Programming Interfaces & SW Licenses (FACE V2)
Secure Network Server
Visualization Tools for Causal Data Mining; Low Cost High Assurance Separation Kernel; Integrity and Authentication of Real-Time Data
Limited Capacity Transfer & Storage
Wireless Information Download
Increased data storage for Video Recording
Higher capacity recording, Red/Black separation w/ Data at Rest encryption
NVG Compatible, LCD
Large Area Programmable Layout Display
Improved Backlighting (LEDs)
Limited Map & Mission Information Capacity
Increased data capacity DTED Level II TAMMAC
Higher fidelity Geo-referenced Maps
Obstacle Representation
Enhanced visualization Perspective Viewing
1553, Fiber Channel, Point to Point Ethernet Buses
High Bandwidth Fiber Optic WDM MLS Networks
Increased data distribution speed
Interoperable Unit Level, Service Oriented Collaborative Planning
Improved framework stability, Faster planning, Air Drops Planning & Aerial Refueling Planning
Increased framework stability, Faster planning, Increased data/detail loading, Data at Rest encryption
DoD Modular Open System Architecture (2008); Encryption of Data at Rest (2007)
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

Baseline Enhancement Objectives and Transition Strategy (continued).

Improved information processing is the key to preserving or enhancing platform mission capabilities. Platforms risk losing relevance in modern warfighting environments if their internal data storage capacity, processing power, or distribution bandwidth get saturated. Several platforms employ unique mission processors that host unique operating systems and mission software applications. Each requires an independent effort to update and platforms end up competing with each other for funds for similar core capability enhancements, such as Mode 5 Combat ID, JPALS, Networking waveforms, and more. Commercial computers of multiple brands use standardized operating systems, and applications are designed to run on virtually all makes and models. For Naval Aviation to achieve these objectives in a timely and affordable manner, integrated avionics need to evolve to more open architectures and standardized interfaces that enable simpler integration of capability enhancements, both in terms of system performance and standardized mission software applications. Glass cockpits being integrated to enable Communications Navigation Surveillance / Air Traffic Management (CNS/ATM) mandate compliance are providing a limited Modular Open System Architecture (MOSA) that partitions communication and navigation software to enable modification without affecting the core Operational Flight Profile (OFP) mission computer software. Although this is a step forward, this solution is still only compatible with specific vendor and government coordinated software and component interfaces. Standardization of interfaces, protocols and software will enable a common operational picture and enhance platform-to-platform interoperability. These concepts are being proven out in Naval aviation applications and implemented across multiple aircraft Type/Model/Series in order to reduce test requirements, integration costs and time required to incorporate new capabilities.

Mandates and Milestones:

Encryption of Data at Rest Policy Memorandum. (Jul 2007) Establishes policy for protection of sensitive unclassified information on mobile computing devices and removable storage media. All unclassified data stored on removable storage devices must be treated as sensitive and be encrypted per standards set by the National Institute of Standards and Technology (NIST) Federal Information Processing Standard 140-2 (FIPS 140-2). This standard affects data storage devices as well as mission planning and mission recording information handling. This policy is an extension of guidance provided in DoDI 8500.2, Information Assurance (IA) Implementation.

Modular Open Systems Architecture (MOSA). (Sep 2011) DOD 5000.02 Instruction dictates operation of the Defense Acquisition System states that program managers shall employ MOSA to design for affordable change, enable evolutionary acquisition, and rapidly field affordable systems that are interoperable in the joint battle space.

Five key principles of MOSA:

- Principle I: Establish an Enabling Environment
- Principle II: Employ Modular Design
- Principle III: Designate Key Interfaces
- Principle IV: Use Open Standards
- Principle V: Certify Conformance

PMA 209 is pursuing the principles of MOSA through the Future Airborne Capability Environment (FACE) initiative by development of an open architecture that is flexible and extensible. Multiple platforms will be able to gain access to common software capabilities due to the portability of FACE conformant applications.

Capability Element Evolution:

A. Information Processing. Modern aircraft are critically dependent upon information processing, not only for management of tactical information but for basic safety of flight operations. The Information Processing capability element addresses mission planning systems, aircraft mission and weapons systems computers, operating systems, data storage and upload/download devices, and displays.

1. **Current Capabilities. Open Systems Processor (Embedded Graphics Card).**

The AN/AYK-14 Naval Standard Airborne Computer has supported mission computing, navigation and targeting applications for decades, and is projected to continue support through 2030. The AYK-14 is deployed in F/A-18 A-D, SH-60B and EA-6B, and is the core processor used for Automated Carrier Landing Systems (ACLS). The Advanced Mission Computer (AMC) was developed to be a common replacement for the AYK-14. The PMA209 Advanced Mission Computer and Displays (AMC&D) team manages AMC variants on F/A-18A-F, EA-18G, AV-8B and T-45. The AMC employs a Commercial Off the Shelf (COTS) based open architecture that runs newer, more versatile High Order Language (HOL) software code to reduce integration cost, schedule and performance risks. The extent of common mission computer integration across platforms is currently limited because the OFP operating system codes are unique and often proprietary. Each separate platform processor configuration needs to be independently modified (and resourced) throughout its life cycle to keep pace with the demands of technological obsolescence, throughput saturation and future capability integration requirements. Rewriting each core code or interface takes time, must be fit into a platform-unique OFP upgrade schedule, is expensive, and usually requires extensive regression and flight testing.

One of the more pervasively fielded processor and systems configurations across the Services is the Common Avionics Architecture System (CAAS), which is found in the majority of U.S. Army rotary wing platforms. Commonality of hardware reduces unit costs and enables upgrades to benefit more users. The CAAS model also enables open order Government Furnished Equipment (GFE) procurement over a large and simplified contract. PMA209’s Mission Systems Management Activity (MSMA) participates in the U.S. Army CAAS Working Group to ensure benefits can be applied to Naval Aviation.

Increasing processing requirements associated with block upgrades saturated the MV-22B Mission Computer Suite well before completion of platform production. An upgrade is being integrated to support integration of desired mission capabilities. Similarly, the AH-1Z and UH-1Y upgrade aircraft are integrating modern modular open HOL systems processors to overcome limitations with the legacy systems. Modern digital diagnostics have advanced to a degree where improved Built In Test (BIT) eliminates unnecessary component removals, provides better operational level repair, and even compensates for inadequate training or corrects improper maintenance actions. AV-8B successfully upgraded their BIT functionality to address readiness and cost impacts associated with A799 (no fault found) component repair challenges.

Elimination of the requirement for new real estate in order to achieve new capabilities was recently demonstrated with successful hosting of the Tactical Aircraft Moving Map Capability (TAMMAC) on a single Embedded Graphics Card (EGC). A redesign pursued to solve obsolescence issues with the existing dedicated TAMMAC Digital Map/Video Map Computer (DMC/DVMC) and storage media resulted in an open architecture solution that can be hosted in various Weapons Replaceable Assemblies (WRAs) as a Government Off the Shelf (GOTS) or COTS single board processor (graphics card). In addition, the card can be utilized as a Shop Replaceable Assembly (SRA) for multi-vendor hardware and software applications. The EGC is available for procurement. The single card form factor can afford space savings and integration flexibility benefits. To date, no platform has chosen to utilize this card primarily due to component vendor lock-in of upgrades to platform avionics systems.

2. Funded Enhancements and *Potential Pursuits*.

Incorporation of core flight operations enhancements and transformation to network-centric warfare require levels of computing performance that exceed most current platform operating system processing capabilities. Both the AYK-14 and AMC have been modified with processing upgrades. Acquisition guidance calls for MOSA design in developmental efforts. Progress is being made with designs that allow systems to keep better pace with processing power and memory capacity advancements. Personal computers use a MOSA that allows interfaces with any peripheral equipment that uses standard interfaces, regardless of which vendor supplies the product. Dell, Sony, Hewlett Packard, Gateway, and others all run Windows or Linux, which allows office tools and game applications to be designed once and run on all hosts. Implementation of this architecture model into aircraft could significantly decrease costs and accelerate capability integration across Naval Aviation.

Onboard Tactical Data Fusion (JSF). (2014) The F-35B Joint Strike Fighter (JSF) is planned to be delivered with increased automated sensor data fusion, which is a key feature of fifth generation fighter aircraft. Most sensors are managed independently and operators select specific modes of system information display. The JSF will incorporate a fusion server that performs closed-loop sensor tasking to present combined system level track information. The track will still be presented with similar key tactical parameters (location, velocity vector, affiliation and identification), but the solution will be derived from a combination of all available sensor system inputs. Fused contributions from multiple sensor systems, including Electronic Warfare (EW), Radar, IFF, electro-optical, distributed aperture, as well as tactical data from networks such as Link 16 and Multi-function Advanced Data-link (MADL), will present a higher fidelity, higher confidence solution.

Multi-Level Security (MLS). (2018) The National Security Agency (NSA) has identified MLS as a key enabler for effective network centric operations. Advancements in technology are required to provide solutions that will enable simultaneous management of multiple security classification levels within single systems. MLS systems will greatly decrease storage space requirements, simplify classified material handling procedures and equipment management, and improve operator situational awareness. A new Common Opportunity Review Process (CORP) project will be initiated in FY-12 to identify the requirements, cost benefit analysis and potential for POM-15 issue sheets to incorporate MLS into the Secure Network Server (SNS) system (described below).

B. Software Management Architecture. Software development has become the most expensive part of any new system or system upgrade. The cost per line of code has continued to rise and most problems encountered during initial testing are related to software. Complete testing of all software phases is often too expensive because it is hard to test every possible aspect of every state of the software. The alternative is less than complete testing with the resultant risk of software errors, freezes, or crashes. Often the program office has to first evaluate whether or not the effort can be included in a planned software block upgrade, which requires even more time and cost. This problem can be mitigated by ensuring that software is created in a modular, partitioned manner. With modern partitioned operating systems and the ability to write software applications that can run in separate partitions on the same hardware, the requirements to modify the operating system and retest all states of the software are reduced, thus significantly reducing the cost. Even though industry has been doing this for years with commercial sector information management products, the Navy has been reluctant to embrace these methods because of the critical nature of the software and the potential severe consequences should the mission computer crash. Some communities are already reporting incidents of having to re-boot computers in flight.

1. Current Capabilities. Modular & Partitioned; Aircraft OFP.

HOL is the current state-of-the-art in software code for Naval Aviation platforms and is currently in use in F/A-18E/F, EA-18G, AV-8B, E-2C/D, P-3C, P-8, AH-1Z, UH-1Y and T-45 aircraft. HOL allows for portability of the software to different operating systems with only minor modification. It also allows for reduction in testing by eliminating some of the retesting of existing software when a new capability is added. However, since current HOL generated software is still developed as a single partition, there is still the possibility of corrupting existing software when new capabilities are added. New requirements must go through a rigorous integration process to reduce the possibility of corruption and to ensure there is adequate throughput and memory.

The PMA209 MSMA team has moved toward modular, reusable software and has successfully fielded cockpit computer systems that reuse software developed for one platform onto another aircraft with the same hardware configuration. The P-3, C-2, E-2, and H-53 have all been installed with a cockpit that uses the CDNU-7000 as the primary computer hardware. The P-3 was the lead platform and was used to develop many common use software capabilities that are now being reused on the other platforms. Today, CNS/ATM has developed Mode 5 software for the H-53 that can be reused on the P-3, giving the P-3 the same capability for a reduced integration cost. While this is a significant first step in software reuse, the contractor in this case is the same for all platform hardware and the software is owned by the contractor. The next step is to accomplish this same kind of software reuse for software developed by third party contractors and on multiple, different hardware configurations.

The Future Airborne Capability Environment (FACE™) supports a modular approach to software design and development. With open interface standards, modularity, and hardware independence, it becomes possible to re-use individual software components without extensive retesting and with reduced error rates in the test results. The NAVAIR Modeling and Simulation (M&S) and Test community are actively engaged in the FACE development effort to leverage test savings.

2. Funded Enhancements and *Potential Pursuits*.

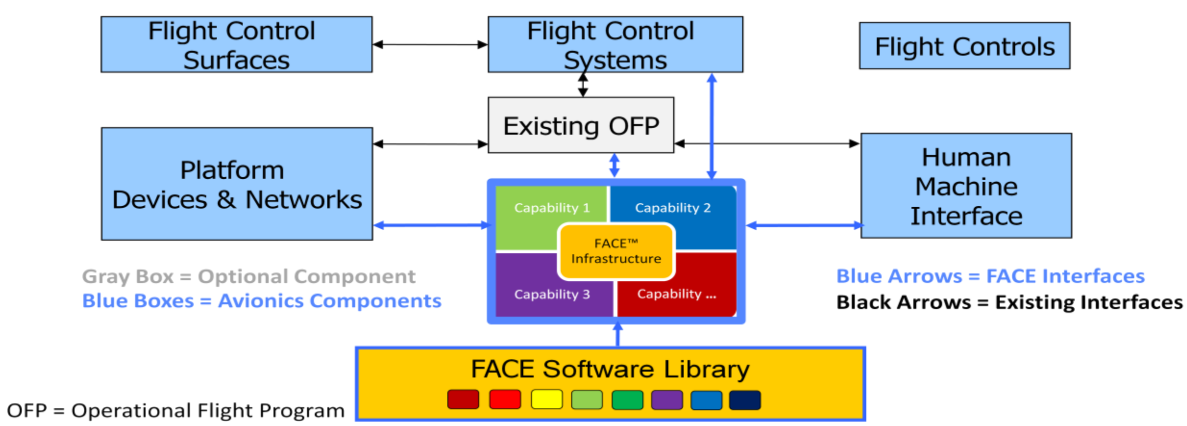
Future Airborne Capability Environment (FACE) Standard Version 1.0. (2012) Commercial aviation has progressed beyond the military in adopting a standards-based approach in developing aviation capability. The lack of a common, standards-based approach has led to recognition that the Government and the defense industry must develop new ways of procuring systems, building upon the philosophies of Open Architecture (OA), MOSA and Integrated Modular Avionics (IMA).

Future expansion of aviation capability will mostly come from integration of systems controlled by software. FACE supports a modular approach to software design and development. This open, modular environment facilitates portability and re-use of software components to build interoperable aviation systems, which results in more flexible and cost-effective ways to enhance airborne capability. FACE is being developed under the auspices of The Open Group FACE Consortium, which is composed of broad industry representation and Government leadership.

The primary purpose of FACE is to address the following challenges with avionics:

- The lack of common and compatible systems and standards has limited portability and re-use of capabilities across aircraft platforms limiting competition.
- The current economic climate suggests that less funding will be available for defense programs.
- Acquisition mechanisms in the airborne defense industry for procuring re-usable software independently from hardware are immature.
- Intellectual Property Rights (IPR) and software licensing issues will be significant factors in acquiring software-based capabilities.
- Current Government guidelines regarding MOSA and Open Systems are too generic and unenforceable.

FACE Version 1.0 involves creation of a software environment on DoD aircraft installed hardware that enables FACE applications to be deployed on different platforms with neglible impact to the FACE application. FACE Version 1.0 will deliver an approved standard, prototype reference architecture and demonstration applications as well as prototype tools such as a Software Developer's Toolkit (SDK) and Integrators Toolkit (ITK). Products aligned with FACE Version 1.0 will be delivered by the end of CY 2012.



FACE Version 2.0. (2014) FACE Version 2.0 will begin in FY12 and build upon progress made in Version 1.0. The FACE Standard will be upgraded to Version 2.0 by focusing on improvement of common data definitions, configuration services and health monitoring capabilities to facilitate maximum software reuse. The software will be used to provide sample code/application development examples and to verify all interfaces and components included in FACE Version 2.0.

FACE Version 2.0 will deliver laboratory ready Conformance Suites updated to Version 2.0, as well as an upgraded and laboratory ready SDK and ITK. The other key deliverables include a Contracting Guide and a Business Model, where a mutual Government and industry team assess the potential cost and benefit factors associated with FACE and develop scenarios and acquisition options that may arise from FACE implementations. Current NAVAIR system efforts are focused on Joint Precision Approach and Landing System (JPALS) and Terrain Awareness and Warning Systems (TAWS), while the Army will focus on a FACE implementation for their Improved Data Modem (IDM). PMA 209 personnel will continue to provide Government guidance and leadership. Current efforts to encourage Joint participation may lead to increased participation by USAF and USA stakeholders. Future editions of the standard may be required in the out years to address standardization requirements such as security driven by Platform implementations.

Secure Network Server. (2018) The Secure Network Server (SNS) initiative would develop a common aircraft network processing capability that allows multiple levels of security interaction, separated processing for hosting networking and other non-flight critical applications, and connectivity through multiple networked radios/systems.

- Creates a hosting point for common applications.
- Enables hosting additional capabilities without going through the lengthy OFP modification or testing cycle.
- Separates flight crew data and mission/passenger data exchanges by providing on-demand security partitioning among on-board users.

The objective is to develop a core capability and common interface architecture so commercial standards and legacy aircraft interfaces can be supported within a NSA-certified secure data partitioning environment. This project may also be considered as a FY-12 CORP project to identify the requirements, cost benefit analysis and potential for POM-15 issue sheets. Currently MV-22, H-1, H-53 and F/A-18 are interested in a potential MLS enhanced SNS.

C. Information Transfer and Storage.

The Storage capability element covers equipment that provides on-board retention of aircraft performance data and mission information for post-flight mission debrief/analysis and maintenance.

1. Current Capabilities. Limited Capacity Transfer & Storage.

Personal Computer Memory Card Interface Adapter (PCMCIA) cards are currently used for upload, download and storage of data, but are becoming obsolete. The most recent specification is version 8.0, released in 2001. PCMCIA Cards fit into a PC during the mission planning function and record waypoints, maps, mission notes and frequencies, and known enemy locations. The cards are then used to transfer information via the Advanced Memory Unit (AMU) portion of the TAMMAC digital map system to display the intended route of flight and planned mission tasks. The Digital

Data Set (DDS), a component of the GPS hardware installed on more than 30 types of U.S. Navy and Marine Corps aircraft, is another high-capacity, solid-state data storage and retrieval system consisting of a removable memory cartridge with embedded PCMCIA cards and a cockpit-mounted aircraft receptacle. PCMCIA card memory size has increased from 2 megabytes to 2 gigabits in response to the demand for larger file storage and upload/download capabilities. Other aircraft use the Mission Loader Verifier System (MLVS) to upload various avionics software upgrades. Other mass memory media technologies include ruggedized rotating disks, digital and analog tape systems, and solid-state devices. Mission sensor files and camera recordings are generally too large for solid-state digital recording. Current systems are also limited to holding one security classification level of data at a time.

2. Funded Enhancements and *Potential Pursuits*.

Wireless Information Download (T-45, JSF). (2012) Wireless download of mission data and maintenance diagnostic information will enable planners and ground crews to get an early start on maintenance issues and accelerate aircraft turnaround for following missions. T-45C is fielding an airborne recorder that will enable wireless download of four audio channels, two video channels, 1553 data bus information, engine performance parameters and airframe structural analysis information. Typical mission and maintenance information for one flight ranges from 1.0 to 1.5 Gigabytes (Gb) of data. The system is designed to download two Gb of data in two seconds at a range up to 2000 feet. The system incorporates a MOSA design, and is planned for expansion to other training platforms, including T-44, TH-57 and T-6.

Similarly, JSF Block II aircraft will be equipped with Prognostic Health Management (PHM) wireless down-link capability in support of mission sortie generation/readiness objectives. Downloaded parameters will include fuel state, ammunition state, expendables state, and component conditions requiring maintenance in order to minimize turnaround time. For the JSF, wireless digital transmission will eliminate the need for additional classified handling equipment, avoid potential loss of data fidelity during manual transfer, and enable maintainers to monitor airframe parameters that could prevent mishaps.

Increased data storage for Digital Video. (2013) UH-1Y and AH-1Z have selected a COTS-based modern digital data loader solution to address current system obsolescence issues and satisfy near term urgent requirements as an interim solution until the next generation system is available. The primary driver for getting a system ahead of the next planned common upgrade is their need to manage higher fidelity digital terrain geo-referencing data (Digital Terrain and Elevation Data - DTED Level II) in support of enhanced Terrain Awareness and Warning System (TAWS-II) terrain and obstacle avoidance during low level missions. Higher level detail (30 meter posting versus 100 meter posting) is required because rotary wing platforms operate closer to the ground and standard algorithms cannot provide rapid enough predictive warnings. (More detail on TAWS provided in Safety appendix). The COTS product also incorporates significant digital memory storage that incorporates compression to mpeg4 format and is capable of recording several missions' worth of digital video. The system currently is not planned to meet Data at Rest requirements, but does incorporate a minimum level of encryption and ability for rapid zeroization.

Higher capacity recording, Red/Black Separation with Data at Rest Encryption. (2016) As has been described, larger map and mission planning data file sizes are driving requirements for higher capacity bulk memory and removable mass memory. Increased capacity is also required for higher fidelity digital terrain geo-referencing data in support of terrain and obstacle avoidance during low level missions or rotorcraft recovery in degraded visual environments. Larger file sizes and increasing load times are also driving a requirement for increased transfer device capacity and interface speed. Hardware obsolescence in the current AQS-215 DDS and TAMMAC AMU presented an opportunity for development of a new common solution that leverages significant improvements in data transfer and memory technologies to increase memory capacity, speed up data transfer, and enable automated separation of various types of data. Obsolete PCMCIA cards are being replaced in commercial practice by faster, more rugged interfaces and high speed bulk memory technologies such as PCExpress or USB drives. File server architectures are being reviewed to determine if they can support multi-purpose, distributed aircraft memory storage. PMA209 Mission Systems is developing state-of-the-art data loaders, recorders and general purpose processors under the Advanced Digital Data Set (ADDS) program. ADDS will be designed as a modular hardware Family of Systems that enables platforms to achieve an entire set of required capabilities or address only those elements that are deficient. The modules are expected to support Red/Black data separation (partitioning), protection of data at rest, anti-tamper protection and Information Assurance requirements. This system will be the first system designed from the ground up to be FACE conformant. MH-60R/S and CH-53K are the lead aircraft.

Column	A	B	C	D	E	F
Component	**DTU**	**G-DTU**	**DTU-P**	**DTU-C**	**DTU-CP**	**CSR**
1 DTD slot		X				
3 DTD slots	X		X	X	X	
Processor			X		X	
CSR				X	X	X
On board System	X		X	X	X	X
Platforms	CH-53K	All	MH-60R, MH-60S	TBD	TBD	TBD

Mission planning involves loading and transfer of both classified and unclassified data. Similarly, sensor systems capture classified and unclassified data for post-mission analysis. Maintenance diagnostics and Military Flight Operations Quality Assurance (MFOQA) also involve download of information captured by recorders during the flight. With increases in capacity and improvements in platform interface, it makes sense to combine multiple functionalities into a single data loader for transport between the squadron work-stations and the flight line.

D. Information Display. The display capability element provides for the information presentation interface between the aircrew and the aircraft information management systems. This section addresses cockpit and crew-member glass displays.

1. Current Capabilities. NVG Compatible, Liquid Crystal Display.

Significant advancements in commercial display applications are making their way into military cockpits. Most Naval Aviation cockpits have integrated different display technologies to support night vision devices and operations in very low levels of illumination. It is usually more challenging to develop adequate contrast and illumination levels in the very bright daytime environment of a tactical cockpit. The latest displays being fielded incorporate enhancements in resolution, brightness, night vision compatibility and flexibility, and employ solid state engineering for higher reliability (tens of thousands of hours) with greater resistance to vibration, shock, humidity, and temperature extremes. Observance of military and industry standards enhances smooth interface and compatibility with associated avionics systems. The two primary leading technologies currently being integrated are Light Emitting Diode (LED) and Active Matrix Liquid Crystal Display (AMLCD) products. The AMC&D program has fielded a 5"x5" AMLCD that brings improved reliability and higher resolution. AV-8B and F/A-18C/D have fielded the Advanced Multi Purpose Color Display (AMPCD), which is a "smart display" (includes internal processing rather than merely presenting an image). Improved sensors such as the Advanced Electronically Scanned Array (AESA) and additional network information sources (such as Link 16) drove the requirement for a larger size, higher resolution 8"x10" Multi Function Display (MFD) to be integrated in the F/A-18F and EA-18G. The Common Cockpit program of the Multi-Mission Helicopter program is affording similar capability to the MH-60S and MH-60R. The PMA209 CNS/ATM team has integrated or is integrating glass cockpits into E-2C, P-3C, CH-53E and MH-53E (procurement not funded), US Coast Guard HC-130H, and C-130T.

2. Funded Enhancements and *Potential Pursuits*.

Overview: Potential near term display improvements include increased luminance and contrast for bright environments, wider dimming ranges for night vision compatibility, weight reductions, power demand reductions, instant-on illumination in extreme cold conditions and reduction of toxic components. Implementation of network-centric data exchange will drive significant increases in the amount of tactical information that can be displayed. CNS/ATM functionalities will increase situational awareness, but will also place more demands on the quality of the display.

3. Large Area Programmable Layout Displays. (2013) JSF Block II aircraft will be equipped with a large (20" x 8") AMLCD cockpit dashboard Panoramic Cockpit Display (PCD) that incorporates presentations of what are normally separate instruments (primary flight and aircraft and engine performance instruments) along with sensor, controller and data page displays. Boeing has proposed a similar large area display for their Foreign Military Sales (FMS) versions of the F/A-18E/F aircraft. Much like personal computer station 'windows' formatted displays, the aircrew can control the size, layout and content of information that gets presented. The single large display design would basically cover the majority of the cockpit dashboard and would enable the flight crew to mix and match any display windows desired depending on the mission. This design will also enable the crew to place individual instrument or tactical display items anywhere on the instrument panel, and to increase the size of preferred primary display elements.

Enhanced Backlighting Light Emitting Diodes (LEDs). (2015) Current AMLCDs employ inefficient backlight technology, which introduces significant power, heat, and reliability penalties that reduce mission effectiveness for airborne applications. Innovative LED illumination and control technologies are being explored which synchronize backlighting with the displayed image and enhance the optical performance of AMCLDs by providing higher contrast ratios and enhanced image clarity.

E. Moving Map. Tactical Aircraft Moving Map Capability (TAMMAC) is the most common moving map and mission data loading system in Naval Aviation platforms.

1. Current Capabilities. Limited Map and Mission Information Capacity.

TAMMAC provides improved overall situational awareness by displaying an aircraft centered depiction of mission routes, threats, terrain features, and aeronautical chart data overlaid on various map and satellite imagery products. The associated mission data loading element is also essential for uploading other mission data, such as communications codes and tactical data, as well as downloading of critical aircraft maintenance data. Proposed TAMMAC obsolescence mitigation and enhancement initiatives include the incorporation of the Global Area Reference System/Common Geographic Reference System map products, real time update of target/threat information (via Link 16), and color overlays for selective features such as kill boxes and Blue Force Tracker (BFT) data. New COTS map products continue to come on the market with improved features such as modularity for execution on multiple hardware and operating systems configurations, smaller footprint using less memory and processing power, and ability to include other applications such as weather, Cockpit Display of Traffic Information (CDTI), and BFT. The EGC was developed to be used in the DMC/DVMC to run TAMMAC software, or to be incorporated into processors capable of running FlightScene software. The EGC successfully ran FliteScene software in the NACRA T-Rex demonstrator aircraft mission computer.

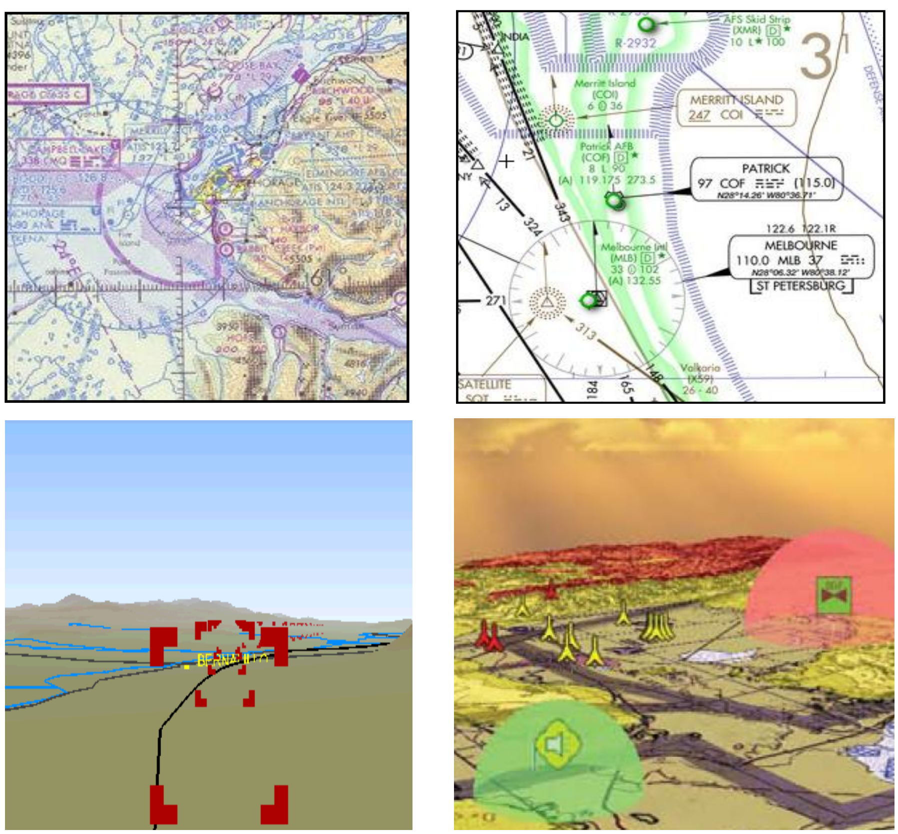
2. Funded Enhancements and *Potential Pursuits*.

Increased data capacity DTED Level II TAMMAC. (2012) TAMMAC currently supports TAWS software which provides a predictive Controlled Flight Into Terrain (CFIT) protection capability. It compares aircraft position against a DTED Level I (100m resolution) to determine if the current flight profile and parameters could result in a collision. The TAMMAC data storage capacity is being increased in order to process higher fidelity DTED Level II (30m) information to safely support helicopter operations. Larger mission planning file sizes and the requirement to cover more area for expeditionary operations or more flexibility in ad hoc mission changes have driven the need for greater transfer device capacity. As part of the obsolescence upgrade program, the TAMMAC system will increase onboard storage for map and mission data from 3.2G to 64G with deliveries available in 2012.

Higher fidelity Geo-referenced Maps. (2013) The AH-1Z and UH-1Y COTS recorder will incorporate increased processing power to run DTED Level II and FlightScene, which provides greater fidelity geo-referenced graphics than legacy chart representation media. FlightScene requires a minimum data transfer rate of five megabytes (Mbps) per second.

Obstacle Representation. (2015) The TAWS team is working with the ADDS team to put an obstacle database in the MH-60R/S aircraft. The obstacle database could reside in the ADDS system to support the TAWS-II algorithm processing in the Mission Computer. One of the primary issues with this program is how to maintain the database with the most current obstacle representation especially when towers can now be constructed in a very short period of time. Once completed, this capability will be made available to any aircraft that will incorporate ADDS or any TAWS capable aircraft that has enough data storage space for the obstacle database. The goal is to enable all aircraft to eventually also incorporate an obstacle database for enhanced safety.

Enhanced Visualization - Perspective Viewing. (2018) Current moving maps primarily display geographical areas in two-dimensional, ‘god’s eye’ or plan view formats. Commercial gaming, Google Map tools and auto GPS display technology advancements are enabling increased imagery quality, smaller data file sizes and increased display options. The National Geospatial Intelligence Agency (NGA) has posted aeronautical charts of all scales, from Joint Operations Graphics (JOGs) down to Citimaps on line. Data file size reduction is enabling faster manipulation of databases which can enable a three-dimensional, virtual perspective view that is easier to interpret for spatial referencing. The extensively fielded TAMMAC product supplier is developing perspective view renderings that can be used to more clearly display obstacles.



Plan Views (top) versus Perspective Views (bottom).

F. Information Distribution. This capability element addresses management of information within the platform.

1. Current Capabilities. 1553, Fiber Channel, Point to Point Ethernet Buses.

For information transfer within the aircraft, the most widely used standard is MIL-STD 1553 bus protocol. Extensive resource availability, simple component interface, relatively low latency, adequate cable run, good fault isolation and relatively low cost have driven nearly ubiquitous incorporation across Naval Aviation. 1553 bus data transmission rates remain suitable for command functions such as flight control and munitions deployment, however they are too slow to serve the increased peer-to-peer communications needed by avionics applications in support of data, audio, and video information exchange. Some modern platforms use Fiber Optic (FO) channel networks to move data, which supports a standard of 1 Gbps and has demonstrated near term potential growth to 4 Gbps. However, FO is much more expensive to run and maintain, and requires newer interfaces and network switches. The current commercial standard for networking applications is Transmission Control Protocol / Internet Protocol (TCP/IP). IP Version 6 (IPv6 - the latest standard; required for systems developed after 2003) offers greater data security and a much larger number of unique addresses.

2. Advanced Research and Technology Development.

High Bandwidth (FO) Fiber Optic Wavelength Division Multi-plexing (WDM) Multi-Level Security (MLS) Network. (2010-2012) 1553 bus wiring transfer rates vary from 1 Mbit/sec to 100 Mbps across the same wiring form factor, with a potential bandwidth of 200 Mbps. The advantage to incorporating these enhancements would be a simpler and more cost effective retrofit effort than trying to incorporate a new transfer medium. Institute of Electrical and Electronics Engineers (IEEE) 1394 Firewire offers 100-400 Mbps throughputs, but has issues with run length and maintenance. Avionics Full Duplex Switched (AFDS) Ethernet provides a deterministic data network for safety critical applications. Fast or Gigabit Ethernet have even faster transfer rates, but have similar integration and sustainment challenges. Serial Express is a newly developing standard that runs on Firewire with 1 Gbps speeds and longer cable runs. Universal Serial Bus (USB) capabilities appear to be growing the fastest [transfer rates: USB 1.0 = 12 Mbps; USB 2.0 = 480 Mbps; USB 3.0 = 5 Gbps]. The newest standard, ExpressCard 2.0, supports transfer speeds up to 5 Gbps. FO runs can support up to 10 terra-bytes per second. When coupled with WDM, FO can also transmit several different channels simultaneously and independently, with varying rates of transmission. Each channel is carried on a separate wavelength, is independent and does not interact with other channels. WDM is being evaluated by the JSF and the P-8 aircraft teams. A working group has been established to define a common standard for DoD WDM.

3. Funded Enhancements and *Potential Pursuits*.

Increased data distribution speed. (2018) Today's complex systems need near real time computer systems operations across internal aircraft networks. Aircraft cannot keep pace with evolving standards, but choosing one optimized standard and integrating it across Naval Aviation could ensure faster, cheaper and broader integration of future enhancements. The PMA209 Mission Systems team is monitoring progress of numerous advanced research projects including Enhanced 1553 (E1553), expansion of the Fiber Channel Network Switch (FCNS), WDM single mode fiber, Highly Integrated Photonics and Electronics (HIPE – FO integrated circuits) and Fast/Gigabit Ethernet.

G. Mission Planning & Execution. Mission planning and execution systems consist of aircrew mission information planning capabilities delivered as software programs integrated into computer systems, data transfer devices used to move the derived products to their supported aircraft avionics/sensors/weapons, platform information upload interfaces, and onboard processors. These systems also support post-mission download, analysis, and reporting of data captured while in flight. Advance planning using operational environment and tactically relevant data enables the aircrew to focus on primary flight functions and to more effectively react to changes. The CNO designated the Joint Mission Planning System – Maritime (JMPS-M) as the single mission planning system for Naval Aviation. JMPS-M systems include software components funded and developed by a broadly dispersed, but collaborative group of organizations/agencies (e.g., various platform, weapon, and sensor PMAs) whose products are then integrated, fielded, and then supported by the PMA281 JMPS Team as platform-specific JMPS-M Mission Planning Environments (MPEs).

1. Current Capabilities. Interoperable Unit Level, Service Oriented Collaborative Planning.

JMPS-M is operationally deployed, has fully replaced Tactical Automated Mission Planning System (TAMPS), and is on track to effectively replace Navy-Portable Flight Planning Software (N-PFPS) and platform-specific mission planning and execution systems for nearly all Naval Aviation platforms by 2014. JMPS provides a Windows-based, automated mission planning capability using digitized terrain, maps/charts, environmental data, aircraft, and avionics parameters. JMPS loads platform data transfer devices with information used to pre-set navigation avionics and flight computers, including route of flight data (e.g., waypoints, sequential steering files), air-to-air radar presets, Navigation Aid identifiers and channel identification files.

JMPS basic flight planning functions include calculations for heading, distance, climb/descent, time, and fuel burned; takeoff/landing and weight/power performance data; route planning, de-confliction and 2D and 3D mission rehearsal/fly-through; display/layering and loading of National Geospatial Intelligence Agency (NGA) imagery, maps and charts; solar/lunar almanac prediction; aerial refueling planning; Combat Air Support (CAS) planning; coordination via MS Outlook email; and mission brief/debrief.

JMPS combat mission planning functions include weapons and sensor planning; aircraft configuration and loadout planning/management; threat data query of Global Command and Control System - Integrated Imagery and Intelligence (GCCS-I3) Modernized Intel Database (MIDB), import/export, management, analysis and masking; query/import and use of Distributed Common Ground Station - Navy (DCGS-N) provided imagery products (e.g., for Automatic Target Acquisition (ATA) capabilities); import/parsing and use of Air Tasking Order (ATO), the Airspace Coordination Order (ACO), target data, force movement information such as tactical graphics, and disposition of assets to Joint commanders and their forces. Naval Aviation platforms depend on JMPS to plan and load critical data/settings for Precision Guided Munitions (PGMs), sensor systems, tactical data-links and secure voice communications. A variation of JMPS known as JMPS-Expeditionary (JMPS-E), is provided to ARG/MEU PHIBRON staffs to support collaboration for ship-to-shore wave planning.

JMPS-M MPEs are currently approved for connection to various naval networks, including Integrated Shipboard Network System (ISNS), Navy/Marine Corps Intranet (NMCI), and Marine Corps Enterprise Network (MCEN), and is expected to be approved for connection to Consolidated Afloat Networks and Enterprise Services (CANES) networks as well. Connections to these networks provide JMPS-M users access to a wide variety of network resources and databases that are helpful for coordination and planning of their missions.

Tables A-1 through A-3 identify Mission Planning support constructs:

	C-2A	E-2C (all)	E-2D	EA-6B (all)	FA-18 (all)	EA-18G	F-35C	X-47B
Mission Planning System	J	J	J	J	J	J	U	U

Table A-1: Carrier Strike Group Users

	AH-1W	AH-1Z *	UH-1Y	UH-1N *	AV-8B	MV-22 (all)	CH-46E	CH-46E	MH-53E *	CH-53 (all)	SH-60B/F	HH-60H	MH-60R/S	F-35B	PHIBRON **
Mission Planning System	J	J	J	J	J	J	J	J	J	J	J	J	J	U	J

Table A-2: Expeditionary Strike Group Users

	EP-3E	P-3C	EP-8A	P-8A	RQ-4A	MQ-8B	C-130 ***	KC-130 ***
Mission Planning System	J	J	U	U	U	U	P	P

Table A-3: Maritime-Patrol and Support Aircraft Users

J=JMPS, P=PFPS, U=Unique.

***** = PFPS software provided as part of a JMPS-M integrated/managed MPE for specific functionality until this function is moved to JMPS application software.

****** = JMPS-Expeditionary (JMPS-E) systems installed on LHA/LHDs for this community.

******* = Aircraft being supported by USAF-provided PFPS system configurations.

Weapons, avionic subsystems, and sensors supported by JMPS:

- High-Speed Anti-Radiation Missile (HARM)
- Advanced Anti-Radiation Guided Missile (AARGM)
- Joint Stand Off Weapon (JSOW)
- Joint Direct Attack Munitions (JDAM)
- Laser JDAM and Dual-mode Laser JDAM
- Standoff Land Attack Missile – Extended Range (SLAM-ER)
- Joint Tactical Information Distribution System (JTIDS)
- Multifunctional Information Distribution System (MIDS)
- Global Positioning System (GPS) equipment
- ARC-210 radios
- HAVEQUICK nets, Blue Force Tracker (BFT)
- Airborne Electronically Scanned Array (AESA) Radar.

Several of the capabilities listed above cannot be employed without JMPS.

For additional details Platform, sensor, and weapon capabilities that are in work by developers across the JMPS Enterprise, contact PMA-281 for coordination assistance with the appropriate developing agency.

2. Funded Enhancements and *Potential Pursuits*.

Improved framework stability, Faster planning, Air drops Planning Aerial Refueling Planning. (2014) Microsoft Windows XP, the current operating system for JMPS-M, will no longer be supported by industry after April 2014. JMPS-M is upgrading to Windows 7 architecture, which provide a more stable framework environment and result in fewer system crashes. It will also increase throughput speed, resulting in faster speed of mission planning. Additionally, there will be new operational capabilities cut in with the new framework, including Airdrop Planning (supports C-130 [if desired] and V-22) and Air Refueling (supports C-130 [if desired]).

Improved framework stability, Faster planning, Increased data/detail loading, Data at Rest encryption. (2018) In order to keep pace with industry, JMPS-M must continue evolving to adopt current and supported versions of operating systems and data management architectures. Current 32 bit processing is challenged to support the huge amounts of data required for planning tactical missions, particularly in F/A-18E/F and EA-18G aircraft. This causes additional system instability that movement to Windows 7 can only partially address. PMA281 would implement a 64 bit data management, which is much more efficient and fast, enabling a quantum leap in data volume management and processing speed. Windows 8 is expected to be the minimal baseline operating system required for the next generation of processors. The combination of Windows 8 and 64 bit processing will again stabilize the systems and speed up planning. Operators will be able to load much more and higher fidelity data for their missions. Additionally, the new architecture would meet Data at Rest encryption requirements established by DoDI 8500.2, Information Assurance (IA) Implementation policies.

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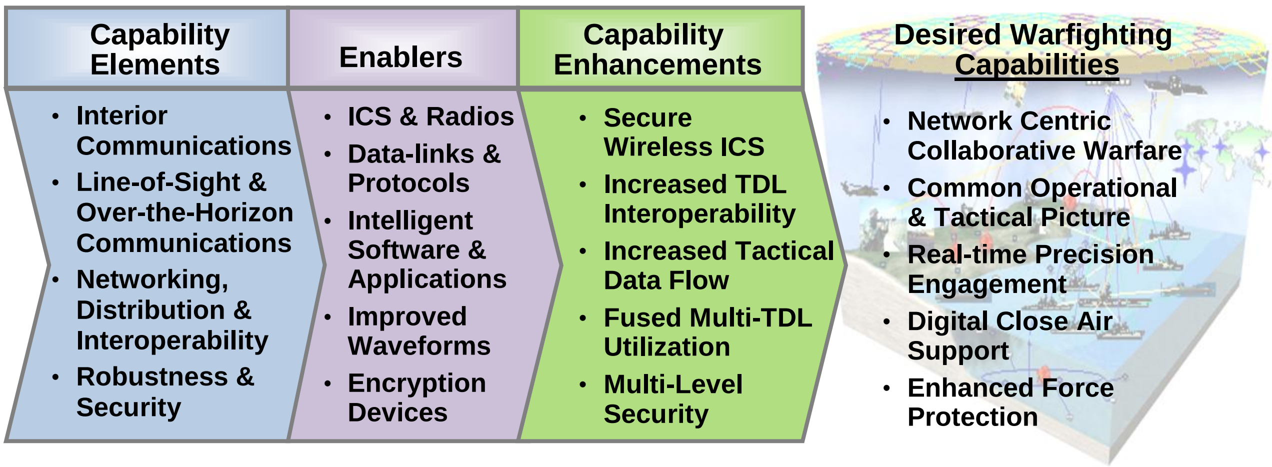
Appendix A-2:
Information Exchange

Scope: This section covers hardware, software, waveforms, protocols and security systems that enable secure/non-secure voice connectivity and data collaboration between aircraft and other warfighters. Information Exchange (IE) covers a broad scope of technologies that can be divided into physical and Networking layers. The physical layer is categorized as Line of Sight (LOS) and Beyond Line of Sight (BLOS) communications. The IE section is divided into three subcategories and is presented in order of the most mature technologies and capabilities to the least mature: (I) LOS Info Exchange, (II) BLOS Info Exchange, and (III) Internet Protocol (IP) Networking.

Capability Evolution:



Objective: Network Centric Warfare and Information Dominance

Baseline Enhancement Objectives and Transition Strategy.

The primary means of tactical collaboration within Naval Aviation today involves voice communications. Enhanced collaborative capabilities are beginning to be fielded using Link 16. Advanced collaborative warfighting operations, such as Network Centric Collaborative Targeting (NCCT) will require airborne networking waveforms such as Tactical Targeting Network Technology (TTNT) or an Advanced Tactical Data Link (ATDL) and network processors supporting Common Operating Environments (COE).

The current state of capability in IE generally enables warfighters to communicate effectively within the same Service group and exchange data within the same mission community. Commercial competition for Radio Frequency (RF) spectrum and increasing warfighter demands for streaming video are exceeding the spectrum allocated to DoD. To some extent, these demands are being met by using data compression, taking advantage of more efficient coding and modulation techniques, and operating at higher frequencies (Ku and Ka band) that require directional antennas. Operating in spectrum below 2 GHz enables utilization of omni-directional antennas, but these frequencies are in high demand by commercial wireless providers. Continued spectrum access is a serious challenge for DoD and will get worse as commercial enterprises' demands for wireless data and new satellite systems continue to increase.

Interoperability between Services and among Coalition partners currently relies heavily on pre-mission configuration planning and system synchronization. Translating, sharing, or "gatewaying" data between dissimilar systems can provide common operational visualizations and data distribution. Gateways have been in development for many years. They principally take small pieces of information in one link format and translate them into equivalent protocol in a different data link. This approach becomes very complex as additional data links, formats, or network connections are added. Message correlation between links, loss of precision, and differing data representations further complicate the task.

Data gateways and range extensions have been demonstrated through several initiatives and fielded experiments. There are no specific acquisition programs of record for gateway capabilities; however, the Battlefield Airborne Communications Node (BACN), Joint Range Extension (JRE), and Interim Objective Gateway/Objective Gateway (IOG/OG) have proven the benefits of information translation.

BACN: is an Air Force system that serves as a BLOS communications relay platform to connect different radio frequencies through a computer controlled bridge in the sky called a gateway manager. The system includes Tactical Digital Information Link (TADIL) radios to transmit data between aircraft, VHF AM and FM voice radios for ground forces, Situational Awareness (SA) data links for ground troops, and satellite communications (SATCOM).

JRE: Joint Range Extension (JRE) Gateway is a multi-protocol router of Link 16 tactical data that provides TADIL-Joint (TADIL-J; NATO designation is Link 16) messaging and voice between LOS terminals or over a BLOS medium. JRE is based on the Joint Range Extension Applications Protocol-C (JREAP-C) in MIL-STD-3011. JREAP-C is a secure data link interface that encapsulates TADIL-J information into IP based networks.

IOG/OG: is an Air Force family of systems connecting data and voice networks to provide mission critical information to Joint forces, coalition partners and civil authorities. Advanced gateway capabilities enable transition from legacy gateways with niche requirements and narrow user-sets to the Global Information Grid (GIG) through a router/ server and a link back to the IP environment. The system also allows different data links, such as Link 16 or TTNT, to communicate with each other. It will also allow legacy communications systems to connect with the Joint Tactical Radio System (JTRS) and allies' systems.

Strategic Approach: The PMA 209 Communications and Airborne Networking (CAN) team has adopted a three pronged strategy to managing the Naval Aviation Enterprise's (NAE) communications and airborne networking capabilities:

1) Support efforts to **maintain** the NAE's existing communications capabilities.
2) Indentify and field improvement and upgrades to our current systems which allow the NAE to expand capabilities through an **evolutionary** approach where practical.
3) **Transform** our communications and airborne networking capabilities by promoting the fielding of a Common Operating Environment (COE) across Naval Aviation and supporting the establishment of standards that enable the rapid fielding of collaborative capabilities.

I. Line of Sight (LOS) Information Exchange.

Mandates and Milestones:

Multifunctional Information Distribution System – Joint Tactical Radio System (MIDS-JTRS) Initial Operational Capability (IOC). (2010) MIDS-JTRS (or MIDS-J) is a form-fit-function replacement for the MIDS Low Volume Terminal (LVT), which provides enhanced through-put Link 16 for tactical aircraft. It was deployed on Super-Hornet in 2011. It provides Tactical Air Navigation (TACAN), Link 16 digital tactical data and digital voice (J-Voice), and programmable encryption to comply with the National Security Agency's (NSA) crypto modernization mandate. It is Software Communications Architecture (SCA) compliant (i.e. capable of running JTRS software waveforms) and has additional transceiver slots to accommodate to future upgrades of JTRS waveforms including the TTNT waveform.

ARC-210 Generation 5 RT-1939(C) IOC. (2012) The Gen 5 ARC-210 was approved for integration on new production aircraft in 2011 and will be operationally deployed in 2012. The Receiver Transmitter (RT) employs a Software Defined Radio (SDR) architecture with an increased frequency range (30-941 MHz) and red-side Ethernet data port. It includes the capabilities resident in earlier ARC-210 versions. Future software upgrades will add UHF SATCOM Integrated Waveform (IW), the updated link layer protocol for Combat Net Radio (CNR), the Second-generation Anti-jam Tactical UHF Radio for NATO (SATURN) waveform, the Enhanced SINCGARS (Single Channel Ground/Airborne Radio System) Improvement Program (ESIP) waveform, the Bandwidth Efficient Advanced Modulation (BEAM) LOS waveform, and hooks to support Joint Precision and Landing Approach (JPALS) and Mobile Users Object System (MUOS) functionality.

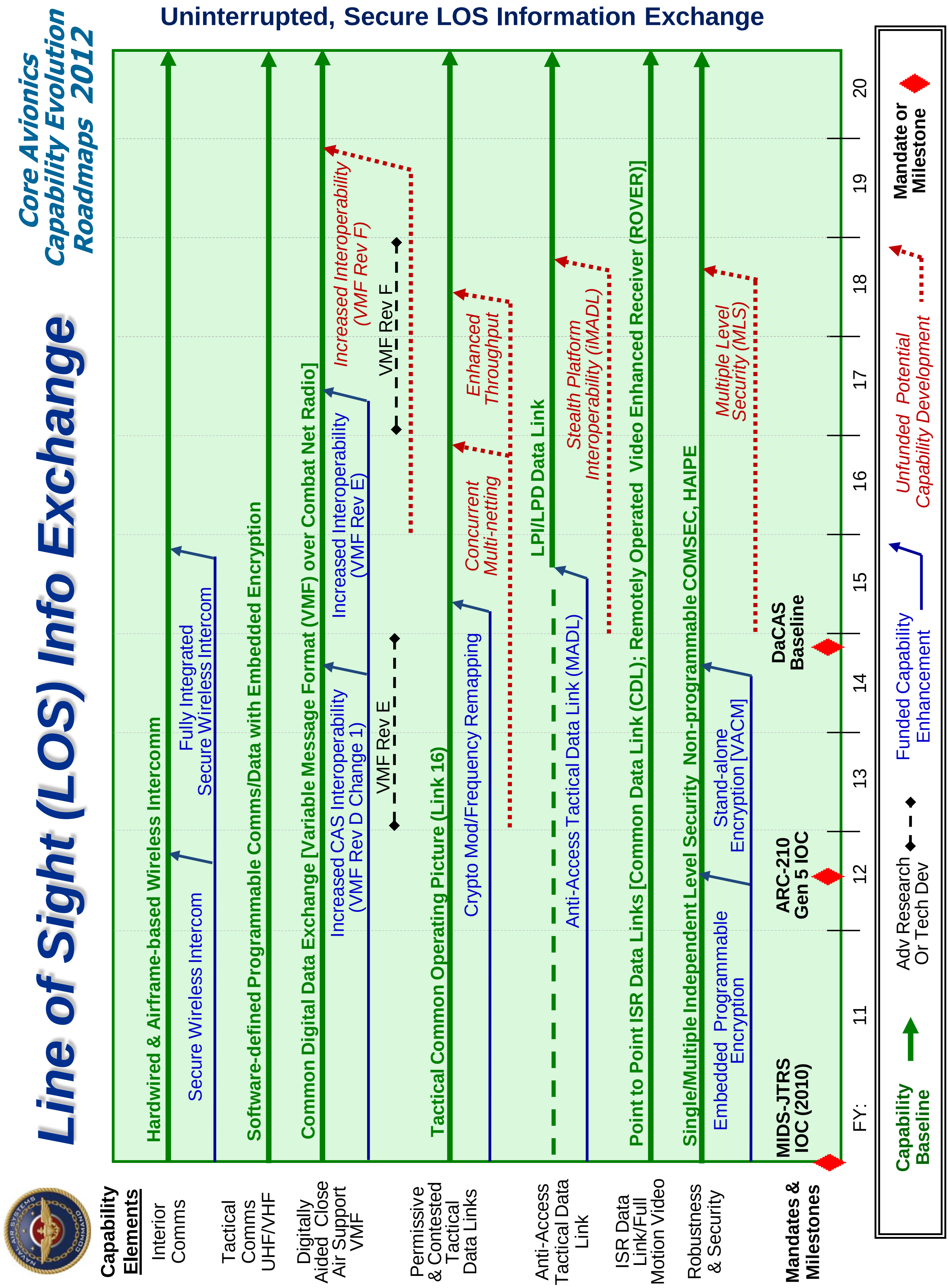
Digitally aided Close Air Support (DaCAS) baseline implementation (2014). In Dec 2009 the Joint Requirements Oversight Council (JROC) approved the Joint Fires Executive Steering Groups objective to digitally interconnect Joint Terminal Attack Controller (JTAC) and Joint Fires Observer (JFO) systems with CAS platforms. The JROC endorsed the Variable Messaging Format (VMF) over CNR as the near term LOS CAS standard protocol, and directed the Joint Forces Command (JFCOM) DaCAS Change Control Board to define a common implementation of the appropriate standards (Block 1) by the end of 2010. Block 1 defines a link layer protocol (MIL-STD 188-220 Rev D Chg1), a message header standard (MIL-STD 47001D), and the VMF message standard (MIL-STD 6017B). CAS mission aircraft must configure for VMF Rev D Chg 1.

Capability Element Evolution:

A. Interior Communications. This element addresses wireless systems used for crew members to communicate with each other within the platform.

1. Current capabilities. Hardwired and Airframe-based Wireless Intercomm.

Naval aircraft primarily use Intercomm Systems (ICS) that require aircrew to be plugged in via a hard cord to an embedded hard-wired system outlet at each operating station. This design restricts crew mobility and presents an entanglement hazard during emergency egress. The current Naval standard for wireless intercom, Airborne Wireless ICS (AWICS), is being incorporated into the C-2, H-46, H-53, H-60, UH-1Y and MV-22.


Line of Sight (LOS) Info Exchange
Core Avionics Capability Evolution Roadmaps 2012
Uninterrupted, Secure LOS Information Exchange
Capability Elements
Interior Comms
Tactical Comms UHF/VHF
Digitally Aided Close Air Support VMF
Permissive & Contested Tactical Data Links
Anti-Access Tactical Data Link
ISR Data Link/Full Motion Video
Robustness & Security
Mandates & Milestones
Hardwired & Airframe-based Wireless Intercomm
Secure Wireless Intercom
Fully Integrated Secure Wireless Intercom
Software-defined Programmable Comms/Data with Embedded Encryption
Common Digital Data Exchange [Variable Message Format (VMF) over Combat Net Radio]
Increased CAS Interoperability (VMF Rev D Change 1)
Increased Interoperability (VMF Rev E)
Increased Interoperability (VMF Rev F)
VMF Rev E
VMF Rev F
Tactical Common Operating Picture (Link 16)
Crypto Mod/Frequency Remapping
Concurrent Multi-netting
Enhanced Throughput
LPI/LPD Data Link
Anti-Access Tactical Data Link (MADL)
Stealth Platform Interoperability (iMADL)
Point to Point ISR Data Links [Common Data Link (CDL); Remotely Operated Video Enhanced Receiver (ROVER)]
Single/Multiple Independent Level Security Non-programmable COMSEC, HAIPE
Embedded Programmable Encryption
Stand-alone Encryption [VACM]
Multiple Level Security (MLS)
MIDS-JTRS IOC (2010)
ARC-210 Gen 5 IOC
DaCAS Baseline
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

2. Funded Enhancements and *Potential Pursuits*.

Secure Wireless Intercom. (2012) NSA provided Information Assurance certification (up to SECRET level with proper software version and appropriately keyed) for the Windtalker Encryption Device (WED). It will provide network security for Wireless ICS, enabling aircrew to maintain secured communications, with the cockpit aircrew while performing combat duties in the landing zone, to include: medical evacuation, search and rescue, refueling and coordination of operations with ground units such as infiltration and extraction.

Fully Integrated Secure Wireless Intercom. (2015) The CH-53K will install the Samina-SCI FireComm Integrated Secure Wireless Intercom System. FireComm will provide secure wireless ICS among aircrew and digital-audio enhanced voice warnings. The system has open architecture, digital processing, and is user configurable. This system is also planned for integration into other Service platforms, including AH-64D, C-27J, C-130J, F-15C/D and CV-22.

B. Tactical Communications (TAC COM) VHF/UHF.

1. Current capabilities. Software-defined, Programmable Digital Comms/Data with Embedded Encryption.

The primary frequency bands used for tactical LOS voice communications and limited point-to-point and networked data, voice and imagery are Very High and Ultra High Frequency (VHF and UHF). DoD frequency allocations are 30 – 88 MHz for VHF Lo-band and 108-174 MHz for VHF Hi-band, and 225 – 400 MHz for UHF. The latest ARC-210 receiver-transmitter variant (RT-1939 Gen 5) radio supports Air Traffic Control (ATC), maritime and civilian first responder bands. The Gen 5 variant supports ATC Voice/HaveQuick/SINCGARS, VMF over CNR, and SATURN LOS fast frequency hopping waveform for improved interoperability between properly configured NATO coalition platforms. Joint Strike Fighter (JSF) is incorporating the SATURN waveform. NSA has certified the Gen 5 for Type 1 encryption, giving it modern, embedded, fully programmable information security. Gen 5 also includes hooks for integration of additional capabilities when they become available, including VMF Rev D Chg 1, JPALS datalink, IW and MUOS SATCOM, and Tactical Secure Voice (TSV). The Gen 5 variant represents the state of the art in tactical communications. It is considered baseline capability because it is already fielded in production aircraft, but meets IOC in 2012.

C. Digitally aided Close Air Support (DaCAS) / VMF. CNR/VMF standards enable DaCAS (exchanging digital data vs. voice communications to execute CAS). Due to the development of non-interoperable standards by each Service for exchange of digital data, the Office of the Secretary of Defense (OSD) directed the Services to develop a common interoperable method for exchanging digital data over tactical radio systems. Services established the CNR Working Group (CNRWG) to develop and control a set of standards. CNR standards enable a small number of users to exchange digital VMF data over LOS radios. They are used extensively by US Army and USMC ground forces and in Naval Aviation to support CAS missions. The CNR network protocol stack consists of a physical layer, VHF/UHF LOS communications (including SINGCARS and HAVEQUICK), a link layer protocol MIL-STD-188-220 (Digital Message Transfer Device Subsystems), a MIL-STD-2045-47001 (Connectionless Data Transfer) application layer header, and the MIL-STD-6017 VMF message standard application.

1. Current capabilities. Common Digital Data Exchange (VMF over CNR).

In order to communicate data via bit level standards, all platforms must implement the same revision levels. Since revisions can occur every 18 months, it is has been difficult to achieve interoperability amongst ground equipment and air platforms. For this reason, and the fact that some platforms are yet to implement the standards, CAS missions are still primarily conducted via voice communications today.

2. Advance Research and Technology Development.

VMF Revision E and F. (2013-14, 2017-18) Jointly managed advanced research initiatives are planned to keep pace with VMF obsolescence and operational needs. VMF Revs E and F each add new capabilities or improvements to VMF Rev D Chg 1.

3. Funded Enhancements and *Potential Pursuits*.

Increased CAS Interoperability (VMF Revision D Change 1) (2014) To address the connectivity problems, the CAS community agreed to make all of the CNR standards interoperable. Rev D Chg 1 updates MIL-STD-188-220D and MIL-STD-2045-47001D, and includes MIL-STD-6017A. Currently the FA-18 and AV-8B are configured to manage different protocol versions of VMF, so JTAC and JFO ground controllers are unable to talk to both FA-18 and AV-8B support assets simultaneously. Lack of connectivity with the asset that happens to be first on site can cause loss of time-sensitive engagement opportunities. Time delays caused by reconfiguring equipment or relaying support requests through other pipes can also result in mission failure. Standardized protocol enables interoperability with both assets, enabling the ground controller to engage with the proper munitions or with a coordinated attack. Aircraft to aircraft interoperability will also allow the airborne assets to improve coordination in advance of engagement, or more effective on-scene mission handoff.

Increased Interoperability (VMF Revision E) (2017). Rev E is funded for development by 2017. Rev E expands CAS interoperability across other communities.

Increased Interoperability (VMF Revision F) (2019). Although Rev F development and integration are not currently funded, managers are planning for a FY16 start to keep pace with requirements expansion and inter-system interoperability gaps.

D. Permissive & Contested Tactical Data Links. Permissive refers to operations where there is reduced threat or jamming. Contested refers to operations where there is significant but not overwhelming threat or jamming.

1. Current capabilities. Tactical Common Operational Picture (Link 16).

The primary LOS data link in use by DoD and by many allied/coalition partners is Link 16. The primary capability provided by Link 16 is common SA from sensor generated tracks. Link 16 is an anti-jam UHF L-band data link widely deployed on ground, maritime and aviation platforms. It enables the exchange of position information, track data via TADIL-J messages and provides two channels of digital J-voice. Link 16 is integrated on F/A-18s, E-2s, EA-6B, EP-3, P-3C, and MH-60R. The F-35, P-8, CH-53K and Broad Area Maritime Surveillance (BAMS) will have Link 16 capability. All except E-2C, EP-3 and the F-35 have integrated MIDS-LVT or MIDS-JTRS terminals for this capability. The E-2C and EP-3 employ a Joint Tactical Information Distribution System (JTIDS) terminal and the F-35B implements Link 16 via their Integrated Communication, Navigation, Identification and Avionics (ICNIA) suite.

2. Funded Enhancements and *Potential Pursuits*.

Crypto Modification and Frequency Remapping of Link 16 Terminals. (2015) Cryptographic Modernization (CM) will re-design cryptographic components for Link 16 terminals. The plan is to integrate programmable Common Crypto Modules (CCM) that use multiple crypto algorithms along with enough memory capacity to store a year's worth of keys. Additionally, frequency remapping will enable interoperability of Link 16 with future radio navigation systems that the FAA may develop. The remap algorithm favors under-utilized frequencies to smooth out frequency hopping schemes.

Concurrent Multi-Netting. (CMN) (2016) CMN addresses the operational need to simultaneously receive on multiple Link-16 nets. It leverages a Link 16 waveform feature that allows multiple signals to be received simultaneously (referred to as 'stacked nets'). Current Link 16 nets are designed to allow C2 platforms to listen to multiple fighter nets. Since Link 16 is a half duplex waveform, these platforms cannot listen while transmitting. CMN capability will enable the C2 assets to listen to multiple participants simultaneously on the limited number of time slots available, and enable fighters to receive data from other fighters while listening to the surveillance net. An additional Link 16 receiver is required for each additional net being received. The CMN objective is to provide a capability to receive on up to four Link-16 nets simultaneously while retaining the capability to transmit.

Enhanced Throughput. (2018) Link-16 Enhanced Throughput (ET) provides the ability to transmit more information via Link-16 without impacting the RF spectrum. Baseband throughput is increased at the expense of range/waveform anti-jam (AJ) performance. Although there are ET modes that could provide close to an order of magnitude increased throughput, modes that achieve useful ranges provide a 3 to 5 times increase in data rate. The MIDS-JTRS (MIDS-J) terminal is the only terminal currently capable of supporting the ET mode; however the 1553 bus interface to the MIDS-J terminal will still limit achievable data rates.

E. Anti-Access Tactical Data Link.

Anti Access refers to operations in regions with a threat level high enough to require Low Observable (LO) platforms.

1. Current capabilities. (none). [2015: LPI/LPD Data Link].

Naval Aviation currently will not have a 5th generation Low Probability of Intercept (LPI) or Low Probability of Detection (LPD) data link until 2015.

2. Funded Enhancements and *Potential Pursuits*.

Anti-Access Tactical Data Link (Multi-function Advanced Data Link – MADL). (2015) MADL is a Ku Band, short/medium range, directional, dynamic, LPI/LPD IP link being developed by the F-35B/C Joint Strike Fighter (JSF) program. It will be the unique LO data link, designed only for the F-35 as an *intra*-flight data link within the Anti-Access Region. It will operate as a linear network ("daisy chain") architecture optimized for a limited number of nodes.

Stealth Interoperability (iMADL) (2018) MADL is proposed to be reengineered to work as an *inter*-flight LO data link within Anti-Access region and be also integrated on the F-22 and B-2.

F. Intelligence Surveillance Reconnaissance (ISR) Data Link / Full Motion Video (FMV).

1. Current capabilities. Point to Point ISR Data Links (Common Data Link - CDL, Remotely Operated Video Enhanced Receiver - ROVER).

The Standard Common Data Link (STD-CDL) is mandated as DoD's ISR data link for wideband transmission of imagery and signals intelligence. STD-CDL is a LOS full duplex link capable of operating in either X-band (9750 – 10440 MHz) or KU-band (14500 – 15350 MHz). Both require directional antennas, making CDL a point-to-point data link. CDL is deployed on Naval Maritime Patrol platforms, helicopters, Navy ships, and Electro-Optical / Infrared (EO/IR) sensor pods, such as the F/A-18 Shared Reconnaissance Pod (SHARP). CDL was originally developed by the Air Force to operate with the U2. The current Rev F version specifies 15 waveforms that provide data rates from 200 Kbps to 274 Mbps. Interoperability has been an issue for CDL systems due to lack of standards beyond the specified physical and link layer specified in the CDL specification. Unmanned Aerial Vehicles (UAVs) had employed various non-standard data links in C, L and S bands to disseminate ISR data until 2005 when STD-CDL was mandated for all UAVs exceeding 30 pounds. A smaller Ku-band Tactical CDL (TCDL) that provides data rates of 10.71 and 21.42 Mbps was developed for smaller tactical platforms, helicopters and UAVs. The latest versions of TCDL support data rates up to 45 Mbps. Man portable receiver terminals have been developed to enable ground troops to receive Full Motion Video (FMV) from airborne terminals. ROVER provides FMV from airborne platforms to LOS users via airborne, mobile, fixed, or man-portable terminals. ROVER I deployed as an air-to-air C-band communications link for Predator video. ROVER II added air-to-ground support for the same video links. ROVER III added L and Ku band coverage along with more robust packaging. Enhanced ROVER III added digital video recording. ROVER IV has S-band coverage and smaller antennas. ROVER V is a handheld form factor that employs advanced encryption standards.

G. Robustness and Security

Communications Security refers to the capability to protect information at all classification levels against unauthorized interception and exploitation. Two aspects of security related to Information Exchange (IE) are: Cryptographic Encryption (COMSEC) of information, both voice and data) to deny unauthorized individuals information derived from telecommunications and to ensure the authenticity of information; and Transmission Security (TRANSEC), the component of COMCSEC resulting from measures designed to protect transmissions from interception and exploitation by means other than cryptanalysis. COMSEC is an important consideration in all three IE domains: LOS Information Exchange, BLOS Information Exchange, and IP Networking.

1. Current capabilities. Single/Multiple Independent Level Security Non-programmable COMSEC, High Assurance Internet Protocol Encryptor (HAIPE).

SINCGARS, HAVEQUICK, SATURN and Link 16 all employ TRANSEC to provide jam resistance and prevent interception of data via frequency-hopping and direct sequence spreading using NSA approved algorithms. They also employ NSA Type I approved crypto security algorithms for voice/data encryption. Current radios are limited to operating at one level of security. HAIPE is an NSA trademarked IP Security (IPSEC) Type I encryption standard mandated for encryption of classified information traversing IP networks. The current HAIPE standard is version 1.3.5.

Current systems are now also capable of Multiple Independent Levels of Security (MILS) architecture. MILS is a high-assurance security accreditation allowing multiple security levels on the same terminal at separate times. When simultaneous operation is necessary, singular systems must operate within one security controlled boundary. Data is moved between security domains through trustworthy monitors such as access control guards, "down-grader" cross-domain tools, or crypto devices. Any MILS versus Multiple Level Security (MLS) accreditation comparison should consider whether the system can be limited to one security domain per single device, or if the application requires the accreditation of a single, more complex MLS kernel connecting multiple domains. The benefit of MILS accreditation is that most applications do not require maximal assurance between internal components because they are in the same security domain.

Existing algorithms currently support secure communications, but are being phased out because they are no longer compliant with NSA requirements. Many embedded COMSEC radios and stand-alone encryption devices are being upgraded to utilize modern cryptographic algorithms. The Air Force's Cryptologic Systems Group (CPSG) is developing VINSON (KY-57/58) and ANDVT (Advanced Narrow-band Digital Voice Terminal) Crypto Modernization (VACM) devices to replace KY-57, KY-58, KY-99, KY-100 and KYV-5 stand-alone encryption devices. VACM devices will be developed in accordance with the Tactical Secure Voice Cryptographic Interoperability Specification (TSVCIS). The ARC-210's embedded COMSEC will be upgraded to meet TSVCIS. Other applications will require other modern encryption standards, such as the Link Encryption Family Interoperability Specification (LEFIS) used by the KIV-7M and the HAIPE Interoperability Specification (HAIPE-IS).

2. Funded Enhancements and *Potential Pursuits*.

Embedded Programmable Encryption. (2012) NSA/Central Security Service (CSS) Cryptographic Modernization initiative requirements for Type 1 cryptographic products and NSA Information Assurance (IA) Directorate policy expect that cryptographic engines for DoD equipment will have a software re-programmable capability. In order to enable timely and affordable upgrades and modernization, future systems must eliminate the need to completely replace hardware. New programmable encryption devices will feature modular architectures with the programmability and scalability to accommodate a wide range of link and IP encryption applications.

Stand-alone Encryption (VACM). (2014) VACM development is an Air Force led effort to provide a Cryptographic Modernization compliant, drop in (Form, Fit & Function) replacement for the KY-57, KY-99A, KY-58, KY-100 and CV-3591/KYV-5 stand alone encryption devices. NSA certification is expected to be complete in the FY13/14 timeframe.

Multi-Level Security (MLS). (2018) Current policies only authorize information flow between applications/components in the same security domain. MLS accreditation would provide an interface capable of allowing a user to access and process content at multiple classification levels simultaneously within a single system. MLS would be implemented by separation mechanisms that support both un-trusted and trustworthy applications through enforcement of one or more internal security policies. NSA has identified MLS as a key enabler for effective network centric operations. A Common Opportunity Review Process (CORP) project will be executed in 2012 to identify the requirements, cost benefit analysis and potential for POM-15 issues to incorporate MLS into a network server product.

Beyond Line-of-Sight Information Exchange.

Mandates and Milestones:

***Note:** Until recently, the Joint Tactical Radio System – Airborne and Maritime Fixed (JTRS-AMF) terminal was planned for potential integration into larger aircraft to enable software managed waveforms utilization. Full rate production had been planned for 2014. The JTRS-AMF program was cancelled by USD AT&L by and Acquisition Decision Memorandum in May 2012.

Integrated Broadcast Service (IBS)/Common interactive Broadcast (CIB). (2015) Cut-over to a new waveform will occur in 2015. No legacy broadcast support is currently anticipated beyond that date. Platform RTs must be modified to receive the new signal.

Mobile User Objective System (MUOS) Fully Operational Capability (FOC). (2015) Five MUOS Satellite Communications (SATCOM) satellites in orbit will establish FOC.

Force XXI Battle Command Brigade and Below (FBCB2) Shutdown. (2017) U.S. Army will no longer maintain the satellite and command station network infrastructure that supports FBCB2 after 2017. Platforms wanting to stay plugged into the Joint BFSA network will need to be equipped to manage the next generation JBC-P utility.

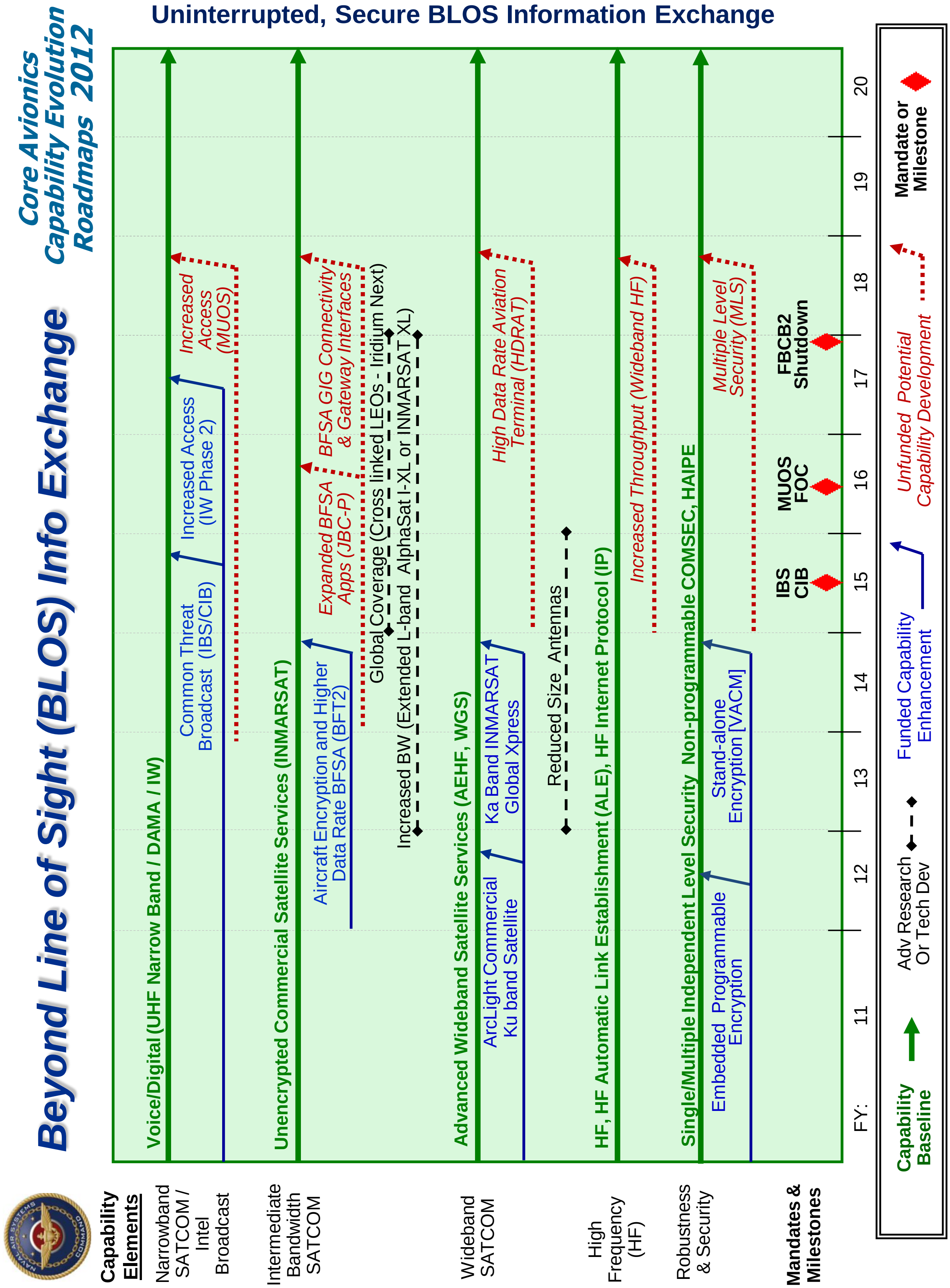
Capability Element Evolution:

A. Narrowband SATCOM / Intel Broadcast.

1. Current capabilities. Voice/Digital (UHF Narrow Band / DAMA / IW).

The majority of Naval Aviation platforms utilize narrow band UHF SATCOM for BLOS voice. The current UHF Follow On (UFO) satellite system allocates specific limited channels for particular services, such as Fleet Secure Voice Common, Fleet Satellite High Command Network (SHCN), Tactical Information Broadcast System (TIBS), or Fleet Flash Net (FFN). Demand Assigned Multiple Access (DAMA) waveform is used to manage military UHF SATCOM usage. The ARC210 is typically used for voice and limited data exchange. The Multi-mission Advanced Tactical Terminal (MATT) is used by platforms requiring access to threat broadcast services. The current UFO SATCOM satellite constellation is vastly over-subscribed and has outlasted its planned service life. By 2015, UFO is expected to have only 40% of its current access capacity.

Integrated Waveform (IW) was designed as an upgrade to DAMA to increase through-put capacity by using more efficient and tighter time partitioning. IW affords a marked improvement in voice quality, a nearly threefold increase in available accesses, improved link margin, and faster, more efficient, more user-friendly terminal operation. Phase I only provides pre-planned pre-assigned services as described in MIL-STD-188-181C and MIL-STD-188-183B. It employs spot beams to enable services on UHF SATCOM networks to run higher performance applications that require more bandwidth. IW is backwards compatible with DAMA. Users of IW can communicate with DAMA users by creating wider IW timeslots that match DAMA timeslots. EUCOM and AFRICOM are requiring in-chopping forces to be IW capable.



Beyond Line of Sight (BLOS) Info Exchange
Core Avionics Capability Evolution Roadmaps 2012
Uninterrupted, Secure BLOS Information Exchange
Capability Elements
Narrowband SATCOM / Intel Broadcast
Intermediate Bandwidth SATCOM
Wideband SATCOM
High Frequency (HF)
Robustness & Security
Mandates & Milestones
Voice/Digital (UHF Narrow Band / DAMA / IW)
Common Threat Broadcast (IBS/CIB)
Increased Access (IW Phase 2)
Increased Access (MUOS)
Unencrypted Commercial Satellite Services (INMARSAT)
Aircraft Encryption and Higher Data Rate BFSA (BFT2)
Expanded BFSA Apps (JBC-P)
BFSA GIG Connectivity & Gateway Interfaces
Global Coverage (Cross linked LEOs - Iridium Next)
Increased BW (Extended L-band AlphaSat I-XL or INMARSAT XL)
Advanced Wideband Satellite Services (AEHF, WGS)
ArcLight Commercial Ku band Satellite
Ka Band INMARSAT Global Xpress
High Data Rate Aviation Terminal (HDRAT)
Reduced Size Antennas
HF, HF Automatic Link Establishment (ALE), HF Internet Protocol (IP)
Increased Throughput (Wideband HF)
Single/Multiple Independent Level Security Non-programmable COMSEC, HAIPE
Embedded Programmable Encryption
Stand-alone Encryption [VACM]
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IBS CIB
MUOS FOC
FBCB2 Shutdown
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

2. Funded Enhancements and *Potential Pursuits*.

Common Threat Broadcast (Integrated Broadcast Service - IBS / Common interactive Broadcast - CIB). (2015) IBS is an integrated, interactive intelligence dissemination system that provides vital situational awareness and rapid threat warning information to the warfighter. CIB will replace or integrate services currently provided by various IBS legacy intelligence broadcasts, including IBS-LOS (formerly Tactical Reconnaissance Intelligence Exchange System - TRIXS), IBS-S (Tactical Related Applications Data Distribution System - TDDS) and IBS-I (TIBS). A phased switchover to the IBS-CIB is planned to begin in 2012. Prior IBS services will cease operation once enough IBS-CIB capable terminals are fielded. Cut-over will occur in 2015 and no legacy broadcast support is currently anticipated beyond that date. The P-3, E-2C, EA-6B and EA-18G have a receive-only IBS requirement and use MATT receivers. The EP-3E uses the Commander's Tactical Terminal/Hybrid Receiver (CTT/HR) because it requires a transmit capability as an information provider. Neither the MATT nor the CTT/HR can be economically upgraded to run CIB and its associated crypto, so they are no longer in production. The EA-18G is pursuing a receive-only variant of the Joint Tactical Terminal (JTT-IBS) which will require a hardware and software modification to run CIB. The EA-6B and E-2C receive-only platforms are buying the Universal Serial Bus – Embedded National Tactical Receiver (USB-ENTR) with Smart Mount to provide the full capability that the MATTs currently have, as well as the ability to be software upgraded to the CIB at the appropriate time. All MATTs are planned be replaced prior to 2015 for most platforms except the EA-18G, which may require continued operations out to 2018. The EP-3E will replace their CTT/HR with the JTT-IBS, and plans to access the IBS network through SIPRNET using broadband SATCOM connectivity. The P-8 is also investigating the feasibility of using this method to receive IBS information, but may consider installing the USB-ENTR starting in 2018.

Increased Access (IW Phase II) (2017) Phase II IW will add pre-planned demand assigned and ad hoc services as described in MIL-STD-188-182B. While these features will not increase the simultaneous user capacity, the effective capacity will increase because users will release resources when they are not in use (dynamic access). Phase II IW will also add CIB software.

Increased Throughput and Access (Mobile Users Objective System - MUOS). (2018) MUOS is the next generation of tactical narrowband UHF Military SATCOM and is the replacement constellation for UFO. MUOS will enable world wide BLOS IP connectivity to the Defense Information Systems Network (DISN), which in turn provides connectivity to the Global Information Grid (GIG). MUOS satellites will have two communications payloads: a legacy UFO payload and a MUOS payload. The MUOS satellites' legacy payloads will extend the capability timeframe for platforms configured with legacy terminals. This will allow for a gradual transition to the MUOS Wideband Code Division Multiple Access (WCDMA) waveform. Higher bandwidth users (usually strategic intelligence mission assets) will be prioritized for integration, which will open more access to the legacy waveform channels for tactical platforms.

Although the MUOS satellites host a legacy SATCOM payload that is fully interoperable with today's terminals, the planned capacity of the legacy UFO payload on the MUOS constellation will be less than half of the current capacity. Unlike past UHF

SATCOM waveform developments which maintained backward compatibility during evolution from dedicated access, to DAMA, to Integrated Waveform (IW), MUOS will employ a completely new waveform that is not interoperable with the legacy waveforms. This difference in waveforms and the reduction of UFO SATCOM payload capacity will impact require some platforms to replace or upgrade their RTs in order to maintain BLOS connectivity. Gen 5 ARC-210 RTs should be able to upgrade via software loads, if the MUOS waveform integration gets prioritized and funded.

The new MUOS waveform is also called the Common Air Interface (CAI). CAI adapts a commercial third generation (3G) Universal Mobile Telecommunications System (UMTS) WCDMA cellular phone architecture to a military UHF SATCOM system using geosynchronous satellites in place of cell towers. MUOS employs 16 beams per satellite which allows for better uplink gain/downlink power and spectral reuse within the satellite footprint. Each beam supports four WCDMA carriers, which equates to 64 WCDMA beam-carriers per satellite. A beam-carrier in MUOS is analogous to a cell tower in the commercial UMTS. This allows for a capacity equivalent to 16,332 accesses of 2.4 kbps channels, compared to the 1078 channels available with legacy UFO satellites using DAMA today. MUOS also implements a packet switched networking infrastructure for all voice and data communications using the IP suite. All MUOS communications will be directed through the Radio Access Facility (RAF) on the ground and can be routed from there to any other MUOS satellite or the DISN via the Teleport interface.

There are three primary components to establishing MUOS capability: terminals, infrastructure (satellites and control facilities), and the waveform. Terminals are not part of the MUOS program and therefore not controlled by PMW-146. Instead the JTRS program is responsible for the development of terminals and the red side waveform. If the ARC-210 program obtains funding for MUOS, it will port the JTRS developed waveform for MUOS capability. Initial on-orbit capability of the infrastructure will be available at the end of Q1 FY12 with Full Operational Capability (FOC) (four satellites plus one on orbit spare) by the end of Q4 FY15. The scheduled release of the combined red and black side waveform is schedule for Q1 FY13.

B. Intermediate Bandwidth SATCOM.

1. Current capabilities. Unencrypted Commercial Satellite Services (INMARSAT).

INMARSAT is a commercial satellite company that manages a geosynchronous satellite system to enable world-wide information exchange between UHF L band capable terminals. It is used extensively by the US Navy for BLOS connectivity to shore sites. It provides IP connectivity (which DoD will not be able to provide until MUOS is available). INMARSAT also currently provides greater per user throughput and system capacity than MUOS will. INMARSAT satellites enable users to connect through internet or Public Switched Telephone Network (PSTN) to any location in the world via ground entry points referred to as Radio Network Controllers (RNC).

INMARSAT aeronautical services:

- Voice, low speed data and safety communications including satellite-aided ATC; Automatic Dependent Surveillance - Broadcast (ADS-B) and Controller/Pilot Data Link Communications (CPDLC).

- $10 per minute Swift 64 dial-up Integrated Services Digital Network (ISDN) service, up to 64 Kbps per channel (channels may be bonded to achieve higher rates).

- SwiftBroadBand (SBB) always-on 3G IP simultaneous voice and data. SBB includes $8 per megabyte (MB) *S*tandard IP service designed to support standard web access (e.g. file transfer, email, chat) with variable bit rates up to 492 Kbps (dependent on traffic), and $12 per minute Streaming IP service with reserved (guaranteed) user capacities from 8 to 256 Kbps for time critical data, including VoIP, and streaming video.

The US Army and USMC have widely fielded Force XXI Battle Command and Control (FBCB2) Blue Force Tracking (BFT) on their ground vehicles and rotary wing aircraft operating in support of ground forces. Navy HH-60H and MH-60S Air Ambulance aircraft have also been equipped with FBCB2 BFT. This system operates over a commercially encrypted, half-duplex, L-band INMARSAT network to provide two-way SA and C2 messaging between the front line warfighter and higher echelon command posts. As installed in aircraft, the system automatically reports Precise Location Information (PLI) every 2300 meters of movement or one minute of flight, whichever occurs first. An Electronic Data Manager (EDM - digital kneeboard) provides the display of the Falcon View moving map and incoming BFT data to the aircrew. The system supports a tailored set of VMF C2 messages, including Free Text. Users claim BFT networks are providing 90 percent of the Common Operational Picture (COP).

2. Advance Research and Technology Development.

Beyond the KGV-72 Type 1 encryption upgrade, technology development efforts associated with BFT are focused on demonstrations in which aircraft sensors automatically report SA, incoming-fires, and general status through the BFT BLOS link, and gateways that connect BFT data to other protocols and waveform networks.

Increased Bandwidth (Extended L-Band AlphaSat I-XL or INMARSAT XL). (2013-2017) The AlphaSat is INMARSAT's new satellite, planned for launch in 2012. It is designed with increased capacity, 750 channels and 400-500 spot beams. Only one is currently planned for launch to provide additional capacity to Europe, the Middle East and Asia. AlphaSat will be operational in 2013 and provide the following benefits:

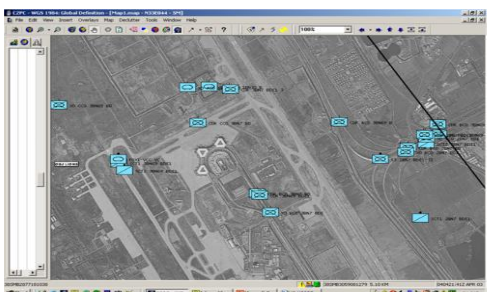
- Same service with smaller user equipment.
- Higher throughput with existing user equipment.
- Same throughput with existing equipment, with less satellite usage and lower cost.

Global Coverage (Cross Linked Low Earth Orbit (LEO) Satellites - Iridium Next). (2015-2017) Iridium NEXT will provide continuous coverage over the entire Earth's surface. Each satellite will be cross-linked to four other satellites. These links will create a dynamic network in space. Voice and data traffic will be routed among Iridium satellites without touching the ground, ensuring a more reliable connection. Iridium NEXT's improvements will include data rates up to 1 Mbps, Ka-band service, private network gateways, and broadcast and netted services. The constellation will also host payloads that leverage Iridium satellite cross-links to enable earth side control centers to deliver additional sensor data to participating entities.

1. Funded Enhancements and *Potential Pursuits*.

Future JBC-P software upgrades are scheduled to begin fielding in the FY15 timeframe. They will support interface with onboard sensors and subsystems such as radar warning receivers and laser threat detectors. The system is also planned to provide enhanced capabilities such as white boarding, Voice over Internet Protocol (VoIP), and exchange of still photo imagery. The Army has included high speed communications links into the design which are intended to facilitate interoperability with GIG Enterprise Services via Net-Centric Service Gateways, as well as to provide connectivity with existing systems such as LINK16.

Aircraft Encryption and Higher Data Rate BFSA (BFT2). (2014) The Army-Marine Corps Board, under the guidance of the JROC, developed a strategy to converge several separate C2/SA systems to a common baseline. In May of 2008, the JROC approved the Joint Battle Command – Platform (JBC-P) Capabilities Description Document (CDD). The transition to JBC-P is enabled by upgrading to the Blue Force Tracker 2 (BFT2) hardware and adding KGV-72 Type 1 encryption. The resulting system begins fielding for ground forces late in FY11 and on aircraft by FY13. It will provide NSA certified Type 1 encrypted, full duplex, near real time SA and C2 messaging between the front line warfighter and higher echelon command posts. Currently, FBCB2 latency is on the order of 6-8 minutes, which is not sufficient for tracking fast moving friendly aircraft. BFT2 is projected to automatically report PLI every 500 meters of movement with an reduction in data latency to a threshold target of 8 seconds, with an objective target of 4 seconds.



FBCB2 to BFT2 enhancements:

- 2.6 kbps to 122 kbps download.
- 0.27 kbps to 3 kbps upload
- 600 msg/min to 7500 forward, 5000 return
- Half duplex to Full duplex
- Upgrade to IP based exchange
- Addition of email
- Addition of Type 3 data security

Expanded BFSA Applications (Joint Battle Command – Platform, JBC-P). (2016) The Army typically fields incremental systems enhancements in 'Capability Sets' (CS). Future Army managed JBC-P software CS15-16 upgrades are scheduled to begin fielding in the FY15 timeframe. They will support interface with onboard sensors and subsystems such as radar warning receivers and laser threat detectors. The system is also planned to provide enhanced capabilities such as white boarding, Voice over Internet Protocol (VoIP), and exchange of still photo imagery. Navy and Marine Corps have not established a formal BFSA program of record. Procurement of equipment has been incrementally resourced via annual Overseas Contingency Operations funds. In POM-14, an issue was submitted to establish a centralized program of record to align with Army capability evolution, organize conversion to next generation JBC-P, manage integrations of new associated equipment, and establish an effective sustainment infrastructure. The driving imperative behind the budget issue is that the FBCB2 satellite architecture will be dismantled by 2017, resulting in current users losing critical existing SA/COP and operational interoperability.

Global Information Grid BFSA Connectivity and Gateway Interfaces. (2018) The Army has included high speed communications links into the JBC-P design which are intended to facilitate interoperability with GIG Enterprise Services via Net-Centric Service Gateways, as well as to provide connectivity with existing systems such as Link 16. These capabilities are expected to be enabled with CS17-18.

C. Wideband SATCOM.

1. Current capabilities. Advanced Wideband Satellite Services (Advanced Extremely High Frequency - AEHF, Wideband Global SATCOM - WGS).

The AEHF satellite provides ten times more capacity and moves data six times more efficiently than the five Military Strategic and Tactical Relay (MILSTAR) II communications satellites currently in use. The higher data rates can send video, battlefield maps, targeting data and other communications in real time. The first AEHF satellite was launched in 2010. AEHF will supply global, secure, jam-resistant and survivable strategic communications for high priority assets. E-6B currently employs a MILSTAR II terminal and is a candidate for a new terminal to support the Extended Data Rate (XDR) capability of AEHF satellites. The Family of Advanced BLOS Terminals (FAB-T) was to provide this capability for airborne platforms, but the program was discontinued. The WGS system is being launched to support DoD's increasing demand for BLOS transmission of ISR data, specifically Full Motion Video (FMV). Existing Electro-Optical/InfraRed (EO/IR) sensor compressed FMV exchange requires approximately 5 Mbps data rate. WGS is a replacement for the Defense Satellite Communications System (DSCS) and provides ten times the capacity of DSCS. Each satellite provides up to 2-3 Gbps of capacity. Five satellites will provide a total capacity of approximately 11 Gbps by 2012. Each satellite has multiple beams, each supporting a 125 Mhz channel which can be sub-divided down to 2.6Mhz increments. WGS terminal antenna size depends on the platform's required data rate. One terminal in development utilizes a 45 inch antenna to achieve 50 Mbps. VIP aircraft are also using evolving Commercial Broadband Satellite Program (CBSP) terminals.

2. Advance Research and Technology Development.

Reduced Size Antennas. (2013-2015) Current antennas available to implement Wideband SATCOM on many air platforms are too large, too costly and difficult to install. In order to reduce the integration cost and complexity, industry is researching development of smaller antennas and other conformal solutions. Smaller antennas would also allow integration onto non-central areas of air platforms where there are significant space restrictions. These technologies are still limited to innovative research and demonstration projects.

3. Funded Enhancements and *Potential Pursuits*.

ArcLight Commercial Ku Satellite Terminal. (2012) Commercial Ku band satellite technology will provide affordable, 2-way, always-on, broadband IP access to mobile ground, airborne, and maritime platforms. Commanders, sensors, and weapons systems will be able to interact seamlessly to establish a real-time view of the battlefield and allocate firepower as effectively as possible. Ku band terminals are currently under development and planned for installation on P-3 Special Projects Aircraft (SPA) and Littoral Surveillance Radar System (LSRS) aircraft.

INMARSAT Global Xpress Ka Band Satellite System. (2014) In addition to its current L-band services, INMARSAT has embarked on a new capability and will soon be launching a new satellite service in the Ka band. Global Xpress has been designed from the bottom up to meet the requirements of government aviation applications such as intelligence surveillance and reconnaissance, which require high sustained data throughput. Global Xpress will provide 50 Mbps downlink and 5 Mbps uplink speeds. INMARSAT expects to have the service in place starting in 2014. As of yet, there are no Naval Aviation programs currently planning to use this service.

High Data Rate Aviation Terminal (HDRAT). (2017) HDRAT would provide for secure Ka/Ku high data rate satellite links (over commercial and government owned assets) and LOS communications supporting Airborne Intelligence, Surveillance, and Reconnaissance (AISR) platforms. It would also provide AISR platforms with antenna solutions, modem assemblies, and the appropriate waveforms capable of supporting high resolution sensor data and C2 links at speeds up to 274 Mbps (platform and mission dependent).

D. High Frequency (HF).

1. Current capabilities. HF, HF Automatic Link Establishment (ALE), HF Internet Protocol (IP).

HF radios operate between 3 and 30 MHz and are still maintained on platforms that can accommodate the antennas for back-up BLOS communications. HF commonly uses ionosphere propagation of radio waves to span BLOS distances. HF data transmissions typically operate at user data rates 1200 to 2400 bps with advanced modem waveforms capable of 9600 bps within 3 kHz channels. HF amplifiers typically transmit at 20 to 150 Watts for portable units and up to 2000 Watts for high power stations. HF usage enables ad hoc connectivity (no prior access permissions or time slot coordination required).

HF - Automatic Link Establishment (HF-ALE) was developed based on the military standard for interoperability and performance standards for medium and high frequency radio systems (MIL-STD-188-141A and -141B). HF-ALE enables the radio to initiate a circuit between itself and another HF radio station or network of stations along with automated frequency selection for the connection. ALE also incorporates NATO Standardization Agreement (STANAG) 5066, which specifies protocols which separate application data and modem/radio level information.

HF internet Protocol (HFIP or HF-IP) is usually associated with ALE and HF radio data communications. HFIP provides protocol layers enabling internet file transfer, chat, web, or email.

2. Funded Enhancements and *Potential Pursuits*.

Increased Throughput (Wideband HF). (2018) Wideband HF is a waveform in development that will be able to offer users higher data rates over HF. MIL-STD-188-110C is the military standard for HF digital voice.

E. Robustness and Security. (see LOS Information Exchange Section G.).

II. IP Networking.

Mandates and Milestones:

Internet Protocol Version 6 (IPv6) Implementation. (2008) In 2003 a DoD Chief Information Officer Memorandum directed the implementation of IPv6 within DoD for applications interfacing with the Global Information Grid (GIG). This guidance also covers Mobile IPv6 (MIPv6). Follow-on guidance set Dec 2008 as the target compliance date for all DoD network systems. The main impetus for moving to IPv6 was the expectation that by 2010, worldwide demand for IP traffic would exceed the 4 billion addresses provided by 32 bit IPv4. IPv6 uses a 128 bit address which enables a virtually infinite number of addresses. The extended header size of IPv6 requires additional bandwidth, which is problematic for tactical links operating in limited spectrum and exchanging short messages.

Automated Digital Network System (ADNS) Increment III. (2016) The US Navy is converting IP Wide Area Network (WAN) to Cipher Text (CT). All platforms connecting to the Navy WAN must be Increment III compliant by 2016.

Capability Element Evolution:

A. Tactical Airborne Network Local Area Network (LAN).

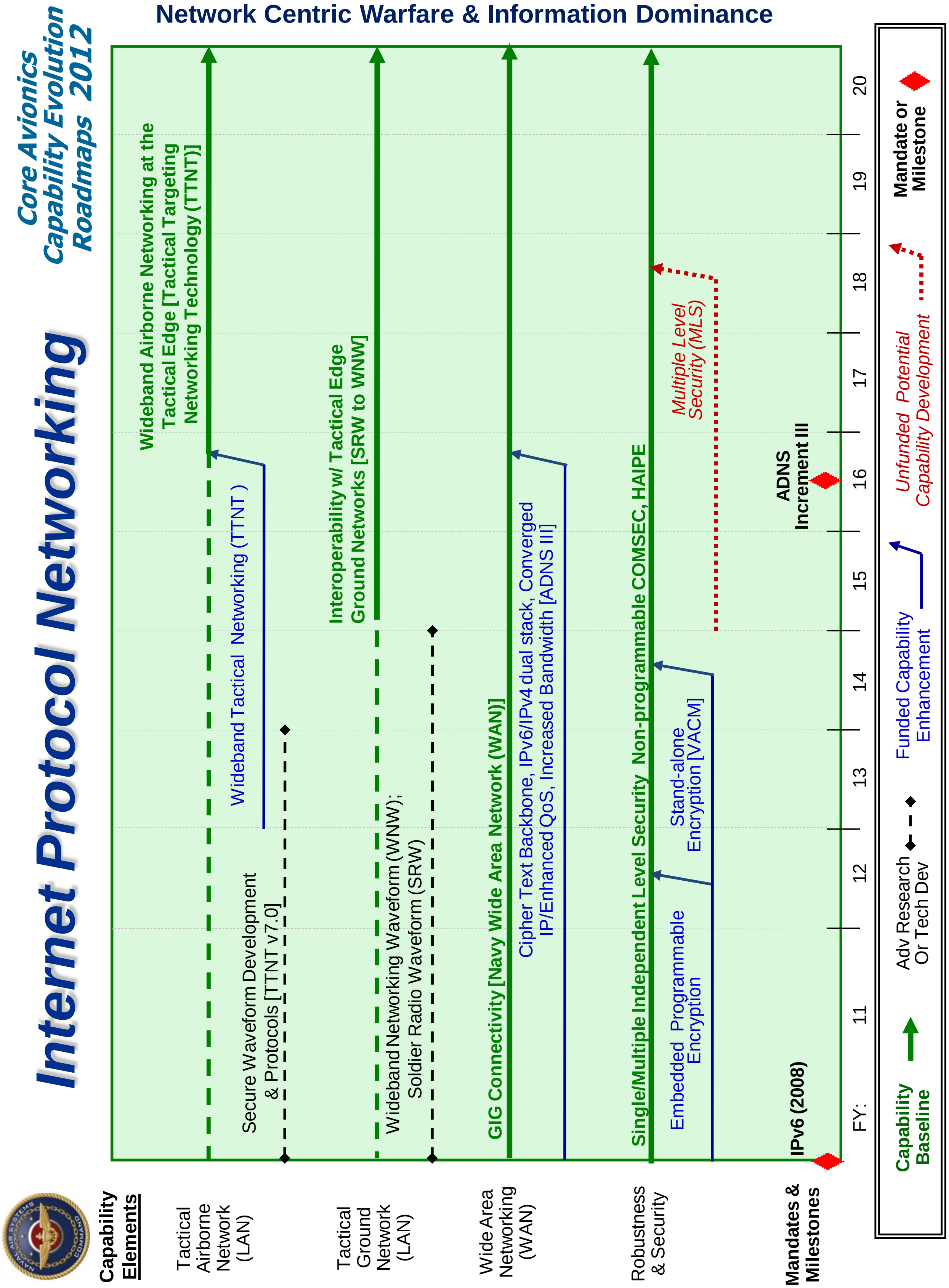
1. Current capabilities. (none). [2016: Wideband Airborne Networking at the Tactical Edge: Tactical Targeting Networking Technology (TTNT)].

There currently is no airborne equivalent to ground-based LANs. The challenge has been to identify a wireless waveform and architecture capable of the bandwidth and security robustness presented by LANs. TTNT had been successfully demonstrated to provide higher bandwidth connectivity in flight testing in 2005, and used as a backbone network in multiple Joint Fleet Exercises (JFEXs) through 2009. However, delays were encountered as the Services tried to Jointly commit to a single waveform. Ultimately, Navy convinced DoD that it was their best option to achieve a near to mid-term solution to meet their requirements.

2. Advance Research and Technology Development.

Secure Waveform Development & Protocols [TTNT Version 7.0] (2011-2013) The Air Force, Navy, and Joint Tactical Radio System (JTRS) Network Enterprise Domain (NED) have continued development of a TTNT JTRS Software Compliant Architecture (SCA) waveform which has been designated as version 7.0. The Critical Design Review (CDR) for this version was completed in 2008 and the JTRS NED schedule for completion of the waveform is 4Q 2013. The TTNT Version 7.0 waveform will provide the following improvements over earlier versions:

- Improved data efficiency through decreased message overhead requirements.
- Improved routing methods through destination and distance evaluations.
- Link Adaptation to allow spectrum reuse.
- New algorithms to reduce retransmissions and multicast messaging.
- Improved Signal In Space performance.
- Compliance with JTRS Software Compliant Architecture (SCA).
- Compliance with NSA Unified Information Security Criteria (UISC) requirements.



Core Avionics Capability Evolution Roadmaps 2012
Internet Protocol Networking
Network Centric Warfare & Information Dominance
Capability Elements
Tactical Airborne Network (LAN)
Tactical Ground Network (LAN)
Wide Area Networking (WAN)
Robustness & Security
Mandates & Milestones
Secure Waveform Development & Protocols [TTNT v7.0]
Wideband Tactical Networking (TTNT)
Wideband Airborne Networking at the Tactical Edge [Tactical Targeting Networking Technology (TTNT)]
Wideband Networking Waveform (WNW); Soldier Radio Waveform (SRW)
Interoperability w/ Tactical Edge Ground Networks [SRW to WNW]
GIG Connectivity [Navy Wide Area Network (WAN)]
Cipher Text Backbone, IPv6/IPv4 dual stack, Converged IP/Enhanced QoS, Increased Bandwidth [ADNS III]
Single/Multiple Independent Level Security Non-programmable COMSEC, HAIPE
Embedded Programmable Encryption
Stand-alone Encryption [VACM]
Multiple Level Security (MLS)
IPv6 (2008)
ADNS Increment III
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

2. Funded Enhancements and *Potential Pursuits*.

Wideband Tactical Networking (TTNT). (2016) Navy has selected TTNT as its best opportunity to establish dedicated wideband networking capability. The current version of the waveform, employed in legacy terminals, is version 6.0. The Unmanned Combat Air System – Navy (UCAS-N) program employed Engineering Development Model (EDM) terminals to accomplish carrier arrestments using a surrogate FA-18D. TTNT is an IP networked waveform that compliments Time Division Multiple Access (TDMA) waveforms like Link 16 in scenarios where broad dissemination of data is important and/or when timeliness and accuracy of data delivery are most important. TTNT is full duplex at the link layer, offering efficient, robust, scalable, simplistic operation for fast movers and other nodes that need information collected by ISR assets and C2 nodes. The chief benefits of TTNT include no network preplanning, dynamic net join and exit, scalability, and automatic network capacity allocation. Multi-level traffic prioritization and class of service messaging ensures the delivery of key data, on time. TTNT integration has been demonstrated on FA-18, E-2C and major ground C2 stations. The funded program completes development of TTNT version 7.0 increments 3 and 4 for the JTRS waveform repository, testing of TTNT JTRS terminals and testing of compatibility with Quint Networking Technology terminals.

B. Tactical Ground Network (LAN).

1. Current capabilities. (none). [2014: Interoperability with Tactical Edge Ground Networks (WNW and SRW)].

There is not a current capability for Interoperability with the Tactical Edge ground networks, but the JTRS Joint Program Office (JPO) is developing Wideband Networking Waveform (WNW) and Solider Radio Waveform (SRW) to fill this capability. So far, no Naval Aviation platforms have committed to integrate this capability.

2. Advance Research and Technology Development.

Wideband Networking Waveform (WNW). (2010-2014) WNW was originally conceived as the JTRS multi-service LOS IP networking waveform. WNW will provide a tactical Wireless Local Area Network (WLAN). WNW features include:

- Multi-Level Security (MLS), multi-waveform and multi-channel radio and route/re-transmit – environmentally adaptive modes trade off throughput for Anti-Jam (AJ).
- Support for up to 250 nodes and data rates up to 2 Mbps.
- Mobile Ad hoc Networking (MANET) – self forming, self healing, Quality of Service (QoS) network.
- Scalable network architecture supporting flat and hierarchical network topology
- Efficient use of capacity via distributed Time Division Multiple Access (TDMA) with dynamic slot allocation.

WNW is viewed by the US Army as the Battalion level network and is primarily used for ground and rotary wing platforms. The Navy and Air Force sponsored an independent review of WNW to determine its applicability to airborne networking and then decided to pursue the TTNT alternative. The requirements for this waveform were developed in a JAN-TE Functional Description Document (FDD).

Soldier Radio Waveform (SRW). (2010-2014) SRW is a JTRS waveform being developed for dismounted and unattended applications with severe Size Weight and Power (SWaP) constraints. The US Army plans to utilize SRW as a stub network, interconnecting to other stub networks via WNW. Waveform characteristics include:

- 3 Signals in Space: SRW, AJ and Low Probability of Intercept / Low Probability of Detection (LPI/LPD).
- Features to minimize SWaP: incorporation of a network architecture that minimizes power demands, optimizes voice communications, and minimizes processing requirements.
- Formation of stub/leaf networks that rely on WNW for backbone services.
- Unique security requirements that support unclassified and classified nodes.

The waveform is designed to operate in varying bandwidths from 75 KHz to 32 MHz and operating frequencies from 225 MHz to 2.5 GHz. The SRW waveform has a threshold data rate requirement of 1.2 Mbps in a 1.2 MHz channel. Achievable range is a function of the path loss, which is a function of terrain, geometry and operating frequency.

C. Wide Area Networking (WAN).

The GIG is defined as: The globally interconnected set of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating, and managing information on demand to warfighters, policy makers, and support personnel. The GIG includes all owned and leased communications and computing systems and services, software (including applications), data, security services and other associated services necessary to achieve information superiority. It also includes National Security Systems. The GIG supports IP networking in accordance with the Internet Engineering Task Force (IETF) established standards. The Defense Information Security Agency (DISA) procures and controls the Defense Information System Network (DISN), which provides the transport infrastructure (teleports, leased lines and commercial satellites) to enable GIG connectivity. Teleports are shore satellite gateways linking deployed forces to the GIG via connectivity to multiple satellite systems. DISA also manages the development of infrastructure services referred to as Net Centric Enterprise Services (NCES) that enable user access (portals), content discovery and delivery, and synchronous collaboration in a service oriented architecture foundation. Further services and additional capabilities are expected to be forthcoming in accordance with the JROC approved GIG 2.0 Initial Capabilities Document (ICD).

1. Current capabilities.

The Navy organic shore infrastructure that interfaces Naval forces with the DISN/GIG is made up of Naval Computer and Telecommunications Area Master Stations (NCTAMS), Naval Computer and Telecommunications Stations (NCTS) and Network Operations Centers (NOC). PMW 790 manages this infrastructure to provide the Navy WAN. The Automated Digital Network System (ADNS) serves as the tactical WAN, providing the network infrastructure and services for Navy IP network operations.

ADNS enables deployed ships, subs and aircraft to interface with the shore infrastructure and connect to the DISN/GIG. ADNS integrates hardware, software Radio Frequency (RF) links and services to provide a mobile WAN. The current version, ADNS increment II, provides the following capabilities:

- Interconnects multiple security enclaves in a common architecture.
- Utilizes multiple simultaneous RF links for reach back and reach forward.
- Supports QoS by prioritizing data and implementing priority processing.
- Interfaces to platform LANs.

SPAWAR PMW-160 manages the ADNS program. PMW-750 is the Air Integration Office responsible for coordinating efforts with NAVAIR platforms. PMW-750 is currently working with NAVAIR program offices to integrate ADNS on E-2C, EP-3E, P3-C, P-8A, MH-60R and BAMS. SPAWAR provides an airborne ADNS package, designated AN/USQ-144(V)8, as a three-quarter Air Transport Rack (ATR) form factor. Platforms are procuring other routers that must be loaded with an ADNS routing template and tested by SPAWAR for compatibility in order to connect to the ADNS network. ADNS interfaces to RF links on these platforms including HF-IP (E-2C, P8A), INMARSAT Swift 64 (EP-3E), INMARSAT Swift Broadband (P-3C Anti-Submarine Warfare Improvement Program [AIP], P-9A, Broad Area Maritime Surveillance [BAMS]), Wideband Global SATCOM (WGS - BAMS), and Common Data Link (CDL - proof of concept on MH-60R).

2. Funded Enhancements and *Potential Pursuits*.

Cypher Text Backbone, IPv6/IPv4 dual stack, Converged IP/Enhanced Quality of Service, Increased Bandwidth (ADNS III). (2016) ADNS increment III is the next generation of ADNS and is currently implemented in NCTAMS LANT and PAC and being fielded on ships. The primary requirement being met by ADNS III is the GIG requirement to implement a Cipher Text (CT) core, implemented via NSA approved IP Security (IP Sec) standards known as High Assurance Internet Protocol Encryption (HAIPE). In order to maintain backward compatibility with Increment II configured platforms not implementing HAIPE, both increments will be operating in the shore infrastructure through 2015. IOC for a switch over to Increment III is 2016. This increment will provide:

- CT Backbone ('black core') routing in compliance with GIG requirement.
- IPv6/IPv4 dual stack (IPv6 in compliance with GIG requirements).
- Converged IP/Enhanced QoS – All traffic, voice, data and video, will be IP with dynamic Quality of Service (QoS) and bandwidth management.
- Load distribution over all RF links.
- Increased bandwidth 25 / 50 Mbps per platform (requires capable RF link).

D. Robustness and Security. (see LOS Information Exchange Section G.).

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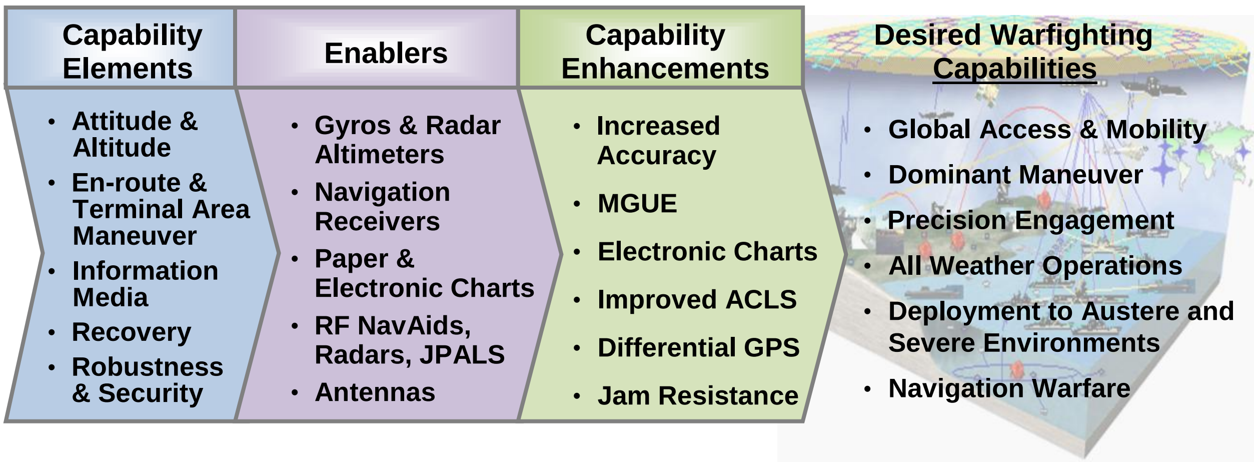
Appendix A-3
Navigation

Scope: This section addresses avionics that enable terrestrial-based, aircraft-referenced, shipboard and space-based navigation systems, including inertial reference units, position reference receivers, antennas, waveforms and chart media.

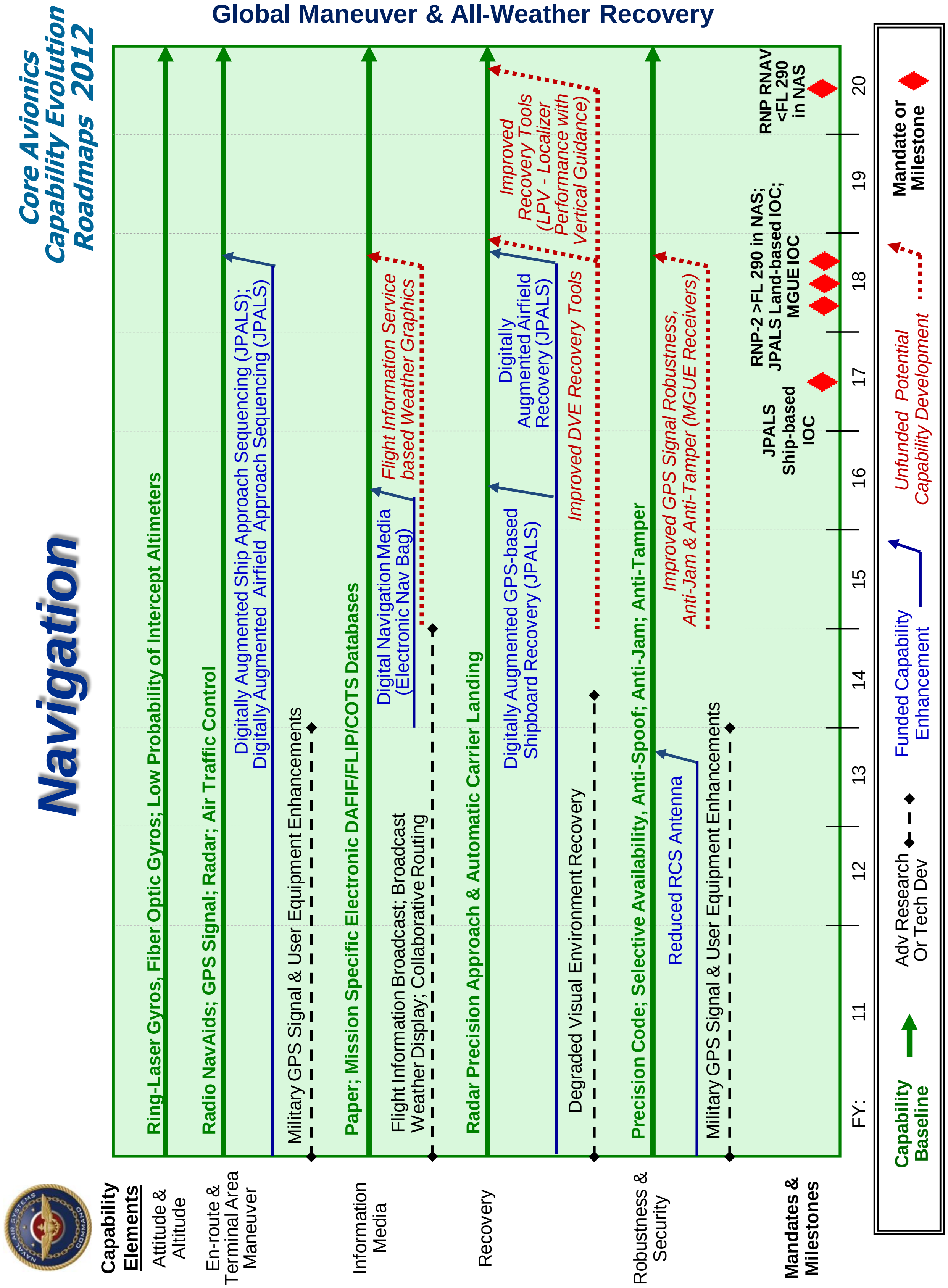
Capability Evolution:



Objective: Global Maneuver and All-Weather Recovery

Baseline Enhancement Objectives and Transition Strategy.

Navy Sea Strike and Sea Basing and Marine Corps Expeditionary Maneuver Warfare critically depend upon accurate navigation to achieve their objectives. Terrestrial-based systems (Non-Directional Beacon [NDB], VHF Omni-Directional Receiver [VOR], Distance Measuring Equipment [DME], Tactical Air Navigation [TACAN] and radars) have been the mainstay of airway and terminal operations for decades. Operators have been authorized to utilize GPS signal accuracy to perform precision strike operations for several years, but have only recently been configured and authorized to use GPS as a primary positioning sensor during Instrument Meteorological Conditions (IMC) navigation enroute and in terminal flight operations. Commercial navigation technology and equipment have undergone significant transformation; however Naval Aviation platform precision navigation certifications have been more limited because many of them have not been modified with a GPS system that can meet “integrity” standards (sufficiently high probability of availability and accuracy), using approved navigation databases and digital glass displays. The Communications Navigation Surveillance / Air Traffic Management (CNS/ATM) program is outfitting cockpits with the digital frameworks and components required to get them certified for GPS-based lateral separation. The GPS L1 Standard Positioning Service (SPS) and L1/L2 Precise Positioning Service (PPS) signals also provide extremely accurate time data used for the synchronization of many communications and datalink systems. Military GPS equipment must eventually be modified to take advantage of the new GPS Military Code (M-Code) signal that will be broadcasted from modernized space vehicles.


Core Avionics Capability Evolution Roadmaps 2012
Navigation
Global Maneuver & All-Weather Recovery
Capability Elements
Attitude & Altitude
En-route & Terminal Area Maneuver
Information Media
Recovery
Robustness & Security
Mandates & Milestones
Ring-Laser Gyros, Fiber Optic Gyros; Low Probability of Intercept Altimeters
Radio NavAids; GPS Signal; Radar; Air Traffic Control
Digitally Augmented Ship Approach Sequencing (JPALS); Digitally Augmented Airfield Approach Sequencing (JPALS)
Military GPS Signal & User Equipment Enhancements
Paper; Mission Specific Electronic DAFIF/FLIP/COTS Databases
Digital Navigation Media (Electronic Nav Bag)
Flight Information Service based Weather Graphics
Flight Information Broadcast; Broadcast Weather Display; Collaborative Routing
Radar Precision Approach & Automatic Carrier Landing
Digitally Augmented GPS-based Shipboard Recovery (JPALS)
Digitally Augmented Airfield Recovery (JPALS)
Improved DVE Recovery Tools
Improved Recovery Tools (LPV - Localizer Performance with Vertical Guidance)
Degraded Visual Environment Recovery
Precision Code; Selective Availability, Anti-Spoof; Anti-Jam; Anti-Tamper
Reduced RCS Antenna
Improved GPS Signal Robustness, Anti-Jam & Anti-Tamper (MGUE Receivers)
Military GPS Signal & User Equipment Enhancements
JPALS Ship-based IOC
RNP-2 >FL 290 in NAS; JPALS Land-based IOC; MGUE IOC
RNP RNAV <FL 290 in NAS
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

Baseline to Objective Transition Strategy (continued).

Radars are currently the primary enabler for precision approach and recovery in low ceiling, low visibility conditions. Automated hands-off fixed wing approach to the carrier deck using differential GPS has already been demonstrated using relative GPS. Insertion of this capability requires significant platform modifications. The Joint Precision Approach and Landing System (JPALS) Program is developing these technologies to replace the antiquated radar Automated Carrier Landing System (ACLS) equipment that is facing obsolescence and driving high sustainment costs. This capability is being developed for rotary wing platform recovery to single spot ships, and is considered a key element of unmanned air vehicle operations at sea. JPALS is planned to replace precision approach systems at military installations and to provide a capability for all-weather recover to temporary expeditionary airfields and landing zones. The strategy is to evolve platform cockpits to provide a Digital Flight Environment (DFE) with the level of integrity to support precision navigation in all phases of flight and weather conditions.

GPS User Equipment (UE) has evolved significantly over the last decade. The latest all-in-view receiver modules incorporate Selective Availability Anti-Spoofing Module (SAASM) GPS receiver cards to prevent spoofing and enhance security of crypto keys. Additional robustness and enhancements are being achieved through the Navigation Warfare (NAVWAR) program with the integration of Controlled Reception Pattern Antennas (CRPAs) that possess significantly improved anti-jam characteristics, such as the GAS-1 and Advanced Digital Antenna Production (ADAP). The next generation of GPS UE, known as Military GPS User Equipment (MGUE), will replace legacy components and be capable of processing both the new M-Code signal and legacy GPS. The M-Code signal possesses even further improved anti-jam characteristics and will be available exclusively for military use. Additionally, MGUE integration will incorporate an enhanced security architecture which provides for layered information assurance and anti-spoofing capability. MGUE and NAVWAR development are managed by the U.S. Air Force led GPS Directorate and PMW/A-170 respectively.

Mandates and Milestones:

JPALS Ship-based Initial Operational Capability (IOC). (2017) The US Navy is the lead for the Joint Service JPALS program, and is responsible for the development of the shipboard solution. JPALS will deployed on the newest aircraft carrier and its assigned carrier aircraft, including C-2A, E-2D, EA-18G, F/A-18E/F, F-35 and MH-60R/S.

Required Navigational Performance (RNP)–2 above FL290 in National Airspace System (NAS). (2018) RNP is a form of performance-based navigation that calls for accuracy of position location on a GPS route to be within a specified number of nautical miles (nm) of intended position. RNP compliance requires 95% fidelity of position accuracy to ensure proper containment for all modes of flight. The GPS receiver must provide Integrity using Receiver Autonomous Integrity Monitoring (RAIM), which ensures that all of the satellites being utilized to determine position are providing useful data. The Federal Aviation Administration (FAA) will require RNP-2 (accurate within a circle with a radius of two nm) for all operations at or above FL 290 in the NAS (similar to Continental United States – CONUS, but also includes Alaska and Hawaii) by 2018.

JPALS Land-Based IOC. (2018) The Air Force is charged with development of land-based JPALS ground stations. Differential GPS will be used to provide an additional military PPS datum reference signal via an encrypted UHF datalink, and an additional civil interoperable SPS datum reference signal via a VHF datalink or SATCOM signal. A fixed station will be installed at every DoD airfield that currently has precision approach capability. A deployable variant will be developed for remote locations.

Military GPS User Equipment (MGUE) Initial Operational Capability. (2018) The Assistant Secretary of Defense, Networks and Information Integration (ASD NII) Global Positioning System User Equipment Development and Procurement Policy Memorandum dated Aug 7th 2006 directs the services to plan and implement MGUE no later than the date the 24th M-Code satellite is declared operational (~2018). MGUE will provide a family of GPS receivers that use the more robust, anti-tamper and anti-jam characteristics of the M-Code capable satellites currently being launched. M-Code is expected to be fully operational by 2018.

Public Law 111-383, Jan 7, 2011, SEC. 913. Limitation on use of funds for purchasing Global Positioning System User Equipment. states:

(a) In General. Except as provided in subsections (b) and (c), none of the funds authorized to be appropriated or otherwise made available by this Act or any other Act for the Department of Defense may be obligated or expended to purchase user equipment for the Global Positioning System during fiscal years after fiscal year 2017 unless the equipment is capable of receiving the military code (commonly known as the ‘‘M code’’) from the Global Positioning System.

(b) Exception. - The limitation under subsection (a) shall not apply with respect to the purchase of passenger vehicles or commercial vehicles in which Global Positioning System equipment is installed.

(c) Waiver. - The Secretary of Defense may waive the limitation under subsection (a) if the Secretary determines that -

> (1) suitable user equipment capable of receiving the military code from the Global Positioning System is not available; or
>
> (2) with respect to a purchase of user equipment, the Department of Defense does not require that user equipment to be capable of receiving the military code from the Global Positioning System

Required Navigational Performance (RNP) Area Navigation (RNAV) below Flight Level (FL) 290 (29,000 feet) in NAS. (2020) The FAA will require RNAV on selected high-density routes in NAS starting in 2020. FAA roadmaps also call for Terminal Maneuvering Areas (TMAs) at the busiest 100 U.S. Airports to have RNP capable Standard Instrument Departure (SID) routes and Standard Terminal Arrival Routes (STAR) routes by 2015. The PMA209 CNS/ATM team is fielding and coordinating certification of systems that meet RNP RNAV criteria. The Naval Flight Information Group (NAVFIG) is designing and fielding RNAV terminal procedures for Naval Air Stations and expeditionary airfields. This mandate was planned for 2015, but has been extended and is now associated with the FAA Next Generation Air Transportation System (NextGen) implementation initiative.

Capability Element Evolution:

A. Attitude and Altitude. This capability element addresses instrumentation that supports basic flight, including: attitude gyros, combination attitude/heading reference systems and altimeters. This equipment ensures safe aircraft orientation and ground clearance to prevent Controlled Flight Into Terrain (CFIT), and is considered critical during aggressive maneuvers, low altitude operations and operations at night or in IMC.

1. Current Capabilities.

Although several platforms have integrated glass cockpits with state of the art flight instrument displays, many are still configured with older generation technology legacy attitude gyro systems and are suffering poor on-wing performance and high repair support costs. Modern Replacement Attitude Heading Reference Systems (R-AHRS) use digital Ring Laser Gyros (RLG's) for attitude reference. RLGs employ laser light technology for more accurate measurement of attitude changes, and employ a small motor to aid in sensing smaller angular velocity changes. Fiber Optic Gyro (FOG) technology also uses light-wave sensing, but eliminates moving parts and uses cheaper fiber for the light path. Micro Electro-Mechanical System (MEMS) technology has been utilized to reduce size of motion sensors used in attitude/heading reference systems; however they can be more influenced by shock and vibration. Solid state components bring substantial gains in accuracy, robustness, reliability and cost avoidances.

Legacy Radar Altimeter systems are accurate only below certain altitudes and angles of bank. The Low Probability of Intercept Altimeter (LPIA) increases range and accuracy of altitude measurements, eliminates interference from suspended loads and provides coverage at higher angles of bank. It incorporates open system architecture, increases reliability and significantly reduces probability of signal intercept. Current and future platforms using this technology are C-2A, E-2C, E-2D, H-53K, P-3 and CV-22. LPIA accuracy also has Built-In-Test (BIT) features which support fidelity of signal data required for predictive Terrain Avoidance Warning System (TAWS) advanced Ground Proximity Warning System (GPWS) and Traffic Collision Avoidance System (TCAS). TAWS uses the accurate altitude data in algorithms to determine if flight parameters are placing the aircraft at risk for CFIT. More detail on safety applications of predictive CFIT warning systems is available in the Flight Safety appendix, A-5.

B. En-route and Terminal Area Maneuver. This capability element speaks to the core of the Navigation capability area. It addresses the ability to follow prescribed en-route airways or precise direct flight legs, and perform precision and non-precision approaches for recovery.

1. Current Capabilities.

The most common radio-navigation utility used to locate the ship is TACAN. TACAN and VOR/DME beacons will continue to be supported on ships and in CONUS for the foreseeable future. Radio-navigation aids are omni-directional, but limited in range by radiated power and line-of-sight. Within appropriate ranges, they can be used for en-route navigation and non-precision approaches. Almost all naval aircraft have integrated embedded GPS receivers and are required to use the encrypted PPS. Modern systems closely couple Inertial Navigation System (INS) elements with GPS to provide update corrections to compensate for drift. Newer models of the Miniature Airborne GPS Receiver (MAGR-2000) and the Embedded GPS/INS (EGI) have “All-in-View” 12 or 24 channel satellite signal reception, which monitors more satellites than legacy four-channel systems for signal triangulation and enables RAIM for signal integrity monitoring. They have recently started incorporating SAASM modules. Aircraft with legacy receivers that do not have integrated RAIM capability are restricted to using GPS as an aide to Situational Awareness (SA) during Visual Meteorological Conditions (VMC) operations in civil airspace. The Hornet Accurate Navigation (ANAV) receiver provides the tightest GPS accuracy and also provides RAIM and SAASM.

Following successful Operational Evaluation (OPEVAL) of an integrated MAGR-2000 Intermediate Frequency (IF) receiver, the MH-53E became the first naval aircraft certified to use GPS for primary means of navigation in controlled airspaces (for en-route and GPS-based non-precision approach). The P-3C is the first naval aircraft certified for RNP RNAV in all modes of flight (RNP 2, RNP 1 and RNP 0.3 accuracy) using military PPS GPS as the primary means of navigation. More precise GPS-based RNP RNAV navigation affords seamless access to worldwide civil airspaces with increased safety. The latest standard GPS receivers support the SAASM, RAIM and 12 channel or 24 channel All-In-View functionalities required for non-precision navigation in civil airspaces. Naval aircraft integrating Wide Area Augmentation System (WAAS) GPS receivers are capable of flying GPS Localizer Performance with Vertical Guidance (LPV) approaches and can achieve Instrument Landing System (ILS) precision approach level performance down to 200 foot Decision Altitudes (DA).

2. Advanced Research and Technology Development.

Military Space Signal & User Equipment Enhancements. (2010-2012) The GPS Directorate is managing design and development of MGUE to use the next generation GPS signal, M-Code. Simultaneously, they are leveraging commercial advancements with GPS antennas and electronic packages. Cell phone and automobile application enhancements have driven GPS UE size and weight reductions. Miniaturization of components is enabling more robust processing by using hundreds of thousands of signal correlators and reducing noise interference. Large numbers of correlators can eliminate latency issues for faster moving aircraft. These enhancements are considered critical to meet weight, size, sensitivity and reliability threshold specifications for unmanned aerial vehicles. Improvements in the RAIM algorithm to an Advanced RAIM (ARAIM) algorithm will allow tactical aircraft to achieve LPV capability using PPS GPS receivers due to improvements in vertical accuracy, integrity and availability. There are also efforts in work to reduce the impacts of signal multi-paths around structural (wings, stabilizers, antennae).

3. Funded Enhancements and *Potential Pursuits*.

Digitally Augmented Ship Approach Sequencing (JPALS). **(2018)** JPALS will provide for increased ship-to-aircraft relative position accuracy to support ship recovery operations using Shipboard Relative GPS (SRGPS). After launch and during recovery operations, aircraft will utilize data-linked ship position and altitude information to establish more efficient aircraft marshalling procedures and approaches to the ship’s Expected Final Bearing (EFB). The SRGPS link between the ship and the aircraft on the EFB will enable the aircraft to perform very laterally and vertically precise approaches to the ship in all weather and all tactical conditions to minimize aircraft recovery time. Utilization of tighter patterns has already demonstrated time and fuel savings in commercial airport operations, and should provide similar benefits in CVN and multi-spot amphibious ship operations. JPALS precision navigation will require 24 channel GPS receiver upgrades and processing upgrades that enable procesing both L1/L2 PPS GPS signals. The first platform planned to utilize JPALS for marshalling will be the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS).

Digital Airfield Sequencing (JPALS). **(2018)** Aircraft that are configured with JPALS will be able to immediately take advantage of improved approach sequencing when JPALS units are established at shore bases. Shore based JPALS at military air stations had planned to implement supplemental ground-based signals (Local Area Augmentation Signal – LAAS) that would utilize one-way unique military datalink information for GPS augmentation to enable precision approach capabilities, but that initiative and solution strategy has been deferred. Instead, JPALS equipped naval aircraft will perform GPS augmented precision approach procedures at civilian airfields by leveraging Satellite Based Augmentation System (SBAS) Wide Area Augmentation System (WAAS) signals, which will not require a datalink to receive the correction signal. Air Force is the lead for this program. USAF Mobility and Combat Commands are negotiating the necessity and prioritization of resources to enable MGUE to support this functionality, but it is still currently tracking as a part of the program of record for availability to configured users in 2018.

C. Information Media. This capability element refers to paper and electronic navigation information media formats.

1. Current Capabilities.

Most users are still using paper charts for primary means of navigation. The National Geospatial Intelligence Agency (NGA) generates DOD Flight Information Publications (FLIP) consisting of Enroute and terminal navigation charts, General Planning (GP), Area Planning (AP) and other flight information for military aviators in paper and digital formats (online in PDF or other graphic formats). NGA would prefer users to utilize digital media to cut distribution costs. The Digital Aeronautical Flight Information Files (DAFIF) is the NGA electronic navigation database for use in aircraft mission computers (MC) and Flight Management Systems (FMS). Civil derivative aircraft and some tactical platforms currently use a Commercial Off The Shelf (COTS) FMS and database to meet RNP RNAV criteria. For those aircraft that are configured with them, electronic chart media can be displayed on moving maps. In 2011, Commander Naval Air Forces (CNAF) provided an Interim Flight Clearance IFC) and Interim Authority To Operate (IATO) for a limited number of deployed Hornet aircraft to utilize iPad-2 tablets for display of navigational charts. USMC provided similar authority to H-1 operators. Users are reporting significant space and weight savings (up to 20 pounds and three 'nav bags' of paper). They also reported operational efficiencies from time saved to correlate positions (especially during expeditionary operations in areas where there are few definitive landmarks) and tactical advantages by getting close air support on station faster or dropping troops closer to the right location.

2. Advanced Research and Technology Development.

Flight Information Service – Broadcast (FIS-B); Broadcast Weather Display; Collaborative Routing. (2010-2014) FAA, commercial airlines and the private civil aircraft industry are out-pacing military aircraft when it comes to development and utilization of navigation aids and implementation of cockpit navigation information systems. A private operator can purchase a GPS-based moving map with 802.11b Wi-Fi or XM Satellite Radio supported geographical weather conditions graphics overlay. Military aircraft integrations are more challenging due to harsh environment specifications, operating system through-put limitations, and the necessity for tighter data integrity (currency of navigation information such as airfield procedure changes, obstacle locations, etc.). Combining higher confidence of position accuracy with greater Air Traffic Control (ATC) connectivity can enable operators to 'collaborate' more precise, efficient routes, thereby saving time and fuel. CNS/ATM digital cockpit implementations will enable increased leveraging of these utilities.

3. Funded Enhancements and *Potential Pursuits*.

Digital Navigation Media (Electronic Nav Bag). (2016) In response to a Dec 2010 USMC Urgent Universal Needs Statement (UUNS), and interim flight clearance was authorized to allow deployed operators to use iPad-2 tablets to store and display electronic chart media. Electronic Nav Bags (ENB), also known as Electronic Flight Bags (EFB), are electronic devices which can store electronic versions of COTS and/or DOD FLIP. The ENB enables the aircrew members to carry and access electronic terminal and enroute chart media without having to carry large cases of paper publications. The UUNS specifically called for a Digital Map Viewer (DMV) tool to display Gridded Reference Graphics (GRG) media, which are used for most warfighting areas of operation. A POM-14 issue was submitted requesting resources to set up sustainment of the initially fielded system, as well as development of a follow-on system that could address military aircraft environmental issues. The proposed program is currently scoped to be limited to non-networked, unclassified chart and aircraft publications media as a cockpit space and weight saver and tactical efficiency tool.

Flight Information Service based Weather Graphics. (2018) European ATC managers and the FAA are in the process of implementing Automatic Data Surveillance – Broadcast (ADS-B) capability for improved safe separation. ADS-B operates on two separate datalinks in the US, 1090 MHz Mode S Extended Squitter and 978 MHz Universal Access Transceiver (UAT) datalink. The UAT-based construct is already enabling commercial users to receive and display real-time weather condition graphics. Digital cockpit configurations designed for CNS/ATM compliance will already have the display and processing components required to leverage Flight Information Service – Broadcast (FIS-B) if UAT 'In' is incorporated. The major benefit of FIS-B is access to service-provided weather graphics, which enable the aircrew to circumnavigate dangerous conditions and allow strategic decision-making on flight path, diverts and avoidance maneuvers. Data-linked services can provide weather awareness to platforms that lack the funds, space or weight margins to integrate a dedicated weather radar sensor, and could afford a more cost effective solution. Although data-linked weather may not provide real time information, or accurate weather depictions at the user's altitude, it does provide much longer range weather SA.

D. Recovery.

1. Current Capabilities.

Current shipboard ACLS radars have critical reliability and obsolescence issues. Naval aircraft use Link 4A to conduct assisted approaches and recoveries. The most advanced tactical jets have hands off recovery capability. Helicopters do not have automated recovery. Only the largest surface vessels offer precision approach. Some aircraft employ Instrument Landing Systems (ILS) transceivers for precision approaches to equipped airfields. Most civil airfields are equipped with ILS approaches, but most Navy and Marine Corps airfields typically are not. Aircraft not equipped with ILS are limited to locations with precision radar for alternative low weather ceiling emergency divert recoveries. Receivers that work ILS frequencies must be equipped with filters to prevent FM station interference. The P-3C is the first Navy aircraft certified to fly GPS-based SIDS, STARS and RNP-0.3 approaches.

2. Advanced Research and Technology Development.

Degraded Visual Environment (DVE) Recovery. (2010-2012) The Naval Aviation Center for Rotorcraft Advancement (NACRA) office and PMA261 (H-53 variants) are analyzing technologies and system options that can present an affordable near term solution for this capability gap. Technologies being tested in multiple Small Business Innovative Research (SBIR) efforts include Laser Radar (LADAR), Millimeter Wavelength (MMW) and Passive MMW (PMMW) or other fused spectrum sensors that can “see through” airborne particles to increase SA. The challenge will be to affordably leverage limited existing on-board sensors or to design something that is small and light enough to practically integrate which does not affect flight performance margins.

3. Funded Enhancements and *Potential Pursuits.*

Digitally Augmented GPS-based Shipboard Recovery (JPALS). (2017) JPALS is a joint effort with the Air Force and Army. The Navy is designated as the Lead Service and is responsible for implementation of shipboard recovery solutions (Increment 1). The F-35 Joint Strike Fighter (JSF) Block 5 will be the first JPALS configured platform. It will start with a temporary solution that will provide needles to the operator to enable a “JPALS assisted” approach. The interim solution will not equip the aircraft to broadcast its position in a manner that can be monitored by JPALS equipment on the ship. Legacy radar will have to be used for the shipboard monitoring of the approach. The Unmanned Carrier-Launched Aircraft Surveillance and Strike (UCLASS) will be the second platform. It will be forward fit with full functionality. JPALS will also be installed on air-wing aircraft (C-2A, E-2C/D, EA18G, F/A-18E/F and MH-60 R/S) to support CVN-79 around 2021-2022. JPALS will eventually replace the ACLS on carriers, SPN-35 radars on LH Class Amphibious ships, and may replace ILS, TACAN, and Precision Approach Radar (PAR) systems at shore stations. JPALS will be interoperable with civil augmentation and FAA certifiable. Shipboard JPALS will use Differential GPS (D-GPS) to provide centimeter-level accuracy for all-weather, automated landings. D-GPS provides a SRGPS reference solution for the moving landing zone. A JPALS technology equipped F/A-18 has demonstrated fully automated recoveries to the carrier. JPALS will also enable silent operations in Emission Control (EMCON) environments.

Digitally Augmented Civil Airfield Recovery (JPALS). (2018) Every aircraft that is equipped with JPALS capability for ship operations will automatically be able to conduct civil airfield GPS precision approaches. UCLASS will be the first equipped aircraft. They will be able to use Satellite Based Augmentation Systems (SBAS) such as the FAA's WAAS, the Indian GPS and GEO Augmented Navigation (GAGAN), the Japanese Multifunctional Satellite Based Augmentation System, or the European Geostationary Navigation Overlay Service (EGNOS) which was recently activated. JPALS will also be interoperable with FAA civil Ground Based Augmentation Systems (GBAS), which also uses differential GPS to enhance GPS signal correlation for improved position accuracy. JPALS adds the protected military PPS GPS signal, anti-jam and UHF datalink to military approaches but the Civil approaches will utilize the unprotected SPS signal. Civil system interoperability will enable aviators to use hundreds of additional divert airfield options. The Air Force is designated to develop and implement shore station JPALS capability. One JPALS land-based unit (Increment 2) can replace all the existing non-precision approach beacons and precision radars required for each major runway, providing increased capability for less capital investment and sustainment costs. The Army is developing portable tactical JPALS systems that will enable precision recovery in remote expeditionary locations.

Improved Degraded Visual Environment (DVE) Recovery Tools. (2018) Current helicopter and V-22 cockpit hover attitude cues, drift cues and automatic flight control systems do not effectively enable pilots to hold position, avoid obstacles or land safely when visual references in the landing zone are lost. More rotary wing aircraft were lost In Operation Enduring Freedom (OEF) due to loss of situational awareness in DVE conditions than were destroyed by enemy fire. A functional performance document has been prepared that lists parameters required for increasing levels of capability to safely operate in DVE conditions. Levels are supported by varying systems, including improved automatic flight control coupling; improved hover attitude, drift and vertical motion visual display cues; improved visual performance using sensors that can see through sand, dust, or snow; sensors that can detect and display dangerous obstacles in real time; and databases that project accurate terrain and obstacle information. NASA studies have documented significant improvements in pilot performance using improved attitude and motion cues. The CH-53E CNS/ATM cockpit design incorporated additional software and display capabilities that could have afforded improved hover/drift cues to partially address the capability gap, but the program was discontinued. NACRA and PMA209 are monitoring platform program offices, Defense Advanced Research Project Agency (DARPA), and Office of Naval Research (ONR) initiatives for potential benefits.

Improved Recovery Tools (Vertical NAV). (2020) With enhancements to existing algorithms, the GPS PPS signal could provide aircraft not equipped with WAAS augmentation capable receivers the ability to safely perform "Vertical Navigation" (VNAV) or "Localizer Performance with Vertical Guidance" (LPV) approach descents to lower minimum altitudes. This functionality would enable those platforms to plan flights to more civilian airfields or use them as suitable alternates during emergency divert situations. More landing options would add flexibility and enable more direct routing for fuel savings, and enhance safety during emergencies. VNAV approach minimums do not require the accuracies of LPV approaches and can be implemented without modifications to the military FMS installations.

E. Robustness and Security. In the Navigation capability area, robustness refers to the strength of the system to retain and provide the accurate navigation solution. For GPS, this trait primarily speaks to anti-jam margin. Security covers the ability to perform signal encryption and the prevent spoofing.

1. Current Capabilities.

GPS Antenna System–1 (GAS-1) Controlled Reception Pattern Antennas (CRPA) with matching Antenna Electronics (AE) have been integrated into platforms to enhance the anti-jam capability. Integration of non-SAASM GPS user equipment requires a waiver (Chairman Joint Chiefs of Staff directive effective October 2006). Non-SAASM configured operators are at increased risk of losing GPS signal to jamming or spoofing, which could result in loss of navigational position and precise timing required to synchronize voice or data-linked communications systems. Anti-Spoofing has to do with encryption and keys that protect the receiver from using false signals. Some systems are being integrated into platforms with commercial GPS cards, which adds risk to mission completion because they only use one GPS frequency (L1) and are more susceptible to jamming and unintentional interference. Training must be provided to ensure operators understand commercial GPS susceptibilities. The Advanced Digital Antenna Production (ADAP), is an evolutionary upgrade to the existing GAS-1. It has the same form and fit but increases functionality through digital processing. ADAP will provide the most advanced anti-jam technology currently available. It achieves increased nulling capability using simultaneous dual frequency nulling on both L1 and L2 signals. ADAP has forward compatibility with M-Code and other planned GPS upgrades, and will be incorporated in most production aircraft.

2. Advanced Research and Technology Development.

Military Space Signal and User Equipment Enhancements. (2010-2013) Smaller GPS antennas and AE are being developed for space-constrained aircraft and small Unmanned Aerial Systems. JPALS compatible beam-steering AE is also being developed for JPALS platforms.

3. Funded Enhancements and *Potential Pursuits.*

Reduced Radar Cross-Section (RCS) Antenna. (2013) F/A-18 needs improved GPS signal availability to support the Active Electronically Scanned Array (AESA) radar system and Precision Guided Munitions (PGMs). The F/A-18 Program Office is integrating NAVWAR protection that will include a Conformal CRPA (C-CRPA) GPS Antenna that is optimized for low observability requirements. The F/A-18 NAVWAR integration will include the C-CRPA, and the ADAP AE on aircraft with the ANAV EGI.

Improved GPS Signal Robustness, Anti-Jam and Anti-Tamper (MGUE Receivers). (2018) GPS III is the next generation GPS Satellite constellation and control segment. Full Operational Capability (FOC) is planned for 2018. It will employ the M-Code, which enables enhanced anti-jam capability and signal security, as well as a flexible signal power capability and improved cryptographic protection. The new satellites are planned to eventually incorporate the capability to boost or concentrate the signal (Spot Beam) to increase signal retention and anti-jam margin. GPS receivers will incorporate the first improved anti-tamper M-Code capable cards (test articles) in 2016.

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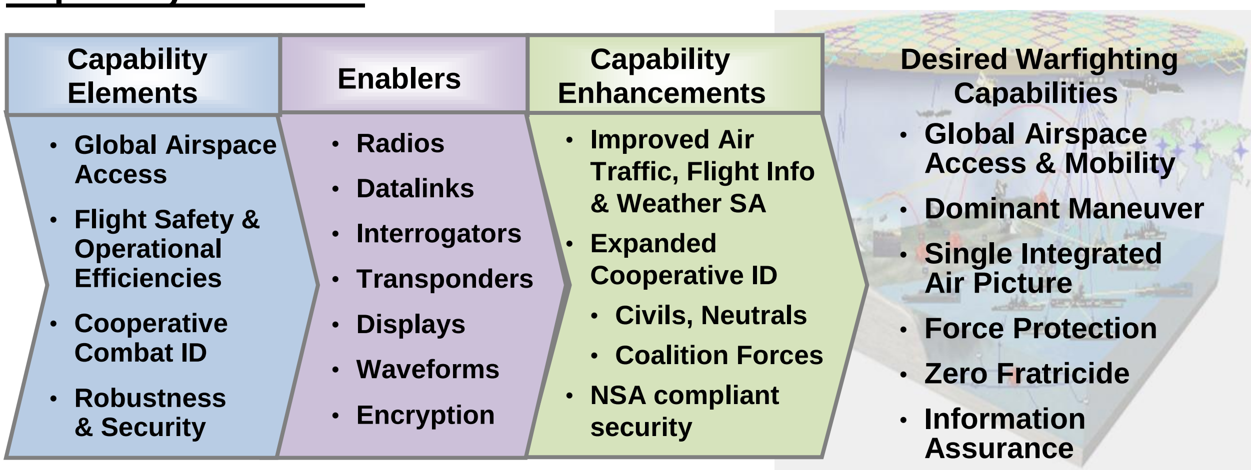
Appendix A-4

Cooperative Surveillance

Scope: This capability area addresses avionics that support Air Traffic Management (ATM) and *cooperative* Combat Identification (CID). Enabling systems, waveforms and protocols include radio transmitters (data communication functions), flight information and Precise Participant Location and Identification (PPLI) datalinks, Identification Friend or Foe (IFF) interrogators and transponders, digital waveforms and encryption. "Cooperative" implies passive or pre-coordinated systems that trade information overtly. Specialized active and passive signature sensor systems are not addressed.

Capability Evolution:

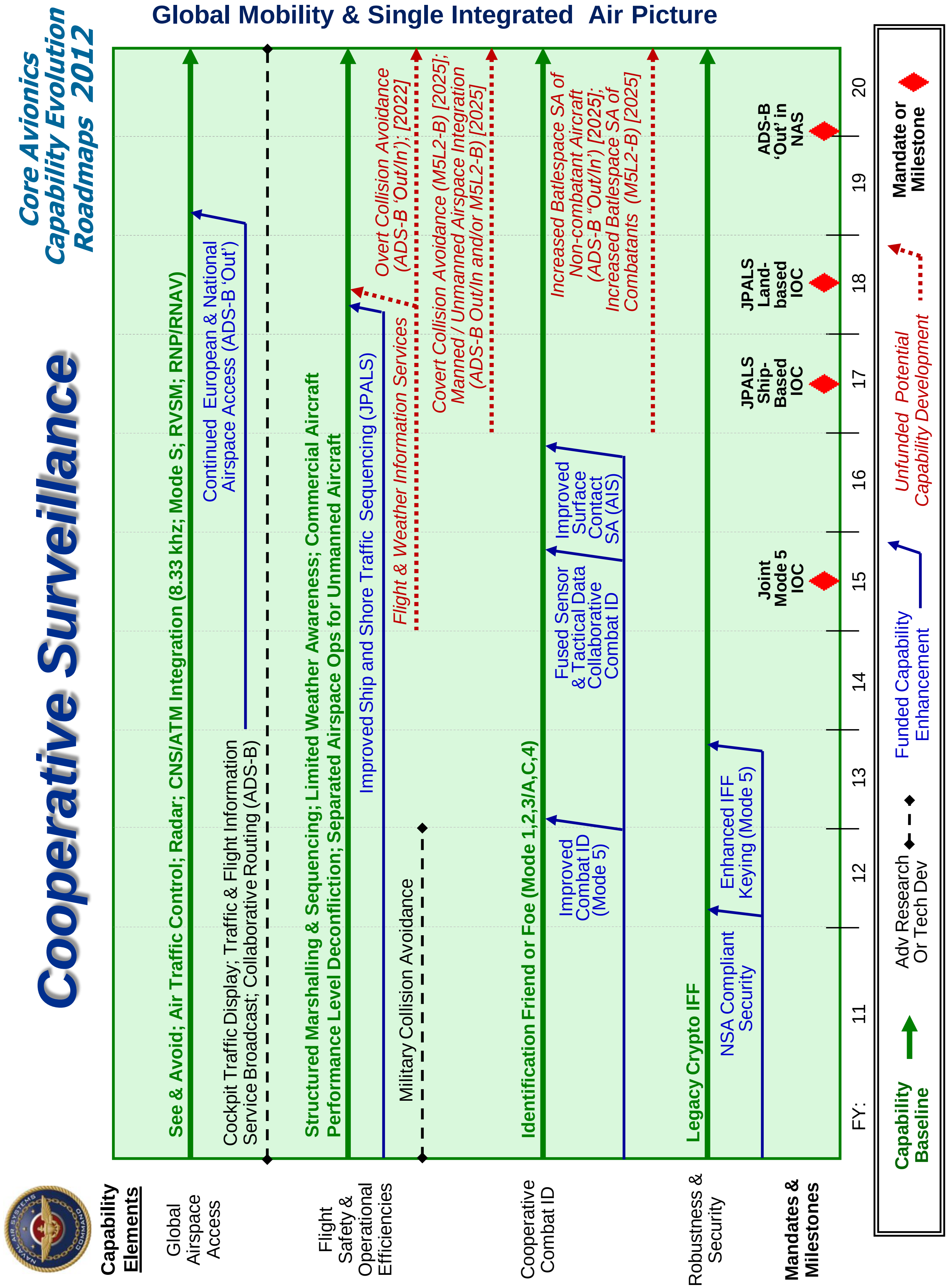


Objective: Global Mobility and Single Integrated Air Picture

Baseline Enhancement Objectives and Transition Strategy.

Military aircraft configurations must meet civil ATM mandates to enable access to all civilian controlled airspaces required for transit to operational areas. Compliance is met by integration of Communications, Navigation, Surveillance / ATM (CNS/ATM) systems and capabilities. Most aircraft have been certified to meet mandate deadlines that have already passed. New production aircraft will be delivered with compliant systems. The primary CNS/ATM functionalities that currently need to be met for operations in the United States National Airspace System (NAS) and European airspaces include:

- 8.33 khz VHF channel spacing for more discrete frequencies to manage traffic loads.
- Protected Instrument Landing System (PILS) to prevent FM radio station interference.
- Reduced Vertical Separation Minimums (RVSM) for high altitude traffic separation.
- Required Navigational Performance (RNP) and Area Navigation (RNAV) for selected levels of lateral separation in terms of nautical miles (nm).
- Mode Select (Mode S) secondary surveillance radar for ground to air data-link selective interrogation to manage increased air traffic capacity, support higher data integrity, reduce radio frequency interference and enable air to ground data exchange.
- Automatic Dependent Surveillance – Broadcast (ADS-B) for automated GPS position, velocity, and quality reporting to ground controllers.


Core Avionics Capability Evolution Roadmaps 2012
Cooperative Surveillance
Global Mobility & Single Integrated Air Picture
Capability Elements
Global Airspace Access
See & Avoid; Air Traffic Control; Radar; CNS/ATM Integration (8.33 khz; Mode S; RVSM; RNP/RNAV)
Continued European & National Airspace Access (ADS-B 'Out')
Cockpit Traffic Display; Traffic & Flight Information Service Broadcast; Collaborative Routing (ADS-B)
Flight Safety & Operational Efficiencies
Structured Marshalling & Sequencing; Limited Weather Awareness; Commercial Aircraft Performance Level Deconfliction; Separated Airspace Ops for Unmanned Aircraft
Improved Ship and Shore Traffic Sequencing (JPALS)
Overt Collision Avoidance (ADS-B 'Out/In'); [2022]
Flight & Weather Information Services
Military Collision Avoidance
Covert Collision Avoidance (M5L2-B) [2025]; Manned / Unmanned Airspace Integration (ADS-B Out/In and/or M5L2-B) [2025]
Cooperative Combat ID
Identification Friend or Foe (Mode 1,2,3/A,C,4)
Improved Combat ID (Mode 5)
Fused Sensor & Tactical Data Collaborative Combat ID
Improved Surface Contact SA (AIS)
Increased Batlespace SA of Non-combatant Aircraft (ADS-B "Out/In') [2025]; Increased Battlespace SA of Combatants (M5L2-B) [2025]
Robustness & Security
Legacy Crypto IFF
NSA Compliant Security
Enhanced IFF Keying (Mode 5)
Mandates & Milestones
Joint Mode 5 IOC
JPALS Ship-Based IOC
JPALS Land-based IOC
ADS-B 'Out' in NAS
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

Baseline to Vision Transition Strategy (continued).

The primary purpose for incorporating capability to meet CNS/ATM mandates is to ensure that military aircraft retain access to sovereign civil airspace. Compliance is accomplished through frequency mapping, filter upgrades to radios, digital cockpit upgrades, incorporation of GPS 'integrity' monitoring (signal verification), and integration and utilization of the Mode S waveform and message sets. Each mandate applies to a specific sovereign airspace and follows specific implementation schedules. Most commercial aircraft have already achieved these new functionalities. Non-compliant military aircraft have become a burden on efficient safe operations. Most Naval aircraft have already achieved 8.33 khz channel spacing, PILS, RVSM and the appropriate Mode S functionality; either Elementary Surveillance (ELS) for fighters and helicopters or Enhanced Surveillance (EHS) for transport type aircraft. The PMA209 CNS/ATM Integrated Product Team is tracking the progress of mandates and working to evolve military systems to meet growing requirements.

The latest civil interoperability mandate that will apply to aircraft flying within the NAS is ADS-B 'Out' (effective 1 January 2020). ADS-B is a broadcast architecture where each aircraft 'squitters' (constant transmissions of at least one pulse per second) its identification, GPS based position and velocity vector. The Federal Aviation Administration (FAA) has identified two different links which can be used for ADS-B broadcasts: Mode S 1090 mhz Extended Squitter (1090ES) and 978 mhz Universal Access Transceiver (UAT). They have chartered an extensive ground infrastructure to capture these aircraft broadcasts which became operational in several locations in the United States National Airspace (NAS) in January 2012. It enables controllers to get more detailed and accurate aircraft PPLI information without using radar equipment. ADS-B receive mode (ADS-B 'In') may eventually also be required, which would enable aircraft to build their own Cockpit Display of Traffic Information (CDTI). ADS-B 'In' using either 1090 ES or 978 mhz UAT enables aircraft to get flight information from ground stations. Only 978 mhz UAT also enables aircraft to get ground based weather depictions. PMA209 is attempting to deliver ADS-B functionality along with RNP/RNAV.

Although the requirement is to retain access to sovereign civil airspace, CNS/ATM integration also enables other military capability growth. Modern hardware and software components being incorporated with CNS/ATM upgrades can provide the digital framework for additional processing and display necessary for other core warfighting functionalities, such as mission information management tools, networked tactical Situational Awareness (SA) tools, data-linked tactical information display (streaming video) and improved aircraft attitude and drift cues for helicopter hover operations in Degraded Visual Environments (DVE). Without these enhancements, several legacy platforms will not be able to host transformational force level capabilities such as Network Centric Operations (NCO), Single Integrated Air Picture (SIAP) and Joint Precision and Approach Landing System (JPALS) marshalling and recovery. Each of these operational capabilities leverages core avionics elements such as improved transceivers, interrogator/transponder, processors, antennas and displays. For the most part, integration efforts are centrally managed by PMA209. The centralized team works with platform experts to leverage existing aircraft architectures. Efficiencies are achieved through re-use of government owned software, economy of scale with common equipment procurement, and reduced management overhead.

Currently, Command and Control (C2) platforms have a comprehensive awareness of identity and location of cooperating military airborne assets, but are less conclusive awareness when it comes to neutral civil platforms. Degree of awareness also decreases when expanding from the tactical coverage area to the regional or strategic theater level. Advancements in the Mode 5 waveform will increase fidelity of target signal differentiation and address signal security issues. Clear and accurate identification, monitoring, and coordination of all traffic and friendly forces will help further the development of the SIAP SA necessary for dominant maneuver, force protection and reduction of fratricide.

The strategy to achieve improved civil interface and military Combat ID is through evolution of existing transponders. Naval Aviation transponders were purposefully designed with open architecture, upgradability and specific hooks for incorporation of Mode S and Mode 5. The Navy will leverage ADS-B ‘Out’ software being developed by U.S.Army programs. Mode 5 (transmit only) and ADS-B ‘Out’ were established as formal requirements, however incorporation of civil and tactical transponder receive capability (ADS-B ‘In’ and Mode 5 Level 2 Broadcast – M5L2-B) would provide additional benefits, such as rapid on-board identification of non-combatant and cooperating coalition operators. Those capabilities have not been embraced as formal requirements for civil interoperability or Combat ID, but are being explored as potential solutions to enable military aircraft performance level collision avoidance. Current collision avoidance products can enable safe separation and conflict resolution for commercial equivalent or transport aircraft flight performance, but fall short during military aircraft rendezvous and formation maneuvers. More detail on Midair Collision Avoidance Capability (MCAC) is provided in the Flight Safety appendix. Finally, transponders will also be modified to incorporate updated encryption algorithms to meet National Security Agency (NSA) requirements and to achieve more efficient and secure keying capabilities. PMA209 and PMA213 are working together to achieve these benefits through collaborative evolution to existing systems versus new and separate products.

Mandates and Milestones:

Joint Mode 5 Initial Operational Capability (IOC). (2015) The March 2007 Joint Requirements Oversight Council Memorandum (JROCM) 047-07 calls for Mode 5 Joint IOC in 2015 and Full Operational Capability (FOC) in 2020.

JPALS Ship-based Initial Operational Capability (IOC). (2017) The US Navy is the lead for the JPALS program, and is responsible for the development of the shipboard solution (Increment IA). JPALS will initially be deployed on the newest aircraft carrier and its assigned aircraft, including C-2, EA-18G, E-2D, F/A-18E/F, F-35 and MH-60R/S.

JPALS Land-Based IOC. (2018) The Air Force is charged with development of land-based JPALS ground stations (Increment II). Differential GPS will be used to provide an additional military PPS datum reference signal via Satellite Based Augmentation System (SBAS) Wide Area Augmentation System (WAAS) signals. A fixed station will be installed at every DoD airfield that currently has precision approach capability. A man-pack variant may be developed for remote locations.

ADS-B 'Out' in NAS. (1 January 2020) The FAA established the requirement for ADS-B 'Out' functionality by updating Title 14 Code of Federal Regulations (CFR) Part 91 in 2010 with a mandatory implementation date of 1 January 2020. ADS-B 'Out' will be required for access to higher density airspaces, which include or effect operations at several major military bases. ADS-B 'Out' architecture has been in operation in Alaska, and opened in several Continental U.S. (CONUS) locations in January 2012. It employs both 1090 ES and 978 mhz UAT formats. *Note:* 978 UAT is a shorter range utility, capable at limited ranges up to 18,000 feet but practically applied to operations under 10,000 feet. Although there are some viable emerging Commercial Off The Shelf (COTS) navigation products that are incorporating UAT-based ADS-B 'Out,' higher performance, faster flying military aircraft will very likely interface better with ATC using 1090 ES (which will also be the only format that enables overseas airspace access). The UAT-based products may effectively support CONUS based helicopter trainers.

Capability Element Evolution:

A. Global Airspace Access. This capability element section addresses safe traffic separation, with more depth on the CNS/ATM compliance criteria. It includes information on functionalities provided by avionics components in the context that they are used to assist Air Traffic Control (ATC) agencies with cooperative surveillance of platform status and location.

1. Current capabilities: See and Avoid; Air Traffic Control; Radar; CNS/ATM Integration (8.33 khz, Mode S, RVSM, RNP/RNAV).

The majority of deployed post-production aircraft utilize voice over VHF and UHF radio channels, Identification Friend or Foe (IFF) Mode 3/A and Mode C signals to communicate with civil ATC. Some IFF systems use Mode S to overcome issues with Mode 3/A. Once established on a route, aircrew who don't have their own radars principally depend upon ATC traffic calls and "See and Avoid" scanning techniques to prevent conflicts or collisions with other traffic. Most civil derivative transports have successfully incorporated commercial CNS/ATM products. In recognition of the time, costs and integration challenges, tactical 'State' aircraft (military platforms) were afforded delays for complying with CNS/ATM mandates. A 2001 FAA memorandum declared that State aircraft would be accommodated *"to the extent practicable based upon existing traffic and safety considerations*." Non-compliant naval aircraft are now more regularly being excluded from high density airspaces. Solutions have been designed to certify compliance with CNS/ATM performance requirements. In the beginning, compliance elements were individually implemented to meet imposed and impending restrictions. Several platforms have now implemented full scale digital cockpit replacements.

- 8.33 KHz VHF channel spacing has been accomplished through higher fidelity digital radio waveforms and radio frequency remapping, primarily in ARC-210 radios.

- Protected ILS Filters have been incorporated into receivers to prevent bleed-over interference (primarily from FM station proliferation/frequency encroachment in Europe).

• RVSM. In 2005, the FAA reduced aircraft vertical separation minima from 2000 to 1000 feet for operations on airways above FL 290 in order to accommodate increasing traffic density. RVSM performance necessitates incorporation of redundant altitude measuring systems that guarantee accuracy when operating at assigned altitudes.

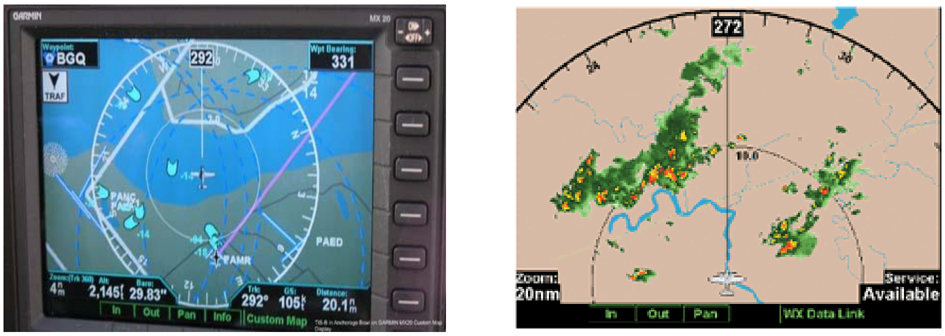
• RNP/RNAV. GPS navigation systems are incorporating Receiver Autonomous Integrity Monitoring (RAIM) platforms to meet RNP/RNAV performance parameters. The FAA will require RNP-2 for all operations at or above FL 290 in the CONUS by 2018. Aircraft flying at lower altitudes must also use RNP/RNAV for favorable routing through congested areas. FAA roadmaps call for all TMAs to have RNP capable SIDs and STARs by 2015. More details on RNP/RNAV are presented in Appendix A-3.

• Mode S. The primary purpose of Mode S is traffic identification and separation. Interrogations are made on 1030 MHz and replies are made on 1090 MHz frequencies. ELS requires a Mode S transponder that can respond to an interrogation with the aircraft's call sign. EHS is met by importing additional aircraft parameter information into the response signal, including roll angle, track angle, ground speed, magnetic heading, indicated airspeed (or mach) and vertical rate. Traffic Alert and Collision Avoidance System (TCAS II) systems, also known as Airborne Collision Avoidance System (ACAS II) systems, have been deployed on civil derivative and transport aircraft. TCAS II uses the Mode S waveform as the communication link to achieve its functionality. These systems incorporate software that determines if aircraft courses present risk of collision and can provide alerts and conflict resolution advisories. Mode S is required for all operations in Europe.

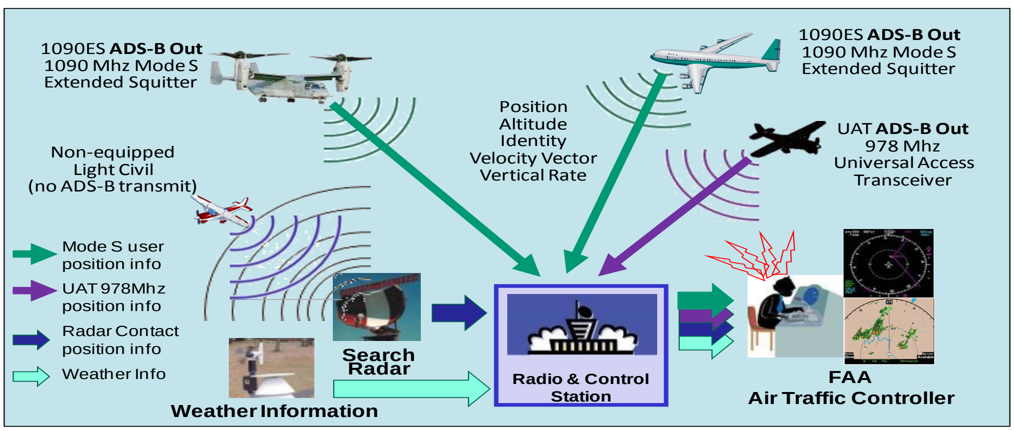
2. Advanced Research and Technology Development. These activities will be under constant enhancement by civil and commercial entities throughout the time period of the roadmap.

Cockpit Traffic Display. (2012-2022) The FAA's Next Generation Air Transportation System (NextGen), will be comprised of three pillars: Required Navigational Performance (RNP) Area Navigation (RNAV), ADS-B, and Data Communications (DATA COMM). Naval aviation is implementing RNP RNAV and requesting funding for ADS-B 'Out' to meet the 2020 mandate. The full implementation of ADS-B, as defined by NextGen, will also include ADS-B 'In.' Both ADS-B 'In' and Data COMM will require integrated cockpit displays. Commercial airlines have already incorporated ADS-B 'Out,' and many commercial aircraft are incorporating ADS-B 'In' functionality as they upgrade to TCAS II. Tactical aircraft without TCAS II will need a different path to achieve ADS-B 'In' in order to enable them to build a CDTI picture for traffic SA. CDTI will enable the aircrew to self-monitor other aircraft that are using ADS-B 'Out.' It also provides more data for an improved understanding of those aircraft's flight vectors that can be more accurately used to provide conflict avoidance guidance. DATA COMM will also require a cockpit display presentation so the aircrew can monitor controller digital text messages. Both ADS-B 'In' and DATA COMM are not expected to be mandated for State aircraft prior to 2025.

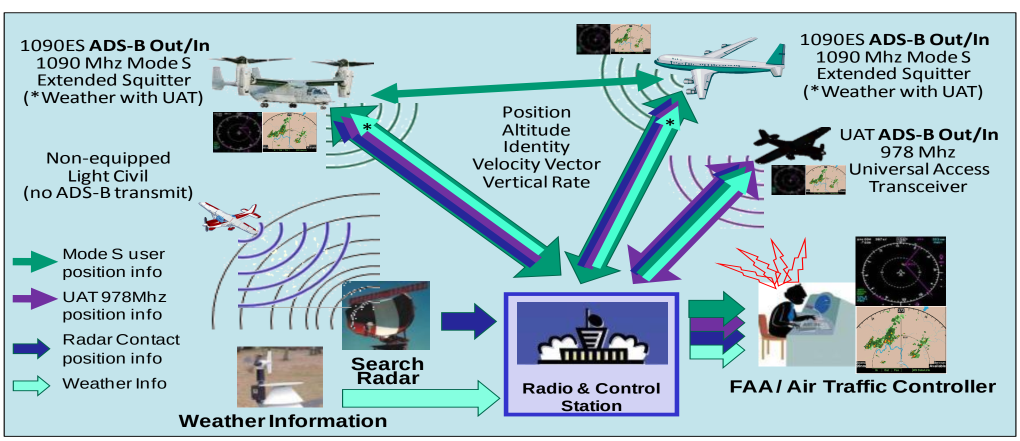
Traffic and Flight Information Service – Broadcast (TIS-B and FIS-B). (2012-2022) TIS-B provides ADS-B 'In' equipped aircraft with secondary surveillance radar position updates of non-ADS-B 'Out' equipped aircraft. This capability provides users with awareness of the location of many smaller general aviation contacts that are using traditional civil transponders. FIS-B provides graphical National Weather Service graphics similar to those seen on internet websites. It also provides Temporary Flight Restrictions (TFRs) and special use airspace information. Aircraft must have appropriate signal management software to view the information provided. TIS-B can work with 1090 mhz systems, but FIS-B is only provided to 978 mhz UAT equipped aircraft. These services are up and operating at several locations in the NAS.



Example TIS-B traffic display and FIS-B Weather Graphics.



ADS-B 'Out' ATC Information Exchanges



ADS-B 'Out' and 'In' ATC Information Exchanges

Collaborative Routing (ADS-B and DATA COMM). (2012-2022) Tighter location accuracy and increased SA enables controllers to have more confidence that aircraft can self-regulate safe separation. Properly equipped operators may be allowed to deviate from a prescribed path and proceed along a more desired direct path to their destination, saving time and fuel. This level of awareness and confidence on both ends supports a concept called “Collaborative Decision Making,” which the FAA is exploring as a concept of operations for NextGen.

3. Funded Enhancements and *Potential Pursuits.*

- **Continued NAS Access (ADS-B ‘Out’). (2019)** ADS-B. 1090ES provides greater position accuracy of aircraft at a higher refresh rate than radar scans. More than 80% of commercial air carriers have already incorporated ADS-B ‘Out’ functionality. Several locations in the NAS are already equipped to operate with ADS-B. The ground infrastructure to support ADS-B is expected to be finished within the NAS by 2013 and the deadline for mandatory aircraft compliance is January 2020. ADS-B ‘Out’ will be required to gain access to Class A, B, C, and E airspaces, which include operations from the ground up within 30 nautical miles of several major airports. These airspaces are required for transit in and out of some major military bases, such as Pensacola, North Island, Dallas Fort Worth, and other locations. The PMA209 CNS/ATM team is attempting to address ADS-B ‘Out’ in conjunction with integration of RNP/RNAV and within the current program of record funding.

B. Flight Safety and Operational Efficiencies.

This capability element focuses on the operational benefits that can be achieved through the cooperative surveillance enhancements incorporated to achieve CNS/ATM compliance.

1. Current capabilities: Structured Marshalling & Sequencing; Limited Weather Awareness; Commercial Aircraft Performance Level Deconfliction; Separated Airspace Ops for Unmanned Aircraft.

At airfields, aircraft are sequenced using established approach routes. Around the ships, aircraft are organized into pre-coordinated marshalling locations. Controllers use timing estimates and heavily rely on the aircrew to coordinate altitude changes and downwind turns in order to manage efficient separation for rapid recovery. The ship’s radar is not as accurate or informative as a GPS-based position reporting format. Very few Naval Aviation platforms have the real estate or power base to integrate onboard weather radar. Aircrew rely on preflight planning to avoid severe weather, but can find themselves at risk of mission impact, or worse, if weather conditions do not progress as predicted. Access to current weather representations could allow aircrews to more effectively avoid hazardous conditions. Current commercial collision avoidance systems can provide useful additional SA of potential conflicts, but cannot provide adequate separation/deconfliction cues for higher performance maneuvers of tactical aircraft, such as higher speed rendezvous or formation flight. Finally, unmanned aircraft operations are presenting increasing risk to manned platforms. Despite airspace partitioning in terms of location and/or altitude, warfighting dynamics are resulting in frequent near mid-air collisions. If unmanned aircraft plan to operate outside special use airspace, they will need to incorporate CNS/ATM functionalities.

2. Advanced Research and Technology Development.

Military Collision Avoidance (Mode 5). (2011-2012) A Small Business Innovative Research (SBIR) projects is exploring utilization of TACAN Air-to-Air mode to perform aircraft collision avoidance functions within the battlespace. This utility was reportedly demonstrated by Spanish F-18 aircraft. Algorithms were developed to place a 'range bubble' around aircraft based upon proximity to another cooperating aircraft who was also operating on TACAN using a specific channel separation.

3. Funded Enhancements and *Potential Pursuits.*

Improved Ship and Shore Approach Sequencing (JPALS). **(2018)** F-35B and C early block deliveries will employ a one-way JPALS data-link integration to facilitate Shipboard Relative GPS (SRGPS) aided recoveries. Block four or five will incorporate the full two-way datalink, which will enable ship controllers to manage improved marshalling for more efficient recoveries. Utilization of tighter patterns has already demonstrated time and fuel savings in commercial airport operations, and should provide similar benefits in carrier and multi-spot amphibious ship operations. For more JPALS details, see the Navigation appendix.

Flight Information Service / Weather. (2018) Digital cockpit configurations designed for CNS/ATM compliance will already have the display and processing components required to leverage FIS-B if 978 mhz UAT 'In' is incorporated. FIS-B graphically provides information that is usually presented in a taped voice message. One major benefit of FIS-B is access to service-provided weather graphics, enabling the aircrew to circumnavigate dangerous conditions, and allow strategic decision-making on flight path, diverts and avoidance maneuvers. Data-linked services can provide weather awareness to platforms that lack the funds, space or weight margins to integrate a dedicated weather radar sensor, and could afford a more cost effective solution. Although data-linked weather may not provide real time information, it does provide much longer range weather SA.

Overt Collision Avoidance (ADS-B 'Out/In'). (2022) Attempts to modify commercial TCAS system algorithms to support tactical aircraft combat maneuvering, rendezvous or formation flight were unsuccessful, resulting in false and nuisance warnings that made the systems unusable. ADS-B system fidelity with Mode S lower latency shows promise to provide a military aircraft collision avoidance capability, which has been pursued as an element of the OPNAV Aviation Safety Systems policy for more than a decade. ADS-B 'Out/In' can be accomplished using both 1090 MHz ES Mode S transceivers and 978 MHz UAT. The roadmap shows this line as a continuation of the POM-15 start to achieve FIS-B because it could leverage that initiative. It is listed as 'overt' because users must be actively broadcasting and receiving, which would provide information on civil aircraft and other cooperating U.S. and coalition aircraft.

Covert Collision Avoidance (M5L2-B). (2025) M5L2-B could provide awareness of military traffic using encrypted Mode 5 instead of unencrypted Mode S. This scheme enables configured military and coalition aircraft to know each other's location while not giving their positions away to unfriendly sensors. M5L2-B could provide 'covert' collision avoidance capability in a combat non-permissive environment where Mode 3/A and Mode C and ADS-B are not broadcasted.

Manned / Unmanned Airspace Integration (ADS-B "Out/In") (2025) FAA is already planning for integration of operations of unmanned platforms into the National Airspace. The drive is coming from requirements to conduct military operations and training, as well as a demand for civil application unmanned platforms (border patrol, property and livestock management, etc.). It is currently felt that the autonomous operations and automatic recovery functions will require both ADS-B 'Out' and 'In' situational awareness in order to ensure safe separation.

C. Cooperative Combat Identification (ID). The Combat ID Capstone Requirements Document (CRD) defines Combat ID as follows: "the process of attaining an accurate characterization of detected objects in the joint battlespace to the extent that high confidence, timely application of military options and weapons resources can occur." The Cooperative Combat ID capability element addresses systems that enable detection and positive identification of friendly forces, coalition partner forces and civil neutrals that are cooperatively providing signals to identify themselves.

1. Current capabilities. Identification Friend or Foe (Mode 1,2,3/A,C,4); One Way Blue Force Reporting.

Most military aircraft provide their identification using modes of the Mark XII IFF legacy systems. Modes 1, 2 and 4 are reserved for military use, with Mode 4 using encrypted interrogations. Modes 3/A and C are used jointly by both civil and military ATC. The legacy IFF architecture is cooperative in nature and employs a Question and Answer (Q&A) exchange format. Replies to interrogations identify contacts as friendly or neutral and provide limited mission data. This information is used to confirm friendly contacts, enhance air traffic control and prevent fratricide. Cooperative Combat ID applies to both military and civil contacts. Civil aircraft are also using Mode S as their primary means to provide PPLI messages to ATC. Those signals, especially if they include EHS parameters, could provide much more information to military operators than can be interpreted by their Mode 3/A and C transponder interrogations; however, few military assets are currently equipped to exploit the Mode S signals. ADS-B 'In' would enable exploitation of the information being widely broadcasted, but is not be expected to be mature until after ADS-B 'Out' is broadly integrated.

2. Funded Enhancements and *Potential Pursuits*.

Improved Combat ID (Mode 5). (2013) NSA decertified Mode 4 in 2003. Mode 4 is currently authorized for use; however, NSA will no longer certify development or modifications of systems that only provide Mode 4. Next generation interrogators and transponders have been designed to facilitate a growth path for the integration of MARK XII/A Mode 5 IFF systems. Current USN Mode 5 equipment includes the AN/APX-123 transponder and the AN/UPX-41(C) shipboard digital interrogator. Other IFF equipment planned for Mode 5 upgrades include the AN/APX-119, AN/APX-122, AN/APX-111(V), and AN/UPX-40. Per the current documented requirement, these systems are being equipped with Mode 5 Level I interrogation and lethal interrogation override. Mode 5 Level 1 provides target identification with a significant improvement in range, better discrimination of closely-spaced platforms (reduced signal garbling using a random reply delay instead of a fixed time delay), reduced false signals and a reduction in spoofing and exploitation vulnerability. This allows multiple aircraft in tactical formation to reply separately, offering greater SA to command and control elements and other tactical participants. The lethal interrogation override function allows interrogators to attempt to get responses from inadvertently secured friendly unit transponders as a last resort prior to engagement. Air Force is also incorporating M5L2-B “squitter” (2 MHz signal) and “triggered” replies into their units. The reply or broadcast signal provides platform identification (unique number for that particular airframe and country of origin), GPS location and a time stamp. M5L2 provides improved SA. To improve security, Mode 5 has a new NSA-developed encryption algorithm that utilizes a shorter crypto validity time and encrypts both the interrogation and reply signal. Mode 5 is backward compatible with existing Mode 4 and civil IFF capability, and is compatible with civil ATC, including Mode S. A Mode 5 interrogator has already been planned for shipboard applications and for select aircraft, including: P-8A, F/A-18A+/C/D/E/F, EA-18G, E-2D and MH-60R. First airborne capability will be deployed in 2013.

Fused Sensor and Tactical Data Collaborative Combat ID (CID). (2015) The fusion server integrated into the Joint Strike Fighter (JSF) hosts software that combines and compares target track information obtained from all on-board sensors, as well as from tactical information data-linked from outside sources. If multiple sensor track parameters are similar, a contact attribute can be considered more reliable than if it were derived from a single source data point. Similarly, intelligence and sensor data combinations can be used to discount parameters that may not be as reliable from a single range or condition limited sensor, or one that may be getting spoofed. Automated fusion will produce a higher confidence factor CID solution.

Improved Surface Traffic SA, Automatic Identification Service (AIS). (2016) AIS is an automated tracking system set up in the Maritime VHF spectrum for surface vessels that mirrors aircraft IFF reporting and ATC management of aircraft. All surface vessels over 300 gross tons are required to employ AIS to broadcast their identification, call sign and track information every 2-10 seconds while underway (3 minutes at anchor). AIS enables Vessel Traffic Services (VTS) controllers to receive data-linked information instead of relying on radars for spotting contacts and radio calls for contact identification. Ships also monitor the data, which assists with navigation and collision avoidance. AIS integrates standardized VHF transceivers with position reporting systems (GPS or LORAN-C receivers) and navigation components such as gyrocompasses or rate of turn indicators. AIS information is usually overlaid on map displays. Surface Search and Rescue (SAR) operations are networked with AIS. SAR and Surface Defense mission aircraft would benefit from AIS SA, versus relying on open communications or visual verifications to confirm surface contact identification. It would allow crews to navigate directly to known contacts, or to eliminate contacts to focus on an unknown who is not broadcasting. P-8A has programmed integration of AIS with Increment II.

Increased Battlespace Situational Awareness of Non-combatant Aircraft (ADS-B ’Out/In’). (2025) Incorporation of ADS-B ‘In’ capability would immediately provide configured users with increased SA of the civil aircraft operating in their vicinity. It would not only display information provided by larger commercial platforms also equipped with ADS-B ‘Out,’ but will display information about smaller general aviation traffic that ATC gets from their secondary surveillance radars. This would enable operators to have a more comprehensive understanding of the status of the air picture, eliminating concern for most of the unknown (neutral) contacts.

Increased Covert Battlespace Situational Awareness of Combatants Mode 5 Level 2 – Broadcast (M5L2-B). (2025) Incorporation of M5L2-B capability would immediately provide configured users with increased SA of the coalition aircraft operating in their vicinity. Their broadcast signals could not be interpreted by other civil or hostile aircraft that were not similarly equipped and aware of the current encryption keys. Hostiles would by default stand out, thereby decreasing detection times. Activating the M5L2-B capability could increase SA and bring additional SIAP or COP functionality for improved coordination between Coalition partner forces. This element and the one above are represented in a separate red line from JBC-P because they do not leverage that effort and are not expected to be mature enough to start until later.

D. Robustness and Security. Cooperative Surveillance robustness and security address system vulnerability to exploitation. Robustness refers to strength of the surveillance signals and architecture against spoofing or jamming, as well as the quality of the positive identification functionality. Security refers to encryption and protection of information across the spectrum of different classifications.

1. Current capabilities. Legacy Crypto IFF.

As previously stated, Mode 4 is still authorized for use. The NSA restriction limits development or modifications of systems that only provide Mode 4. The Mode 5 waveform has already been designed and will be deployed for shipboard and airborne applications. It is more robust, which enables receivers to establish and maintain a stronger signal lock to avoid spoofing and jamming. Mode 5 also utilizes an improved encryption process with algorithms that encrypt both the interrogation and reply signals.

2. Funded Enhancements and *Potential Pursuits.*

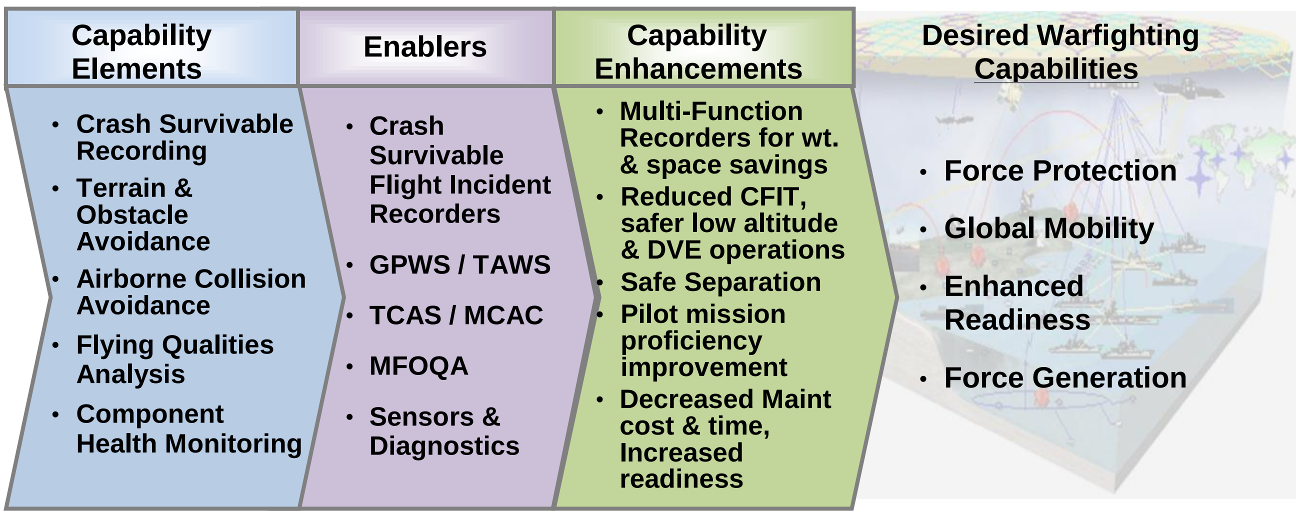
NSA Compliant Security. (2012) As with Mode 4, NSA has decertified crypto algorithms associated with some legacy IFF key-loading equipment. Replacement algorithms are being developed and certified to replace the decertified software.

Enhanced IFF Keying (Mode 5). (2013) Integration of Mode 5 functionality will address security and keying support issues that are problematic with Mode 4, thereby enhancing system security. The Mode 5 Crypto Modernization effort will provide upgrades to the Electronic Key Management System (EKMS). Mode 5 does not upgrade EKMS, but EKMS upgrades are required to support MODE 5, including new keying devices which enhance key loading capabilities, reduce key loading time, and eliminate problems with improperly keyed systems. All Mode 5 keying material will be electronic. Mode 5 systems are also capable of storing multiple days of key information and automatic selection of the Communications Security (COMSEC) validity interval, which eliminates issues with key rollover and encryption code change times.

Appendix A-5
Flight Safety

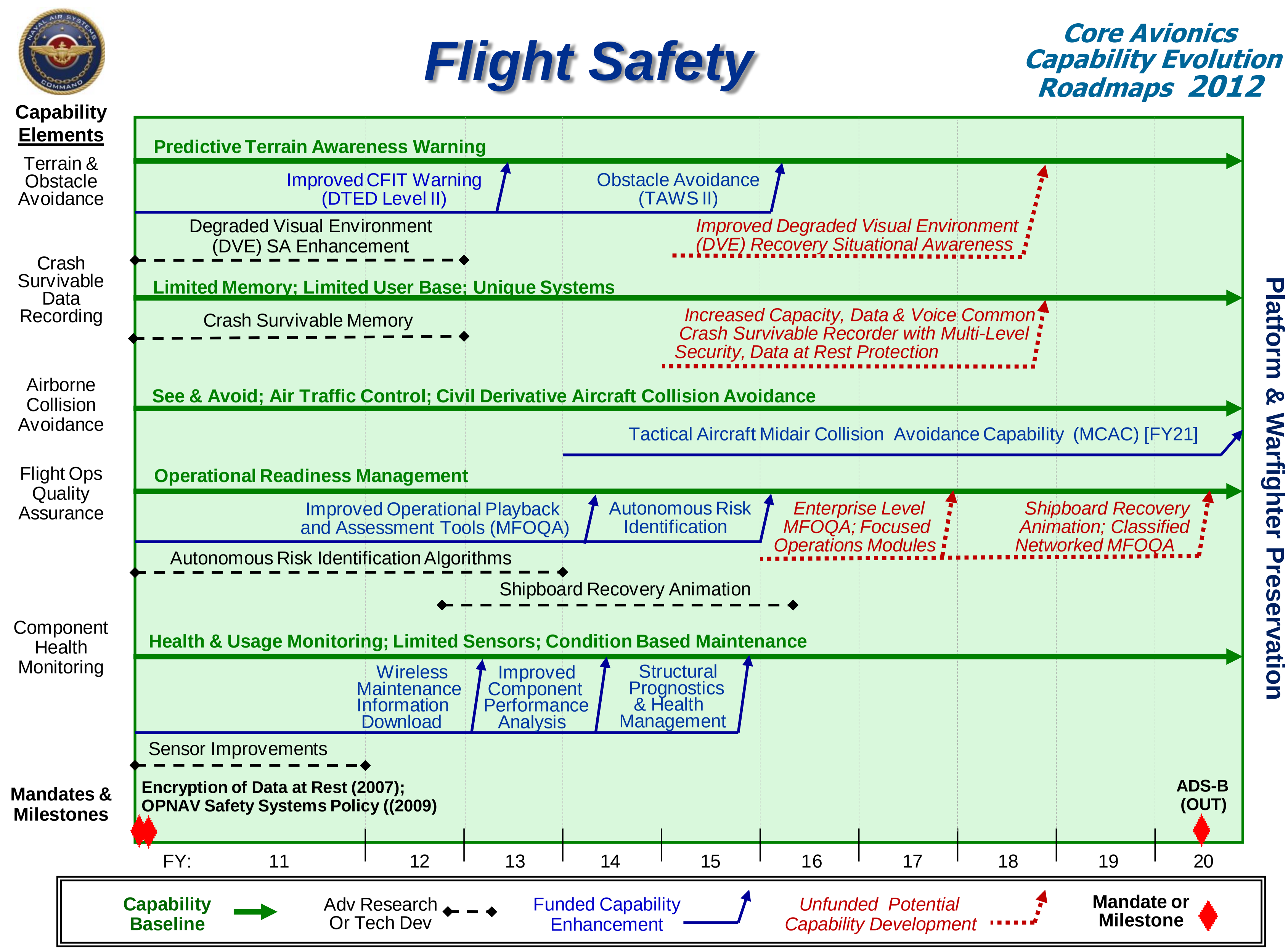
Scope: The Flight Safety capability includes elements that provide protection during flight operations, enable post-flight proficiency and component performance trend analysis tools, and support post-mishap analysis. Enabling systems include predictive ground collision protection, crash survivable recorders, military aircraft performance level collision avoidance systems, flight operations quality analysis tools and component condition monitoring systems.

Capability Evolution:



Objective: Platform & Warfighter Preservation

Baseline Enhancement Objectives and Transition Strategy. OPNAVINST 13210.1A (Sep 2009) calls for incorporation of basic safety system elements into all aircraft. While the goal is to provide maximum protection to all operators, it is recognized that there are technological limits to solutions for some applications, significant integration challenges for some legacy platforms, and limited resources available for investments. The policy includes consideration for waivers, but only under particular circumstances and with assumption of acceptable risk. Most new production aircraft are configured with each of the safety capability elements when they are delivered (in recognition that integration during design and development is more affordable). Digital cockpit upgrades to meet civil Communications, Navigation, Surveillance / Air Traffic Management (CNS/ATM) interoperability requirements provide opportunities to solve some technical and integration challenges and enable more affordable retrofit of safety capabilities to legacy platforms. Safety systems managers are leveraging technological advancements in commercial computing to improve crash recorder processing and memory capacity, and are exploring multi-functionality efficiencies (combining safety data recording, mission data recording, safety algorithm processing, and more). Military Flight Operations Quality Assurance (MFOQA) will leverage significant demonstrated success in the commercial airline sector, and is expected to provide the next transformational leap forward toward meeting DoD and SECNAV mishap reduction objectives.


Flight Safety
Core Avionics Capability Evolution Roadmaps 2012
Capability Elements
Terrain & Obstacle Avoidance
Crash Survivable Data Recording
Airborne Collision Avoidance
Flight Ops Quality Assurance
Component Health Monitoring
Mandates & Milestones
Predictive Terrain Awareness Warning
Improved CFIT Warning (DTED Level II)
Obstacle Avoidance (TAWS II)
Degraded Visual Environment (DVE) SA Enhancement
Improved Degraded Visual Environment (DVE) Recovery Situational Awareness
Limited Memory; Limited User Base; Unique Systems
Crash Survivable Memory
Increased Capacity, Data & Voice Common Crash Survivable Recorder with Multi-Level Security, Data at Rest Protection
See & Avoid; Air Traffic Control; Civil Derivative Aircraft Collision Avoidance
Tactical Aircraft Midair Collision Avoidance Capability (MCAC) [FY21]
Operational Readiness Management
Improved Operational Playback and Assessment Tools (MFOQA)
Autonomous Risk Identification
Enterprise Level MFOQA; Focused Operations Modules
Shipboard Recovery Animation; Classified Networked MFOQA
Autonomous Risk Identification Algorithms
Shipboard Recovery Animation
Health & Usage Monitoring; Limited Sensors; Condition Based Maintenance
Wireless Maintenance Information Download
Improved Component Performance Analysis
Structural Prognostics & Health Management
Sensor Improvements
Encryption of Data at Rest (2007); OPNAV Safety Systems Policy ((2009)
ADS-B (OUT)
FY: 11 12 13 14 15 16 17 18 19 20
Platform & Warfighter Preservation
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

Mandates and Milestones:

DoD Encryption of Data at Rest Policy Memorandum. (Jul 2007) Establishes policy for protection of sensitive unclassified information on mobile computing devices and removable storage media. All unclassified data stored on removable storage devices must be treated as sensitive and be encrypted per standards set by the National Institute of Standards and Technology (NIST) Federal Information Processing Standard 140-2 (FIPS 140-2). This standard affects data storage devices as well as mission planning and mission recording information handling. This policy is an extension of guidance provided in DoDI 8500.2, Information Assurance (IA) Implementation.

OPNAVINST 13210.1A Naval Aviation Policy for Aircraft Safety Systems Avionics. (03 Sep 2009) Directs incorporation of specified flight safety capabilities:

- Controlled Flight Into Terrain (CFIT) avoidance.
- Crash survivable aircraft parameter, flight information and audio recording.
- Airborne collision avoidance protection.
- Military Flight Operations Quality Assurance (MFOQA).

Required system performance parameters are delineated for each of the capabilities. It calls for compliance reviews to be conducted at each program milestone, and encourages pursuit of common system solutions. Waiver requests are to be submitted to OPNAV (N98) and must include type/model/series, which safety element is being requested for waiver, justification for the waiver, assessment of risk, actions taken toward compliance and plan ahead to achieve compliance.

Automatic Dependent Surveillance – Broadcast Out (ADS-B Out) in National Airspace. (2020) FAA established the requirement for aircraft operating in high density traffic airspaces within the National Airspace (NAS) to be equipped with ADS-B "Out" functionality by 2020. Non-compliance may result in airspace exclusion.

Capability Element Evolution:

A. Terrain and Obstacle Avoidance. This capability element addresses the capability to provide awareness to the pilot of potential ground and/or man made obstacle impact to prevent CFIT mishaps.

1. **Current capabilities. Predictive terrain awareness warning.**

There are two primary CFIT avoidance solutions integrated into several platforms. Ground Proximity Warning System (GPWS) software is an embedded implementation of an algorithm that uses aircraft dynamics and sensor data to determine whether there is a high risk of CFIT. If such a risk is found to be present, the pilot is provided a directive cue (i.e., the pilot is told what maneuver to execute in order to initiate safe recovery of the aircraft from the CFIT condition). Terrain Awareness Warning System (TAWS) uses *predictive* software algorithms improve CFIT warning capability by comparing aircraft altitude, attitude, and airspeed developed from GPS and/or Inertial Navigation System (INS) against on-board Digital Terrain Elevation Data (DTED) database information. This capability is only available to those platforms that can host the database and have sufficient processing power to drive the TAWS algorithm. TAWS provides improved dynamic flight profile protection over GPWS as well as aural or visual cues that have been credited for saving aircraft. Since incorporating TAWS, there has not been one F/A-18E/F CFIT mishap.

Rotary wing aircraft are suffering significant losses in current Overseas Contingency Operations. On a daily basis (almost on a per-mission basis), helicopters frequently encounter Degraded Visual Environment (DVE) conditions (also known as ‘brown-out”). The landing attitude and heavy disk loading of the CH-53 make it particularly prone to creating DVE conditions. Its delivery mission means it can experience DVE several times per mission. Over some periods in the last decade, more aircraft were damaged or lost due to reduced situational awareness in DVE conditions than were lost to enemy fire. Mishaps occur from CFITs, roll-overs, collisions with obstacles or collisions with other aircraft. Legacy platforms lack adequate attitude and hover drift indications, hover-capable automatic flight controls, or sensors necessary to enable them to conduct routinely safe, controlled recoveries in DVE conditions. Aircrews currently compensate for the conditions using pilot experience and minimum hover touchdown techniques.

2. Advanced Research and Technology Development.

DVE Situational Awareness (SA) Enhancement. (2011-2012) There are several advance research activities underway to explore technologies that could support improved SA in DVE scenarios. PMA261 (H-53 variants) is currently managing industry demonstrations and reviews of prototype systems, analyzing them for weight, size, power requirements, versatility, effectiveness and cost. PMA209 is leading a Small Business Innovative Research (SBIR) initiative that is testing the use of Flash Light Detection and Ranging (LIDAR or LADAR) to enable aircrew to see through airborne particulates or to “see and remember” an environment so that a virtual representation (“synthetic vision”) can then be created for safe maneuvering. The Office of Naval Research (ONR) is managing the Helicopter Product II effort in support of associated Future Naval Capabilities (FNCs) which is exploring fusion of LADAR and Passive Milli-Meter Wave (PMMW) technologies with terrain databases for similar objectives. These pursuits can also serve to achieve improvements in obstacle avoidance.

3. Funded Enhancements and *Potential Pursuits.*

Improved CFIT Warning (DTED Level II). (2013) Higher fidelity DTED information is required to adequately protect platforms when they operate closer to the ground. DTED Level I is the basic medium resolution elevation data source for all military activities and systems that require landform, slope, elevation, and/or gross terrain roughness in a digital format. The information content is approximately equivalent to the contour information represented on a 1:250,000 scale map (100 m post spacing). DTED Level II (DTED II) is a higher resolution elevation data source that is equivalent to the contour information represented on a 1: 50,000 scale map (30 m post spacing).

Obstacle Avoidance (TAWS II). (2016) The TAWS CFIT function will be enhanced by implementing an obstacle database to warn pilots of possible impact with manmade obstacles (i.e. towers). The algorithm will use the National Geospatial-Intelligence Agency (NGA) data base to predict obstacles in the platforms flight path. When the TAWS II algorithm predicts a potential impact the pilot will receive an audio and visual warning. TAWS II will use DTED II data; which, as described above, is a uniform gridded matrix of terrain elevation values that provides resolution equivalent to 30 m post spacing. Modern processors will host the increased memory and processing power required to enable TAWS II. The increased database fidelity is required for low level operations and improved obstacle avoidance.

Improved Degraded Visual Environment (DVE) Situational Awareness. (2018) Naval Aviation Center for Rotorcraft Advancement (NACRA) is monitoring Navy and U.S. Army developmental and demonstration efforts to keep pace with promising capability evolution that could be transitioned into Department of Navy aircraft. Several technologies and options are being reviewed for affordability, degree of capability provided and potential for near term implementation. Potential solutions include improved aircraft attitude, drift and hover cues, automated hover controls, sensors that could enable the crew to see through the degraded environment and sensors that detect the ground and obstacles to then present a clear virtual visual presentation. Most current solutions are relatively large and expensive, which presents significant integration challenges, potential loss of aircraft performance, and affordability impacts.

B. Crash Survivable Data Recording. The crash survivable data recording capability element primarily addresses a Family Of Systems (FOS) that records flight information parameters for mishap analysis. Technology advancements are enabling expansion of capability to include simultaneous recording of mission and aircraft component condition information.

1. Current capabilities. Limited memory; Limited user base; Unique systems.

OPNAVINST 13210.1A refers to the Safety Center's Letter (NAVSAFECEN Ltr Ser 03/0414 of March 2001) list of recommended flight and systems performance parameters to be recorded in different platforms. Some aircraft are recommended to record more information than others, depending on the type of aircraft, type of recording system they use, aircraft systems configuration and platform architecture (whether or not they have a digital data bus). The letter also presents parameter ranges, sampling times, desired accuracies, minimum recommended data resolutions and number of voice channels to be recorded. The prescribed minimum duration for voice recording is thirty minutes. The Naval Safety Center also recommends consulting with them before substituting video recording for data recording. The Aviation Safety Technology Working Group is building a new list of common parameters for all Services, as well as a target list of common Mishap Investigation Parameter Standards (MIPS).

Many platforms are configured with legacy technology flight recorders that are significantly limited in memory capacity. Crash survivable recorders are designed to continuously over-write recorded data, and some are able to provide only the last twenty to thirty minute portion of flight. Several do not record voice. Some recorders are integrated into multiple aircraft, but most are unique systems that will require dedicated and redundant modernization and sustainment efforts. As a result, integration and life cycle support costs for the Naval Aviation Enterprise (NAE) are substantially increased. Most of the unique systems also employ proprietary download and analysis tools supported by a single vendor, resulting in extra time and cost to recover mishap data.

2. Advanced Research and Technology Development.

Crash Survivable Memory. (2011-2012) Technological advancements with solid state systems in the commercial Digital Video Recorder (DVR) market present opportunities to improve unit survivability, robustness, physical footprint and an increase in memory capacity. This initiative seeks to design a digital module that can be hosted in a processor within the crash survivable recorder system.

3. Funded Enhancements and *Potential Pursuits*.

Increased Capacity, Data and Voice, Common Crash Survivable Recorder with Multi-Level Security and Data At Rest Protection. (2018) Fleet requirements groups have identified capability gaps with their legacy mission recorders, including poor reliability, limited capacity, time-consuming and proprietary down-load and analysis, and obsolescence issues with systems components or recording media. The amount of mission data desired to be captured already exceeds most legacy system capacities and will continue to increase in the digital warfare environment. Some systems use antiquated download and analysis tools that cannot meet the short turnaround times necessary in today's operations to support effective follow-on mission planning. Super V-8 or VHS recording media are obsolete. In most cases, separate systems are used to record structural data and critical component health status to provide the capability to maximize the airframe service life and reduce unnecessary maintenance. Most legacy systems are not capable of handling multiple levels of information security. Mission location and voice exchanges may be classified and need to be handled accordingly, or more practically, separated for simpler management. Additionally, per the 2007 Encryption of Data at Rest guidance and subsequent Department of Navy interpretation for application to integrated aviation systems, recording devices must be enabled to provide protection against disclosure.

C. Airborne Collision Avoidance. Aircraft midair collision avoidance is a function of Situational Awareness (SA) of adjacent traffic and its relative movement. SA can be provided by communications with ground controllers using radar or cooperative surveillance tools, or by integrated on-board equipment. The focus of this section is on integrated aircraft cooperative location exchange systems, or Midair Collision Avoidance Capability (MCAC), which until 2011 was known as Airborne Collision Avoidance Systems (ACAS). MCAC addresses OPNAV 13210.1A's reference to ACAS.

1. Current capabilities. See and avoid; Air Traffic Control; Civil derivative aircraft collision avoidance.

ACAS standards and recommended practices are defined by International Civil Aviation Organization (ICAO) standards, annex 10, volume IV. ACAS II is the current standard in civil aviation. Traffic Alert and Collision Avoidance System version 7.0 or 7.1 (TCAS II) is the Commercial Off-The-Shelf (COTS) ACAS II solution. COTS solutions cannot provide adequate collision avoidance protection for tactical military aircraft due to their extreme velocities, high closure rates during rendezvous and close proximity during formation flight. PMA209 conducted a Midair Collision Avoidance System (MCAS) study in 2009 to explore options for protection of tactical military aircraft. The study characterized USN and USMC Mid-Air and Near Mid-Air Collisions (MAC, NMAC) and identified available and predicted systems that may be used to prevent them. Analysis of 45 MACs and 152 NMACs revealed that 83% of the MACs could have been prevented with such protection. The MCAS study also evaluated several COTS and evolving potential ACAS solutions to determine the best strategy to address this capability gap. It recommended continued use of TCAS II systems for commercial derivative fixed-wing transports, and exploration of algorithms using low-latency data-linked position information for a tactical aircraft solution. KC-130J uses TCAS II for loose form flight. CV-22 operators also speak positively about TCAS II traffic separation situational awareness benefits.

2. Funded Enhancements and *Potential Pursuits.*

Midair Collision Avoidance Capability (MCAC). (2021) Platforms will be required to have Automatic Dependent Surveillance – Broadcast 'Out' (ADS-B 'Out') capability to meet CNS/ATM civil airway access compliance mandates by 2020. Using ADS-B 'Out,' aircraft constantly "squitter" (pulse) their location, identification and flight parameters to Air Traffic Control (ATC). ATC uses an "ADS-B In" receiver to capture the signals and manage safe separation of reporting platforms. Integrating ADS-B In functionality onto the platform, along with proper relative position analysis algorithms and a display, would provide a Cockpit Display of Traffic Information (CDTI) for situational awareness of traffic in the vicinity, even when operating independently or in areas of reduced ATC support. If ATC support is available, they could provide additional data to the aircraft that can be used to prevent collisions with non-Mode S light civil aircraft that they are tracking with radar or other utilities. MV-22s submitted an Urgent Universal Needs Statement (UUNS) for collision avoidance and are slated to be the first aircraft equipped with this capability. Additional information on ADS-B 'Out' and 'In' is provided in Appendix 4. There is strong interest in the Fleet to get MCAC sooner, but ADS-B Out/In exchange has been identified as the nearest available technology that can provide position fidelity with low enough latency to support military aircraft maneuvers, including formation flight and rendezvous. This strategy leverages the civil sector technology and product development efforts to meet the 2020 CONUS ADS-B Out mandate. Funding for development of a solution that is expected to use this technology is programmed to start in 2014. The capability is conservatively projected for delivery in 2021 since it will come on the heels of the ADS-B Out integration and require additional algorithm integration and testing. A POM-14 issue was also submitted to accelerate the initiative.

D. Flying Quality Assurance. This capability element involves the collection and analysis of flight parameters, mission information and component performance data to enhance aircrew proficiency and reveal trends that identify potential risk, thereby enhancing safety, improving readiness and mitigating mishaps.

1. Current capabilities. Operational Readiness Management.

Unless aircrew are training in a simulator or operating on a training range supported with telemetry, they do not have standardized automated tools to conduct post-flight analysis of the mission to analyze quality of the crew's mission performance or to identify opportunities for proficiency improvement. The only formally institutionalized process operators currently use is Operational Risk Management (ORM). ORM is a five-step process that manages risk through hazard identification, assessment, option selection (based upon minimizing impacts or accepting warfighting benefits), establishment of controls and supervision with follow-up evaluations and adjustments. It is primarily instituted through crew communication and coordination during preflight, execution of procedures while operating, and post-flight debriefings. Commander Naval Air Forces invested in design and demonstration of a post-flight recreation and analysis tool, but it has not been developed as an official program of record through competitive acquisition, systems engineering processes or standard formal testing and certification. H-60, T-45, executive transport and commercial equivalents tools were used to help identify baseline requirements for the formal program of record solution.

2. Funded Enhancements and *Potential Pursuits.*

Improved Operational Play-back and Assessment Tools - Military Flight Operations Quality Assurance (MFOQA). (2014) The commercial airline industry instituted a Flying Operations Quality Assurance (FOQA) program to help with procedural standardization and pilot proficiency. The major airlines reported that the program produced measurable improvements in aircrew proficiency and significant reductions in hazardous events. An OSD memorandum (dated 11 Oct 2005) for Secretaries of the Military Departments directed all Department of Defense (DoD) components to implement a multi-faceted MFOQA capability. Subsequently, the Secretary of the Navy issued a similar memorandum (dated 2 Feb 2006) to the Commandant of the Marine Corps and the Chief of Naval Operations supporting the MFOQA process.

Military Flight Operations Quality Assurance (MFOQA) is a knowledge management capability and a software-based process that will be hosted on existing Department of the Navy (DON) Information Technology (IT) assets. MFOQA will collect, merge, and analyze pre-recorded aircraft flight data and other available data, such as aircrew information, and make the results available to authorized users. MFOQA is a risk mitigation tool which will provide a proactive approach to identify human errors and failing material components so corrective actions can be taken prior to an aircraft mishap or costly maintenance failure. Changes in flight procedures, habit patterns, training methods, and maintenance practices based upon MFOQA analysis have the potential to reduce the flight mishap rate and increase readiness.

Whereas ORM is a proactive and subjective process based on operator analysis of potential risks and implementation of risk mitigation strategies, MFOQA objectively analyzes actual performance data. It involves rigorous post-flight off-aircraft analysis of data downloaded after every flight. MFOQA supports four primary functional purposes:

- Flight Data Analysis (FDA): Automated computer analyses of every flight to identify hazardous events and trends before mishaps occur, or events and trends of user interest, which can be presented to an authorized user in the form of automated, tailorable reports highlighting significant events or sampling multi-flight aggregate data for trend analysis.

- Post-Mission Aircrew Debrief (PMAD): Post-flight digital replay and automated report generation for any portion of a flight presented to an authorized aircrew to enhance aircrew training.

- Aircraft Maintenance and Trouble-Shooting (AMATS): Quantitative downloaded aircraft system information presented to an authorized aircraft maintenance user to assist in maintenance and to improve the operational readiness of aircraft.

- Mishap Investigation (MI): When aircraft flight data is not destroyed in a mishap, the aggregation of PMAD, AMATS and FDA analyses capabilities can provide much improved and objective evidence to the Aviation Mishap Board (AMB) to identify causal factors for remediation of flight and ground mishaps.

These features permitting aircrew, maintainers and leadership to assess performance, validate ORM strategies, and proactively implement changes to processes and procedures to improve future readiness, efficiency, and safety. Analysis tools are available at the squadron level immediately after each flight, which can be applied in the aggregate across all flight records stored in a file repository. MFOQA will aid in risk management and improve readiness across the spectrum of operations, including Maintenance, Operations, Safety and Training. The maintenance aspects of MFOQA are designed to supplement current maintenance procedures and processes, and will not replace any established systems. The Navy MFOQA program is the approved Enterprise program of record for Naval aircraft. The F/A-18C-F and EA-18G are the lead platforms for integration of this capability.

Autonomous Risk Identification. (2016) Software is being developed to analyze aircraft data and automatically identify desired trend information. For MFOQA purposes, the goal would be to identify operational or proficiency trends that present potential risks or imminent mishaps. This tool would reduce manpower workload for instructors or squadron analysts, and allow a higher level of analysis across dozens or hundreds of sorties versus compilation of individual post-flight assessments. It could also enable higher level commands, such as Wing commanders or Chief of Naval Air Training (CNATRA), to get automated risk identification on a larger scale across squadrons.

Enterprise Level MFOQA. (2017) The first increment of MFOQA enables post-flight analysis at the squadron level. MFOQA Increment 2 would incorporate enhancements that support multi-squadron and cross-platform reporting and trending analysis for a broader view of data trends across the Enterprise.

Focused Operations Modules. (2017) With additional work, MFOQA analysis tools could be developed to enable comparison of aircrew specific maneuvers performance to “gold standards.” Commander Naval Air Forces (CNAF) has expressed interest in developing modules to support Field Carrier Landing Practice (FCLP), strike, and auto-rotation evolutions to enhance Safety and Training. Analysis modules developed by CNAF would be adapted and integrated into the MFOQA program of record.

Shipboard Recovery Animation. (2020) The current MFOQA program of record does not include complex analysis and software development required to enable the ability to visualize takeoffs or landings in the highly dynamic shipboard environment. MFOQA Increment 3 is planned to include enhancements that would incorporate ship position and motion into the visualization module to enable accurate portrayal of a flight during embarked operations.

Classified MFOQA. (2020) Certain platform missions regularly involve utilization or download of classified information and/or capabilities. MFOQA Increment 3 would be a classified variant of the Increment 2 baseline unclassified Enterprise level utility, and is intended to perform the same functional requirements.

E. Component Health Monitoring. The component health monitoring capability element addresses systems that capture indications of the performance and integrity of major dynamic components on the airframe.

1. **Current capabilities. Health and usage monitoring; Limited sensors.**

Many Naval Aviation aircraft incorporate some form of health monitoring capability. Most of these systems are unique and are often managed by platform prime vendors. They are primarily used to record operating time against forecasted airframe fatigue life. Some take selected measurements of key component attributes, or record equivalent strain and stress counts for engineering calculations of structural life usage. Many legacy platform maintenance schedules are built around operating time instead of actual component health degradation or evidence of potential impending failure. The Integrated Mechanical Diagnostic and Health and Usage Monitoring System (IMD HUMS) is used on both rotary and fixed wing aircraft and assists with maintenance check flights, warns of potential defects, tracks operational and structural life usage, and records exceedances. Some systems track component vibration signatures to compare them against known healthy or problem signatures. Some are also designed to analyze signature change trends to alert maintainers to perform integrity inspections. Few of these systems offer any capability to analyze performance trends. Major component inspections and removals are usually conducted based simply upon time of operation, which does can result in removal and replacement of systems with plenty of useful life remaining, or allowing degraded equipment to fail before removal.

The V-22 uses a Condition Based Maintenance (CBM) maintenance, which is designed to monitor actual component condition and performance so that removals and replacements only occur when they are needed (to reduce workload and cost), and to ensure degraded systems are removed before failure (to increase readiness and prevent mishaps). Their Comprehensive Automated Maintenance Environment Optimized (CAMEO) system provides an adaptable, government-owned, open-source (no licensing costs), non-proprietary, Joint-service, Automated Logistics Environment (ALE) and improved Condition Based Maintenance (CBM+) capability, supporting continuous integration and automation of operational, maintenance, and logistical processes and technical data to improve aircraft readiness and reduce sustainment costs. It incorporates Interactive Electronic Technical Manual (IETM) publications, hosts an integrated prop-rotor track and balancing system, and enables Built In Test (BIT), engine performance and vibrations trending analysis. This system has several planned upgrades and will eventually tie in with MFOQA functionalities.

2. **Advanced Research and Technology Development.**

Sensor Improvements. (2011) This effort is a Small Business Innovative Research (SBIR) initiative that will evaluate the potential for benefits of incorporating micro-miniature wireless sensors into health monitoring systems. Wireless components could be more easily and cost-effectively fitted to locations that cannot be connected to the recorder by wires. Other digital and material technology advancements are being applied to the aircraft and component health monitoring field. Sensors are detecting signatures over larger frequency ranges with finer sensitivities. Filters are becoming more capable at detecting smaller metal or composite traces. Some technology gains are already being incorporated in unmanned aerial vehicles applications.

3. Funded Enhancements and *Potential Pursuits.*

The Joint Aeronautical Commanders Group (JACG) is a Joint Service, three-star level agency that is chartered with leveraging commodity system benefits across the Services. They established the Condition Based Maintenance Advisory Board to analyze benefits of CBM. The board determined that 9-12% of Class A-E mishaps between 2002-2008 could have been avoided with active CBM programs, and have projected that 11-12 Class A mishaps could be avoided over the next decade. They also concluded that based upon 2010 flight hours, CBM practices could avoid more than $200M per year in parts replacements and drive a 5-8% increase in readiness.

Wireless Maintenance Information Download. (2013) The T-45 Digital Data Set (DDS) is being upgraded to incorporate wireless data download of maintenance diagnostic information, which will enable operations planners and ground crews to decrease aircraft turnaround following syllabus events which will ultimately increase the overall aircraft readiness level. Wireless digital transmission basically eliminates the requirement for additional ground support equipment and minimizes potential corruption of data seen during manual transfer. The new system transfers the maintenance data in conjunction with recorded mission audio and video data at a rate of 1 gigabits per second. Current download of engine life monitoring data can take two maintenance personnel up to ninety minutes per aircraft. With an average of 300 sorties per day, the rapid wireless download capability produces significant man hours and cost savings. The system also enables higher fidelity data collection by increasing the sampling rate from 8 to 32 hz.

Improved Component Performance Analysis. (2014) When MFOQA is fielded on Hornets and Growlers in 2014 it will enable AMATS enhanced trouble-shooting. Maintainers will be able to play back flights and directly observe primary aircraft flight performance information, maintenance status panel codes, and physical movement of control surfaces. They will also be able to get a much better feel for the aircraft environment and operating parameters that may have contributed to the anomaly at the time of the occurrence, such as high angle of attack for the engine intake, high g-load for actuators, etc.

Structural Prognostics and Health Management. (2015) Joint Strike Fighter (JSF) will field Structural Prognostics and Health Management (PHM) capability in support of mission sortie generation/readiness objectives. Wirelessly downloaded parameters will include fuel state, ammunition state, expendables state, and component health conditions requiring maintenance in order to minimize turnaround time. Real time, accurate down-link of specific component conditions supports CBM, which will significantly enhance readiness by enabling maintainers to move from time-scheduled removals and inspections to removing items only when required. Removing components only when they have achieved their tolerance limit of safe operations can also return significant cost avoidances by extending the lives of the parts beyond their engineering estimates, thereby reducing the costs of repairs or replacements. CBM may also result in reduced requirements for spares inventories or deployed spare support footprints.

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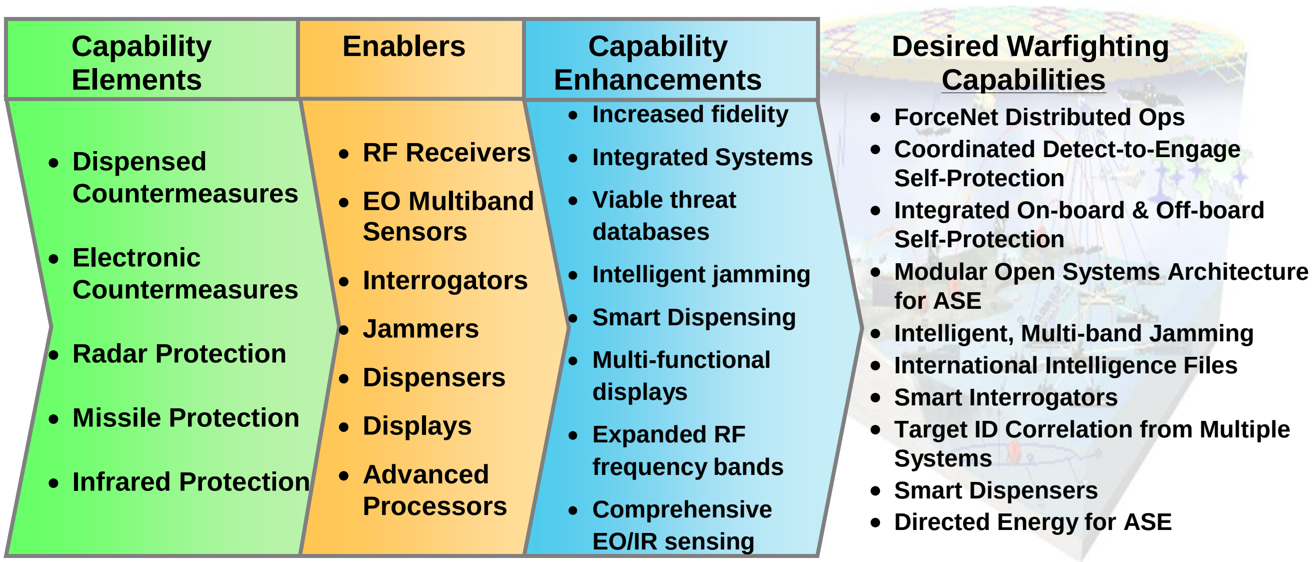
Appendix A-6

Self-Protection

<u>Scope</u>: Addresses Aircraft Survivability Equipment (ASE) for Electronic Support (ES), Electronic Attack (EA) and advanced Electro-Optic/Infrared (EO/IR) sensing that enable platforms to successfully conduct operations in a battlefield. The systems enable susceptibility reduction through Radio Frequency (RF) confusion, prevent self-identification, create deceptive targets, detect radar signals and threat lasers, identify hostile radar detectors and detect ballistic events (such as guided missiles, unguided rockets and unguided ballistic fires, i.e. hostile fire). They also employ tactics and countermeasures against threats using directed RF and IR jamming, chaff dispensing, flares, decoys or other obscurants that prevent hostile weapons system effectiveness.

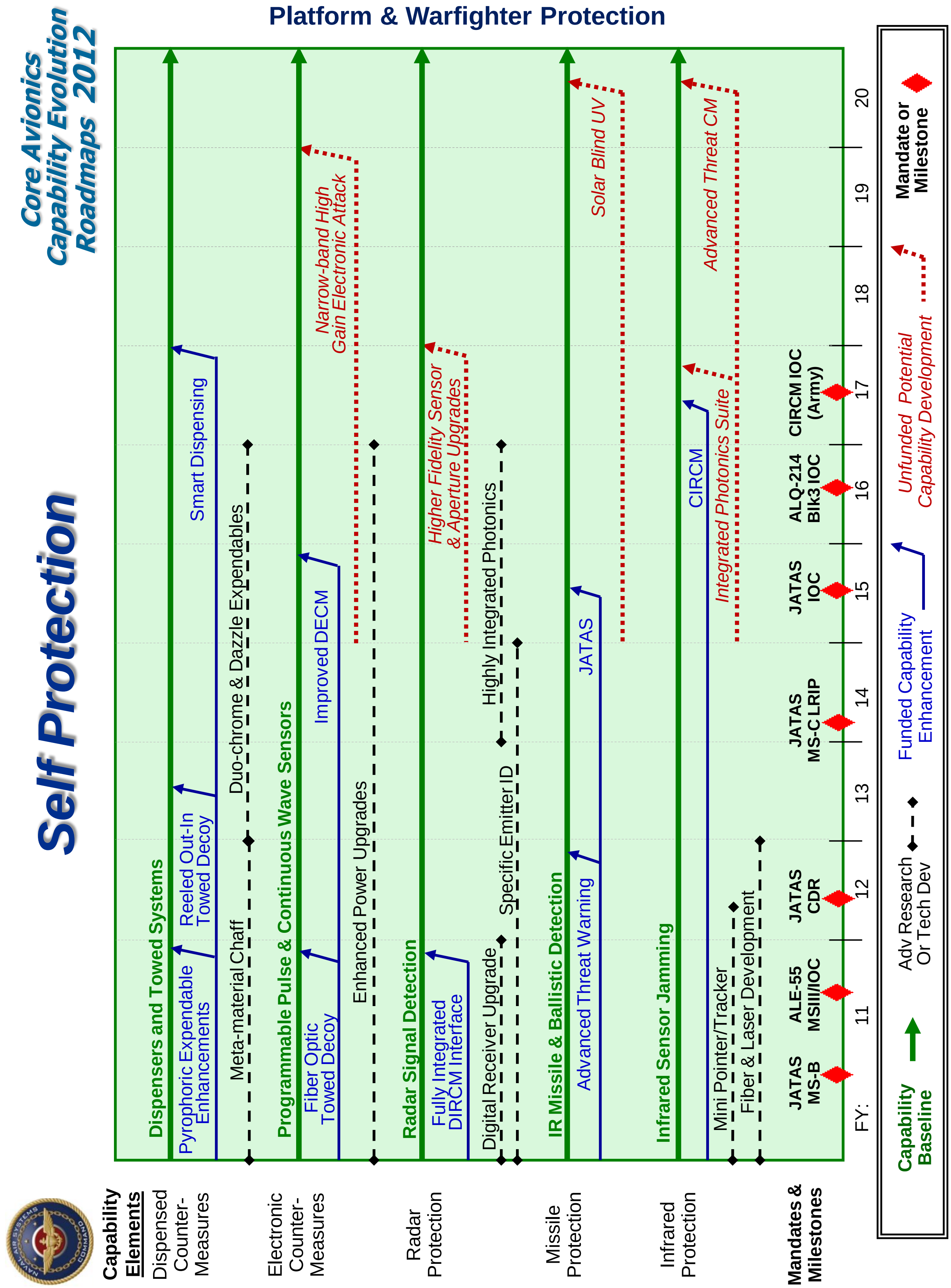
<u>Capability Evolution</u>:



Objective: Platform & Warfighter Protection

Baseline to Objective Transition Strategy:

Current baseline mission sensor capabilities equip Navy and Marine Corps fixed-wing, tilt-wing and rotary-wing aircraft with a variety of situational awareness (SA) and countermeasure capabilities in the RF and EO/IR spectrums. Many of these capabilities are aircraft platform-specific solutions that support each platform's required operational threat environments and contribute into platform tactics, techniques and procedure for susceptibility reduction. The vision of the Naval Aviation Enterprise (NAE) is to equip all naval aircraft with integrated aircraft survivability equipment (IASE) systems with modular, open system architectures that are optimized to ensure survivability across the platform's full range of operations. PMA-272, N98 and CNAF combine to form the NAE's Advanced Tactical Aircraft Protection Systems (ATAPS) team, which is chartered to achieve this objective.


Core Avionics Capability Evolution Roadmaps 2012
Self Protection
Platform & Warfighter Protection
Capability Elements
Dispensed Counter-Measures
Electronic Counter-Measures
Radar Protection
Missile Protection
Infrared Protection
Mandates & Milestones
Dispensers and Towed Systems
Pyrophoric Expendable Enhancements
Reeled Out-In Towed Decoy
Smart Dispensing
Meta-material Chaff
Duo-chrome & Dazzle Expendables
Programmable Pulse & Continuous Wave Sensors
Fiber Optic Towed Decoy
Improved DECM
Narrow-band High Gain Electronic Attack
Enhanced Power Upgrades
Radar Signal Detection
Fully Integrated DIRCM Interface
Higher Fidelity Sensor & Aperture Upgrades
Digital Receiver Upgrade
Specific Emitter ID
Highly Integrated Photonics
IR Missile & Ballistic Detection
Advanced Threat Warning
JATAS
Solar Blind UV
Infrared Sensor Jamming
CIRCM
Integrated Photonics Suite
Advanced Threat CM
Mini Pointer/Tracker
Fiber & Laser Development
JATAS MS-B
ALE-55 MSIII/IOC
JATAS CDR
JATAS MS-C LRIP
JATAS IOC
ALQ-214 Blk3 IOC
CIRCM IOC (Army)
FY: 11 12 13 14 15 16 17 18 19 20
Capability Baseline
Adv Research Or Tech Dev
Funded Capability Enhancement
Unfunded Potential Capability Development
Mandate or Milestone

PMA-272 also collaborates with numerous other DoD and Service-specific entities, including the Joint Electronics Advanced Technology (JEAT), Naval Aviation Center for Rotary Wing Advancement (NACRA), Joint Aircraft Survivability Program Office (JASPO), all Service laboratories (DARPA, NRL, AFRL and ARL), and other Service's science and technology development organizations such as Army Intelligence, Information Warfare Directorate (I2WD) to achieve that goal.

Requirements.

Mission sensor and countermeasure avionics that provide Electronic Warfare (EW) self-protection capabilities are mission enablers in Joint Functional Concepts such as Battlespace Awareness, Force Application, and Force Protection. These joint concepts flow into the naval capabilities of Sea Strike and Sea Shield outlined in Sea Power 21. Top-level EW requirements for Airborne Electronic Attack and Counter Air/Counter Air Defense are presented in an EW Initial Capabilities Documents (ICD).

PMA-272 program office manages the aircraft survivability equipment (ASE) portfolio in accordance with the budgetary process, urgent needs statement requirements from customer groups, Fleet Forces Command and other directives for ASE. The maintenance of a constant open channel of communication between PMA-272 and NAVAIR, USMC Aviation P and its customer base through the Commander, Naval Air Forces' (CNAF) Naval Aviation Readiness Group (NARG) provides a process to receive fleet input for electronic warfare, in general, and self-protection, in specific.

A. Dispensed Countermeasures.

1. Current Capabilities.

The AN/ALE-39 Counter Measure Dispenser System (CMDS) is a legacy system capable of dispensing chaff, flare and/or other expendables. This aging system is being replaced with the AN/ALE-47 system.

The AN/ALE-47, the current generation CMDS, protects host aircraft in a multi-threat environment and provides expendable countermeasure dispensing capability through the use of programmable dispense programs and parameters through a Memory Loader/Verifier Set (MLVS) over a MIL-STD-1553 type data bus. It is capable of full integration with the defensive avionics suite of the host aircraft for automatic threat-adaptive dispensing of expendable countermeasures based on a loadable mission data file. It can be operated independent of any other avionics system in a manual mode for direct pilot control in the event of interfacing equipment failure, non-availability or mission requirements. The AN/ALE-47 has four operational modes to dispense expendables: manual, bypass, semi-automatic, and automatic. In the automatic and semi-automatic modes, the AN/ALE-47 receives threat information from the threat sensors and uses the data to calculate dispense program parameters using a "cocktail" of expendables to implement against specific threat(s). The AN/ALE-47 also has up to six manual dispense programs that the pilot/aircrew can release. The CMDS provides the aircraft with an expendable countermeasures capability against RF, IR, and EO threats from Anti-Aircraft Artillery (AAA), Surface-to-Air Missiles (SAMs), Air-to-Air Missiles (AAMs), and Airborne Interceptors (AIs). The CMDS design is programmable that will allow the system to counter future threats when deployed through mission data file modification, which increases capability with newly developed expendables and dispensing sequences (a.k.a. cocktails) that will meet the threat.

The F/A-18 T3F Launcher for the AN/ALE-50A and the AN/ALE-55 Advanced Airborne Expendable are designed to seduce incoming RF-guided missiles away from the aircraft in the endgame phase of an enemy missile's flight. The decoys are launched when needed and towed behind the host aircraft until it is severed before landing. The AN/ALE-55 is an advanced Fiber Optic Towed Decoy (FOTD) that is capable of more advance techniques than the AN/ALE-50. Both Decoys use the version of the AN/ALE-50A launcher. The complete system uses the Integrated Multiple Launch Controller (IMPLC) Dispenser and the towed decoy.

Expendable IR Countermeasures (IRCM): The IRCM decoy deploys from the AN/ALE-47 CMDS and is a device designed to provide an alternative heat source and seduce the threat missile away from the aircraft towards the flare. Its function is to act as a false target or decoy to the approaching heat-seeking missile. When dispensed from the target platform, the flare falls away in such a way as to divert the threat missile from the target. Because of the complexity of advance threat missiles and the lack of SA about which missile type is inbound, comprehensive techniques utilizing multiple decoys must be devised and tailored for each type aircraft.

RF Passive Countermeasures: Also deploying from the AN/ALE-47, chaff is one of the most widely used and effective expendable self-protection devices, a form of volumetric radar clutter consisting of multiple metalized radar reflectors designed to interfere with and confuse radar operation. It is dispensed into the atmosphere to deny radar acquisition, generate false targets, and to deny or disrupt radar tracking. Chaff is designed to be dispensed from an aircraft and function for a limited period.

Active RF Expendable Jammers: Active RF expendable jammers are designed to provide endgame protection for tactical aircraft against SAM and AAM radar guided missiles.

2. Funded Enhancements and *Potential Pursuits.*

Power PC Processor. (2010) The AN/ALE-47(V) currently uses a 16-bit MIL-STD-1750A Central Processing Unit (CPU) as the main processor. Due to the age of the architecture, the 1750A does not provide the needed growth or capability required of the AN/ALE-47 in future years. Availability, memory restrictions, throughput restrictions and increased maintenance costs are all mission vulnerabilities created by the continued use of the 1750A processor. In order to reduce these mission vulnerabilities the Department of the Navy is planning to replace the 1750A CPU with a Power PC processor. The AN/ALE-47(V) can be integrated with on-board systems to receive aircraft attitude, altitude and airspeed as well as threat angle of arrival (AOA), range, etc. The capability to use these parameters to optimize dispense program effectiveness and expendable consumption, also known as Smart Dispensing, is being pursued for aircraft with integrated systems.

Enhanced Expendables. (2012) The expendables used in the AN/ALE-47 dispenser system are constantly being upgraded with technological enhancements to improve safety, reliability or producibility, and to increase their effectiveness against the advanced IR and RF threat. A replacement for the GEN-X Electronic Decoy is currently being studied to provide a capability required for future contingencies. Advances in pyrotechnic and pyrophoric type decoys are being pursued to enhance countermeasure effectiveness, centered on defeating the counter-countermeasures of the advanced IR MANPAD, including tailoring the spectral output, output in different bands, improving aerodynamic qualities and improving kinematic performance. The expendable dispense techniques are as important to defeat the advanced threat as the expendables, so a continuous effort is required to derive, test and field more sophisticated, effective techniques. To this end, the program office has added a program element called Aircraft Survivability Program Optimization (ASPO) funding line in the budget to optimize threat response techniques and tactics, increase modeling and simulation efforts and to increase in-field ASE grooming. ASPO will help meet future threats that demand expendables and directed energy solutions be synergized.

B. Electronic Countermeasures.

1. Current capabilities.

The AN/ALQ-126B is a programmable airborne Defensive Electronic Countermeasures (DECM) system capable of intercepting, identifying, and processing received radar pulse (only) signals and applying an optimum countermeasures technique, thereby improving individual aircraft probability of survival against a variety of legacy surface-to-air RF threats. The system operates in a variety of host aircraft in a stand-alone or EW Suite mode. In the EW Suite mode, the AN/ALQ-126B interfaces with the Radar Warning Receiver (RWR) in a coordinated, non-interference manner sharing information for enhanced operation in a non-interference basis.

The AN/ALQ-162(V)1 is a programmable airborne DECM system capable of intercepting, identifying, and processing received Continuous Wave (only) radar signals and applying an optimum countermeasures technique in the direction of the radar signal; thereby, improving individual aircraft probability of survival against a variety of active and semi-active RF radar-guided missile threats. The system is installed in pylons on Foreign Military F/A-18 and F-16 aircraft, installed with the AN/ALQ-126B in the AN/ALQ-164 pod on USMC and Foreign Military AV-8B aircraft, and internally mounted in a variety of U.S. Army rotary wing aircraft. The system operates in a stand-alone or EW Suite mode. In the EW Suite mode, the AN/ALQ-126B interfaces with the Radar Warning System (RWS) in a coordinated, non-interference manner sharing information for enhanced operation in a non-interference basis. An upgraded version of the system, ALQ-162(V)6, was developed and produced via a joint Foreign Military Sales (FMS) initiative to add Digital Radio Frequency Memory (DRFM)-based, pulse Doppler radar jamming capability and increased transmitted power using a Microwave Power Module (MPM). The AN/ALQ-164(V)6 configuration is installed in F-16 pylons and internally aboard AH-64D Apache helicopters.

The AN/ALQ-165, the Airborne Self-Protection Jammer (ASPJ) is an airborne DECM, a programmable modular automated system capable of intercepting, identifying, processing received radar (pulse and continuous) signals and applying an optimum countermeasures technique, thereby improving individual aircraft probability of survival against a variety of surface-to-air and air-to-air RF threats. The system operates in a variety of host aircraft in stand-alone or EW Suite mode. In the EW Suite mode, the AN/ALQ-165 interfaces with the RWR in a coordinated, non-interference manner. The AN/ALQ-165 was designed to operate in a high density electromagnetic hostile environment with the ability to identify and counter a wide variety of multiple threats including those with Doppler characteristics.

The AN/ALQ-214 is the onboard jammer (OBJ) an advanced airborne Integrated DECM programmable modular automated system capable of intercepting, identifying, processing received radar signals (pulsed, pulsed Doppler, and continuous wave) and applying an optimum countermeasures technique, thereby improving individual aircraft probability of survival against a variety of surface-to-air and air-to-air RF threats. The system operates in a stand-alone or EW Suite mode. The AN/ALQ-214 Block III Upgrade is the current baseline system and works with the AN/ALE-55 fiber FOTD. The AN/ALQ-214 was designed to operate in a high density electromagnetic hostile environment with the ability to identify and counter a wide variety of multiple threats including those with Doppler characteristics.

2. Funded Enhancements and *Potential Pursuits.*

On-Board Jammer Enhancements. (2012) The ALQ-214 is being modified to render it suitable for carrier-based operations, when installed in the F/A-18C/D, while retaining full functionality, to include driving the AN/ALE-55 FOTD, when installed in an F/A-18E/F. This modified design will provide F/A-18C/D aircraft the capability to detect and respond to pulsed, pulsed Doppler, and continuous wave threats. This Engineering Change Proposal (ECP) for block IV effectively alters the ALQ-214 onboard jammer to a Modular Open Systems Architecture (MOSA) and institutes size, weight and power reductions along with other upgrades.

C. Radar Protection.

1. Current capabilities.

The AN/ALR-67(V)2 RWR has provided warning capability for both US and foreign military aircraft since 1982. It has three different types of receivers; a broadband crystal video receiver, a super-heterodyne receiver, and an integrated low-band receiver. It also has an antenna array and an azimuth indicator, which are controlled by a CP-1293C threat processor. The AN/ALR-67(V)2 was produced by Northrop Grumman and is used in the F/A-18, and AV-8B aircraft. The FMS version of this system has implemented diminishing manufacturing sources and material shortages (DMSMS) programs to maintain system operational capabilities as this system ages.

The AN/ALR-67(V)3 is the newest generation RWR and is installed in the F/A-18E/F Super Hornet. The purpose of the RWR is to detect, identify, and localize the radar of potentially threatening weapon systems. Contracted for development in 1989 to Hughes Aircraft Company (now Raytheon), the AN/ALR-67(V)3 uses channelizer rather than Crystal Video Analog-to-digital (CVAD) technology. The system has added millimeter wave capability, while retaining low band and the 4-quadrant high band microwave capabilities. The high band antennas are an improvement over the AN/ALR-67(V)2 antennas.

The AN/APR-39A(V)2 is a multi-service Radar Signal Detection Set (RSDS) and is one of the most widely used RWRs in the world. The RSDS detects, determines direction, classifies, and provides audible and visual cues to the aircrew when radar signals illuminate the platform. A key feature of the AN/APR-39A(V)2 is a reprogrammable memory unit that stores a Mission Data Set (MDS) containing radar signatures and processing information specific to the geographical area of operation.

The MDS determines how signals are classified and prioritized, and associates audible messages and visual symbols that will be displayed to the aircrew. The AN/APR-39A(V)2 can operate independently, providing audible alerts over the platform audio bus, and symbols on the IP-1150A display. The RSDS has been upgraded to the AN/APR-39B(V)2 configuration for the U.S. Navy and Air Force on aircraft (such as the AH-1Y or AH-1Z) with integrated avionics bus processing, the AN/APR-39B(V)2 acts as the EW bus controller, polling and controlling other Aircraft Survivability Equipment (ASE) on the platform, including the AN/AVR-2 Laser Detecting Set, AN/AAR-47 Missile Warning Set, and AN/ALE-47 Countermeasures Dispenser. The AN/APR-39B(V)2 acts as the integration processor for the federated ASE sensor suite.

The processor stack has an upgraded interface card inserted to allow the system to be a receiver/transmitter on a MIL-STD-1553 data bus. The AN/APR-39B(V)2 provides RSDS status and symbol display information via the data bus for use on aircraft equipped with integrated avionics processors and Multi-Function Displays (MFDs).

2. Funded Enhancements and *Potential Pursuits*.

The program office has obtained FY10/11 funding to replace existing ALR-67(V)2 with the newer ALR-67(V)3 in lieu of pursuing continued DMSMS solutions.

Processor Upgrades. (2015) The AN/APR-39A/B(V)2 is being upgraded for sustainability and to meet emerging DECM requirements. The AN/APR-39C(V)2 processor upgrade will replace seven circuit card assemblies with three modernized processor cards to increase the processing speed and emitter library memory size. The AN/APR-39C(V)2 will also incorporate an AN/AAQ-24(V)25 Directed Infrared Countermeasure (DIRCM) interface for improved pilot awareness and system management. Further planned improvements (i.e. AN/APR-39D(V)2) will include: replacing the analog-tuned receiver with a digital receiver and replacing the spiral antennas with dual-pole spiral antennas which will increase the probability of detection of pulse-Doppler radars, cross-pole/circular polarization and improve accuracy of Angle-of-Arrival (AOA). These enhancements will provide for the operational viability of the AN/APR-39 well into the 21st century and preclude impending Diminishing Manufacturing Sources (DMS). The AN/APR-39, with technology upgrades, is well positioned to be the ASE central processor and will act as the platform's EW bus controller.

D. Missile Protection.

1. Current capabilities:

The AN/ALQ-144 Omni-Directional IR Jammer is pre-emptive jammer to protect rotary wing platforms from early generation IR seeking missiles. The Navy and Marine Corps have made a decision to retain this system on aircraft where installed while other IRCM efforts mature.

Deployed on helicopters and transport aircraft, the AN/AAR-47 Missile Warning System (MWS) warns of threat missile approach by detecting ultraviolet radiation associated with the rocket motor and automatically initiates flare dispense. In 2011, the AAR-47 algorithm update included the ability to detect small arms fire, a.k.a. hostile fire indication (HFI). The MWS provides attacking missile declaration and sector direction finding and interfaces directly to the AN/ALE-39/47 countermeasures dispenser. Detection algorithms are used to discriminate against non-approaching radiation sources. The AN/AAR-47 is a passive system consisting of four sensor assemblies housed in two or more sensor domes, a central processing unit, and a control indicator. Recent development of AAR-47B(V)2 increase the probability of missile warning detection in harsh, UV-cluttered operating environments.

As the first fielding of a directed energy weapon system, the AN/AAQ-24(V)25 Department of Navy (DoN) Large Aircraft Infrared Countermeasure (DoN LAIRCM) program provides a laser-based, directed infrared countermeasure (DIRCM) solution to increase the survivability of Marine Corps rotary wing assault aircraft against IR guided threats. The DoN LAIRCM system is an upgrade to the Air Force's AN/AAQ-24 LAIRCM missile warning system developed by the USAF. DoN LAIRCM integrates 2-color IR missile warning sensors with the improved Guardian Laser Transmitter Assemblies. The DoN LAIRCM system is designed to provide CH-53E (lead) and CH-46E platforms with self-protection against IR guided surface-to-air missiles by detecting their signatures and defeating them with laser jamming. The DoN LAIRCM system successfully demonstrated Early Operational Capability in November 2009 and was approved for limited fielding of 32 systems on CH-53E aircraft in support of Operations OIF and OEF. DoN LAIRCM capable CH-53Es are currently flying operational missions in-theater. The two-color IR sensor in DoN LAIRCM will undergo an upgrade in 2012 to be able to detect hostile fire from unguided munitions. Due to size, weight and power restrictions, this system is not being considered for smaller platforms. The Army CIRCM program development is being conducted in close cooperation with the PMA-272 program office since the CIRCM will be procured for inclusion onto Navy and Marine Corps aircraft with the MV-22 as the lead platform for the Navy's efforts.

2. Funded Enhancements and *Potential Pursuits.*

Joint and Allied Threat Awareness System (JATAS). (IOC 2015) The next generation MWS will be the Joint and Allied Threat Awareness System (JATAS) which commenced a competitive Engineering and Manufacturing Development phase with a single vendor in 2011. JATAS, in its final form, will be a two-color IR sensor that will provide integrated missile warning, laser warning, situational awareness and HFI for Assault Support aviation. Intended host platforms include the MV-22B, AH-1Z, UH-1Y, MH-60R/S. The system will be developed with Modular Open Systems Architecture (MOSA) to enable upgrade, technology refresh and integration with other platforms. Per SECDEF guidance, the Navy is the lead Service and is working closely with the program office of the Army (Program Directorate ASE) in the development of JATAS capabilities and interfaces to meet inter-Service transfers of this system onto Army platforms.

Advanced Threat Warning (ATW). (IOC 2012) The DoN LAIRCM 2-color sensor will undergo an engineering change to attain the capability for hostile fire warning through a change in processor, high speed detector chip and software.

Guardian IRCM Pod upgrade. (IOC 2013) Using assets from a 2004-2007 Department of Homeland Security commercial airline IRCM program, PMA-272 will update and convert several pods in 2012 for demonstration as a pilot program to expand the IRCM capability to fixed-wing airframes. PMA-207 is the transition partner to outfit common-user aircraft.

E. Infrared Protection.

1. Current capabilities: The AN/ALQ-157 infrared jammer deployed on CH-46E and CH53D aircraft, will also remain in place until future system installation (see AN/ALQ-24(V)25) is complete.

2. Funded Enhancements and *Potential Pursuits.*

Common Infra-Red Counter Measure (CIRCM)*.* Navy and Marine Corps fixed and rotary wing platforms have a need for covert, highly effective protection against advanced IR-guided SAMs and AAMs. The use of an onboard laser provides for essentially unlimited platform protection. This constitutes a desirable capability since the protection currently available to Navy platforms is severely limited by the number of countermeasure assets that can be carried onboard. The IRCM ASE Acquisition Decision Memorandum (ADM) identifies the Army's Next Generation Advanced Tactical Infrared Countermeasure (ATIRCM) system must satisfy the joint need for a compact, light weight, highly reliable IR countermeasure. The Army and Navy requirements offices are currently developing a capabilities development document for this follow on capability, known as the Common Infrared Counter Measure (CIRCM). The Navy will participate in this Army development program.

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Acronyms

AAA	Anti-Aircraft Artillery
AAM	Air-to-Air Missile
ACAS	Aircraft Collision Avoidance System
ACIST	Aviation Capability Integration Systems Team
ACLS	Automatic Carrier Landing System
ACO	Airspace Coordination Order
ACS	Advanced Crew Station
ADAP	Advanced Digital Antenna Production
ADM	Acquisition Decision Memorandum
ADNS	Automated Digital Network System
ADS-B	Automatic Dependent Surveillance-Broadcast
AE	Antenna Electronics
AEHF	Advanced Extreme High Frequency
AESA	Advanced Electronically Scanned Array
AFDS	Avionics Full Duplex Switched (Ethernet)
AI	Airborne Interceptors
AISR	Airborne Intelligence, Surveillance & Reconnaissance
AJ	Anti-Jam
AMC	Advanced Mission Computer
AMC&D	Advanced Mission Computer and Display
AMPCD	Advanced Multi-Purpose Color Display
AMU	Advanced Memory Unit
AMWS	Advanced Missile Warning System
ANDVT	Advanced Narrowband Digital Voice Terminal
AOA	Angle of Approach
AP	Area Planning
APB	Acquisition Program Baseline
API	Application Programming Interface
APN	Aviation Procurement, Navy
APW	Aviation Weapons Systems Requirements Branch
ARAIM	Advanced Random Autonomous Integrity Monitoring
AS	Acquisition Strategy
ASD/NII	Assistant Secretary of Defense/ Networks & Information Integration
ASN/RDA	Assistant Secretary of the Navy Research, Development, & Acquisition
ASPJ	Aircraft Self-Protection Jammer
ASE	Aircraft Survivability Equipment
ASO	Air Support Operations
ATAPS	Advanced Tactical Aircraft Protection System
ATC	Air Traffic Control
ADTL	Advanced Tactical Data Link
ATO	Air Tasking Order
ATFLIR	Advanced Targeting Forward Looking Infra-Red
ATM	Air Traffic Management
ATR	Air Transport Rack
AVDLR	Aviation Depot Level Repair
AWICS	Airborne Wireless Internal Communications System
BACN	Battlefield Airborne Communications Node
BAMS	Broad Area Maritime Surveillance
BEAM	Bandwidth Efficient Advanced Modulation
BFSA	Blue Force Situational Awareness
BFT	Blue Force Tracker
BIT	Built In Test
BLOS	Beyond Line of Sight
BLT	BEAM Line-of-sight Transmission
BOSS	Buy Our Spares Smart
bps	Bytes Per Second
BRNAV	Basic Area Navigation
C2ISR	Command and Control, Intelligence, Surveillance and Reconnaissance
CAAS	Common Avionics Architecture System
CAMP	Core Avionics Master Plan
CAN	Communications and Networking
CAS	Close Air Support
CBM	Condition-Based Maintenance
CCM	Common Crypto Module
C-CRPA	Conformal Controlled Reception Pattern Antenna
CDD	Capability Development Documents
CDNU	Control Display Navigation Unit
CDR	Critical Design Review
CDRA	Critical Design Review Assessment
CDTI	Cockpit Display of Traffic Information
CEC	Cooperative Engagement Capability
CFE	Commercial Furnished Equipment
CFIT	Controlled Flight into Terrain
CIB	Common Interactive Broadcast
CID	Combat Identification
CIO	Chief Information Officer
CIRCM	Common Infra-Red Counter-Measures
CJCS	Chief, Joint Chiefs of Staff
CM	Cryptographic Modernization
CMDS	Countermeasure Dispenser System
CMN	Concurrent Multi-Netting
CNAF	Commander, Naval Air Forces
CNATRA	Chief of Naval Air Training
CNR	Combat Net Radio
CNRWG	Combat Net Radio Working Group
CNS/ATM	Communications, Navigation and Surveillance/Air Traffic Management
COCOM	Combatant Commander
COE	Common Operational Environment
COMSEC	Communications Security
COP	Common Operational Picture
COTS	Commercial Off-the-Shelf
CPD	Capability Production Document
CPDLC	Controller/Pilot Data Link Communications
CRD	Capstone Requirements Document
CRPA	Controlled Reception Pattern Antenna
CSAD	Cabin Situational Awareness Device
CSR	Crash Survivable Recorder
CSS	Central Security Service
CT	Cipher Text
CVAD	Crystal Video Analog to Digital
CW	Collaborative Warfare
CWE	Collaborative Warfare Environment
CWRIIP	Cost Acquisition Wise Readiness Integrated Improvement Program
DA	Decision Altitude
DC(A)	Deputy Commandant (Aviation)
DDS	Digital Data System
D-GPS	Differential Global Positioning System
DaCAS	Digitally Aided Close Air Support
DAFIF	Digital Aeronautical Flight Information Files
DAMA	Demand Assigned Multiple Access
DAP	Downlink Aircraft Parameters

DDS	Digital Data Set
DGPS	Differential Global Position System
DECM	Defensive Electronic Countermeasures
DFE	Digital Flight Equipment
DIRCM	Directed Infrared Countermeasures
DISA	Defense Information Systems Agency
DISN	Defense Information System Network
DMC	Digital Map Computer
DMD	Digital Memory Device
DME	Distance Measuring Equipment
DMS	Diminishing Manufacturing Sources
DMSMS	Diminishing Manufacturing Sources and Material Shortage
DoN LAIRCM	Department of the Navy Large Aircraft IR Countermeasure
DoD	Department of Defense
DODI	Department of Defense Instruction
DOTMLPF	Doctrine, Organization, Training, Material, Leadership, Personnel & Facilities
DP	Departure Procedures
DRFM	Digital Radio Frequency Memory
DSN	Defense Switch Network
DSCS	Defense Satellite Communications System
DTED	Digital Terrain and Elevation Database
DVE	Degraded Visual Environment
DVR	Digital Video Recorder
ECP	Engineering Change Proposal
EDM	Engineering Development Model
EFB	Expected Final Bearing
EFB	Electronic Flight Bags
EGI	Embedded GPS in INS
EHS	Enhanced Surveillance
EKMS	Electronic Key Management System
ELS	Elementary Surveillance
EMCON	Emission Control
EO	Electro-Optical
ESIP	Enhanced SINCGARS Implementation Program
ET	Enhanced Throughput
EW	Electronic Warfare
FAA	Federal Aviation Administration
FAB-T	Family of Advanced BLOS Terminals
FAR	Federal Acquisition Regulations
FBCB2	Force XXI Battle Command Brigade and Below
FCC	Federal Communication Commission
FDD	Functional Description Document
FFC	Fleet Forces Command
FFN	Fleet Flash Network
FIS-B	Flight Information Service – Broadcast
FLIP	Flight Information Publication
FLIR	Forward-Looking Infra-Red
FMS	Flight Management System
FMV	Full Motion Video
FNC	Future Naval Capability
FO	Fiber Optic
FOC	Full Operational Capability
FOG	Fiber Optic Gyro
FOTD	Fiber Optic Towed Decoy
FOV	Field of View
FRP	Full Rate Production
GAS-1	GPS Antenna System
GBAS	Ground Based Augmentation System
GCAS	Ground Collision Avoidance System
GCCS-M	Global Command and Control System – Maritime
GENSER	General Service
GFE	Government Furnished Equipment
GIG	Global Information Grid
GP	General Planning
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GWOT	Global War on Terrorism
GRC	Grid Reference Graphics
HAIPE	High Assurance IP-Based Encryption
HAIPE-IS	High Assurance IP-Based Encryption – Interoperability Specification
HARM	High-speed Anti Radiation Missile
HAVEQUICK	UHF Encrypted Waveform
HDRAT	High Data Rate Aviation Terminal
HF	High Frequency
HF-ALE	High Frequency – Automatic Link Establishment
HFI	Hostile Fire Indication
HIPE	Highly Integrated Photonics Electronics
HMDS	Helmet Mounted Display System
HOL	High Order Language
HQ-II	HaveQuick II
HUMS	Health & Usage Monitoring System
HUD	Heads-Up Display
IA	Information Assurance
IAP	Instrument Approach Procedures
IBS	Integrated Broadcast Service
ICAO	International Civil Aviation Organization
ICD	Initial Capability Documents
ICNIA	Integrated Communications Navigation and Avionics
ICS	Interior Communications System
ID	Identification
IDECM	Integrated Defensive Electronic Countermeasures
IEEE	Institute of Electrical and Electronics Engineers
IETF	International Engineering Task Force
IF	Intermediate Frequency
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrumented Metrological Conditions
IMD	Integrated Mechanical Diagnostic
IMD HUMS	Integrated Mechanical Diagnostic and Health and Usage Monitoring System
IMPLC	Integrated Multiple Launch Controller
INS	Inertial Navigation System
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IP	Internet Protocol
IPSEC	Internet Protocol Security
IPv6	Internet Protocol Version 6
IPL	Integrated Priority List
IR	Infrared
IRCM	Infrared Counter-Measures
ISR	Intelligence Surveillance & Reconnaissance
IT/NSS	Information Technology/National Security System
IW	Integrated Waveform
JAN-TE	Joint Airborne Network – Tactical Edge
JATAS	Joint and Allied Threat Awareness System
JBFSA	Joint Blue Force Situational Awareness
JBC-P	Joint Battle Command - Platform
JCA	Joint Capability Area
JCD	Joint Capability Document
JCTD	Joint Capabilities Technology Demonstration
JCIDS	Joint Capability Integration and Development System
JDAM	Joint Direct Attack Munitions
JASPO	Joint Aircraft Survivability Program Office
JEAT	Joint Electronic Advance Technology
JFCOM	Joint Forces Command

JFO	Joint Fires Observer
JHMCS	Joint Helmet Mounted Cueing System
JMPS	Joint Mission Planning System
JMPS-E	Joint Mission Planning System – Expeditionary
JMPS-M	Joint Mission Planning System Maritime
JPALS	Joint Precision Approach and Landing System
JPEO	Joint Program Executive Office
JRE	Joint Range Extension
JREAP-C	Joint Range Extension Applications Protocol (C)
JROC	Joint Requirements Oversight Council
JROCM	Joint Requirements Oversight Council Memorandum
JSF	Joint Strike Fighter
JSOW	Joint Stand-off Weapon
JTA	Joint Technical Architecture
JTAC	Joint Tactical Air Controller
JTIDS	Joint Tactical Information Distribution System
JTRS	Joint Tactical Radio System
JTT-IBS	Joint Tactical Terminal – Integrated Broadcast System
JUON	Joint Urgent Operational Need
JVMF	Joint Variable Message Format
KPP	Key Performance Parameter
KSA	Key Systems Attributes
LAAS	Local Area Augmentation Systems
LADAR	Laser Radar
LAIRCM	Large Aircraft Infrared Counter-Measures (Air Force)
LECP	Logistics Engineering Change proposal
LED	Light Emitting Diode
LEFIS	Link Encryption Family Interoperability Specification
LOS	Line of Sight
LO	Low Observable
LPD	Low Probability of Detection
LPI	Low Probability of Intercept
LPIA	Low Probability of Intercept Altimeter
LPV	Localizer Performance with Vertical Guidance
LSI	Lead Systems Integrator
M5L2-B	Mode 5 Level 2 – Broadcast
MADL	Multi-Function Advanced Data-link
MAGR	Miniaturized Airborne GPS Receiver
MANET	Mobile ad hoc Networking
MANPADS	Man-Portable Air Defense System
Marine AvPlan	Marine Aviation Plan
MATT	Multi-mission Advanced Tactical Terminal
MAWS	Missile Approach Warning System
MC	Mission Computer
MCAS	Midair Collision Avoidance System
M-Code	GPS Waveform
MCP	Military Capability Package
MDA	Milestone Decision Authority
MDF	Mission Data File
MDPS	Maintenance Data Processing Station
MELP	Mixed Excitation Linear Prediction
MEMS	Micro Electro-Mechanical System
MFD	Multi-Function Display
MFS	Maritime/Fixed Station
MFTD	Multi-Function Threat Detector
MFOQA	Military Flight Operations Quality Assurance
MGCAS	Manual Ground Collision Avoidance System
MGUE	Military GPS User Equipment
MIDS	Multi-functional Information Distribution System
MIDS-LVT	MIDS Low Volume Terminal
MIDS-JTRS	MIDS Joint Tactical Radio System
MILS	Multiple Independent Level Security
MILSTAR	Military Strategic & Tactical Relay
MIPS	Mishap Investigation Parameter Standards
MIPv6	Mobile Internet Protocol Version 6
MJU	Mobile Jettison Unit
MLS	Multi-level Security
MLVS	Memory Loader-Verifier Set
MOSA	Modular Open Systems Architecture
MPM	Microwave Power Module
MSMA	Mission Systems Management Activity
MUOS	Multi-User Objective System
NACRA	Naval Aviation Center for Rotorcraft Advancement
NAE	Naval Aviation Enterprise
NARG	Naval Aviation Requirements Group
NAS	National Air Space
NASA	National Air & Space Administration
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Aviation Systems Command
NAVICP	Naval Aviation Inventory Control Point
NAVFIG	Naval Flight Information Group
NAVPlan	Naval Aviation Plan
NAVRIIP	Naval Aviation Readiness Integrated Improvement Program
NAVWAR	Navigation Warfare
NCCT	Network Centric Collaborative Targeting
NCES	Network Centric Enterprise Services
NCO	Network Centric Operations
NCTAMS	Naval Computer & Telecommunications Area Master Station
NCTS	Naval Computer & Telecommunications Station
NCW	Network-Centric Warfare
NDB	Non-Directional Beacon
NDI	Non-Developmental Item
NGA	National Geospatial-Intelligence Agency (formerly National Imagery and Mapping Agency (NIMA)
NOC	Network Operations Center
N-PFPS	Navy-Portable Flight Planning Software
NRE	Non-returnable Engineering
NSA	National Security Agency
NWCF	Navy Working Capital Funds
OAG	Operational Advisory Group
OBJ	On Board Jammer
OBL	Optical Break Lock
OFP	Operational Flight Program
ONR	Office of Naval Research
OPEVAL	Operational Evaluation
ORM	Operational Risk Management
OSA	Open Systems Architecture
OSD	Office of the Secretary of Defense
OTAR	Over-the-Air Rekey
OTAT	Over-the-Air Transfer
OTAZ	Over-the-Air Zeroization
PAR	Precision Approach Radar
PBA	Performance Based Acquisition
PBL	Performance Based Logistics
PCD	Panoramic Cockpit Display
PCMCIA	Personal Computer Memory Card International Association
PDF	Paper Digital Format
PDR	Preliminary Design Review
PDRA	Preliminary Design Review Assessment
PEO	Program Executive Office
PEO(A)	Program Executive Office (Air ASW, Assault & Special Missions Programs
PFPS	Portable Flight Planning System
PILS	Protected Instrument Landing System

PGM	Precision Guided Munitions
PHM	Prognostic Health Management
PLI	Position Location Information
PM	Program Manager
PMDSS	Portfolio Management Decision Support System
PMMW	Passive Milli-Meter Wave
PoPS	Probability of Program Success
POM	Program Objective Memorandum
PPBE	Planning Programming Budgeting and Execution
PPLI	Precise Participant Location and Identification
PPS	Precise Positioning Service
PRR	Program Requirements Reviews
PSK	Phase Shift Keying
Q&A	Question and Answer
RAHRS	Replacement Altitude Heading Reference System
RAIM	Random Autonomous Integrity Monitoring
RCS	Radar Cross-Section
RDT&E	Research Development Test and Evaluation
RF	Radio Frequency
RINU-G	Replacement Inertial Navigation Unit – GPS
RIP	Reliability Improvement Program
RLG	Ring Laser Gyro
RNAV	Area Navigation
RNC	Radio Network Controllers
RNP	Required Navigation Performance
ROI	Return on Investment
RORI	Reel Out Reel In
ROVER	Remotely Operated Video Enhanced Receiver
RPG	Rocket Propelled Grenade
RSDS	Radar Signal Detection System
RTOS	Real Time Operating System
R/T	Receiver/Transmitter
RVSM	Reduced Vertical Separation Minimums
RWR	Radar Warning Receiver
RWS	Radar Warning System
SCA	Software Communications Architecture
SCI	Sensitive Compartmented Information
SAASM	Selective Availability Anti-Spoof Module
SAFF	Small Airborne Form Factor
SAM	Surface to Air Missile
SATCOM	Satellite Communications
SATURN	Secure Anti-Jam, Tactical, UHF, Radio for NATO
SBAS	Space Based Augmentation System
SBB	SwiftBroadBand
SBIR	Small business Innovative Research
SCA	Software Compliant Architecture
SCI	Sensitive Compartmented Information
SDR	Software Defined Radio
SECNAV	Secretary of the Navy
SHARP	Shared Airborne Reconnaissance Pod
SHCN	Satellite High Command Network
SIAP	Single Integrated Air Picture
SIDS	Standard Instrument Departures
SINCGARS	Single Channel Ground/Airborne Radio System
SLAM	Stand-off Land Attack Missile
SLAM-ER	Stand-off Land Attack Missile – Extended Range
SPOT	Strike Planning Optimization Tool
SPP	Sponsor's Program Proposal
SPS	Standard Position signal
SOA	Service Oriented Architecture
SRGPS	Shipboard Relative Global Positioning System
SRW	Soldier Radio Waveform
SSG	Senior Steering Group
STANAG	Standardization Agreement
STARS	Standard Terminal Arrivals
STD-CDL	Standard Common Data Link
STOM	Ship to Objective Maneuver
SWaP	Size Weight and Power
TACAIR	Tactical Aircraft
TACAN	Tactical Communications Aid to Navigation
TADIRCM	Tactical Aircraft Directed Infrared Countermeasures
TADIL-J	Tactical Digital Information Link – Joint
TADL-J	Tactical Digital Information Link – Joint
TAMMAC	Tactical Aircraft Moving Map Capability
TAMPS	Tactical Automated Mission Planning System
TAWS	Terrain Awareness Warning System
TCAS	Traffic Alert and Collision Avoidance System
TCP/IP	Transmission Control Protocol/Internet Protocol
TDDS	TRAP Data Dissemination System
TDMA	Time Division Multiple Access
TFR	Temporary Flight Restriction
TIBS	Tactical Information Broadcast System
TIS-B	Traffic Information Service – Broadcast
TMA	Terminal Maneuvering Area
TMS	Type Model Series (also T/M/S)
TPL	TYCOM Priority List
TPP	TYCOM Priority Panel
TRE	Tactical Receive Equipment
TRANSEC	Transmission Security
TRAP	Tactical Receive Equipment and Related Applications
TRIXS	Tactical Reconnaissance Information Exchange System
TTNT	Tactical Targeting Network Technology
TYCOM	Type Commander
UAT	Universal Access Transceiver
UCAS-N	Unmanned Combat Air Systems - Navy
UCLASS	Unmanned Carrier Launched Airborne Surveillance and Stike
UE	User Equipment
UFO	UHF Follow-on
UHF	Ultra High Frequency
UNCLAS	Unclassified
UNS	Universal Needs Statement
USB	Universal Serial Bus
USB-ENTR	Universal Serial Bus – Embedded National Tactical Receiver
UUNS	Urgent Universal Needs Statement
VACM	VINSON and ANDVT Cryptographic Modernization
VECP	Value Engineering Change Proposal
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VMF	Variable Message Format
VNAV	Vertical Navigation
VoIP	Voice Over Internet Protocol
VOR	VHF Omni-Directional Receiver
WAAS	Wide Area Augmentation System
WAN	Wireless Airborne Network
WCDMA	Wideband Code Division Multiple Access
WED	Windtalker Encryption Device
WGS	Wideband Global SATCOM
WNW	Wideband Network Waveform
XDR	Extended Data Rate

Points of Contact

Avionics Requirements and Resourcing Managers:

COMNAVAIRFOR	757-445-7590
OPNAV N9815	703-692-8308
Flight Safety	703-693-6158
HQMC APW71	703-693-8390/8552

Commodity Program Offices and Services Agents:

PMA209 Air Combat Electronics	301-757-6464
PMA213 ATM (JPALS) & Combat ID	301-737-2115
PMA272 Electronic Warfare	301-757-7906
PMA281 Strike Planning & Execution	301-757-8011/6152
PMW/A170 GPS	301-995-4683
Obsolescence Mgt Supt Branch (Keyport)	360-315-7503/3428

Capability Element Managers:

Capability Element	Office	Phone Number
Airborne Collision Avoidance	PMA209	301-863-2204
Aviation Capability Integration Sys Team	PMA209	301-757-6736
Attitude and Altitude	PMA209	301-757-0906
CFIT Avoidance	PMA209	301-757-6466
CNS/ATM	PMA209	301-757-6457
Communications Security	PMA209	301-757-1792
Cooperative Combat ID	PMA213	301-737-2121
Crash Survivable Recording	PMA209	301-757-2626
Datalinks & Networking	PMA209	301-342-3689
Data Storage	PMA209	301-757-6145
Data Transfer & Distribution	PMA209	301-757-9441
Voice Communications	PMA209	301-757-2820
FACE Consortium	PMA209	301-995-4971
Flying Operations Quality Assurance	PMA209	301-757-6706
GPS Navigation	PMW/A170	301-995-4683
Information Displays	PMA209	301-757-6468
Information Processing (FACE)	PMA209	301-995-4971
Interior Communications	PMA209	301-757-6726
Joint Tactical Networking	PMW209	301-342-3689
Mission Planning	PMA281	301-757-8011/6152
Mission Processing	PMA209	301-757-9441
Moving Map	PMA209	301-757-6771
Precision Recovery (JPALS)	PMA213	301-737-2117
Self Protection	PMA272	301-757-7906

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