Navigation & Sensors Capability Management

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I. Definition: The Navigation and Sensors Team (NAST) within PMA209 is responsible for monitoring and managing the health of Naval Aviation navigation and sensor systems to efficiently and effectively meet maritime strategy, CNO Guidance, and OPNAV/HQMC direction. The team develops and maintains a core of acquisition and technical expertise for the strategic and tactical management of aircraft navigation and sensor systems in support of naval strategic and operational objectives. The NAST is the lifecycle manager for designated embedded GPS/inertial navigation (LN-100/251 and the H-764G), attitude heading reference (NavPac family of systems), altimeter (AN/ARN -194, RT-1805), and the displacement & rate gyro systems (SBU-28/29/30/32 & 33) throughout their lifecycle. This will be accomplished from material solution analysis, technology development, engineering and manufacturing, to production and deployment, and through support for the life of the system in accordance with DoD Directive 5000.1 and DoDINST 5000.02. In addition, the team will provide liaison with other program offices, various DoD organizations, other services, Fleet representatives, and industry to remain informed of all new Navigation and Sensors (N&S) initiatives that may impact Naval Aviation Programs.

II. Scope: The NAST focuses on solutions that provide Naval Aviation common, supportable and innovative navigational system capabilities by providing avionics, instruments, and systems adept at operating in a network and data centric environment. These capabilities are attained through the development, acquisition and fielding of affordable technologies that maximize current fleet readiness, which satisfy Navy and Marine Corps warfighter requirements.

The following specific capabilities are included under Navigation and Sensors management. The current capability and expected evolutionary activity of each area is defined in detail in the Core Avionics Master Plan (CAMP). Those items marked with an asterisk (*) have strong ties to and require significant coordination with other programs in PMA209 including Communication and Airborne Networking (CAN), Mission Systems (MS), Safety and Flight Operations (SFO), and the Fleet Avionics Sustainment Systems Team (FASST) as indicated.

1. **Attitude/Altitude** (Navigation, CNS/ATM, FASST)
    - CNS/ATM (*MS - AMC, CDU, CDNU, MSMA ; CAN- AN/ARC-210)
    - Software (*MS (Mission critical and non-mission critical))
    - Carrier Aircraft INS
    - Commercial INS
    - Attitude Heading and Reference
    - Magnetic Heading
    - Legacy Gyro (Rate and Displacement)
    - Vertical Velocity

2. **En-route Maneuver**
    - Mode-S
    - ADS-B (978 and 1090ES In/Out)
    - Embedded Global Positioning System/Inertial Navigation System (GPS/INS)
    - Inertial Navigation Systems (INS)
    - RNP RNAV

- M Code
- MAGR2K
- TACAN
- Doppler

3. Information Media

- Electronic Chart's (publications (low/high charts, terminal approach procedures/Stars/SIDS))
- Map overlays
- Weather Technology in the Cockpit
- Electronic Aeronautical Databases (Government and Commercial)

4. Sensor Systems (Sensor, NAV, FASST)

- Barometric Altitude Indicating Systems (AAU-3/4/19/21//32/53)
- Radar Altimetry (RADALT) AN/ARN-171, 194, LPIA RT-1805)

5. Exclusions

The following capabilities are managed by other program offices and are closely monitored and coordinated with where required for integration into platforms in parallel with N&S efforts.

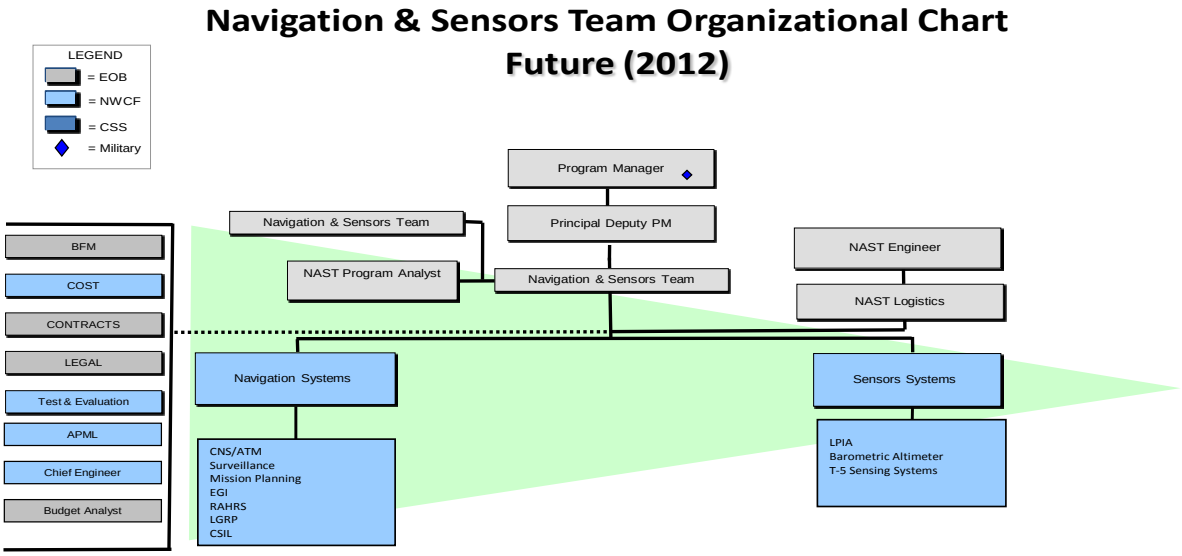
- GPS (PMW/A170)
- JPALS (PMA213)
- IFF (PMA213)
- NEXTGEN Joint Program Office (JPO) (PMA213)

III. Navigation and Sensors Management: The Navigation and Sensors Capability Management Area have evolved significantly over the past few years and will continue to evolve to meet the needs of the customers. This management area has grown from a provider of box level components such as gimbaled gyros for displacement and rate sensing, mechanical attitude heading and reference systems (AHRS), barometric altimeters, to a provider of common cockpit navigational capabilities, and Communication Navigation Surveillance Air Traffic Management (CNS/ATM) functionality. Primary CNS/ATM capabilities required for access to performance-based airspace include Reduced Vertical Separation Minimums (RVSM), Required Navigation Performance Area Navigation (RNP RNAV), 8.33 kHz VHF communications, Mode S data links for Elementary and Enhanced Mode S operations. Solid state Replacement Attitude Heading and Reference Systems and solid state Legacy Gyro Replacement systems, and the Low Proximity Intercept Altimeter have provided improved sensors for navigation requirements. There have been significant changes in the past several years on management of avionics hardware and software systems. Capabilities are integrated by working with the platform office to develop an integrated solution using common components - both hardware and software. The solutions take into account both current and future requirements. The use of Open System Architecture (OSA) will allow capabilities to be integrated independent of existing hardware and software. In order to provide the best solution with the lowest cost, the NAST has established a "Capability Leadership Team" led by the Deputy CAPability Area Manager (DCAP). Within the NAST, systems are managed by three capability IPT leads:

- Navigation Systems
- CNS/ATM
- Sensors

The primary function of the NAST is to support the Fleet, our Sponsors, and Platform Program Offices. NAST also meets with platform customers who have new navigation and sensor requirements. Current capabilities are documented and compared to desired requirements in order to implement the best solution from either an existing fielded system or through a new system development program. This requires the members of the Capability Leadership Team to be cognizant of systems both in and outside of PMA209. Leads must be aware of new technologies that are approaching maturity and navigation/sensor systems in platforms not supported by PMA209. Solutions will not be limited to current PMA209 systems but will be open to other systems that may have been developed by other program offices, other services, or commercial sources. The team also maintains awareness of science and technology initiatives in areas associated with navigation and sensors and aligns maturing initiatives with platforms requirements.

The chart below depicts the proposed plan for the organization of Navigation and Sensors team. The proposed plan will properly align Navigation and Sensors Capability Management with customer requirements.



IV. Customer Requirements (Identification of gaps): Requirements for Navigation and Sensors Systems come from multiple sources including platform PMAs, other commodity PMAs, Operational Advisory Groups, Naval Aviation Requirements Groups, FMS customers, and other internal PMA209 programs. The Navigation and Sensors Systems Deputy Capability

Area Manager (DCAP) is responsible for collecting and evaluating these requirements and looking for opportunities to provide solutions from existing systems or new development. If the best solution is determined to be an existing program or an upgrade to an existing program, the effort will be passed to that IPT for planning and execution. If the determination is made that the best solution is a new acquisition, the effort will be passed to the Navigation or Sensors IPTL and vetted through the N&S CAP for POM planning and submission, acquisition planning, and execution. In some cases, the Common Opportunity Review Process (CORP) will be followed to determine the business case for common versus unique solutions. In all cases, the CAMP is the document that will be used to capture baseline capabilities, planned upgrades, technology insertions and funding status.

V. Technology Push: As new innovative technologies are identified for their potential benefits for future Naval Aviation systems, they will be assessed for inclusion in PMA supported SBIRs, future upgrades to existing systems, new development systems, and/or demonstrations to prove the technologies. Once these technologies have been shown to provide benefit to Naval Aviation platforms, they will be captured in the CAMP and shared with customers of products that might benefit from these advancements.

VI. Capabilities / Mandates: The following chart is a list of current N&S capability and mandates along with USN/USMC aircraft platform utility. More information on these may be found in the CAMP.

	CNS/ATM (FAA Mandates)					VNAV	GPS/INS	AHRS	Attitude Gyro (enhanced)	Barometric Altimeter	Radar Altimeter	TACAN	Weather
Platform	RNP RNAV	Mode S	RVSM	8.33	ADS-B								
C-2A													
E-2C													
E-2D													
P-3C									SBU-33				
EP-3									SBU-33				
CH-53E									SBU-32				
MH-53E									SBU-29,30,32				
CH-46E													
MH-60R/S									SBU-28/30				
F/A-18A+													
F/A-18CD													
F/A-18E/F													
F/A-18G													
AH-1Z													
UH-1Y													
MV-22A/B													
VH-60N													
VH-3D													
T-45													
AV-8B													
EA-6B ICAP II													
EA-6BICAP III													
CH-46E													
KC-130J													
C/KC-130T													

Notes:

Installed

Not Planned Currently

Potential Future Capability (needs more research)

Planned Outyear

No Requirement

In addition to the chart above, the capability areas defined are:

1. **Attitude/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 instrument flight conditions.

1.1 Gyro Systems

Many platforms 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 attitude reference gyros. Ring Laser Gyros (RLG's) employ laser light technology for more accurate measurement of attitude changes, but also employ a small motor to aid in sensing smaller angular velocity changes which are provided in the SH-60B/F, H-60R&S, HH60 (Coast Guard), MH-60R/S and CH/MH-53E. Technology improvements and future installs replacing Ring Laser Gyro's is Fiber Optic Gyro (FOG) technology. FOG also uses light-wave sensing, but eliminates moving parts and uses cheaper fiber for the light path. Currently the F/A18 E&F and H-53K aircraft are scheduled to incorporate this technology.

1.2 Micro Electro-Mechanical System (MEMS) Technology has been utilized to reduce size of vertical and directional motion sensors used in attitude/heading reference systems; however mechanical systems are more influenced by shock and vibration and are inherently less reliable than solid state systems. Solid state components also bring substantial gains in accuracy, robustness, and cost avoidances.

2. **En-route Maneuver –** This capability element speaks to the core of the Navigation capability area. It addresses the ability to follow prescribed en-route airways, perform precision and non-precision approaches for recovery, and precise location awareness that enables precision engagement. 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 the continental United States 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. The FAA, which is transitioning away from the use of TACAN, is looking toward the DoD to sustain TACANs in CONUS. The US Navy currently does not have a plan to navigate without TACANs. Shipboard use will require TACAN for the foreseeable future. TACAN also provides an effective backup to GPS in CONUS for both commercial and tactical platforms.

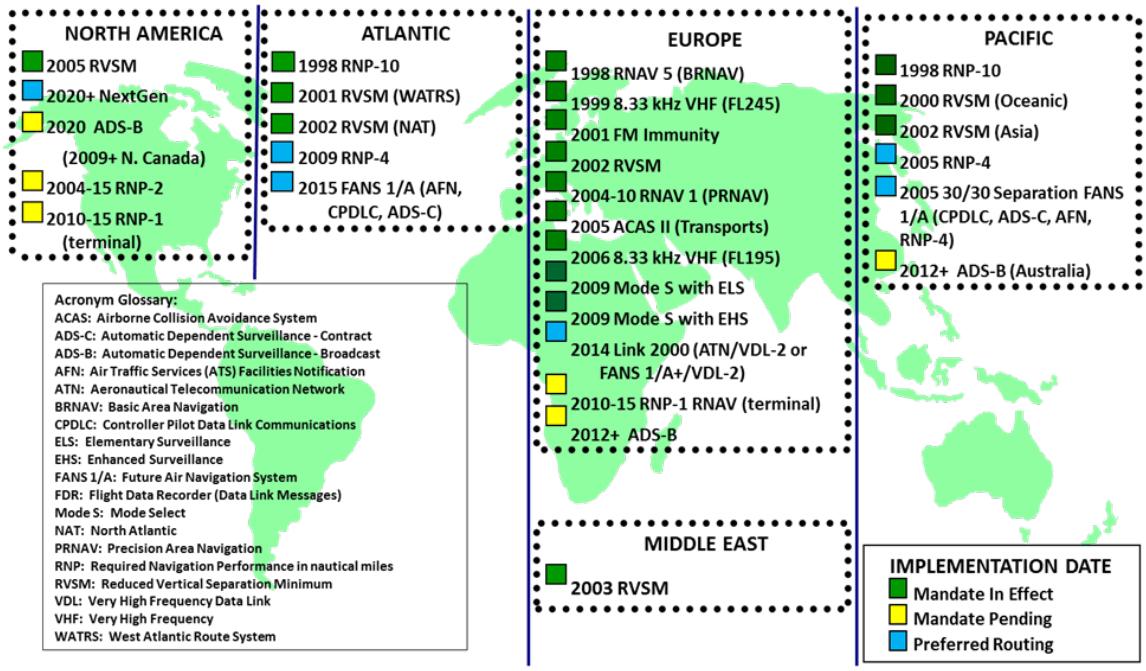
2.1 Embedded GPS Almost all naval aircraft have integrated embedded GPS receivers and are required to use the encrypted Precise Positioning Service (PPS) signal. Modern systems closely couple Inertial Navigation System (INS) elements with GPS to provide update corrections to compensate for drift. Newer models of the Miniature Airborne GPS Receiver (MAGR-2000) and the Embedded GPS/INS (EGI) have "All-in-View" 12 channel satellite signal reception, which monitors more satellites for signal triangulation and enables Receiver Autonomous Integrity Monitoring Fault Detection Exclusion (RAIM FDE) for signal integrity monitoring. Current capability is included in C-2A, E-2C, H-53E, H-46E, F/A-18A+, EA-6B,

HC-130H, H-1Y/Z, and P-3C. Latest systems upgrades include the 24 channel Selective Availability / Anti-Spoofing Module (SAASM) due to obsolescence issues. Aircraft with legacy receivers that do not have integrated RAIM capability are restricted to using GPS as an aide to situational awareness for Visual Meteorological Conditions (VMC) operations in civil airspace.

2.2 MAGR-2000 Following successful operational evaluation 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 Aviation aircraft certified for RNP 4, 2, 1, and 0.3, and is also certified to fly airways using military GPS as the primary means of navigation. 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 12/24 channel All-In-View functionalities required for non-precision navigation in civil airspaces.

2.3 Carrier Aircraft Inertial Navigation System (CAINS II) The AN/ASN-139 Carrier Aircraft Inertial Navigation System (CAINS II) is a ring laser gyro INS and is a form, fit and function replacement for the AN/ASN-130A. It is designed for high-performance carrier-based aircraft. The accuracy specifications are better than 1 n mile/h CEP and 3 ft/s velocity with a 4 minute reaction time. Current Navy/Marine Corps platforms using CAINS II are F/A-18E/F, E-2C and AV-8B.

2.4 Communication Navigation Surveillance / Air Traffic Management (CNS/ATM) CNS/ATM has been defined as a system employing digital technologies, including satellite systems together with various levels of automation, applied in support of a seamless global air traffic management system. The main elements of CNS/ATM systems are described in detail in the ICAO Global Air Navigation Plan for CNS/ATM Systems (ICAO, 1998a). CNS/ATM systems will use very high frequency (VHF) and high frequency (HF) communication channels to transmit digital data between aircraft and between aircraft and ground stations. Satellite data and voice communications capable of global coverage are also being introduced. Improvements in navigation include progressive introduction of area navigation (RNAV) capabilities based on a global navigation satellite system (GNSS). Improvements in surveillance techniques will allow aircraft to automatically transmit their positions using data link technology. The Navigation and Sensors Team (NAST) has encompassed the civil side and incorporated a military structure in order to fly in controlled airspace. The below chart describes the mandates that are currently required.



3. **Information Media –** This capability element refers to paper and electronic navigation information media formats. Although mission planning systems for several platforms have incorporated the capability to upload geographical data to support mission accomplishment, most users are still using paper charts for primary means of navigation. The National Geospatial Intelligence Agency (NGA – formerly the National Imagery and Mapping Agency) shifted provision of chart media from the internet to NIPR net in 2007. En-route charts and Flight Information Publications (FLIP) terminal approach diagrams are now provided in PDF file and Digital Aeronautical Flight Information Files (DAFIF) formats. For those aircraft that are configured with them, electronic chart media can be displayed on moving maps. This information currently must be loaded onto the aircraft for each flight. Weather radar can also be integrated into the aircraft by various means such as internet, satellite (XM, Iridium constellation, Inmarsat) and ADS-B (In) Flight Information Service Broadcast (FIS-B) on UAT 978. Weather information will improve the safety of operations by enabling cockpit technologies and improve situational awareness to the warfighter.

4. **Sensor Systems** – This capability element addresses altitude detection (both barometric and radar altimetry).

   4.1 Barometric Altimeters are installed in all aircraft and provide only the altitude above sea level. Altitude can be determined based on the measurement of atmospheric pressure (the greater the altitude, the lower the pressure). When a barometer is supplied with a nonlinear calibration so as to indicate altitude, the instrument is called a pressure altimeter or barometric altimeter. Barometric altimeters currently being supported are the AAU-3/4 (F-5E, T-38A and T-45A), AAU-19 (E-2C, EA-6B, F-5E/F, T-2C, T-38A and

C-2A), AAU-21 (H-46, CH-53D, KC-130F, T-39D, TE-2C, AH-1W, UH/HH-1N, H-3 and P-3), AAU-32 (AH-1W, UH-1N, MH-53E and H-60) and AAU-53 (AV-8B and F/A-18).

4.2 Radar Altimeters measure the actual altitude above the terrain. The AN/APN -171 has many functions available with this system, including low-altitude warning, radar altitude warning set input, aircraft rate, aircraft altitude errors and landing gear warnings. Three basic AN/APN-171 radar altimeter systems supported are the 0 to 1,000 ft system, the 0 to 2,500 ft system and the 0 to 5,000 ft system and are currently installed in the C-130, E-2C and CH-53. The Low Probability of Intercept Altimeter (LPIA) is accurate up to 35,000 feet as opposed other RADALTS which are accurate only below certain altitudes and angles of bank. The LPIA provides increased range and accuracy of altitude measurements and coverage at higher angles of bank than existing radar altimeters. It also provides an approach to eliminate interference from suspended loads. The LPIA incorporates commercial-off-the-shelf (COTS) digital signal processor (DSP) technology to enhance altimeter capabilities, increase reliability and significantly reduce probability of signal intercept. Current and future platforms using this technology are E-2D, H-53K, C-2A, E-2C, P-3 and CV-22. The LPIA also includes continuous Built-In-Test capability to assure the reliability of output data as required for the predictive Terrain Avoidance Warning System (TAWS) advanced Ground Proximity Warning System (GPWS) and Traffic Collision Avoidance System (TCAS).

VII. Driving Requirements: 2025 Nav Vision dated 1 July 08 by N84 Rear Admiral D. A. Grove, provides the vision and purpose of where Naval Navigation is going in the future. In his memorandum, he described navigation capability survivability as

> "*Navigation Capability must be survivable (graceful degradation), providing robust, uninterrupted capabilities (all environments) to the operator through an optimized and integrated mix of functional components"*.

That being said, having a Navigation Capability Manger as oversight to Naval Aviation Enterprise is essential to view new technologies, and to ensure commonality can be achieved. Understanding the need for safe navigation, we need to continue to pursue new technology.

1. **Altitude/Attitude:**
   - Sensor based navigation open up exciting new possibilities for complementing traditional GPS navigation. Vertical Navigation (VNAV) can provide that need for non-precision approach without using a local augmentation system such as Wide Area Augmentation System (WAAS) or Local Area Augmentation System (LAAS). Currently, some manufactures are researching and developing VNAV systems for future requirements.
   - The new M-Code signal threshold parameters call for signal acquisition time and accuracy of position to be at least equal to existing military P(Y) signal values, but designers are expecting technology improvements will afford faster ("direct") signal acquisition and tighter position accuracy. The satellites would employ more power for a stronger signal, and incorporate a spot beam capability that enables them to

focus signal at even higher power values to concentrated areas. The stronger signal would also provide more margins against jamming and spoofing.

2. **En-route Maneuver:**
   - European Air Traffic Control managers and the FAA are in the process of developing requirements and timelines for implementing Automatic Dependant Surveillance – Broadcast (ADS-B) capability for improved safe separation and increased level of detail pertaining to the identification, status and operating parameters of participating aircraft. NAST is currently drafting a Functional Requirements Document for ADS-B. ADS-B data *OUT* of aircraft will be implemented first. ADS-B data *IN* to aircraft is a next step to bring situational awareness to the pilot by providing a graphical display of other aircraft in the vicinity. Software monitoring of ADS-B *IN* data and warning to the pilot could provide an improved level of safety above existing collision avoidance systems. Available frequencies for implementing ADS-B are 1090 MHz and 978 MHz. The 978 MHz based version can provide additional data to users, such as display of real-time weather condition graphics, as well as airfield conditions and status information from Flight Information Service providers (visual equivalent of taped voice messages that are currently transmitted on radio channels with more depth and real-time currency). These additional services are available in CONUS, not over ocean. CNS/ATM cockpit component integrations are laying the foundation that will support growth to ADS-B functionality. This weather information could present a more affordable and simply integrated alternative to stand-alone weather radar when operating in covered geographic areas.

   - FAA, commercial airlines and the private civil aircraft industry are out-pacing military aircraft when it comes to development and implementation of navigational aids and 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 for less than $1000. Military aircraft integrations are of course more challenging due to harsh environment specifications, operating system through-put limitations, and necessity for tighter data integrity (currency of navigation information such as airfield procedure changes, obstacle locations, etc.). Although some current COTS XM weather systems are being installed on platforms to meet immediate requirements. XM data service is currently available in North America only. Combining higher confidence of position accuracy with greater Air Traffic Control connectivity can enable operators to request and be authorized deviations (short cuts) from prescribed routes, thereby saving time and fuel.

   - Current Requirements. The current driving requirements are CNS/ATM Functional Requirements Documents (FRDs) for USN/USMC platforms. To achieve a required civil functionality using military avionics and integrations, an FRD specifies the details of a civil functionality to enable the platform to achieve the same capability using military avionics. It provides the basis for Navy test and evaluation leading to Navy platform certification of functionality. It also ensures system functional commonality in all aircraft while using different hardware, software and cockpit

displays. Four FRDs are currently being implemented on USN/USMC platforms.

- 8.33 kHz Channel Spacing – This FRD defines the functionality required to operate in European airspace where 8.33 kHz is mandated at high altitudes for communication with air traffic control agencies.

- Mode S – This FRD defines the functionality required to operate in airspace where Mode S surveillance is being mandated (Europe). This includes both Elementary (ELS) and Enhanced Surveillance (EHS) requirements.

- RNP RNAV – This FRD defines the functionality required to operate in airspace where performance based navigation mandates are emerging. It defines the navigation accuracy, containment, integrity and appropriate alert**s** to file and fly from departure through NPA with PPS GPS as the primary positioning source. The RNP RNAV FRD also covers other navigation performance requirements (i.e. BRNAV, RNP-10, VNAV, etc).

- RVSM – This FRD defines the functionality required to operate in airspace where Reduced Vertical Separation Minimums (RVSM) is required. This now includes almost all the sovereign airspace of the world

- A fifth FRD is currently in work and will be implemented when approved.

  - ADS-B (out) – This FRD is a platform-based surveillance service that broadcasts a platform's position, velocity and identification. The Federal Aviation Administration mandate directs a nationwide transition to ADS-B technology by 2020 as a part of the NextGen architecture.

3. Information Media:

- Electronic charts are the next generation of navigational charts. Their use in electronic charting systems simplify traditional navigation processes such as route planning and chart updating, and also enable automation of route tracking through use of satellite positioning devices. These features can greatly enhance navigational safety by improving situational awareness, especially in busy or confined waters. Digital technology is used to develop electronic charts from traditional paper charts and directly from marine survey data. The importance of using official data is, as with paper charts, absolutely paramount to maximizing safety and other related benefits.
- Map overlays; There are several aeronautical overlays on the market today that enable visual cues. Many types of maps are supported, but the primary ones of interest to most users are aeronautical charts, satellite images and elevation maps. The federal government has funded the development of FalconView and is a nonproprietary "government off-the-shelf application and is free of any license fees for government use. This includes the use of the Software Developers Kit (SDK) which documents the interfaces for use by government developers and contractors working on government programs. FalconView supports a large number of overlay types that can be displayed over any map background. The current overlay set is targeted toward

military mission planning users and is oriented towards aviators and aviation support personnel. FalconView is an integral part of the Portable Flight Planning Software (PFPS). This software suite includes FalconView, Combat Flight Planning Software (CFPS), Combat Weapon Delivery Software (CWDS), Combat Air Drop Planning Software (CAPS) and several other software packages built by various software contractors.

- Weather technology in the Cockpit; 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 Extended Squitter and Universal Access Transceiver (UAT) datalink on 978 MHz. 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) when UAT (in) is incorporated. The 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 situational awareness.
- Electronic Aeronautical Databases (Government and Commercial); There are several formats that provide "Safe" navigation information and situational awareness in the cockpit. The CNS/ATM program and ACIST has provided viable options during platform integration. Working with NGA and companies like JEPPESEN are described below enabling the information to be displayed.
    - ENROUTE CHARTS - NGA Aeronautical ENROUTE Charts are available to DoD customers via the NIPRNet and other secure access points in PDF format. The charts are duplicates of those contained in paper FLIP and are updated with each production cycle. The DoD Enroute charts are available on the DAFIF ED 8 DVD in PDF format as well.
    - ENROUTE LOW ALTITUDE CHARTS - These charts portray the airway system and related data required for IFR Operations at altitudes below 18,000 feet Mean Sea Level. Thirty-six variable scale charts are printed on eighteen sheets, L-1 through L-36, covering the entire United States. Publication cycle is every 8 weeks.
    - AREA CHARTS - These charts portray the airway system and related data required for IFR Operations in selected terminal areas at altitudes below 18,000 feet Mean Sea Level. Twelve variable scale charts are printed on one sheet. Publication cycle is every 8 weeks. See the new IAP Chart Format and RNAV chart minima at the end of this chapter.
    - ENROUTE HIGH ALTITUDE CHARTS - These charts portray the airway system and related data required for IFR operations at altitudes at and above 18,000 feet Mean Sea Level. Twelve charts are printed on six sheets. Charts 1-11 cover the entire United States, with Chart 12 duplicating data shown on H-

9, H10, and H-11 for those who frequently plan flights North and South along the East Coast within the area of coverage. Publication cycle is every 8 weeks.

- JeppView services provide full color, high-quality vector-based electronic approach charts in a variety of configurations. JeppView contains all the same information as the Airway Manual coverage providing you with electronic terminal approach charts, arrival and departure procedures, and airport diagrams. In addition, every JeppView coverage also comes with paper enroute and area charts to supplement the digital versions. When used in flight with a tablet or other mobile PC, pilots will have at their fingertips the state-of-the-art in navigational information and positional awareness tools. A subscription fee is required annually.
- Standard Information Departure (SID) are published to expedite clearance delivery and to facilitate transition between take-off and enroute operations. The SID provides a standard route from the terminal to the enroute structure. There are often transitions which connect the end of the SID to one of several enroute possibilities. SIDs furnishes pilots departure routing clearance information in graphic and textual form. This simplifies the issuance of a departure clearance by allowing ATC to simply specify the SID by name without having to describe, in detail, the route. The clearance may include the basic SID name and number, plus a transition to the enroute portion of the flight plan.
- Standard Terminal Arrival Route (STAR) charts are designed to expedite ATC arrival procedures and to facilitate transition between enroute and instrument approach operations. They present the pilot a preplanned IFR ATC arrival procedure in graphic textual form. Each STAR procedure is presented as a separate chart and may serve a single airport or more than one airport in a given geographic location. To accept a STAR you must have at least a textual description. A STAR has many similarities to a SID and is represented in similar format.

4. Sensors

- Barometric and Radar altimeters are continuously evolving to digital format and are more robust. NAST continues to provide increased awareness of updated hardware and software to the units currently being supported. Advanced Ground Proximity Warning System (GPWS) is currently supported by the AN/APN-171 Radar Altimeter which is in most Navy/Marine Corp aircraft. However, efforts are underway to provide a better Radar Altimeter such as the Low Proximity Intercept Altimeter (LPIA). The LPIA provides an increase in range and accuracy of altitude measurements and coverage at higher angles of bank. The LIPA is accurate up to 35000 feet as opposed to other radar altimeters. The LPIA also has a Built-in-Test (BIT) capability to assure reliability of the output data which meets another GPWS requirement.

VIII. Near term Navigation and Sensor Capability requirements: In able to provide a safe navigation and sensor environment, the Navigation and Sensors Capability Team needs to understand those future requirements before they become mandates or out of date capabilities

due to technology. Being a part of working groups such as N84's Navigation 2025 and Joint Planning and Development Office (Next Generation) is where information about both Naval and FAA Navigation studies are being generated. Being a participant in those working groups can provide valuable information exchange while keeping up to date on new efforts and mandates. Memberships in Professional organizations such as the Institute of Navigation (ION) can provide training and understanding of a broad range of navigational and sensor studies, journals, publications and articles.

IX. Capability Management: The NAST shall accomplish this responsibility by maintaining technical expertise, developing funded products, and by fostering awareness of issues/coordinating activities across the NAE.

To implement this strategy, the NAST DPM/DCAP and team shall:

Maintain Awareness: The NAST DPM and DCAP will work with the Air 4.5 Avionics Engineering, Air 4.1 (System Engineering), Air 4.9 (Research and Engineering), 5.1.2.3 (Test and Evaluation) competencies as well as PMA213 (IFF and JPALS) to ensure that NAST is adequately staffed for its ongoing programs and that Subject Matter Experts are covering the complete navigation and sensors spectrum and are identified and easily contacted by members of the NAE community. These SMEs are expected to maintain a state of the art awareness of industry and academic initiatives in the navigation and sensors field. The NAST shall maintain a navigation and sensors roadmap and assessment for all Naval Aviation platforms. The NAST team shall facilitate across NAE, awareness of navigation and sensors related issues facing naval aviation through the hosting of related conferences for the NAE such as the Navigation Review, AIMS conference, CNS/ATM conference, Joint Navigation conference, GPS conference, Global Navigation Satellite Systems (GNSS) conference, Airborne Electro-Optical Sensor Systems conference and ACE User Conference.

Coordinate Requirements Reviews: NAST shall provide OPNAV (N88) and HQMC a single point of entry into NAVAIR pertaining to matters concerning the establishment and review of navigation and sensors requirements. Working with the Interoperability Leads (PEO and PMA level), the NAST will coordinate the review of navigation and sensors related JCIDS documents (ICDs, CDDs, CONOPS).

Program/Issue Development/Coordination: NAST DPM and DCAP shall identify new programs or issues with ongoing programs and shall coordinate their development with platform program offices and resource sponsors.

Concept Exploration: NAST shall conduct studies and identify opportunities to prototype and or demonstrate new navigation and sensor concepts or systems.

Support the Commonality Opportunity Review Process: NAST shall support CORP to ensure that there is a focus on common system solutions across USN and USMC aviation platforms in order to reduce NAE total ownership costs, increase interoperability and reduce warfighter's logistics footprint.

X. Supporting Documents: **S**upporting documents that contain further descriptions of the aforementioned concepts, programs and equipment discussed in the paper.

- PMA209 Common Avionics Management Plan (CAMP)
- JPDO Next Generation Avionics Roadmap
- N84 Avionics 2025
- Chief of Naval Operations Functional requirements Document (CNO FRD) for 8.33 kHz Channel Separation Revision A, dated 1 August 2005.
- Chief of Naval Operations Functional requirements Document (CNO FRD) for Mode Select (S) Revision A. dated 17 May 2006.
- Chief of Naval Operations Functional requirements Document (CNO FRD) for Required Navigation Performance Area Navigation (RNP RNAV) Revision A. dated 17 April 2006.
- Chief of Naval Operations Functional requirements Document (CNO FRD) for Reduced Vertical Separation Minimum (RVSM) dated 7 January 2003.
- 2010 FAA Document AC 20-165 Airworthiness Approval of Automatic Dependent Surveillance Broadcast 21 May 2010