STATUS OF THE U. S. NAVY CNS/ATM TEAM EFFORTS

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Abstract

This paper will report on the current status of the PMA-209, Air Combat Electronics (CNS/ATM) team activities. The team has completed the development of the Functional Requirements Documents that convert civil documents prepared by the International Civil Aviation Organization (ICAO), Federal Aviation Administration (FAA), and other Civil Aviation Authorities plans to implement a new air traffic architecture to meet this need. Our team is taking advantage of emerging technologies in communications, navigation, and surveillance to improve air traffic management. The CNS/ATM requirements for voice, data link, navigation, and surveillance are being met by integration into legacy and new USN/USMC platforms. This paper will discuss the issues and program status of the current CNS/ATM efforts for the P-3C, EA-6B, F/A-18 E/F and other platforms; CNS/ATM as it applies to Network Centric Warfare utilizing a digital cockpit for precision strike, common operational picture, improved situational awareness and operational effectiveness. Mulitiple data links that are required for Joint and Coalition operations such as Link 16, Mode 5 and CLIP will be discussed.

Introduction

Military aircrews are beginning to experience the benefits of having quality Global Positioning System (GPS) navigation information available in the cockpit to support their tactical missions. The big improvement in situational awareness and tactical effectiveness has begun as several U.S. Navy aircraft are capturing the capabilities of Communications, Navigation, Surveillance / Air Traffic Management (CNS/ATM). Since tactical military aircraft do not have the space available to install civil approved avionics, they must develop dual use avionics and capture CNS/ATM functionality with military avionics equipment. Specifically, military aircraft must transition from airways flying using ground based navigation aids to area navigation (RNAV) and Required Navigation Performance (RNP) using GPS with a geodetic database. For access to some airspace, tactical military aircraft must transition from surveillance with Identification Friend or Foe (IFF) (Modes 3/A and C) to Mode S and eventually Automatic Dependent Surveillance Broadcast (ADS-B). Significant improvement in situational awareness and tactical effectiveness will be possible when tactical military aircraft can file and fly with GPS and also self-report position and identification via the Mode S ADS-B data link.

Civil Transition to Required Navigation Performance Airspace

The primary function of civil airspace management is to support air traffic in a safe and efficient manner during both visual and non-visual meteorological conditions. Since most aircraft flying in civil airspace do not have the capability to locate and avoid other aircraft during non-visual conditions, the airspace management rules were established to provide this function. For example, aircraft flying east are at a different altitude than aircraft flying west, east is odd and west is even. Likewise, other rules were established to allow aircraft at the same altitude to avoid conflicts during overtaking and crossing situations. The simplest solution to this problem is to put the aircraft on airways, highways in the sky, and keep slow aircraft on different airways and altitudes than faster aircraft. The basic form of overland aircraft navigation since the early 1950s, VHF Omni-directional Range (VOR), supports the airways system. The principle of operation of the VOR is very simple: the VOR facility transmits two signals at the same time. One signal is an omni directional 30 Hz pulse, while the other signal rotates in the horizontal plane about the station at 30 Hz. The airborne equipment receives both signals, looks (electronically) at the difference between the phases of the two signals, and interprets the result as a radial from the station. With 2 VOR stations, an aircraft is capable of determining its location by knowing its magnetic radial from each VOR station. Aircraft navigation to and from VOR stations is fairly simple and the overland airways system today is based on aircraft doing exactly that. With VOR, aircraft can also locate airway intersections, establish holding, and fly non-precision approaches to the destination airfield.

Tactical military aircraft use an equivalent Tactical Air Navigation (TACAN) instead of VOR. TACAN introduced another useful navigation tool called Distance Measuring Equipment (DME). In the operation of DME, paired pulses at a specific spacing are sent out from the aircraft and received at a ground station. The ground station then transmits paired pulses back to the aircraft at the same pulse spacing but on a different frequency. The time required for the round trip signal exchange is translated into slant range distance (nautical miles) between the aircraft and the ground station. Usually TACAN, DME and VOR stations are located together and the airways system based on these navigation stations is usable by aircraft equipped with any or all this equipment. When an aircraft is authorized to fly in the airways system because it has an approved VOR, DME, or TACAN installed, this authorization is called equipment-based certification.

The concept of flying from one TACAN/VOR to another TACAN/VOR does not yield the most direct route costing time and money. The ability to navigate from any given geodetic fix to another geodetic fix is called Area Navigation (RNAV). Modern aircraft with Flight Management Systems (FMS) can use several VORs, VOR/DME, or even DME/DME/DME to locate their present position and calculate the proper course to fly to another geodetic fix selected by the aircrew. RNAV is becoming fairly common. RNAV is also useful when using other positioning sources such as LORAN or GPS. With RNAV, the route of flight can be much shorter than flying the airways route and this direct routing saves both time and money.

To obtain the navigation benefits of CNS/ATM, accurate, repeatable and predictable navigation performance must be demonstrated regardless of the positioning source. The capability to perform to a specified level of navigation performance regardless of the positioning source is called Required Navigation Performance (RNP). With RNP, aircraft will be authorized to fly in instrument conditions not due to specific certified equipage but because the entire navigation system, including the aircraft and the pilot, has demonstrated a specified, repeatable and predictable, level of navigation performance. For example, if the required accuracy for a designated airspace is 4 NM (RNP 4), it is assumed that for 95% of the total flying time an aircraft flying in this airspace will maintain a position within ±4 NM of its Air Traffic Control (ATC) cleared route. With RNP RNAV, an aircraft will also be required to achieve a specified level of integrity and continuity guaranteeing the aircraft shall not error outside twice the accuracy (for RNP 4, 2 x 4 NM = 8 NM) without an annunciation to the aircrew. For tactical military aircraft, the transformation from TACAN to RNP RNAV as a primary means of navigation will be a significant achievement since tactical aircraft will not use civil approved avionics but capture this new capability in avionics designed for military missions.

A Tactical Aircraft Solution for Required Navigation Performance

For large military cargo and troop transports, the transition to CNS/ATM will leverage commercial system design used by commercial aviation. By using the civil CNS/ATM solutions, the certification of the military transports will be fairly simple since the civil commercial air carriers will have already received civil certification. However, for tactical military aircraft where the addition of civil avionics is not possible, guidance was found in the Chairman of the Joint Chiefs of Staff Master Positioning Navigation and Timing Plan. This guidance states: "The development of minimum performance standards for military users is the responsibility of the Services. These military standards must conform with civil airspace required navigation performance (RNP) requirements, prevent violation of civil air traffic clearances, and ensure safe separation of military and civil air traffic." From this guidance, a performance based requirements document was developed to capture civil RNP RNAV functionality appropriate for Navy and Marine Corps tactical military aircraft.

Scope and Limitations of RNP RNAV Specification

The first step in the effort to achieve RNP in tactical military aircraft was to decide what level of RNP would be the goal. Presently, there is airspace where RNP 5 (BRNAV) has been implemented and additional airspace where RNP 10 or RNP 4 is required. Future plans also call for RNP 2 and RNP 1 in selected airspace. Since the US DOD policy is to transition to GPS as the primary positioning source, the decision was made to use Precise Positioning Service (PPS) GPS as a primary means of navigation. The PPS GPS based navigation system will provide accurate positioning to RNP 0.3 which is required for approach and departure

Looking at the various documents published by ICAO, RTCA, FAA, and JAA, we discovered various contradictions and ambiguities related to the minimum functional requirements for RNP RNAV. There were contradictions as to required capabilities such as route leg types, containment limits, and required augmentation for GPS. Some of the RTCA publications have been updated several times and are still not implemented by the FAA. Since official guidance for RNP RNAV is still pending and the tactical military aircraft will not be using commercial avionics, guidance was needed to establish the appropriate functionality for RNP RNAV in tactical military aircraft. This new guidance is called RNP RNAV Functional Requirements Document (FRD). Tactical military aircraft with navigation systems that are designed, integrated, and tested to meet the functional performance specified in the RNP RNAV FRD will be capable of meeting minimum RNP RNAV operational approval requirements to file and fly RNP RNAV flight plans from takeoff through a published Non Precision Approach (NPA).

Obviously, a document that establishes the minimum requirements will not contain capabilities that may later be desired or required. We accept this possibility and view the RNP RNAV FRD as a living document with plans to review this document on a regular basis and incorporate new functionalities, if required. We anticipate most future capabilities will be captured with software updates. A precision approach capability is a future requirement and is not contained within this document. Neither is the requirement for vertical guidance. The RNP accuracy requirement pertains to cross track deviation, only. Along track deviation is really a function of ground speed and the RNP RNAV FRD does not address required timing issues or 4-D navigation. If these, or other functionalities that are not covered by this document, become a requirement somewhere in the world, aircraft integrated and tested in accordance with the current RNP RNAV FRD will not be qualified to participate.

Even though the requirements are limited to the minimum functionality required, this limitation does not restrict the aircraft integrator from providing increased functionality above the specification. This document will provide the Naval Air System Command testers the minimum functionality that must be demonstrated during developmental testing of RNP RNAV on board an aircraft. Other capabilities, not covered by this document, will need to be properly defined and tested prior to being utilized.

Navigation Sensors

All civilian applications of GPS use the Standard Positioning Service (SPS) GPS. Both Ground Based Augmentation Systems (GBAS) and Space Based Augmentation Systems (SBAS) are planned to support SPS GPS. One very good reason why the RNP RNAV FRD is required is the requirement to use PPS GPS for primary positioning. There are no ICAO, FAA or JAA documents that address PPS GPS utility. DOD policy dictates that military platforms will use PPS GPS receivers and those receivers shall be operated in the keyed mode. This means that there is no civilian guidance available and it will be DOD responsibility to ensure military aircraft are compatible with civil standards using the military PPS GPS. We do not anticipate a problem demonstrating the required accuracy, availability, continuity, and integrity to meet the civil standards for RNP 0.3. However, it is important that civil air authorities realize that the required functional performance is met even though not by the commercially available means. This realization may require an educational effort to explain how equivalent civil functionality is achieved with military avionics.

PPS GPS is a two-frequency signal that measures and corrects for the error introduced by ionospheric distortion and supplies position information at ten times the rate of the single frequency SPS signal. The greater accuracy of PPS GPS provides the user the needed integrity availability to fly in RNP 0.3 airspace without augmentation. No attempt is made to fly precision approaches, where RNP 0.15 is required, based on this document. SBAS implementations such as the United States Wide Area Augmentation System, the European Geostationary Navigation Overlay Service, and Japan's Multifunctional Transport Satellite Space-based Augmentation System provide enhanced accuracy over the SPS GPS signal but their use is not required. PPS GPS will provide tactical military aircraft the required performance worldwide to support air operations from take-off through enroute recovering to Non-Precision Approach minimums.

Few publications address the contribution of an Inertial Navigation System (INS) to augment the GPS navigation solution. Since most naval aircraft are either equipped or plan to equip with at least one INS, the ability to provide PPS GPS with aircraft based augmentation (ABAS) is planned. The RNP RNAV FRD does not require INS augmentation to meet the RNP 0.3 requirements but if an INS is available, full utilization is anticipated. The possibility of using inertial navigation system "coasting" for periods when the GPS signal is unavailable will augment the navigation system continuity capability of the GPS/INS integration. The full utility of the Embedded GPS INS (EGI) to meet the accuracy, integrity, continuity and availability requirements for RNP RNAV is a topic for further study.

Vertical Guidance

Although the requirements for vertical guidance or VNAV are listed in an appendix to the RNP RNAV FRD, there is no mandate for VNAV in the initial publication of the document. If individual platforms have a need or desire to implement a VNAV capability, the VNAV capability must meet the requirements in the FRD. In some discussions, a glide slope could be considered as part of a non-precision approach but until these issues are more mature, no attempt to provide a glide slope is established as a minimum requirement for RNP RNAV. The precision approach capability for naval aviation is part of the Joint Precision Approach and Landing System (JPALS) program, which will establish the minimum requirements for a precision approach separately.

Path Definition Requirements

The list of required leg types for the RNP RNAV FRD are limited to Track to Fix, Initial Fix, Direct to Fix, and Course to Fix legs. These leg types are as defined in RTCA/DO-236A. Other leg types such as Radius to Fix, Fix to Altitude, and Hold legs were discussed but not considered a minimum requirement. The Radius to a Fix algorithm is considered a function associated with an autopilot vice manually flying the aircraft. The RNP RNAV FRD contains no functionality that will require an autopilot upgrade to military aircraft for two reasons. First, military pilots of tactical aircraft do not let the autopilot fly the aircraft as much as commercial air pilots and it is not our intention to change the normal procedures and training of the military pilots. Second, there is no requirement for an autopilot as a distinct requirement to fly RNP RNAV. Likewise, Fix to Altitude and Holding legs are related to requirements for vertical guidance and since VNAV is not required, these leg types are also not required.

The procedures for the terminal area are described in detail with strict guidance to prevent human error. No manual changes will be allowed to an approach procedure found in the electronic database and the approach must be selectable with a single keystroke. The aircraft shall provide auto sequencing of successive waypoints from procedure initiation until the designated Missed Approach Holding Point. Likewise, "direct to" the Missed Approach Point shall not be permitted due to the obstacle rich environment in close proximity to the airport.

Database Management

Flight with GPS is very dependent on the quality of the digital database being used. Most civil air carriers use a commercial product database that is compatible with the Flight Management System (FMS) installed in the aircraft. For the United States military, the National Geospatial-Intelligence Agency (NGA) is responsible for providing electronic Digital Aeronautical Flight Information Files (DAFIF) database. This federal agency performs the database maintenance and controls DAFIF distribution. Database integrity is a critical component in RNP RNAV and the assurance of database integrity is vital to the aircraft. An undetected error in the database can be as fatal as an undetected error in positioning.

To ensure database integrity on board the aircraft, the navigation system is required to perform hardware fault detection initially and periodically as a regular course of operation. The software shall perform error detection and correction of information read from the database to ensure that corrupted data is not used. The aircraft system prohibits the manual modification of stored data. Should the database become corrupted, the pilot shall be alerted. All RNP RNAV is referenced to the World Geodetic Survey – 84 (WGS-84). WGS-84 is the standard geodetic reference used throughout the world by the GPS system and has been accepted by ICAO and the US Department of Transportation for air navigation.

Naval Aviation RNP RNAV Certification Process

The RNP RNAV FRD establishes the requirement and will be used for the certification process for naval aviation. With the current Chief of Naval Aviation (N78) signed RNP RNAV FRD, the minimum functionality that each type aircraft will obtain has been established. The contradictions and ambiguities found in the various ICAO, RTCA, JAA, and FAA documents related to RNP RNAV have been resolved. The systems engineering teams are now integrating this defined functionality into the lead aircraft for the P-3C, C-2A, E-2C, EA-6B and F/A-18 E/F. The various components will include a PPS GPS receiver with integrity, INS aiding (if available), electronic DAFIF database, various cockpit displays, and a cockpit processor to host the RNP RNAV software. During this developmental process, software industry standards will be followed appropriate for the severity of the potential failure condition.

A Test and Evaluation Master Plan is written to ensure all details of the defined functionality will be completely demonstrated. Reliability and maintainability will be evaluated as well as appropriate aircrew training. At the completion of developmental testing, the properly integrated aircraft will be given to the operational testers for a through evaluation in the operational environment. When the fleet representative aircraft is declared operational effective and operational suitable by the operational testers, the paperwork will be routed to the decision authority for the authorization for fleet use. This authorization for fleet use is the naval aviation equivalent of civil certification. It is important to note that all the functionality defined in the RNP RNAV FRD will be obtained or the aircraft will not be authorized for fleet use.

Civil Transition to Aircraft Self Reports

The monitoring of air traffic with RADAR, whenever possible, allows controllers to ensure flight clearances are followed and supports the direct vectoring of traffic as required to promote safety and efficiency. To support this monitoring function, civil air traffic service providers use both Primary Surveillance Radar (PSR), the reflected energy off the aircraft's skin, and Secondary Surveillance Radar (SSR), the triggered response from the aircraft's transponder. Air traffic surveillance requires that the aircraft must first be detected, then identified and then continuously tracked. Due to the safety of flight and time critical nature of air traffic control, little tolerance is allowed for misidentification or inaccurate tracking of aircraft.

Today, civilian air traffic controllers use SSR to both detect and identify air contacts. Primary surveillance radar is used as a detection backup and for weather surveillance. Air Traffic Control Radar Beacon System (ATCRBS) is the civilian version of SSR and it uses Question and Answer (Q&A) procedures with Modes A, and C, to track air traffic. Civil Mode A is the same as military IFF

Mode 3 and is usually called Mode 3/A. Mode C, which was first implemented by civil aviation, is the altitude readout (100 ft increments) and is the basis for altitude separation monitoring. Even after Mode S functionality is installed, Mode 3/A capability will still be required. The deficiencies associated with SSR Modes 3/A and C include:

- Signal garble due to overlapping replies from two or more aircraft that are in the main beam with approximately the same slant range (synchronous garble)
- Signal interference caused by replies from a transponder in response to an interrogation from another interrogator (FRUIT)
- No response from a transponder due to over-interrogation and the resultant transponder unavailability (fanning the transponders)
- Ghost targets displayed due to reflections off obstacles (multipath)
- Inefficient use of frequency spectrum with multiple interrogations and multiple replies and total reliance on 2-party Q & A procedures
- Only 4,096 codes available with Mode 3/A

Civil aviation is transitioning to Mode S because Mode S enables improved target degarbling and provides more information from the targets. Mode S is a digital data link with protocol formats, error detection, and correction. Mode S permits selective interrogation since each interrogator and transponder has its own unique Mode S address. The operation of Mode S airborne equipment requires assigning a unique 24-bit aircraft address code to each individual aircraft. Within the high traffic density airspace of Europe, Mode S will be required by 2005 for instrument flight clearance and by 2008 for visual flying. All Mode S transponders also broadcast their unique aircraft address once per second. This "squitter" is the first step in the transition to broadcast architecture for air traffic surveillance with information available to the entire line-of-site network. Specific advantages of Mode S include:

- Improved target degarbling due to unique discrete address, selective interrogation, and error detection/correction
- Improved target azimuth accuracy due to Monopulse interrogator with single replies
- Improved spectrum channel efficiency with lockout, scheduled transponder replies and squitters for network information broadcasts
- Digital data link capability that is used for Enhanced Surveillance, Extended Squitter, and Resolution Advisory (RA), and aircraft-to-aircraft coordination
- Compatible with the Aeronautical Telecommunications Network (ATN)
- 2 to the 24th power or > 16 Million unique 24 Bit aircraft addresses available

The concept of aircraft self-reporting their geodetic location, both in the air and on the ground, via a periodic line of sight broadcast is called ADS-B. The goal is to routinely use ADS-B self reports as a primary source of aircraft surveillance. The accuracy of the GPS position and the positive aircraft identifications can be captured to improve the quality of air traffic surveillance. Three different data links are under consideration for civilian ADS-B utility. They are Mode S Extended Squitter (1090ES), VHF data link Mode 4 (VDL 4), and Universal Access Transceiver (UAT). All three data links capture aircraft self reports, provide the aircraft a Cockpit Display of Traffic Information (CDTI), and have potential to bring value to the air traffic surveillance problem. However, interoperability will always be an issue. The FAA plans to use both 1090ES and UAT within the National Airspace System (NAS) with a multi-link gateway in the terminal area.

All ADS-B reports use the same geodetic reference, World Geodetic Survey of 1984 (WGS-84). WGS-84 is the standard geodetic reference used throughout the world by the GPS system and has been accepted by the US Department of Transportation for use in the NAS. This use of one standard geodetic reference for all ADS-B reports enables uncomplicated aircraft integrations regardless of which data link to improve situational awareness and empower traffic deconfliction from the cockpit. Airborne Collision is used. By using

WGS-84, ADS-B will facilitate a cockpit display of traffic information that can be used Avoidance System (ACAS II) is capable of using this ADS-B information to reduce the number interrogations. ADS-B is truly a major step toward Air Traffic Management (ATM) vice Air Traffic Control (ATC) and a big step toward Free Flight.

Civil ADS-B for Tactical Military Aircraft

Since the military aircraft will be installing Mode S transponders for civil interoperability, the first ADS-B opportunity for the military aircraft should be 1090ES ADS-B. Another advantage of using 1090ES self-reports for ADS-B is its interoperability with ACAS II equipped aircraft. All aircraft that install Level II Mode S functionality will be able to provide the 1090 MHz Extended Squitter broadcast required for 1090ES ADS-B. This includes aircraft that install Mode S with their 2 box ACAS II system and also those aircraft that install Mode S but do not install ACAS II box. However only the aircraft that install ACAS II will have the 1090 MHz receiver required to receive the Extended Squitter broadcast of other aircraft in the vicinity. Without the ability to receive on 1090MHz, tactical military aircraft that will not install the ACAS II box will not have a functional 1090ES ADS-B and will not be able to build the CDTI picture.

- To address the requirement for Mode S in tactical aircraft, the Naval Air Systems Command has developed a digital common transponder, APX-118, with legacy Mark XII IFF functionality and also Mode S functionality as a baseline capability. The new APX-118 has the form factor of the APX-100, will fit in all tactical aircraft, and also has a growth option for a 1090 MHz receiver; see Figure 1. When this growth option of the APX-118 is completed, the ability to receive on 1090 MHz will enable tactical military aircraft to participate in civil 1090ES ADS-B. Even though there are two other data links available for ADS-B, (UAT and VDL-4), 1090ES appears to be the cost effective way to go. There are several reasons why ACAS II, with its automatic interrogations of other aircraft, is not appropriate for tactical military fixed wing or rotary winged aircraft. With 1090ES ADS-B, there will be no capability to interrogate other aircraft but even without the ability to interrogate, military aircraft will still be able to use the self-reports of other civil and military aircraft to build a quality picture of participating aircraft in the vicinity. Other services in development such as Traffic Information Service (TIS & TIS-B) will complete the air picture by providing information on local aircraft without ADS-B. This 1090 MHz receive transponder upgrade will promote safety, facilitate civil interoperability, improve situational awareness, and greatly improve both military and civil air traffic surveillance.

ADS-B also has the potential to play a significant role in improving military as well as civil air surveillance. GPS is at least 20 times more accurate than military air search radar in determining the location of any aircraft. However, aircraft have not been able to share their improved location accuracy since they do not have a common data link available for that purpose. The biggest improvement in battle space situational awareness will come when military aircraft start to share their new level of location accuracy with a self-report. A functional requirements document is in work to establish the minimum requirements for Mode S and 1090ES ADS-B.

	1030 MHz Tx	1030 MHz Rx	1090 MHz Tx	1090 MHz Rx
MK XII IFF Transponder		YES	YES	
MK XII IFF Interrogator	YES			YES
Digital				
Mode S Transponder		YES	YES	
Mode S Interrogator	YES			YES
ACAS II	ACAS II Box	Mode S box	Mode S box	ACAS II Box
1090 MHz ADS-B		YES	YES	YES
	1030 MHz Tx	1030 MHz Rx	1090 MHz Tx	1090 MHz Rx

Figure 1. ADS-B Capability: The Key Requirement for 1090ES ADS-B is To Be Able to Receive on 1090 MHz.

Conclusion

Commercial aviation will use RNP RNAV in the near future. Likewise, ADS-B self-reports will improve air traffic surveillance and provide sufficient situational awareness in each cockpit to support free flight. If tactical military aircraft are to operate within this new performance based airspace, they will require operational RNP RNAV, Mode S, and 1090ES ADS-B functionality. To achieve these new functionalities, dual use avionics and integrations must be found to capture civil functionality with military equipment. The bottom line is that tactical military aircraft will achieve the required functionality or they will not be authorized for fleet use. This paper describes how the U.S. Navy is getting RNP RNAV, Mode S, and 1090ES ADS-B capability in tactical military aircraft.

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Acronyms

- 1090ES---1090 MHz Extended Squitter
- ABAS---Aircraft Based Augmentation System
- ACAS II---Airborne Collision Avoidance System
- ADS-A---Automatic Dependent Surveillance - Addressed
- ADS---Automatic Dependent Surveillance
- ADS-B---Automatic Dependent Surveillance - Broadcast
- APX-118---Common IFF Digital Transponder
- ATC---Air Traffic Control
- ATCRBS---Air Traffic Control Radar Beacon System
- ATM---Air Traffic Management
- ATN--- Aeronautical Telecommunications Network
- CDTI---Cockpit Display of Traffic Information
- CJCS---Chairman, Joint Chiefs of Staff
- CNS/ATM--- Communications, Navigation, Surveillance / Air Traffic Management
- DAFIF--- Digital Aeronautical Flight Information File
- DME---Distance Measuring Equipment
- EGI---Embedded GPS INS
- EUROCAE---European Organization for Civil Aviation Equipment
- FAA----Federal Aviation Administration
- FMS---Flight Management System
- FRD---Functional Requirements Document
- FRUIT---Friendly Replies Uncorrelated In Time
- GBAS---Ground Based Augmentation
- GPS---Global Positioning System
- ICAO---International Civil Aviation Organization
- IFF---Identification Friend or Foe
- INS---Inertial Navigation System
- JAA--- Joint Aviation Authorities
- JPALS--- Joint Precision Approach and Landing System
- MASP---Minimum Aviation System Performance Standards
- MHz---Megahertz
- Mode S---Mode Select
- MOPS---Minimum Operational Performance Standards
- NAD-83---North American Datum of 1983
- NAS---National Air Space System
- NIMA--- National Imagery and Mapping Agency
- NM---Nautical Miles
- NPA---Non-Precision Approach
- PPS---Precise Positioning Service
- PSR---Primary Surveillance Radar
- Q&A---Question and Answer
- RA---Resolution Advisory
- RNAV---Area Navigation
- RNP----Required Navigation Performance
- RTCA---RTCA Inc.
- SARPs---Standards And Recommended Practices
- SBAS--- Space Based Augmentation
- SPS---Standard Positioning Service
- SSR---Secondary Surveillance Radar
- TACAN---Tactical Air Navigation
- TIS-B---Traffic Information Service - Broadcast
- TIS---Traffic Information Service
- UAT--- Universal Access Transceiver
- VDL 4---VHF data link mode 4
- VNAV---Vertical Navigation
- VOR----VHF Omni-directional Range
- WGS-84--- World Geodetic Survey of 1984