Aerospace Management Systems

Communications, Navigation, Surveillance / Air Traffic Management (CNS/ATM)
Air Traffic Control and Landing Systems (ATCALS) – Weather
Airspace Modernization (NEXTGEN and SESAR)

- GLOBAL ACCESS FOR GLOBAL REACH -

Communications, Navigation, Surveillance /
Air Traffic Management (CNS/ATM)

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What is CNS/ATM?

The tremendous growth in air traffic presents increasing challenges for air traffic service providers, air carriers, and the military. Such growth is straining airspace capacity and airport resources. The air traffic system requires significant upgrades to increase system capacity and flight efficiency while continuing to meet flight safety standards. The International Civil Aviation Organization (ICAO), Federal Aviation Administration (FAA), and other Civil Aviation Authorities (CAA) plan to implement a new air traffic architecture to meet this need. This new architecture takes advantage of emerging technologies in communication, navigation, and surveillance to improve air traffic management.

Dynamic routing gives operators the freedom to choose their own routes, speeds, and altitudes in real-time, thus providing Visual Flight Rules (VFR) flexibility with Instrument Flight Rules (IFR) protection and separation and a shift from Air Traffic Control (ATC) to Air Traffic Management (ATM). The civil aviation community refers to these changes as Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM). The United States Department of Defense (DoD) has established the CNS/ATM program to modernize its aircraft.

The ability to reduce aircraft separation and implement other new ATM procedures while maintaining or improving safety standards is enabled by the use of new technology. The most critical technology elements of the new CNS/ATM environment are satellite-based navigation, increased use of data links rather than voice for pilot/controller communication in oceanic/remote airspace as well as en route and terminal environments, and improved surveillance that enhances both ground and cockpit situational awareness. If aircraft are not equipped with the appropriate new technologies, they may not be able to operate in airspaces where new separation standards and ATM procedures are implemented by civil aviation authorities, and may therefore be excluded from those airspaces. For DoD aircraft to operate in this environment, significant modifications to existing aircraft must be accomplished. The CNS/ATM group of technologies provides the means to achieve the operational capabilities required thus enabling unrestricted global operations.
THE ESC/HBAI TEAM

- Participates actively in civil aviation forums, influencing implementation timelines and defining alternate methods to meet technical performance
- Maintains performance matrices based on civil airspace access requirements
- Assists United States Air Force (USAF) Major Commands (MAJCOMs) in determining the operational impacts of CNS/ATM noncompliance
- Converts operational requirements into CNS/ATM technical performance requirements
- Meets with avionics vendors to understand their current product line and to express military needs in terms of future requirements
- In conjunction with platform System Program Offices (SPOs), develops candidate system and technical architectures to comply with international standards
- Supports acquisition strategies revolving around maximum use of commercial off the shelf (COTS) and non-developmental items (NDI) to lower acquisition costs
- Issues Indefinite Delivery/Indefinite Quantity (ID/IQ) contracts to support CNS/ATM avionics acquisition. Integration and logistics support from vendors is also under these contracts
- Performs CNS/ATM performance assessments of platforms, when requested by platform SPOs
- Prepares a Letter of Compliance (LOC) documenting platform CNS/ATM performance
- Audits and certifies AF navigation data chain
- Shares information with the aviation community to foster clear intent and understanding for the mutual benefit of industry and AF organizations
ENGINEERING SUPPORT

Team of Communications, Navigation, and Surveillance engineers assist Platform Program Offices to perform CNS/ATM upgrades
- Expert engineers in all facets of CNS/ATM
- Central repository of lessons learned
- CNS/ATM Performance Matrices gather civilian requirements into one document that is used for Performance Assessments

iGATM (https://igatm.hanscom.af.mil)

A web site providing:
- On-line catalog for purchasing CNS/ATM equipment that allows the customer to “one-stop shop” for key CNS/ATM products, including TCAS and SATCOM
- Worldwide CNS/ATM Requirements

CNS/ATM SharePoint

A web site providing everything Air Force or other interested personnel need to know about CNS/ATM:
- Generic CNS/ATM Performance Matrices
- Key CNS/ATM Documents

STRATEGIC PROJECTION OF AIRSPACE REQUIREMENTS AND CERTIFICATIONS (SPARC)

We are in the process of revamping this tool. Look for the new tool to be available soon.
Recently the RCAT has added a suite of modeling and simulation tools to support Unmanned Aircraft System (UAS) Ground Based Sense and Avoid (GBSAA) research including X-Plane and STK. We have also been leading research in the areas of ACARS message encryption, RF-subnetwork evaluation for the NextGen DataComm program, and assessment of alternative SATCOM systems (Iridium and INMARSAT BroadBand) for FANS 1/A applications.

The RCAT offers significant advantages over testing with a real aircraft or Air Traffic Services Unit (ATSU). It is reconfigurable, i.e., it can currently emulate the avionics suites of multiple aircraft (VC-25A, KC-135). The RCAT’s benefits also include the ability to perform instant software updates, have quick responses and turn around times, and operate on a cost-efficient basis (saving money on fuel, air crews, maintenance) when compared to flying a real aircraft.

For more information on the RCAT or to schedule a visit/demo/tour, please contact:

Michael W. Bernock, ESC/HBAI
**DIRECTED SUPPORT**

**DESCRIPTION**
AMS Division provides CNS/ATM technical/engineering support, upon the request of platform program organizations.

**BENEFITS**
Platform programs utilize AMS Division expertise in specific areas to further expedite and reduce technical risk for CNS/ATM implementation and airworthiness certification.

**SAMPLE ACTIVITIES FROM DIRECTED SUPPORT AGREEMENTS**
- Evaluation of voice and data communication security issues
- Support Preliminary Design Review (PDR) and Critical Design Review (CDR) activities
- Technical support for platform related source selection activities
- Support testing and verification processes
- Assess CNS/ATM impact to training simulators
- Provide technical risk reduction through simulation in the RCAT

**GETTING STARTED**
- Determine areas that require CNS/ATM related technical support
- Define a work plan
- Contact ESC/HBAI, 781-225-5436, or DSN 845-5436
- Agree on work plan, funding, etc.
- Document agreement, e.g., Memorandum of Agreement (MOA), coordinated between AMS Division and Platform Program Office System Program Directorates (SPDs)
Aircrew, supported commander, and Air Operations Center feedback from Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF) highlight the importance of meeting international Communications, Navigation, and Surveillance (CNS) requirements. The price of not meeting these requirements is manifested in increased flying time per mission, non-optimal routing and altitudes, and increased cost. More importantly, safety of flight and operational impacts are becoming the price to pay for not equipping to meet mandated CNS requirements.

Senior leadership now realizes, based on this real-world contingency feedback, that not being CNS/ATM compliant no longer simply means being slightly inconvenienced when trying to accomplish the mission. ACC/DO tasked all Air Combat Command (ACC) Wing Commanders to quantify and detail their aircrews' OIF CNS/ATM issues and impacts. This initial data call found that Airborne Warning and Control System (AWACS), B-52, Compass Call, and B-2 aircrews experienced substantive CNS/ATM safety, cost, and airspace impacts. At the 26 Jun 2003 CNS/ATM Integrated Product Team (IPT) at the Air Staff, AQQ, DXOR and DXOO recommended OIF CNS/ATM mission impacts and safety issues be included in future CNS/ATM briefings to senior general officer conferences.

The Global Access, Navigation, and Safety (GANS) Integrating – IPT (I-IPT) directed the establishment of a working IPT in support of our request to conduct an analysis of impacts to USAF Operations based on present and future CNS/ATM requirements. The results of this analysis confirmed that not being properly CNS/ATM equipped will increase costs, negatively affect safety, and can lead to airspace denial. The initial modeling and simulation effort showed that properly equipping a single non-capable aircraft, sooner rather than later, can have a significant impact on overall mission effectiveness.

We need your help! If you have any input to this important mission please contact the ESC/HBAI POC below to help us with data collection and monitor the progress of the ongoing effort.

Tell us your “CNS/ATM War Story!”

Contact:
Capt Robert Walker, ESC/HBAI
CNS/ATM Impact Analysis Project Officer
## CNS/ATM Systems

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Requirements are levied by Flight Information Region (FIR). FIRs are organized into ICAO Regions:

- AFI – Africa & Indian Ocean
- ASIA – Asia
- CAR – Caribbean
- CONUS – Continental United States
- EUR – Europe
- MID – Middle East
- NAM – North America
- NAT – North Atlantic
- PAC – Pacific
- SAM – South America
- CONUS – Continental United States
COMMUNICATIONS MANAGEMENT FUNCTION (CMF)

FUNCTIONALITY DESCRIPTION:
The Communication Management Function (CMF) performs two important tasks: it manages access to the various data link sub-networks and services available to the aircraft and also hosts various applications related to data link. The data sub-networks typically managed by a CMF include Very High Frequency (VHF), VHF Data Link Mode 2 (VDLM2), Satellite Communications (SATCOM) and High Frequency Data Link (HFDL). Applications that may be hosted by the CMF include those related to operational C2 and also Air Traffic Services (ATS). The CMF routes application data between the aircraft and the ground by converting data between the airborne and the air-ground message structures.

CAPABILITIES REQUIRED:
- Management of network access
- Message routing
- Peripheral interfaces
- Message prioritization by type
- User policy configuration
- Application hosting

CNS/ATM AIRSPACE APPLICABILITY:
- AFI
- ASIA
- CAR
- EUR
- NAM
- NAT
- PAC
- SAM

DOCUMENTATION:
- FAA AC 20-115B
- FAA AC 20-140A
- RTCA DO-178B/ED-12B
- ARINC 758 -3
- ARINC 618-6
- ARINC 619-3
- ARINC 620-6
- Boeing ATS SR&O D926T0280
- ICAO Global Operational Data Link Document (GOLD), 1st edition
- GATM CRD, USAF 003-97
COMMUNICATIONS (cont’d)

VERY HIGH FREQUENCY (VHF) – Voice & Data Link

FUNCTIONALITY DESCRIPTION:
VHF voice communications will continue to be an essential component of aviation for the foreseeable future. The US will retain the existing 25 kHz band separations. Europe is experiencing very high densities and has mandated that 8.33 kHz band separations be adopted. It is essential that voice traffic is reduced as the airspace density increases. There are two VHF data link sub-networks, both using the 25 kHz band. The Aircraft Communication Addressing and Reporting System (ACARS) Network using the ACARS protocol (also known as Plain Old ACARS, or POA) is being replaced by VDL Mode 2 Protocols, using the Aviation Link Control (AVLC) protocol, which provides a 10-fold bandwidth increase over POA. To coexist with the ACARS Network, the AVLC Protocol needs to be mapped to the ACARS Network. This is known as ACARS over AVLC (AOA). These two data link sub-networks will exist simultaneously for some time. To aid in moving voice traffic to data link, the Controller Pilot Data Link Communications (CPDLC) application has been developed. It is expected that much of the current voice traffic will be transmitted via CPDLC in the future.

CAPABILITIES REQUIRED:
- 25 kHz and 8.33 VHF Band Separation
- Analog or Digital Interface to CMF for POA Data Link Sub-network
- D8PSK Modem for AOA Data Link Sub-network
- Communications Service Provider Contract

HIGH FREQUENCY DATA LINK (HFDL)

FUNCTIONALITY DESCRIPTION:
In oceanic, remote and polar airspace, air traffic voice services are provided via high frequency (HF) radio circuits relayed by a communications service provider. HF voice communications tend to be slow, inefficient and prone to interruption by atmospheric and solar disturbances. In non-polar regions, HF voice services are supplemented by SATCOM voice and data services. SATCOM may eventually become the preferred mode of communication in these regions. The one drawback is that SATCOM tends to have relatively high equipment, installation, and transmission costs. It is hoped that HFDL will provide a low cost alternative to SATCOM circuits with equivalent message assurance and integrity. However, HFDL transmits at speeds of 600 to 1800 bps and will result in slower transmissions than SATCOM. Consequently, oceanic, remote, and polar communications are evolving from relative slow, inefficient HF voice message contacts, to shorter duration SATCOM data messages, complemented by HFDL and HF voice. The FAA approved HFDL for use in air traffic operations in early 2012.

CAPABILITIES REQUIRED:
- Polar access
- Selection between voice and data link
- Auto tuning
- Communications Service Provider Contract

CNS/ATM AIRSPACE APPLICABILITY:
- AFI
- ASIA
- CAR
- CONUS
- EUR
- MID
- NAM
- NAT
- PAC
- SAM

DOCUMENTATION:
- RTCA DO-178B/ED-12B
- RTCA DO-186B
- RTCA DO-224C
- RTCA DO-281A
- EUROCAE ED-23C
- ARINC 429
- ARINC 750-4
- FAA TSO-C169a
- GATM CRD, USAF 003-97
- MIL-STD-461
- MIL-STD-454

AEROSPACE MANAGEMENT SYSTEMS
SATELLITE COMMUNICATIONS (SATCOM) – Voice & Data Link

FUNCTIONALITY DESCRIPTION:
SATCOM provides highly reliable beyond line of sight (BLOS) network connectivity for aircraft. This allows flight crews to communicate directly with both C2 and ATC in oceanic and remote areas via voice or data link. Aeronautical SATCOM provides digitized voice and data communication services using a satellite network that provides worldwide coverage and has proven both timely and reliable. Inmarsat SATCOM was approved for use in air traffic control operations by the FAA in the early 1990s. Iridium SATCOM network was approved for the same in 2011. Use of SATCOM for routine and non-time-critical operations is an essential element in the transition to the CNS/ATM airspace of the future.

CAPABILITIES REQUIRED:
- Continuous network access
- Timely transmissions
- Integrity and assurance
- Communications Service Provider Contract

CNS/ATM AIRSPACE APPLICABILITY:
- AFI
- ASIA
- CAR
- NAT
- PAC
- SAM

DOCUMENTATION:
- FAA AC 20-140A
- FAA AC 20-150A
- FAA TSO-C132
- FAA TSO-C159A
- RTCA DO-210D
- RTCA DO-215A
- RTCA DO-262A
- RTCA DO-178B/ED-12B
- GATM CRD, USAF 003-97
Communications (cont’d)

FANS-1/A DATA LINK APPLICATIONS
Automatic Dependent Surveillance – Contract, Controller Pilot Data Link Communications, and Air Traffic Service (ATS) Facilities Notification are three software applications essential for FANS 1/A operations. These applications provide direct connectivity between the aircraft and air traffic control for communication and flight following. FANS 1/A operations began in 1995 in oceanic and remote airspace around the world and are available to roughly 40% of the traffic traversing busy oceanic regions. SATCOM data link is also required. FANS 1/A operational benefits include reduced reliance on voice, more direct routing, ability to change flight plan en route and more.

ATS FACILITIES NOTIFICATION (AFN)

FUNCTIONALITY DESCRIPTION:
ATS Facilities Notification (AFN) provides for the initiation of FANS-1/A data exchange between a pilot and controller via data link. AFN is initiated by the pilot prior to entering FANS 1/A airspace and is essentially an introduction between the aircraft and the Air Traffic Services (ATS) facility. Once a successful AFN has occurred each party has the necessary information for utilization of the Automatic Dependant Surveillance – Contract (ADS-C) and Controller Pilot Data Link Communications (CPDLC) applications. AFN is also used during handoffs between ATS facilities to help reduce the workload on the flight crews.

CAPABILITIES REQUIRED:
- Specific message header formatting
- ICAO codes/conversion
- Message set
- CRC
- Time stamp

CNS/ATM AIRSPACE APPLICABILITY:
- AFI
- ASIA
- CAR
- EUR
- NAM
- NAT
- PAC
- SAM

DOCUMENTATION:
- FAA AC 20-115B
- FAA AC 20-140A
- FAA AC 25.1309-1A
- FAA AC 27-1B
- FAA AC 29-2C
- RTCA DO-258A/ED-100A
- RTCA DO-178B/ED-12B
- ARINC 622-4
- ARINC 618-6
- ARINC 619-3
- ARINC 620-6
- Boeing ATS SR&O D926T0280
- GATM CRD, USAF 003-97
CONTROLLER PILOT DATA LINK COMMUNICATIONS (CPDLC)

**FUNCTIONALITY DESCRIPTION:**
The CPDLC application provides for the exchange of flight planning, clearance, and informational data between a flight crew and air traffic control. This application supplements voice communications and in some areas will likely supersede it in the future. CPDLC contains a series of preformatted messages that can be used by flight crews and pilots to communicate during a flight. CPDLC provides direct connectivity between aircraft and air traffic control in regions where it was unavailable before. CPDLC provides standard message templates for en route message traffic and also offers automatic event reporting (e.g., report reaching altitude).

**CAPABILITIES REQUIRED:**
- AFN
- Specific message header formatting
- ICAO codes/conversion
- Message set
- CRC
- Time stamp

AUTOMATIC DEPENDENT SURVEILLANCE – CONTRACT (ADS-C)

**FUNCTIONALITY DESCRIPTION:**
Automatic Dependant Surveillance (ADS) provides for the automatic exchange of aircraft position, intent, and flight data by data link from the aircraft to the Air Traffic Services (ATS) facility without pilot interaction. The type of ADS included in FANS-1A airspace is ADS-C. ADS-C consists of various contracts between the aircraft and the ATS facility, all initiated by the controller. The contracts can be either demand (send the requested data now), periodic (send it every x minutes), or event driven (send it when an altitude, waypoint, vertical speed, or cross-track error threshold is exceeded). The aircraft can support contracts with up to 5 ATS facilities (or 4 facilities and one flight operations connection). Currently the operational environment for ADS-C is FANS-1A airspace.

**CAPABILITIES REQUIRED:**
- AFN
- Specific message header formatting
- ICAO codes/conversion
- Message set
- CRC
- Time stamp

CNS/ATM AIRSPACE APPLICABILITY:
- AFI
- ASIA
- CAR
- EUR
- NAM
- NAT
- PAC
- SAM

DOCUMENTATION:
- FAA AC 20-140A
- RTCA DO-258A/ED-100A
- RTCA DO-178B/ED-12B
- ARINC 622-4
- Boeing ATS SR&O D926T0280
- GATM CRD, USAF 003-97
The EUROCONTROL LINK 2000+ Programme packages a first set of en-route controller-pilot data-link-communication (CPDLC) services into a beneficial and affordable set for implementation in the European Airspace using the ATN and VDL Mode 2 (Aeronautical Telecommunication Network and VHF Digital Link). LINK 2000+ implements three basic services automating the routine tasks which fill up to 50% of controllers’ time today, and provide for 11% capacity increase (when 75% of flights are equipped):

- **ATC Communications Management (ACM):** to handle repetitive frequency changes
- **ATC Clearances (ACL):** to provide standard clearances (e.g. "Climb to level 350")
- **ATC microphone check (AMC):** to enable communication in case of blocked frequencies.

These services do not replace voice as a primary means of communication - both media will always be available, thus providing mutual back-up, a definite safety improvement; in case of non-standard communications or emergency, "revert to voice" is the procedure.

The standards comprising the LINK 2000+ baseline combine the entire output of more than three ICAO panels specifying operational, technical and data-link standards over at least seven years (approximately 1990-1997). These were then used to define the interoperability, safety and performance requirements in EUROCAE and RTCA between 1999 and 2005.

CPDLC is also a prerequisite for further progress in implementing more advanced data-link services, since it provides key improvements in avionics and ground system infrastructure. The time saved by relieving pilots and controllers of routine tasks can be also used for new operational functions. After LINK 2000+, other programmes will re-use and update LINK 2000+ services and infrastructure.
Communications (cont’d)

Link 2000+ Baseline Services: DLIC, ACM, ACL, AMC
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Data Link Initiation Capability (DLIC)

FUNCTIONALITY DESCRIPTION:
This service is initiated by aircrew on first contact with an ATC unit that supports data communications. It is a pre-requisite to the operational data-link services and allows flight plan/address association in the ATC system. The following information is provided to the ground system: airframe identification, aircraft identification, supported air-ground data-link services, departure and destination airports, and estimated off block time (EOBT), when available.

CNS/ATM AIRSPACE APPLICABILITY:
- EUR

DOCUMENTATION:
- RTCA DO-280B/EUROCAE ED-110B
- RTCA DO-178B/EUROCAE ED-12B
- ICAO Doc 9705/9880 Part 1
- EUROCONTROL Spec 0116

ATC Communication Management (ACM)

FUNCTIONALITY DESCRIPTION:
The ACM service supports the transparent transfer of data communications, in synchronization with the transfer of voice communications. It also retains the operational principle that there is only one controlling authority, and that the controlling authority is properly and unambiguously identified. (Current sector controller initiates this service to transfer ATC communications to next sector).

ATC Clearances (ACL)

FUNCTIONALITY DESCRIPTION:
Allows the request (aircrew) and delivery of (controller) en-route clearances such as level (including constraints based on time, position, vertical rate-of-change), heading, speed (IAS/Mach), direct route, and rate of climb/descent. The ACL service also enables SSR code change instructions and provides acknowledgements in both directions.

ATC Microphone Check (AMC)

FUNCTIONALITY DESCRIPTION:
Provides controllers with the capability to up-link an instruction for all aircraft to check that they are not inadvertently blocking a given voice channel.
Navigation

Worldwide civil navigation requirements continue to evolve as most recently evident in the latest version of the ICAO Performance Based Navigation (PBN), published April 2007 as an update to ICAO Doc. 9613. The PBN establishes a baseline for Area Navigation (RNAV) and Required Navigation Performance (RNP) performance standards. RNAV defines total positional accuracy in addition to functional requirements. RNP performance compliance includes total positional accuracy, containment monitoring, integrity monitoring and availability in addition to functional requirements. Each phase of flight establishes a range of RNAV/RNP performance levels that complement minimum airspace separation and/or obstacle clearance requirements. En route RNP categories are RNP-1, RNP-2, RNP-4, RNAV-5, RNAV routes (Q and T routes), and RNAV-2. Oceanic routes are classified RNP-10 and RNP-4 Oceanic. Although RNP-10 for oceanic routes has the performance requirements associated with RNAV, i.e. monitoring and alerting functions are not required, the RNP designation has been allowed to remain because of its historical acceptance. Designations for BRNAV (RNP-5), and PRNAV were reclassified, resulting from the publication of the PBN, as RNAV-5 and RNAV-1, respectively. The value (number) in the name is the allowed nautical mile deviation from the assigned route. RNP-x and RNAV-x requires that 95% of the time the total aircraft positional deviation from the designated flight path is less than x nautical miles (NM). When referring to RNP these constraints support Reduced Horizontal Separation Minimums (RHSM) in both lateral and longitudinal dimensions. RNP values that are less than RNP-1 are associated with special approach procedures, final approach and missed approach.

Reduced Vertical Separation Minimum (RVSM) allows 1,000 foot separations (versus 2,000 ft) from Flight Level 290 to FL410, inclusive. RVSM and RHSM together allow aircraft to fly much closer and hence provide more capacity for the airspace. RHSM has been implemented in association with RVSM in Oceanic airspace.

In addition, upgrades to equipment are necessary in some instances to meet the navigation requirements for operation in the evolving civilian airspace. This list includes Protected Instrument Landing System (P-ILS) / FM Immunity (FMI) and Precision Landing Systems (PLS). The goal is to provide access to civilian airspace as these navigation requirements are imposed.

**PERFORMANCE BASED NAVIGATION (PBN)**

PBN is a concept based on the use of Area Navigation (RNAV) systems that is not defined by a limited statement of required performance accuracy but requires extensive statements of performance in terms of accuracy, integrity, continuity and availability. The defined performance includes descriptions of how this capability is to be achieved in terms of aircraft and crew requirements. The general capabilities are defined in ICAO Doc 9613, Performance Based Navigation Manual Implementation Guidance for National Airspace System (NAS), and through Federal Aviation Administration Advisory Circulars.
PERFORMANCE BASED NAVIGATION Terms

**Area Navigation (RNAV)** systems:
- Capable of enabling aircraft operation on any desired flight path within the coverage of space or terrestrial navigation aids or within the limits of the capability of self-contained aids, or a combination of these.
- Not required: performance monitoring and alerting within the aircraft navigation system

**RNAV** routes:
- Routes defined by obstacle clearance requirements, traffic density, configuration and ATS intervention
- Terminal, en-route, SIDs and STARs

**RNAV** operational requirements:
- Defined by flight plan designation
- Minimum equipment list (MEL)
- Flight crew training

**RNAV-(x)**, the accuracy value (x) represents the navigational system accuracy, total system accuracy or minimum airspace/route performance requirement

**Required Navigation Performance (RNP)** compliant systems:
- RNAV systems plus:
  - Required to incorporate containment, integrity, continuity and availability requirements
  - Required to implement performance monitoring and alerting within the aircraft navigation system
  - Required compliance with path following procedures (e.g. leg types)

**RNP** airspace/routes:
- Applicable to all flight phases (includes approach)
- Selectively inclusive of vertical navigation requirements
- May require specific communications and surveillance capabilities, e.g. RNP-4 requires FANS 1/A communications for Oceanic phase for 30/30 separation

**RNP** operational requirements:
- Same as RNAV plus
- Requires ATC notification when/if non-compliance occurs

**RNP-(x)**, the accuracy value entered represents the navigational system accuracy, total system accuracy or minimum airspace/route performance requirement
TOTAL SYSTEM ERROR (TSE)

Instrumentation (PEE)

Avionics

Navigational Database (PDE)

Internal/External References

Flight Technical Error (FTE)

Pilot/Autopilot

Aircraft

RNAV and RNP accuracy values are based on Total System Error (TSE). TSE is the root sum square (rss) of the Path Estimation Error (PEE), the Path Definition Error (PDE) and the Flight Technical or Path Steering Error (FTE/PSE).

CONTAINMENT LIMIT

Defines the bound where the probability of the navigation system error exceeds the containment limit (2xRNP). That probability of occurrence must exceed $10^{-5}$ per flight hour.
Aerospace Management Systems

Navigation (cont’d)

Oceanic Airspace

FUNCTIONALITY DESCRIPTION:
Oceanic Airspace defines those regions that are governed by international procedures defined in the ICAO Annexes. Examples of oceanic airspace under the responsibility of the FAA are the western half of the North Atlantic, the Gulf of Mexico, the Caribbean, and the North Pacific. This airspace starts where domestic air traffic services end, in the case of the US, this is outside the 12 NM coastal boundary plus any control airspace areas. In other locations this limit will vary.

PERFORMANCE: RNP-10
RNP-10 requires that an aircraft be equipped to ensure it stays within ±10 NM of its assigned position 95% of the time. As noted earlier, the RNP designation in RNP-10 does not accurately define the performance identified for this airspace. This RNP designation reflects a historical reference to oceanic performance prior to the 2007 addition ICAO Doc 9613. The current addition of Doc 9613 standardized terminology such that RNAV navigational systems that lack performance monitoring and alerting were identified as RNAV. RNP-10 navigation systems must meet availability criteria of $10^{-5}$ probability of loss of navigation.

PERFORMANCE: RNP-4
For RNP-4 Oceanic and Remote operations, it is required that an aircraft be equipped to ensure it stays within ±4 NM of its cleared position 95% of the time. As an RNP navigational system, there must be performance monitoring and alerting functions incorporated and the system is required to meet integrity thresholds. The database that is used for navigation must have Type 1 & 2 Letter of Acceptance for the Data Chain associated with its development.

CAPABILITY REQUIRED:
RNP-10
- Requires an aircraft be within 10 NM of its assigned position (both lateral and longitudinal) 95% of time
- Dual Navigation system recommended to achieve reliability, availability, and integrity.
  - Dual Inertial Navigation System (INS) or Inertial Reference Units (IRUs) and/or
  - GPS with RAIM and FDE approved for primary means of navigation

RNP-4
- Requires an aircraft be within 4 NM of its assigned position (centerline) 95% of time.
- FMS Functionality Required
- ADS-C
- CPDLC
- Navigation database with Type 1 & 2 Data Chain Certification

DOCUMENTATION:
RNP-10
- FAA Order 8400.12A, "Required Navigation Performance 10 (RNP-10) operational approval."
- FAA AC 20-138B
- FAA Notice 8110.60
- RTCA DO-236B
- Required Navigation Performance (RNP) Compliance Methodology, MITRE Corporation, September 1999

RNP-4
- FAA Order 8400.33
- RTCA DO-236B
- RTCA DO-283
- RTCA DO-200A/ED 76
- RTCA DO-201A
- AC 20-138B
**FUNCTIONALITY DESCRIPTION:**
En route airspace is defined as the region above a continental landmass where certified/suitable ground-based navigational aids are available or an airway has been defined. Navigation in the en route airspace can be accomplished by VOR, TACAN, DME/DME, INU or GPS/GNSS. En-route navigation can be classified as conventional procedure or area navigation (RNAV). Conventional procedures rely on terrestrial radio navigation stations such as VOR/DME, TACAN or VORTAC. Aircraft equipped with the appropriate receiving equipment follow predetermined courses based on station identity, location and frequency assignment. A flight plan is loaded into an FMS containing the station information and executes the plan by flying point-to-point over each station via courses_RADIALS connecting the stations.

RNAV procedures are defined by waypoints entered into a flight plan and stored in an FMS. The waypoints define a published route or can represent a route manually defined by the flight crew. The waypoints are identified by name, latitude and longitude. RNAV procedures are similar to RNAV routes but utilize leg types to establish complex paths/routes between waypoints. The Victor airway versus the area navigation route is depicted in the figure below.

**PERFORMANCE: Domestic RNAV-2 & RNP-2**
Both RNAV-2 and RNP-2 require navigational performance that supports TSE of ±2 NM. Both RNAV and RNP require Type 1 & 2 Data Chain certifications.

RNAV-2 (formerly USRNAV) has been designated for RNAV equipped aircraft as Q-routes for en route operations for FL180 to FL 450, and as T-routes for low altitude instrument flight rules (IFR) terminal transitions.

RNP-2 requires monitoring and alerting functions as well as navigational system integrity. RNP-2 has been designated for en-route navigation; however, minimum requirements have not been defined in AC 20-105. Currently RNP-2 has not been implemented in the route structure.

**PERFORMANCE: International RNAV-5**
It is a requirement that an aircraft be equipped to ensure it stays within ±5 NM of its cleared position 95% of the time. RNAV-5 (formerly BRNAV) compliance generally can be achieved by most existing aircraft equipage and uses the current navigation infrastructure. (Current en route navigational aids). Only RNAV-5 equipped and certified aircraft may fly IFR on the ATS Routes of the Flight Information Regions (FIR), Upper Information Regions (UIR), and/or designated Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) in and out of Terminal Management Areas identified in the European Regional supplement (ICAO Doc 7030/4).

**DOCUMENTATION:**

**RNAV-2**
- FAA AC 90-96A
- FAA AC 90-100A
- RTCA DO-200A/ED 76
- AC 20-138B

**RNP-2**
- ICAO Doc 9613, April 2007
- FAA AC 90-105
- RTCA DO-236B
- RTCA DO-283
- EUROCAE ED 58, 75B, 76
- RTCA DO-200A/ED 76
- RTCA DO-201A
- AC 20-138B

**RNAV 5**
- FAA AC 90 -96A
- JAA AMJ-20X2, 28/07/98
- German AIC IFR 5/96, AIC IFR 13 Aug 97
- Eurocontrol Std Doc 003-93
- ICAO Supplemental Procedures - Doc 7030/4
Navigation (cont’d)

Terminal Airspace

**FUNCTIONALITY DESCRIPTION:**
Terminal airspace/area is generically defined as airspace in which approach control service or airport traffic control service is provided. Navigation in the terminal area is provided by ground-based navigation aids (VOR, DME, TACAN), own-ship systems such as INS, or satellite based system. Terminal operations include arrivals, approaches, missed approach and departures operations. In general, terminal operations are conducted based on conventional procedures, RNAV-1 procedures, or RNP-1 procedures, except for final approach. Obstacle clearance restrictions or special authorization required may affect the actual airspace requirement. Arrivals when conducted in controlled airspace utilize a fix that enables metering of air traffic into the procedure. Approach is divided into three primary segments, initial, intermediate, and final. The final approach segment will be addressed in detail in the next section.

**PERFORMANCE: RNAV-1 & RNP-1**
RNAV-1 and RNP-1 require the same navigational and total system accuracy. However, RNP-1 requires additional performance and integrity monitoring. RNAV-1 (formerly PRNAV in Europe) is the aircraft and operator approval requirement that is introduced for RNAV procedures in ECAC Terminal Airspace. Terminal Airspace procedures that require RNAV-1 approval are designed following common principles which ensure that procedure design and execution are fully compatible. RNAV-1 allows Terminal Airspace operations that are consistent in the various ECAC States, based on procedures design principles and aircraft capabilities that meet the requirement.

In addition to the minimum performance and functional requirements appropriate for Terminal Airspace RNAV operations, RNAV-1 and RNP-1 approval includes navigation data integrity requirements (Type 1 & Type 2 Letter of Acceptance) and flight crew procedures.

The required level of navigation accuracy can be achieved using DME/DME, GPS or VOR/DME. It can also be maintained for short periods using INS (the length of time that a particular INS can be used to maintain RNAV-1 accuracy without external update is determined at the time of certification).

**CAPABILITY REQUIRED:**
- Requires an aircraft be within 1 NM of its cleared position (centerline) 95% of time.
- FMS functionality required for flight plan execution
- Ability to execute leg types
- RNP capable equipment must be able to calculate reasonableness of sensor input and estimate of position error based on time.
- RNP capable equipment must meet containment integrity and continuity requirements
- Navigation database and Type 1 & 2 LOAs

**DOCUMENTATION:**
**RNAV-1**
- JAA TGL-10
- FAA AC 90-96A
- FAA AC 20-100A
- RTCA DO-200A/ED 76
- RTCA DO-201A

**RNP-1**
- FAA AC 90-105
- RTCA DO-236B
- RTCA DO-283
- EUROCAE ED 58, 75B, 76
- RTCA DO-200A/ED 76
- RTCA DO-201A
- AC 20-138B
**Navigation (cont’d)**

**Approach Airspace**

**Approach**

**Functionality Description:**
An Instrument Approach Procedure (IAP) has four separate segments defined as initial, intermediate, final, and missed approach. The initial and intermediate segments include turns and other maneuvers required to position the aircraft for the final approach and are identified on the approach plates (charts) carried in the cockpit. A typical distance from the start of the initial segment to final approach completion is 60 nautical miles. Navigation for an IAP can be supported by conventional radio navigation aids, such as VOR, TACAN, ILS or MLS. This section addresses the topic of RNP/RNAV procedures using GPS as the primary IAP navigation mode. Applicable topics include accuracy requirements involving LNAV and VNAV and augmentation.

The final approach fix (FAF) is the start of the approach phase as discussed here. This segment is also identified on the approach plates. The final approach is the segment in which alignment and descent for landing are accomplished. The segment begins at the FAF/precise final approach fix (PFAF) and ends at the missed approach point (MAP) and/or Decision Altitude (DA). A typical distance for this phase is approximately 10 nautical miles.

GPS receiving equipment can be classified in two categories, augmented or non-augmented. Performance is enhanced using augmentation techniques which provide supplementary information to improve navigation accuracy. SBAS (space-based augmentation system) or GBAS (ground-based augmentation system) provide augmentation which allows lower decision heights and more accurate approaches plus improves the integrity monitoring of the satellite constellation. GPS alone does not provide this performance particularly for the vertical position solution.

RNP/RNAV approach procedures are documented in Flight Information Pamphlet (FLIP) charts, also known as approach plates, which are published every 28 days to reflect changes in the navigation data base.

**Approach Categories:**

Lateral Navigation (LNAV) does not contain vertical guidance. Lateral Navigation/Vertical Navigation (LNAV/VNAV) includes vertical navigation and reduces the approach minimums over LNAV alone.

Approach types are categorized as:
- Non-precision (300-500 feet above touchdown) and apply generally LNAV/VNAV approaches
- Category I approaches (200 feet above touchdown) requires either SBAS/WAAS or GBAS augmentation and are noted as LPV approach on FLIPs
- Category II approaches (100 feet above touchdown) requires GBAS augmentation. These approaches are not yet defined.

Although these categories reflect ILS implementation, there is an equivalency for GPS. See the JPALS segment of this manual for more information.

**Documentation:**
- Form 8260.3B Incl Chgs 1-21
- Form 8260.52
- AC 90-105
- AC 120-29A
- AC 20-138B
- AC 90-101A
- AC 90-100A
- RTCA DO-236B
- TSO-C129A
- TSO-C196
- Title 14 of the Code of Federal Regulations (14 CFR Parts 91, 121, 125, 129, and 135

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**The Four Instrument Approach Segments**

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**Aerospace Management Systems**

23
APPROACH (cont’d)

PERFORMANCE:
Lateral Guidance

During operations on the final approach segment when LNAV minima are used, the lateral TSE must be within 0.3 NM for at least 95 percent of the total flight time. The along-track error must also be within 0.3 NM for at least 95 percent of the total flight time. A flight director and/or autopilot must be coupled for RNP approaches if the lateral TSE cannot be demonstrated without these systems. The Flight Technical Error (FTE) should not exceed 0.25 NM on the final approach segment of the approach.

Other performance requirements that must be met include integrity, continuity, performance monitoring and alerting, navigation displays, an extended list of system capabilities, and the capability to automatically execute leg transitions and maintain tracks consistent with ARINC 424 path terminators to include Initial fix (IF), Course to fix (CF), Direct to fix (DF) and Track to fix (TF).

GPS-based approaches that have challenging obstacle clearance requirements or that overlay ILS are categorized as RNP AR (formerly SAAAR) approaches and will have an RNP value of RNP 0.3 or less. RNP AR will require barometric vertical navigation (baro-VNAV) capability.

Vertical Guidance

Vertical guidance can be obtained from the barometric altimeter system in conjunction with a flight management function (FMF) or from a GPS input to an FMF. When derived from a GPS for approach, the vertical solution requires augmentation to meet accuracy and integrity requirements.

Baro-VNAV provides vertical path information defined by vertical angles or altitudes at fixes in the procedure. The use of baro-VNAV generally allows lower decision heights than approaches with lateral-only guidance. Baro-VNAV systems are optional capabilities (except for RNP AR) that are not a minimum requirement to fly RNAV (GPS) or GPS approaches using the LNAV line of minima.

For en route, terminal, and approach IFR operations, the airborne Baro-VNAV system must have TSE components in the vertical direction that are less than those shown in Table 1 below, 99.7% of the flying time.

<table>
<thead>
<tr>
<th>Altitude Region (MSL)</th>
<th>Level Flight Segments &amp; Climb/Descent Intercept of Clearance Alitudes</th>
<th>Flight Along Specified Vertical Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>At or below 5000 ft</td>
<td>150 ft</td>
<td>160 ft</td>
</tr>
<tr>
<td>5000 ft. to 10000 ft</td>
<td>200 ft</td>
<td>210 ft</td>
</tr>
<tr>
<td>10000 ft. to 29,000 ft</td>
<td>200 ft</td>
<td>210 ft</td>
</tr>
<tr>
<td>Above 29,000 ft to 41,000 ft</td>
<td>200 ft</td>
<td>260 ft</td>
</tr>
</tbody>
</table>
**REDUCED VERTICAL SEPARATION MINIMUM (RVSM)**

**FUNCTIONALITY DESCRIPTION:**
RVSM enables the reduction of vertical separation to 1,000ft (from the current 2,000ft minimum) from FL290 to FL410, inclusive. This allows aircraft to safely fly more optimum profiles, gain fuel savings, and increase airspace capacity. In 1988, the ICAO Review of General Concept of Separation Panel (RGCSP) completed a study on RVSM and concluded that safe implementation of the 1,000-ft separation standard was technically feasible.

**AIRSPACE APPLICABILITY:**
- NAT -- Jan 2002, FL290 - 410
- PAC -- Oct 2000, FL290-410
- EUR -- Jan 2002, FL290 - 410
- CONUS/Canada South -- Jan 05 DRVSM, FL290 - 410
- SAT -- Jan 2002, FL290 - 410
- WATRS -- Jan 2002, FL290-410
- WPAC/S CH Sea -- Feb 2002, FL290 - 410
- Mid East -- Nov 2003, FL290 - 410
- North Canada -- Apr 2002, FL290 - 410

**DOCUMENTATION:**
- FAA AC 91-85
- Primary AIC’s: AIC Nr 33/00, AIC A 16/01, AC 91-4, AIC A2/01, AIC 5/100, AIC 16/2001
- FAA AIC 80/9096 (Yello 226)
- EUROCAE Documents 9574, 9536, 9572
- Civil Regulatory Documents: FAA FAR Part 91, Annex G

**FM IMMUNITY, PROTECTED INSTRUMENT LANDING SYSTEM, AND VHF OMNIDIRECTIONAL RANGE (FMI, P-ILS, VOR)**

**FUNCTIONALITY DESCRIPTION:**
In Europe the FM radio station transmissions have been found to interfere with the Instrument Landing Systems (ILS) localizer signals, VHF Omnidirectional Range (VOR) navigation aids, and VHF voice communications. For this reason, Europe has established a requirement that navigation radios be “FM immune.”

**CAPABILITY REQUIRED:**
- ILS receivers in Europe must meet new FM Interference Requirements.
- The VOR and VHF voice receivers must be upgraded or Radio Frequency (RF) filters must be installed.

**AIRSPACE APPLICABILITY:**
- Europe since Jan 2001

**DOCUMENTATION:**
- UK CAA Airworthiness Notice No. 84
- Ger Nfl II 68/94
- Ger Nfl 75/96
- ICAO EUR, Doc 006/5, ILS/VOR/FM Compatibility in European Region, Ver 5, Sep 1999, App A-F(Table)
VERTICAL NAVIGATION (VNAV)

FUNCTIONALITY DESCRIPTION:
Vertical navigation (VNAV) capability enables vertical path guidance to be computed as deviation from a desired ascending or descending path to a specified altitude at a waypoint. Vertical guidance is generally provided as a linear deviation from the desired track defined by a line joining two waypoints with specified altitudes or as a vertical angle from a specified waypoint. VNAV may be enhanced by inclusion of secondary inputs such as optimized climb or descent profiles, vertical acceleration and true airspeed. The desired vertical path may be pilot-selectable or may be determined by the VNAV computer by computations based on the altitudes associated with successive waypoints.

A vertical navigation system may be approved for en route, terminal and approach use.

CAPABILITY REQUIRED:
- VNAV-capable FMS with temperature compensation
- Baro-altimetry system

DOCUMENTATION:
- RTCA DO-200A
- RTCA DO-201A
- RTCA DO-236B
- FAA AC 20-138B

AIRSPACE APPLICABILITY:
- NAS and selected CAAs
- Supports LNAV/VNAV approach
- Approved Baro-VNAV systems support terminal and en route operations
TIME OF ARRIVAL CONTROL (TOAC)

FUNCTIONALITY DESCRIPTION:
The TOAC function provides the temporal or speed control that enables 4 dimensional (4D) navigation to be accomplished. This function supports the spacing and metering associated with air traffic management. Typical of the parameters for time of arrival control are the computation of path length to the time-constrained fix, ground speed, time remaining, target speed and speed error. Having determined the time of arrival error, the time of arrival control function computes a target speed for the aircraft. This target speed may be supplied to the flight control system or displayed to the flight crew. The target speed is used to correct arrival time errors at the time-constrained fix. The overall time control achieved will depend upon the accuracy of the parameters input or calculated, the control system accuracy, external factors such as winds, and the aircraft performance.

CAPABILITY REQUIRED:
- FMS/Mission Computer capable of combining position and airspeed sensor inputs to provide temporal calculations

DOCUMENTATION:
- FAA AC 20-138B
- RTCA DO-283
- RTCA DO-236B

AIRSPACE APPLICABILITY:
- 4D RNAV & 4D RNP RNAV (future, 2025)
GLOBAL POSITIONING SYSTEM (GPS)

FUNCTIONALITY DESCRIPTION:
A constellation of 30 satellites orbiting 11,000 miles above the earth emits signals to receivers on earth. When receiving signals from at least 4 satellites, a GPS receiver can determine latitude, longitude, altitude and time. The Department of Defense (DoD) also uses GPS for navigation in civil airspace, including non-precision approach operations, and maintains an upgrade path to ensure unique military use of GPS can be exploited.

CAPABILITY REQUIRED FOR IFR OPERATIONS:
- MSO or TSO certified GPS receiver
- Receiver Autonomous Integrity Monitoring (RAIM)
- Fault Detection/Exclusion (FDE)

AIRSPACE APPLICABILITY:
- Required for all DoD aircraft 2005 for missions
- En route and terminal when not augmented
- Supports all RNP/RNAV Operations

DOCUMENTATION:
- FAA TSO-C196
- FAA Notice 8110.60 GPS Primary Means Oceanic and Remote Navigation
- FAA requirements of TSO-C146 (using GPS augmented by WAAS/LAAS)
- FAA requirements of TSO-C145 (using GPS augmented by WAAS/LAAS)
- OASD C31 Security Policy
- FAA-P-8000-3 A Guide for Approval of GPS Receiver Installation and Operation
- MASP5, RTCA DO-217
- MOPS, DO-229B (WAAS)
- DO-178B (Software)
- MOPS DO-208 (GPS)
- MSO-C145A
- FAA AC 20-138B

DIFFERENTIAL GLOBAL POSITIONING SYSTEMS (DGPS)

GPS alone does not meet navigation requirements for accuracy, integrity and availability for all operations. DGPS corrects for the GPS satellite position errors, atmospheric delays, and other disturbances in the GPS signals, improving the accuracy and reliability of the users’ position solution. There are currently two forms of augmentation, Satellite Based and Ground Based.
SATELLITE BASED AUGMENTATION SYSTEMS (SBAS)

FUNCTIONALITY DESCRIPTION: (gps.faa.gov)
SBAS is a navigational system representing an enormous leap forward in air navigation. It provides vertically-guided approach capability at thousands of airports and airstrips where this capability had previously not been affordable. It is a core element in transitioning to the satellite-based air traffic control system of the future. SBAS is designed to improve the accuracy and ensure the integrity of positioning and timing information from GPS satellites. The system also provides the necessary guarantees that its signal will be accurate, available, and safe to use at all times. More importantly, SBAS warns the pilot when the satellites are not functioning correctly and should not be used for navigation.

SBAS ground stations take measurements of the Global Navigation Satellite System (GNSS) satellites in view, and are able to compute corrections to the GPS signals it is receiving. Using these measurements, information messages are created and sent to one or more Geostationary communication satellites for broadcast to an appropriately equipped aircraft.

SBAS requires an aircraft equipped to be able to receive and decode the signal being broadcast by the geostationary satellites. It also requires a navigation database certified per DO-200A/201A in order for the system to compute corrected aircraft position against the expected (database) flight path.

SBAS is being used operationally in the following areas:
1. United States – Wide Area Augmentation System (WAAS)
2. Japan - Multi-functional Satellite Augmentation System (MSAS)
3. Europe - European Geostationary Navigation Overlay Service (EGNOS)

DOCUMENTATION:
- TSO-C129A
- TSO-C145A
- TSO-C146A
- AC 20-130A
- AC 20-138B
- AC 90-94
- RTCA/DO-229D

CAPABILITY REQUIRED FOR IFR OPERATIONS:
- TSO-Certified GPS receiver
- DO-200A/201A certified navigation database (Critical level)

AIRSPACE APPLICABILITY:
- SBAS is not mandated for use, but is an operational enabler for aircraft conducting IFR Category I approaches into airfields not equipped with an Instrument Landing System and sufficient obstacle clearance margins of safety. It is also an enabler for RNP and RNAV capability on aircraft.
GROUND BASED AUGMENTATION SYSTEMS (GBAS)

FUNCTIONALITY DESCRIPTION: (gps.faa.gov)
GBAS augments GPS to provide an all-weather approach and landing navigation capability. GBAS provides precision approach service within a nominal 23-mile coverage volume around the airport where the ground system is installed. The ground system broadcasts differential GPS corrections, integrity messages and approach path data via a VHF radio data link to the aircraft. GBAS meets the high accuracy and availability performance requirements necessary for Category I, II, and III precision approach operations. GBAS is expected to provide improved service over existing Instrument Landing Systems (ILSs) and reduced operating costs.

In addition, a single GBAS ground system can provide precision approach capabilities to all runways at an airport. This reduces the need for costly redundant infrastructure found with ILS. Also GBAS can provide precise positioning information to the aircraft that can be used to prevent runway incursions during low visibility conditions. The system also allows for curved and segmented approach paths, not possible using current ILSs, for Category I, II, and III precision approaches.

Aircraft equipage of C/A Code GPS receivers and VHF data radios are required to implement GBAS. Also, onboard aircraft processing is required to provide a differentially corrected position and approach path guidance.

The requirements for Category I approaches have been validated with ICAO and established in civil GBAS installations across the United States and other countries. Currently, the requirements for Category II/III are in the process of ICAO and system validation.

CAPABILITY REQUIRED FOR IFR OPERATIONS:
- TSO-C161 Certified GBAS-capable GPS receiver
- TSO-C162 Certified VHF receiver

DOCUMENTATION:
- ICAO Standards and Recommended Practices for the GBAS aircraft element
- FAA-E-3017
- RTCA DO-253C
- RTCA DO-245A
- RTCA DO-246D
- TSO-C162
- TSO-C161
- ED-88
- ED-95
- ED-114
- ED-144

AIRSPACE APPLICABILITY:
- GBAS is not mandated for use, but is an operational enabler for aircraft conducting IFR Category I/II/III approaches into airfields not equipped with an Instrument Landing System.

Aircraft System Functional Architecture (GBAS)
JOINT PRECISION APPROACH AND LANDING SYSTEMS (JPALS)

FUNCTIONALITY DESCRIPTION:
JPALS is a militarized GBAS that will operate in all military environments; at sea, and on shore in a permanently fixed and a quickly deployable tactical configurations. JPALS’ will augment GPS P(Y) Code to provide an all-weather approach and landing navigation capability in GPS threat environments. JPALS is expected to provide a single interoperable solution for all DoD Services.

The military ground system broadcasts differential GPS corrections, integrity messages and approach path data via an encrypted ultra high frequency (UHF) radio data link to the aircraft. JPALS initial capability will meet the accuracy, integrity, continuity and availability performance requirements necessary for Category I precision approach operations.

In addition, a single JPALS ground system can provide precision approach capabilities to all runways at an airport. This reduces the need for costly redundant infrastructure found with ILS. Also JPALS can provide precise positioning information to the aircraft that can be used to prevent runway incursions during low visibility conditions. The system also allows for curved and segmented approach paths, not possible using current ILSs for Category I precision approaches.

Aircraft equipage of P(Y) Code GPS receivers and UHF data radios are required to implement JPALS. Also, onboard aircraft processing is required to provide a differentially corrected position and approach path guidance.

CAPABILITY REQUIRED FOR MILITARY MODE IFR OPERATIONS:
- Certified GPS receiver per JPALS Aircraft Integration and Requirements Specification (AIRS)
- UHF Data Link Receiver
- Processing of Differentially Corrected Position and Guidance

DOCUMENTATION:
- Land-Based JPALS SRD ~ 2012
- Land-Based JPALS AIRS (To Be Developed ~ 2015)
- Land-Based JPALS ICD (To Be Developed ~ 2015)
- Land-Based JPALS Aircraft Integration Guide (To Be Developed ~ 2014)

AIRSPACE APPLICABILITY:
- JPALS provides a single technology (DGPS) to support all DoD land-based and sea-based precision approach and landing capabilities.
AMS Division Navigation Data Chain Responsibility

A crucial element of navigation safety is navigation data integrity. Changes in navigation data integrity can have serious flight and mission consequences. The AMS Division is responsible for certifying that the production and distribution of aeronautical navigation data for the United States Air Force (USAF) is consistent with civil standards.

NAVIGATION DATA CHAIN

FUNCTIONAL DESCRIPTION:
A data chain is the linked series of people, processes and systems that the navigation data takes from the data originator to the user of the data in the aircraft. The figure to the right is a simplified representation of the current USAF data chain. The data chain includes both the forward path that the data follows as well as the error reporting or feedback paths. Operations on the data by any node in the chain can include format changes, coordinate changes, and transmission. The preparation and distribution of aeronautical navigation data at the wing for specific aircraft is supported by software tools. These tools are procured as part of the Mission Planning System acquisition.

NAVIGATION DATA SUPPLIER:
For the DOD/USAF, the National Geospatial Intelligence Agency (NGA) is responsible for collecting navigation data from various sources (e.g., sovereign “states”) and supplying the data in a standard format (the Digital Aeronautical Flight Information File (DAFIF)).

NAVIGATION DATA USERS:
USAF aircraft platforms’ Mission Planning Systems (MPS) extract a mission-specific subset of the navigation data from DAFIF, transform the data into an aircraft-specific format, and load the transformed data into an aircraft’s navigation database load media.

CNS/ATM APPLICABILITY:
- RNAV-1
- RNP-4
- RNP-1
- RNP-0.3

DOCUMENTATION:
- FAA AC 20-153
- RTCA DO-200A
- RTCA DO-201A
- AFPD 63-13
- AFI 63-1301
Certification Process

AMS DIVISION CERTIFICATION ROLE AND RESPONSIBILITY:
The AMS Division certifies that the navigation data is prepared and distributed in a manner that is consistent with civil standards. These standards provide confidence that integrity of navigation data is maintained throughout the entire data chain – supplier and user segments, i.e., that the operations on the data (e.g., format changes, coordinate changes, and transmission) do not change the accuracy and resolution of the data. The supplier-to-user data chain segment addressed by AMS Division, depicted by the shaded area in the navigation data chain figure, includes DAFIF production at NGA, preparation of the aircraft’s navigation data load, loading data into aircraft systems, and the error reporting chain (currently handled by the Mission Planning System Support Facility). The certification does not address the original data quality/resolution from its sources or the operation of aircraft avionics (e.g. Flight Management Systems – FMS). The operation of aircraft navigation systems is addressed as part of the performance assessment process.

CERTIFICATION TYPES:
Type 1 Certification: A Type 1 certification, defined in FAA AC 20-153, is generic in nature. Type 1 certifications are never tied to a particular configuration of aircraft or navigation equipment. Type 1 certification indicates that a particular organization has implemented the required processes and procedures deemed necessary to satisfy the requirements for producing navigation data.

Type 2 Certification: A Type 2 certification, defined in FAA AC 20-153, indicates that a specific set of procedures, using a specific configuration of hardware/software tools, will satisfy the requirements for delivering data for a particular navigation purpose in a specifically configured aircraft. A Type 2 certification is always given to a particular configuration which must be identified.

Tool Certification: In addition to the approvals described in the civil standards, AFI 63-1301 directs the AMS Division to “certify Air Force Mission Planning Systems navigation data processing will meet CNS/ATM requirements.” This tool certification supports an airworthiness assessment of the mission planning tools and does not, by itself, imply a certification of the data chain.
AUDITS:
The AMS Division certifies the navigation data chain by performing audits. The audits are performed to a degree commensurate with (but not necessarily identical to) established civil requirements. AMS Division audits NGA for a Type 1 certification based on data requirements captured in RTCA DO-200A, AC 20-153, the DAFIF Data Quality Requirements Document and the DAFIF Product Specification. Both of the latter two documents are approved by the services through the Flight Information Publication (FLIP) and Data Aeronautical Working Group (FDAWG). The data chain as a whole is audited for Type 2 certifications based on requirements from the end-user, which are aircraft-specific, as well as RTCA DO-200A, RTCA DO-201A and FAA AC 20-153. In the USAF, several organizations work together to implement the data chain. Consequently, multiple audits of different organizations are required for a Type 2 certification. The Tool Audit is a part of the Type 2 audit process.

CERTIFICATION DOCUMENTATION:
The AMS Division issues letters documenting certification: one for a Type 1 certification, one for each Type 2 certification, and one for each Tool certification. The Type 1 Certification Letter states that NGA is a certified supplier of navigation data (i.e., DAFIF). This means that AMS Division has determined that NGA has instituted the required processes and quality management controls. The Type 2 certification letter identifies the specific data chain configuration being certified, and identifies which requirements have been certified.

In 2010, the FDAWG asked the FAA to assess NGA’s compliance as a Type 1 aeronautical navigation data provider. In April 2011, the FAA issued their Letter of Approval (LOA) attesting to NGA’s positive compliance status. The FAA’s LOA is contingent on AMS continuing to monitor and audit NGA’s compliance status.

<table>
<thead>
<tr>
<th>Requirements Sources</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAFIF Data Quality Requirements</td>
<td>A/C-specific requirements</td>
<td>A/C-specific requirements</td>
<td></td>
</tr>
<tr>
<td>DAFIF Product Specification</td>
<td>RTCA DO-200A</td>
<td>RTCA DO-200A</td>
<td></td>
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<tr>
<td>RTCA DO-200A</td>
<td>RTCA DO-201A</td>
<td>RTCA DO-201A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scope of Certification</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic navigation data supplier, not specific to any particular aircraft</td>
<td>Specific to a particular aircraft and navigation requirement</td>
<td>Specific to a version of a software tool and a particular aircraft / navigation requirement</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject of Certification</th>
<th>Type 1</th>
<th>Type 2</th>
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<td>Data chain for use on a specific aircraft</td>
<td>Specific version of Software Tool</td>
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Terrain Awareness and Warning System (TAWS) and Predictive and Reactive Windshear Systems are NAVSAFETY related functions. These functions provide flight crews with situational awareness, alerts and, where applicable, recommended maneuver guidance. These systems are mandated by Air Force direction, since 1996, for passenger and troop carrying aircraft.

**TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)**

**FUNCTIONALITY DESCRIPTION:**
The Terrain Awareness and Warning System (TAWS) supports safe operation by providing three functions: Forward-Looking Terrain-Avoidance (FLTA), Premature Decent Alert (PDA) and Ground Proximity Warning.

**CAPABILITY REQUIRED:**
- TAWS system with associated user interfaces

**AIRSPACE APPLICABILITY:**
- USAF Nav Safety Requirement, civil requirement in CONUS

**DOCUMENTATION:**
- AC 25-23, Airworthiness Criteria for the Installation Approval of TAWS Approved for part 25 aircraft
- TSO-C151B
- RTCA DO-161A
- ARINC 723-1
REACTIVE AND PREDICTIVE WINDSHEAR

FUNCTIONALITY DESCRIPTION:
Windshear is the generic term used to describe rapidly changing horizontal (1 and 3 in the figure) or vertical (2 in the figure) air currents. Windshear detection systems can be classified in two categories:

a) Reactive Systems use various sensor inputs to identify the presence of windshear once the phenomenon is encountered and provides the pilot with timely warning and adequate flight guidance to improve the probability of recovery from the windshear encounter. This system will include both windshear warning and windshear caution alerts. The system provides the crew with flight guidance information to improve the recovery probability once encountering a windshear phenomenon. A reactive system may also integrate or couple an autopilot and/or auto-throttle systems of the aircraft with an airborne windshear flight guidance system.

b) Predictive systems are radar-based and provide a pilot with anticipatory information on levels of turbulence in the flight path. The radar processes the characteristics of precipitation returns to determine if windshear is present. Predictive windshear systems are usually capable of windshear detection, weather detection and ground mapping.

CAPABILITY REQUIRED:
- Weather radar with appropriate performance and processing software
- Multifunction display capable of presenting windshear indications

AIRSPACE APPLICABILITY:
- USAF Nav Safety Requirement, civil requirement in CONUS

DOCUMENTATION:
- Reactive
  - FAA TSO-C117A
  - FAA AC 25-12
  - SAE ARP 4102/11
- Predictive
  - RTCA DO-173
  - RTCA DO-220
The surveillance needs are the Traffic Alert and Collision Avoidance System (TCAS) II, Mode Select (Mode S) Transponder, and Automatic Dependent Surveillance – Broadcast (ADS-B). TCAS II is a well established capability that is a military requirement on troop or passenger carrying aircraft. Mode S is the evolutionary replacement of the Air Traffic Control Radar Beacon System (ATCRBS) transponder and is required in most Western European states. A Mode S transponder is required for TCAS II systems. Mode S supports a number of advanced capabilities including air-ground and air-air data link. ADS-B uses positional information transmitted from the aircraft in lieu of an independent surveillance system (e.g., a radar). The United States mandated airspace and avionics performance requirements for ADS-B after January 1, 2020. The European ADS-B mandate is January 1, 2019, but State aircraft should be able to receive exemptions until January 1, 2020. The goal is to provide continuing access to civilian airspace as these surveillance/safety requirements are imposed. The ADS-Contract (ADS-C) is an application of communication and is covered the communications part of this booklet. ADS-C was previously referred to as ADS-Addressed (ADS-A), or simply as ADS. ADS-C is covered in the Communications part of the brochure.

**TRAFFIC ALERT and COLLISION AVOIDANCE SYSTEM (TCAS)**

**FUNCTIONALITY DESCRIPTION:**
TCAS is an airborne safety system which provides Traffic Advisories (TA) and vertical Resolution Advisories (RA) for collision avoidance. TCAS I provides TAs, while TCAS II provides additional vertical collision avoidance maneuver RAs. Version 7.0 is the accepted system. Correspondingly, ICAO has defined Airborne Collision Avoidance Systems (ACAS) I and II. All TCAS II V 7.0 systems meet the international standards for ACAS II. Variants are available which meet military-specific needs. For example, the Enhanced-TCAS II (E-TCAS) has functionality to support station keeping in air-to-air refueling and MILACAS FR to support formation flight. Although TCAS II 7.1, an update to 7.0, is required in European Airspace, the specified policy is that it is a recommendation for State aircraft.

**CAPABILITY REQUIRED:**
- TCAS II version 7.0 / ACAS II System (requires antenna installation)
- Mode S Transponder (TCAS version 7.0 /7.1 compatible, no change is needed to support version 7.1)
- Stand-Alone Display, EFIS, or Integrated MFD
- Controls and audio alerts

**AIRSPACE APPLICABILITY:**
- USAF: All USAF troop or passenger carrying aircraft must be equipped
- USA: The FAA TCAS II requirement is not applicable to DoD aircraft
- Foreign: TCAS II operation in RVSM airspace requires version 7.0 or higher
- Europe: EASA and EUROCONTROL have a rule to require TCAS II Version 7.1 for aircraft flying in General Air Traffic (GAT), but the stated policy is that it is a recommendation for State aircraft.
- Germany: State (military) aircraft 31 March 2006 exemptions have been given when requested

**DOCUMENTATION:**
- FAA AC 20-151A, Airworthiness and Operational Approval of TCAS and Mode S Transponder
- EUROCONTROL Specimen AIC – TCAS
- FAA TSO-C-119B
- ARINC 735
- RTCA DO-185B
- ICAO Annex 10 volume 4
- ICAO Doc 7030/4
**Surveillance (cont’d)**

**AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST (ADS-B)**

**FUNCTIONALITY DESCRIPTION:**
ADS-B allows pilots and air traffic controllers to see aircraft traffic with more precision than has been possible before. The FAA and EUROCONTROL have identified more than 20 uses of ADS-B to improve safety and provide more efficient use of the airspace.

Each ADS-B equipped aircraft broadcasts its precise position as well as other data, including future intent. This provides anyone with ADS-B receive equipment (airborne or ground based) to develop an accurate depiction of air traffic. ADS-B can provide coverage at low altitudes and on the ground, so that it can be used to monitor traffic on the taxiways and runways of an airport, and in valleys and behind mountains where radar coverage is limited.

ADS-B OUT provides the broadcast of information from the aircraft and ADS-B IN provides the reception of ADS-B information and display of this data to the pilot on a Cockpit Display of Traffic Information (CDTI). ADS-B 1090ES versions 0 and 1 (per DO 260 and DO 260A respectively) are in use today. Version 2 (Based on 260B) is mandated for use in the US in 1/1/2020 and in Europe in a similar time frame (European mandate for 1/1/2019 but State aircraft should be able to qualify for exemption to 1/1/2020).

Australia has implemented ADS-B OUT version 0/1/2 as a radar alternative. On Jan 1, 2010 Canada began providing preferential access to FL 350-FL400 to ADS-B version 0/1/2 equipped aircraft over the Hudson Bay with the intent to extend across all of northern Canada and to northern Europe. The US FAA and Europe are jointly studying the applicability of ADS-B both IN and OUT.

**CAPABILITY REQUIRED:**
- DoD preference is 1090ES which is also recognized as the common international link. The Universal Access Transceiver (UAT) is a second US FAA ADS-B link authorized for aircraft that fly below 18,000 feet.
- Position, velocity, integrity, and intent information from the navigation system and FMS or GPS
- Mode-S Transponder for 1090ES
- Cockpit Display of Traffic Information (CDTI) function to see the data in the aircraft (for ADS-B IN)

**AIRSPACE APPLICABILITY:**
- Alaska – FAA has fielded “Capstone” which includes air and ground UAT infrastructure with 1090ES infrastructure being installed.
- Canada – The Hudson Bay area is equipped with ADS-B ground stations. Access to FL350 – 400 is reserved for aircraft with approved ADS-B installations. ADS-B requirements will expand East, West and vertically over the rest of the country.
- Netherlands – Low altitude (4000 ft and below) over the North Sea will be restricted to ADS-B aircraft in the next few years.
- Europe –ADS-B rule in the same general time frame as the FAA rule
- Current users including UPS and Embry-Riddle University.
- Future plans are being considered in numerous places around the world.

**DOCUMENTATION:**
- RTCA DO-242A (currently being updated)
- RTCA DO 260, DO 260A, DO-260B for 1090ES version 0, 1, and 2 respectively
- RTCA DO 282B for UAT
- RTCA DO 317B for ADS-B IN
- FAA TSO-C166B (1090ES) and FAA TSO-C154B (UAT)
- FAA AC 20-165 (current version)
**Surveillance (cont’d)**

**MODE SELECT BEACON SYSTEM (MODE S) TRANSponder**

**FUNCTIONALITY DESCRIPTION:**
The Mode Select (Mode S) Radar Beacon System is an evolutionary replacement for the Air Traffic Control Radar Beacon System (ATCRBS). It is compatible with ATCRBS and operates on the same internationally allocated frequencies (1090 MHz transmit and 1030 MHz receive). The primary role of the Mode S transponder is to respond to interrogations from a ground sensor or a Traffic Alert and Collision Avoidance System (TCAS), and to provide airborne data information including identification and altitude.

The FAA has no plans to require Mode S transponders, except as required for TCAS II. However, aircraft equipped with TCAS II must have a Mode S transponder to provide a datalink between the aircraft and the ground sensor and between TCAS II equipped aircraft.

Seven central European countries require Elementary Surveillance (ELS) and four (Germany, France, Switzerland, and UK) have further defined Enhanced Surveillance (EHS for transport-class aircraft) requirements for their airspace for both civilian and military aircraft. The mandated equipage date for military aircraft was 3/31/2009. Specifically, for ELS the transponder must transmit the following data: 24-bit aircraft address, SSR Mode 3/A code, aircraft identification (flight ID), altitude (25 foot increments desired), flight status, data link capability report, common usage GICB capability report, and the ACAS active resolution advisory (if ACAS is installed on the aircraft).

The EHS additionally requires the ability to download information from three additional transponder registers to support advanced ATC applications. This is sometimes referred to as Downlink of Aircraft Parameters (DAP). Transport class aircraft and a few others are expected to have EHS. It is not required of high performance and highly maneuverable aircraft.

Mode S is fully operational in CONUS at over 140 sites. Exemptions for State (including military) aircraft flying in ELS and EHS designated airspace in Europe have been issued and are in effect.

**CAPABILITY REQUIRED:**
- Mode S Level 2 Transponder compliant to ICAO SARPS Annex 10 Vol. 4
- DoD Mode S/IFF transponders that is AIMS certified
- An additional FAA TSO is strongly recommended
- Version 7 upgrades should be included to support TCAS II
- Associated antenna(s) and controls

**AIRSPACE APPLICABILITY:**
- Europe: State Aircraft (including military)
- ELS and EHS from 3/31/2009
- Germany will not allow Mode 3/A and C operations by the end of 2012
- USA: No expected requirement from the FAA except as required for TCAS II

**DOCUMENTATION:**
- RTCA DO-181C currently and DO-181E (3/17/2011) when integrated with ADS-B version 2
- ICAO Doc 7030/4
- ICAO Document 9871
- ICAO annex 10 volumes III and IV
- German AIC 23 Jan 03
- EUROCONTROL Specimen AIC, Intro of SSR Mode S
- TSO-C112 (current version)
- AC 20-151 (current version)
- ARINC 718(a) as applicable to military installations
- EUROCONTROL Specimen AIC ICAO 24-bit aircraft address and aircraft identification reporting
- European Aviation Safety Agency (EASA) document AMC 20-13 for EHS
**Ground Based Sense And Avoid**

Ground Based Sense and Avoid (GBSAA) is an effort to use ground based radars to replace the eyes of the pilot in an aircraft with sensor data that can be used by the pilot of a Remotely Piloted Aircraft (RPA) to avoid cooperative and non-cooperative aircraft in civil airspace.

**FUNCTIONALITY DESCRIPTION:**
The GBSAA system uses ground based surveillance radar to detect objects capable of carrying a human being, displaying that information to the RPA pilot so that the Pilot in Command (PIC) can safely maneuver the RPA to ensure the RPA passes well clear of that object. The Initial Operational View (OV-1) is included on the next page.

**CAPABILITY REQUIRED:**
- Ground based surveillance radar, a fusion tracker and a display located with the RPA pilot in the Launch and Recovery Element (LRE) or Ground Control System (GCS)

**AIRSPACE APPLICABILITY:**
- All airspace, but focused on gaining access to civil airspace in the US National Airspace System (NAS)

**DOCUMENTATION:**
- Phase I Concept Demonstration focused on validating ASR-11 radar model and exploring the Dynamic Protection Zone (DPZ). Phase I demonstration was completed at Gray Butte using existing air traffic control radars, a fusion tracker and display in the GCS using surrogate aircraft (Cessna 172/182). The radar model was validated and much information was gleaned from the DPZ scenarios flown. Phase II will focus on DPZ improvements, altitude estimation and avoidance algorithms is planned for the Summer 2012.

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**Images:**
- Radar
- Fusion Tracker & Display
- RPA
Ground Based Sense and Avoid Capability

- Must detect and track flight objects that can support a person at altitude (RCS ≈ 1 m²)
- ATC may not be able to see non-cooperative flight objects that RPA must avoid
- Location of the Observer and the TIN selected to meet local needs
- Pilot & Observer staff share GBSAA information
- Special Training for Observer & Pilot
- With the addition of appropriate automation, the observer might be eliminated
- Pilot and AT controller communicate by voice only until FAA’s data link program is operational

“"The task of the observer is to provide the pilot of the UAS with instructions to steer the UA clear of any potential collision with other traffic."” – FAA AIR-160 – Interim Operational Approval Guidance 08-01

OV-1 High Level Operational Concept Graphic (initial)
National Airspace System (NAS) Modernization

THE WAY AHEAD

Wind farms are rapidly being installed in the United States and abroad to meet the need for clean, renewable energy. Yet, wind farms can interfere with ATC radar system performance, mainly through the introduction of non-stationary clutter. Wind turbine clutter can prove misleading and has been documented by radar operators to appear as anomalous weather and/or aircraft. Wind turbine induced interference effects also result in the desensitization of the radar, reducing the probability of detection for aircraft-even those flying at altitudes significantly above the wind farm. The NAS Program Office is exploring potential Wind Turbine mitigation strategies with Raytheon for modifications to the ATC radar hardware/software to help restore/improve performance to affected systems.

New capabilities are being added to both DAAS and APEX, e.g., ADS-B data fusion and harmonization w/ host-nation ATC systems (Korea).

For more information on the NAS program, please contact:

Burton J. Wadas, ESC/HBAG
781.225.4676, Burt.Wadas@hanscom.af.mil

FUNCTIONALITY DESCRIPTION:
- The DOD NAS is comprised of the Digital Airport Surveillance Radar (DASR), DoD Advanced Automation System (DAAS), and Automated Protocol Exchanger (APEX)
- Modernization/replacement of aging air traffic control (ATC) systems to meet increasing military ATC needs of the twenty-first century, by providing improved radar coverage, system automation, and improved communications to war fighters
- Multi-service and interagency acquisition program
- Program is in Full Rate Production (FRP) and Deployment

SYSTEM CAPABILITY:
- State-of-the-art digital ATC systems providing increased reliability, maintainability, safety, performance and workload efficiency
- Interoperable with FAA modernization
- Replaces aging DoD ATC systems, providing identical service to military and civil aircraft
AF Weather Systems are designed to facilitate weather operators’ support of AF and Army flight operations and ground safety, and mission planning/execution. AF Weather Systems are an integrated, component-based, scalable system of systems, which includes multiple system acquisitions tailored to meet operational support requirements at all levels of weather operations. The multiple weather programs are aligned with core AF meteorological processes to collect, analyze, predict, tailor, and disseminate timely, accurate, and relevant battlespace natural environmental information for the warfighter. Three organizations acquire systems for the AF Weather enterprise: Space and Missile Center (SMC), Air Force Weather Agency (AFWA), and Weather Systems Branch (HBAJ) of Electronic Systems Center (ESC). AFWA is the Lead Command and user representative for the AF Weather Systems. Air Force Weather operates in three major echelons, including AF Weather Production Center and AF Climatology Center (AFWA and 14WS), Operational Weather Squadrons (OWSs), and Weather Flights and Detachments (WF/Dets).

ESC/HBAJ manages the following AF Weather Systems: Joint Environmental Toolkit (JET), Weather Data Analysis (WDA), FMQ-22, Fixed-Base Weather Observing System (FBWOS), Portable Doppler Radar (PDR), and Mission Planning Weather.

**JOINT ENVIRONMENTAL TOOLKIT (JET)**

**FUNCTIONALITY DESCRIPTION:**
- A scalable, standard software and hardware toolkit that gives weather forecasters the capability to provide operational decision makers at all levels quality weather information

**CAPABILITY REQUIRED:**
- Facilitate weather forecasters at OWSs and WFs/dets in providing decision-quality weather information to support flight operations and ground safety, and mission execution and planning.
- Collect and delivers web-enabled, decision-quality weather data, services and products to weather forces and AF/Army warfighters
- Interface with applicable C2 systems and replaces disparate legacy weather systems with a single, integrated capability

**AIRSPACE APPLICABILITY:**
- Airfield weather sensor displays (observations)
- Terminal Aerodrome Forecast (TAF) production
- Airfield Advisory/Watch/Warning production
- Flight Weather Briefing production
- Aviation Hazard Forecasts Product creation
- Provides weather data to Air Traffic Control (Tower/RAPCON) systems

**Requirements Basis:**
- Increment 1: FS-21 ORD, dated Mar 99
- Increments 2-4: CDD, dated April 08

**Major Customers:**
- Army, MAJCOMs, COCOMs

**Schedule:**
- Inc 1, SP 2 Fielding complete: May 2011
- Inc 2, Build A MS C/Fielding Decision: Dec 2011
- Inc 2, Build B MS C/Fielding Decision: Jul 2012

**Contractor:**
- Raytheon I&IS, Omaha, NE
WEATHER DATA ANALYSIS (WDA)

FUNCTIONALITY DESCRIPTION:
Reengineer/modernize infrastructure and core functions at the AF Weather Agency (AFWA) Production Center.

CAPABILITY REQUIRED:
- Create Joint Meteorology and Oceanography (METOC) database segments for storage/subscription/dissemination/cataloging of different types of weather data.
- Modernize Meteorological Satellites (METSAT) data ingest, exploitation, and dissemination capabilities to include new NPP/JPSS and legacy satellite data.
- Ingest and process weather data (regardless of source) to enable rapid availability for the Warfighter.
- Data-centric and net-centric solution using Joint METOC Broker Language (JMBL) and Consolidated Dissemination Capability (CDC).

AIRSPACE APPLICABILITY:
- Central AF database for weather data supporting safety of flight and battlespace awareness.
- Observations, TAFs, Pilot Reports (PIREPS), radar images, satellite images and data, weather model (forecast) data.

Requirements Basis: CDD dated 1 Feb 08
Major Customers: AFWA
Schedule: Inc 4, Build A, Feb 12 turnover to AFWA
Contractor: Raytheon I&IS, Omaha, NE (P)
Weather Systems (cont’d)

**FIXED-BASE WEATHER SENSORS (FBWOS, FMQ-22)**

**FUNCTIONALITY DESCRIPTION:**
- Fixed-base weather sensors for major airfields (FBWOS)
- Fixed-base weather sensors for minor airfields, ranges, helicopter pads, and missile sites (FMQ-22)

**CAPABILITY REQUIRED:**
- Automatically senses, collects, formulates, displays and makes weather information available for dissemination locally, to OWS and AFWA
- Detects: Wind/temperature/humidity/dew point/clouds/visibility/precipitation/present weather/thunderstorm/lightning/barometric pressure
- Automatically generates weather reports for aviation
- Formats Observations, sends locally, to OWS and AFWA

**AIRSPACE APPLICABILITY:**
- Provide official terminal aerodrome weather observation (METAR, SPECI) for Air Traffic Control (Tower/RAPCON) as well as provides real-time sensor readings
- Airfield weather observations support generation of weather advisories/watches/warnings, TAFs, aviation hazards forecasts, and flight weather briefings

**FBWOS**
- Requirements Basis: OS-21 ORD, Sep 99 (re-validated Dec 09)
- Major Customers: AF, Army, ANG, ANR
- Schedule: Fielding Decision, 4QFY13
- Contractor: Mesotech

**FMQ-22**
- Requirements Basis: OS-21 ORD, Sep 99
- Major Customers: AF, Army, ANG, ANR
- Schedule: Full-Rate Production, 30 Aug 10
- Contractor: Vaisala Inc., Louisville, CO

**PORTABLE DOPPLER RADAR (PDR)**

**FUNCTIONALITY DESCRIPTION:** Portable weather radar with Doppler capabilities to accurately detect and interrogate precipitation and wind fields

**CAPABILITY REQUIRED:**
- Precipitation detection (180nm), wind field detection (50nm)
- Receive, process, display and store Doppler products
- Portable, quick set-up/tear down, fit on one pallet
- Operate 24 hours/day; 7 days/week
- Remote workstation capability
- Distribute products to weather systems
- Remote diagnostic & maintenance ability

**AIRSPACE APPLICABILITY:**
- Weather radar products supporting safety of flight and battlespace awareness
- Weather radar products support generation of weather advisories/watches/warnings, TAFs, aviation hazards forecasts, and flight weather briefings

**Requirements Basis:** TWR ORD, 4 Jun 97
- Major Customers: AFWA
- Schedule: Full-Rate Production, 30 Aug 10
- Contractor: Lapoint-Blasé Industries, Inc. (EWR), St. Louis
Weather Systems (cont’d)

MISSION PLANNING WEATHER

FUNCTIONALITY DESCRIPTION:
Overlay weather impact information on warfighter applications and provide a local store of weather data to support effective mission planning and execution.

CAPABILITY REQUIRED:
- Provides near-real time and forecast weather data, products, and impacts on the Portable Flight Planning System (PFPS)/FalconView and the Joint Mission Planning System (JMPS)
- Provides observations, TAFs, PIREPS, radar and satellite images, lightning and forecast graphics
- Simple, lightweight user interface
- Fully net-centric; supports high bandwidth reach-back to disconnected ops

PFPS FalconView Weather (FVWx)
Requirements Basis: Mission Planning Systems CDD, Jun 04
Major Customers: DoD Mission Planners, AOC Operations
Schedule: FVWx 1.2: fielding Jan 12
Contractor: Northrop Grumman, Omaha, NE

JMPS Weather Common Component (WxCC)
Requirements Basis: Mission Planning Systems CDD, Jun 04
Major Customers: DoD Mission Planners, AOC Operations
Schedule: WxCC 3.0: fielding Feb 12
Organic Sustainer: 519th SMXS

AIRSPACE APPLICABILITY:
- Provides required weather data to calculate planned routes using Flight Performance Modules (FPM)
- Provides real-time weather information to enhance battlespace situational awareness and safety of flight
- Provides local store of weather data to support planned route optimization
- Facilitates mission planner’s submission of Flight Weather Briefing requests

FVWx Overlay

WxCC Overlay
When necessary for military missions, CNS/ATM functions can be turned off. Oceanic/remote; mandatory in parts of Southern PAC.

Currently effective above FL195 in EUR. Mandate likely to extend to ground in 2014 for civil aircraft and in Dec 2018 for state aircraft.

Currently charted as “RNAV (GPS)” in US.

In support of Link 2000+ services in Europe; state and FANS 1/A-equipped aircraft are currently exempt.

Mandatory worldwide for ATS communications except oceanic and remote.

In support of Link 2000+ services in Europe; state and FANS 1/A-equipped aircraft are currently exempt. Preferred routing for those who equip with FANS 1/A in oceanic & remote; NAT mandate possible: 2013 in OTS, 2015 in MNPS.

Preferred routing for those who equip with FANS 1/A in oceanic & remote; NAT mandate possible: 2013 in OTS, 2015 in MNPS.

Mandatory in parts of western Europe and Asian countries bordering eastern Europe; an ICAO requirement for all VHF avionics.

Mandate to fly in the airspace. May apply to some aircraft but not others.

Mandate for civil aircraft with exemption for some or all state aircraft.

Not required, but equipage yields benefits

Military Requirement

* "First Need Date" is the legal mandate OR when MAJCOM determines an operational benefit to equip, whichever comes first. Legal mandates sometimes permit exemptions for military aircraft, but noncompliance can mean adverse operational impacts and sometimes denial of airspace access.

15 Feb 2012, ESC/HBAI, POC: whershey@mitre.org
Appendix A: CNS/ATM Policy

- U.S. is a signatory to ICAO along with 185 other countries
- Flight procedures outlined by ICAO are implemented by Federal Aviation Regulations (FAR)
- FARs carry the rule of law . . . violations of FARs are equal to violations of law
- Capstone PMD, 14 Jul 97, CAPSTONE PROGRAM MANAGEMENT DIRECTIVE (PMD) for Global Air Traffic Operations/Mobility Command and Control (GATO/MC2) CAP-PMD-GATO/MC2, No. 01-97

Note: draft AFI 63-137 awaiting SAF/AQ signature; incorporates new policy and implementing instructions for all Air Force stakeholders.
Appendix B: 
CNS/ATM Glossary

1090 ES – 1090MHz Extended Squitter: An ADS-B Extended Squitter is a spontaneous transmission containing information about the aircraft’s location, equipage, and intent. It is broadcast on the frequency 1090 MHz and uses the Mode S transponders as a basis for operation.

8.33KHz spacing – Because of congested voice communications in Europe, it was necessary to divide the 25 kHz VHF band (118-137MHz) into three 8.33 kHz bands. Currently implemented above FL 195.

ABSAA – Airborne Sense and Avoid: The use of various sensors on board Remotely Piloted Aircraft (RPA)/Unmanned Aircraft Systems (UAS), vehicle control systems, communications links and procedures to proved for the safe operation of RPA/UAS in the National Airspace System (NAS).

AC – Advisory Circular: Produced by the FAA, the AC provides guidance material that is not mandatory and does not constitute a regulation. It outlines method of compliance with the rules. In lieu of following this method without deviation, the applicant may elect to follow an alternative method, provided the FAA determines that the alternative method is an acceptable means of complying with FAA regulations. Because the method of compliance presented in an AC is not mandatory, the terms "shall" and "must" apply only to an applicant who chooses to follow this particular method without deviation.

ACARS – Aircraft Communications Addressing and Reporting System: A digital data link network providing connectivity between aircraft and ground end systems (command and control, air traffic control, etc.)

ACAS II – Airborne Collision and Avoidance System: International equivalent to TCAS II, version 7 [see “TCAS”]

Accuracy – For Navigation: The degree of conformance between calculated position and true position.

Accuracy – For Navigation Data: The degree of conformance between estimated or measured value and its true value.

ACL – ATC Clearances: The service, associated with Link 2000+, that allows the aircrew request and delivery of en route clearances such as level, heading, speed, direct route, and rate of climb/descent.

ACM – ATC Communication Management: The service, associated with Link 2000+, that supports the transparent transfer of data communications, un-synchronization with the transfer of voice communications.

ACO – Aircraft Certification Office: An FAA organization. There are many ACOs throughout the USA. Primary concern is operational safety, which includes monitoring the safety performance of certified or approved aeronautical products, and monitoring FAA representatives. It makes findings of compliance, based upon the showing of compliance to the Federal Aviation Regulations, on products presented to the FAA for certification.

ACTFAST – ATC Communications Test Facility and Avionics System Test: The ACTFAST is located at Edwards AFB, CA. It benefits program offices, integrators, and test centers by serving as an air traffic control ground end system for ground and flight test. ACTFAST allows users to test air traffic control data link applications over a live network.

ADL – Aeronautical Data Link: A digital network providing communication between aircraft and ground systems.

ADS-A – Automatic Dependent Surveillance-Addressed: Also known as ADS-C. [see ADS-C]

ADS-B – Automatic Dependent Surveillance-Broadcast: A vehicle or object will broadcast a message on a set regular basis which includes its position (such as lat, long, altitude), velocity, and possibly other information. These position reports are based on accurate navigation systems. There are three accepted links, ADS-B: 1090 Extended Squitter [see “1090 Extended Squitter”], Universal Access Transceiver [see “UAT”], and VDL-4 [see “VDL-4”]. Military aircraft will use 1090 ES with few exceptions.

ADS-C – Automatic Dependant Surveillance-Contract: ADS-C is the same as ADS-A. Automatic Dependent Surveillance-Addressed is a data link application that provides for contracted services between ground systems and aircraft. Contracts are established such that the aircraft will automatically provide information obtained from its own on-board sensors, and pass this information to the ground system under specific circumstances dictated by the ground system (except in emergencies).

AEEC – Organization that creates value for airlines and the aviation industry by developing engineering standards and technical solutions for avionics, networks, and cabin systems throughout the aircraft. AEEC was established to foster increased efficiency and reduced life cycle costs throughout the aviation community.

AERO-C – Inmarsat satellite service providing store-and-forward message capability. Aero-C provides data rates of approximately 600bps.
Appendix B:  
CNS/ATM Glossary (cont’d)

AERO-H – Inmarsat satellite service providing high gain multi-channel digital voice [9.6kbit/sec], fax [4.8 KB/sec] and data [2.4 KB/sec] services.

AERO-I: Inmarsat satellite service providing intermediate gain multi-channel digital voice/circuit-mode data, fax, and packet data services; operates in the spot beams (which have lower power requirements) of the new generation INMARSAT-3 satellites.

AERO-M (aka “Mini-M Aero”): INMARSAT satellite service providing single channel, two-way voice and data communication services. Aero-M provides data rates of approximately 2400bps.

AFFSA – Air Force Flight Standards Agency: Located at Tinker AFB, OK, AFFSA develops, standardizes, evaluates and certifies procedures, equipment, and standards to support global flight operations and to centrally manage ATCALS for the AF.

AFMSS – AF Mission Support System: A family of systems that provide automated mission planning materials, preparation, and post-mission debriefing reports. The AFMSS family includes the Portable Flight Planning Software (PFPS-PC based) and the Joint Mission Planning System (JMP-PC Based). Both the MPS and PFPS consist of the following software components:

Core: Basic mission planning functions.
Avionics/Weapons/Electronics (A/W/E) - Specific aircraft planning functions. AMC uses a single A/W/E concept called Tanker, Airlift, & Special Mission (TASM). TASM is a common A/W/E core with the integration of individual aircraft modules.
Flight Performance Module (FPM) - Aircraft flight performance data (takeoff & landing data, fuel calculations, etc.).

Combat Weapons Delivery Software (CWDS) - Used by ACC aircraft for gravity weapons delivery.

Precision Guided Munitions (PGM) A/W/E - Used by ACC aircraft for PGM mission planning. There is a unique planning module for each different PGM. PFPS incorporates a limited PGM planning capability.

AFN – ATS [Air Traffic Services] Facilities Notification: ATS Facilities Notification (AFN) provides for the initiation of FANS-1A data exchange between a pilot and controller via data link. AFN is initiated by the pilot prior to entering FANS-1A airspace and is essentially an introduction between the aircraft and the Air Traffic Services (ATS) facility.

AFTN – Aeronautical Fixed Telecommunications Network: The standard ground – ground communication network used by ATC; it’s based on teletypewriter technology.

AIMS – ATCRBS/IFF/MKXXII System Program Office: Located at Warner-Robins AFB, the AIMS program office oversees the compliance and overall performance of Interrogator Friend or Foe (IFF) systems for the DoD. Because IFF reply systems are integrated in the transponder, they certify both transponders and transponder installations. Additionally, they certify IFF interrogators, both airborne and land based. Their role includes international (including NATO) coordination of IFF installations.

AMC – ATC Microphone Check: The service, associated with Link 2000+, that provides controllers with the capability to up-link an instruction for all aircraft to check that they are not inadvertently blocking a given voice channel.

AOA – ACARS Over Aviation VHF Link Control: AOA is an attempt at gaining some early benefits of digital technology without the full risk of ATN. It is a step between full ACARS and full ATN. The most significant near-term benefit is the reduction of VHF congestion problems by transitioning traffic to the VDL-2 air/ground network. AOA allows airborne and airborne host applications to remain unchanged (character format). The airborne AOA process packages the data so that it can be routed over the digital VDL-2 network. At some point on the ground, the data is restored to its original format for processing by legacy airline host applications. It moves data at 31.5kbps vs. ACARS’ 2.4kbps service.

AOC – Airline Operational Control [aka Aeronautical Operational Control]: Operational messages used between airline and airline dispatch centers or, by extension, the DoD to support flight operations. This includes, but is not limited to, flight planning, flight following, and the distribution of information to flights and affected personnel.

APV – Approach Procedure with Vertical Guidance: A non-precision approach using GPS that has some vertical guidance. This vertical guidance is less precise than that for a precision approach (e.g., ILS) and therefore the approach minimums (weather, ceiling, and visibility) are higher.

AQP – Avionics Qualification Program: A series of tests and compliance procedures intended to validate and qualify avionics suites for operation over the ARINC network.

ARINC – A global industry leader depended on by airlines around the world to deliver flexible, highly-reliable, cost-effective solutions, to evolve and adapt technology that optimizes and expands customer capabilities, and to seamlessly meld a true GLOBALink of voice and data communications.
Appendix B: 
CNS/ATM Glossary (cont’d)

ARTCC – Air Route Traffic Control Center: United States facilities responsible for controlling instrument flight rules aircraft en route in a particular volume of airspace at high altitudes between airport approaches and departures. There are twenty-one ARTCCs in the United States National Airspace System (NAS).

ATN – Aeronautical Telecommunications Network: An internetwork architecture that allows ground地面, air地面, and avionic data sub networks to interoperate by adopting common interface services and protocols based on the ISO OSI Reference Model.

ATOP – Advanced Technologies and Oceanic Procedures: Replaces systems at the Anchorage, New York, and Oakland centers. The new system will collect, manage, and display oceanic air-traffic data (including electronic flight-strip information) on the computer displays.

ATSU – Air Traffic Services Unit: A unit established for the purpose of receiving reports concerning air traffic services and flight plans submitted before departure. It is a generic term meaning air traffic control unit, flight information center, or air traffic service reporting office.

Availability – For Navigation: It is the percentage of the time that the required accuracy and integrity are useable to meet a specified flight phase.

BLOS – Beyond Line of Sight: Oceanic or remote communications that are not line-of-sight (LOS). SATCOM and High Frequency Data Link (HFDL) are examples of BLOS data link systems.

BRNAV – Basic Area Navigation: Now known as RNAV-5. Implemented in Europe in 1998 for altitudes above FL 095, it's essentially an area navigation [RNAV] capability with an accuracy equivalent of RNAV-5. BRNAV can be achieved using ground navigation aids, self-contained reference systems, GPS, or a combination thereof.

CANSO – Civil Air Navigation Services Organization: The global voice of the companies that provide air traffic control. Founded in 1996, it represents the interests of the Air Navigation Service Providers (ANSPs) worldwide.

CAPSTONE – A joint industry and FAA Alaskan Region effort to improve Alaskan aviation safety and efficiency through installation of government-furnished Global Positioning System (GPS)-based avionics and data link communications suites in most commercial aircraft. Compatible ground systems, equipment, and services will also be provided. In addition to the avionics suites, it will deploy a ground infrastructure for weather observation, data link communications, surveillance, and Flight Information Services to improve safety and enable eventual implementation of new procedures. The demonstration areas are non-radar environments where most of the air carrier operations have been limited to VFR.

CAT I – Category I: An instrument approach or approach and landing with a decision altitude (height) or minimum descent altitude (height) not lower than 200 ft and with either a visibility not less than 1/2 statute mile, or a runway visual range not less than 1800 ft. [ref AC 120-29a]

CAT II – Category II: An instrument approach or approach and landing with a decision height lower than 200 ft but not lower than 100 ft and a runway visual range not less than 1200 ft. Runway lighting criteria must be met and be operational. The FAA approves U.S. carriers for Cat II operations in specific aircraft. It also approves specific runways at specific airports for Cat II operations. [ref AC 120-29a]

CAT III – Category III: An instrument approach or approach and landing with a decision height lower than 100 ft, or no decision height, or a runway visual range less than 1200 ft. (Adapted from ICAO - IS&RP Annex 6).

Category IIIa: An instrument approach and landing with a decision height lower than 100 ft, or no decision height and a runway visual range not less than 700 ft.

Category IIIb: An instrument approach and landing with a decision height lower than 50 ft, or no decision height and a runway visual range less than 700 ft but not less than 150 ft. [FAA Note - the United States does not use Decision Heights for Category IIIb.]

Category IIIc: An instrument approach and landing with or without a decision height, with a runway visual range less than 150 ft.

The aircraft uses its FMS, autopilot, and auto-throttles for approach and landing. Runway lighting criteria must be met and be operational. The FAA approves U.S. carriers for Cat III operations in specific aircraft. It also approves specific runways at specific airports for Cat III operations.

CDTI – Cockpit Display of Traffic Information: Avionics technology that displays the relative location of nearby aircraft to enhance the pilot’s awareness of the surrounding environment.

CMU – Communication Management Unit: The CMU performs two important functions: it manages access to the various data link sub-networks and services available to the aircraft and hosts various applications related to data link. It also interfaces to the flight management system (FMS) and to the crew displays.
Appendix B:  
CNS/ATM Glossary (cont’d)

CNS/ATM – Communication, Navigation, Surveillance/Air Traffic Management: CNS/ATM is a system based on digital technologies, satellite systems, and enhanced automation to achieve a seamless global Air Traffic Management in the future. Modern CNS systems will eliminate or reduce a variety of constraints imposed on ATM operations today.

Continuity – For Navigation: This is the probability that a navigation system will maintain its performance level for the duration of an operation presuming system availability at the beginning of that period.

CPDLC – Controller-Pilot Data Link Communications: The CPDLC application provides for the exchange of flight planning, clearance, and informational data between a flight crew and air traffic control. This application supplements voice communications and in some areas will likely supersede it in the future.

CRC – Cyclical Redundancy Check: A CRC, or polynomial code checksum, is a non-secure hash function designed to detect accidental changes to raw computer data, and is commonly used in digital networks.

CRD 1 – Capstone Requirements Document 1: Establishes requirement to equip airlifters, tankers, operational support/DV, aero medical evacuation, and "special use" aircraft (e.g., JSTARS E-8 and AWACS E-3) to operate in civil airspace to the extent required by their missions.

CRD 2 – Capstone Requirements Documents 2: Properly known as Phase II annex to CRD 1, it covers all aircraft not listed in CRD 1.

CVR – Cockpit Voice Recorder: A CVR is a flight recorder used to record the audio environment in the flight deck of an aircraft for the purpose of investigation of accidents and incidents. This is typically achieved by recording the signals of the microphones and earphones of the pilots' headsets and of an area microphone in the roof of the cockpit. Each recorder is equipped with an Underwater Locator Beacon (ULB). The device, called a "pinger," is activated when the recorder is immersed in water. The beacon can transmit from depths down to 14,000 feet. It records the last continuous 30 min (2 hours for solid state digital units) and then recycles.


DAP – Down link Aircraft Parameters: This is data down-linked to the ground, via the Mode S transponder, that provides information about the aircraft operations and planned route. The three types of DAP are “basic functionality” (altitude, squawk code, transponder capability, and flight status), “elementary” (ELS) surveillance additionally providing Flight ID (Call sign) and RA downlink, and “enhanced” (EHS) and functionality providing flight intent and additional operation information.

DAR – Designated Airworthiness Representative: An individual appointed by the FAA who may perform examination, inspection, and testing services necessary to the issuance of certificates. There are two types of DARs: manufacturing and maintenance. A Manufacturing DAR must possess aeronautical knowledge, experience, and meet strict qualification requirements. A Maintenance DAR must hold a mechanic's certificate with an airframe and power plant rating.

Decision Altitude: The decision altitude (DA) is the altitude, relative to mean sea level (MSL), a pilot must acquire visual contact of the approach runway for landing or otherwise initiate a missed approach. The DA reference is replacing the decision height (DH) reference as the international standard term.

Decision Height: The decision height (DH) is the altitude, relative to height above ground level (AGL), a pilot must acquire visual contact of the approach runway for landing or otherwise initiate a missed approach. This term is being replaced by DA.

DER – Designated Engineering Representative: An individual who can approve engineering data, recommend approval of test plans and witness engineering tests on behalf of the FAA.

DGPS – See GPS-D

DLIC – Data Link Initiation Capability: The service, associated with Link 2000+, that is initiated by the aircrew on first contact with an ATC unit that supports data communication. It is a pre-requisite to the operational data link services.

DME – Distance Measuring Equipment: The DME is an L-Band navigation aid that is used by an aircraft to determine its distance from a known point (the DME ground station transponder). DME avionics include an interrogator that transmits omnidirectional radio frequency pulses that are received on the ground by the DME transponder. After a predetermined delay, the pulses are retransmitted back to the aircraft on a paired frequency and the roundtrip delay is measured minus the predetermined delay. The delay time is translated into the distance from the DME ground station.
Appendix B: CNS/ATM Glossary (cont’d)

DME/DME – Scanning Distance Measuring Equipment: DME/DME is a navigation capability that uses the distance to known DME stations to determine position, somewhat similar to GPS. The scanning DME or DME/DME function is implemented in the FMS. Using DME/DME positions, an FMS references the flight plan to determine DME stations with the appropriate geometry to provide a position solution. Once the position is established the FMS calculates the deviation to the flight plan course.

DRVSM – Domestic RVSM: This is the US program to require RVSM over CONUS.

DTED – Digital Terrain Elevation Data: An NGA product, DTED is a uniform matrix of terrain elevation values which provides basic quantitative data for systems and applications that require terrain elevation, slope, and/or surface roughness information for military applications.

EASA – European Aviation Safety Agency: Agency of the European Union (EU) which has been given specific regulatory and executive tasks in the field of civilian aviation, taking over functions of the Joint Aviation Authorities (JAA). The agency’s responsibilities include: giving advice to the EU for drafting new legislation; implementing and monitoring safety rules, including inspections in the Member States; type-certification of aircraft and components, as well as the approval of organizations involved in the design, manufacture and maintenance of aeronautical products; authorization of third-country (non EU) operators; safety analysis and research.

ECAC – European Civil Aviation Conference: International organization developed to promote the continued development of a safe, efficient, and sustainable European air transport system by harmonizing civil aviation policies and practices amongst its Member States and promoting understanding on policy matters between its Member States and other parts of the world.

EFIS – Electronic Flight Instrumentation System: Digital display that combines aircraft attitude and performance data from different sources on a single display.

EGI – Embedded GPS/INS: A military, self-contained position source which provides positioning, velocity, and acceleration data for the aircraft. The EGI receives signals from GPS that are blend with INU data in a Kalman Filter for processing by a flight management function for navigation.

EGNOS – European Geostationary Navigation Overlay Service: Europe’s counterpart to WAAS [see “WAAS”].

EGPWS – Enhanced Ground Proximity Warning System: Honeywell’s trademark name for TAWS [see “TAWS”]. Designed to complement or replace the current functions of GPWS and provide terrain warnings in situations where the current GPWS does not. The two key major functions are forward looking terrain alerting and terrain display. Both functions use the EGPWS self-contained worldwide airport and terrain databases, which are used in conjunction with aircraft position (from the FMS), barometric altitude (from Air Data System), and flight path information (from Air Data System) to determine potential terrain conflicts and providing much earlier alerting than is possible with the basic GPWS. The EGPWS provides caution/warning-level alerts and then calculates corresponding envelopes. If these envelopes conflict with data in the terrain database, alerts are activated. The look-ahead caution alert is provided approximately 40 to 60 seconds before a potential terrain conflict. The look-ahead warning alert is provided approximately 20 to 30 seconds before such a conflict.

ELT – Emergency Locator Transmitter: A “Nav/Safety” item. A crash resistant box that emits a signal on VHF/UHF frequencies (121.5 MHz, 243.0 MHz and 406.025 MHz) to aid in locating a downed aircraft.

E-TCAS – Enhanced TCAS: A military-unique TCAS application for tankers that is used for air refueling rendezvous.

EUROCAE – European Organization for Civil Aviation Equipment: A nonprofit organization that was formed in Europe to provide a forum for resolving technical problems with electronic equipment for air transport. EUROCAE is similar to RTCA in the United States.

EUROCONTROL – European Organization for the Safety of Air Navigation: An inter-governmental organization made up of 39 Member States and the European Community whose primary objective is the development of a seamless, pan-European Air Traffic Management (ATM) system that is safer, performance-driven, and environmentally sustainable.

FANS-1/A – Future Aircraft Navigation System 1/A: A set of operational capabilities centered around direct data link communications between the flight crew and air traffic control. Operators benefit from FANS-1/A in oceanic and remote airspace around the world.

FAR – Federal Aviation Regulations: Rules prescribed by the FAA governing all aviation activities in the United States.

FDE – Fault Detection/Exclusion: A GPS receiver processing scheme that autonomously provides automatic determination of which GPS satellite(s) tracked by the receiver is (are) causing the RAIM [see “RAIM”] alert. It requires six or more visible satellites. The FDE consists of two distinct parts: fault detection and fault exclusion. The fault detection part identifies the faulty satellite(s). Upon detection, fault exclusion follows and excludes the faulty satellite(s) from the GPS navigation solution. Flight in some civil airspace requires both RAIM & FDE.
Appendix B:
CNS/ATM Glossary (cont’d)

FDR – Flight Data Recorder: A flight recorder used to record specific aircraft performance parameters for accident investigation, as well as analyzing air safety issues, material degradation, and engine performance. These devices are carefully engineered and sturdily constructed to withstand the force of a high speed impact and the heat of an intense fire. The exterior of the FDR is coated with heat-resistant bright orange paint for high visibility in wreckage, and the unit is usually mounted in the aircraft's tail section, where it is more likely to survive a severe crash. Each recorder is equipped with an Underwater Locator Beacon (ULB). The device, called a "pinger," is activated when the recorder is immersed in water. The beacon can transmit from depths down to 14,000 feet. It records for 25 continuous hours.

FHA – Functional Hazard Assessment: Conducted at the beginning of the aircraft/system life cycle, it identifies and assesses each hazard (e.g., loss of attitude indication), identifies the potential effects (e.g., hull loss) of each hazard, and classifies (e.g., catastrophic) each hazard based on the potential effects. Identifies the required level (e.g., “A”) of system development assurance. The FHA is used as the starting point for conducting the (PSSA). (Ref. SAE ARP 4754)

Final Approach Segment: The final approach segment is defined between the final approach fix (FAF) and a missed approach point (MAP) with associated minimum descent altitude (MDA), decision height (DH) or decision altitude (DA). The final approach segment is straight without any maneuvering, aligns with the runway centerline laterally and terminates in either a landing or missed approach. Note, there are final approach segments that are associated with the airport in general, not a specific runway, that are circling approaches. The final approach segment has a vertical component, identified by a minimum descent altitude, or by a defined glide path terminating in a DH or DA.

FLEX TRACKS – Optimal flight routes calculated each day using the most recent weather information, these routes take advantage of prevailing wind patterns.

FMI – Frequency Modulation Immunity (aka P-ILS, Protected-ILS): European FM radio signals may interfere with aeronautical ILS, VOR, and VHF voice communications. Therefore, the affected countries require aeronautical radios be immune from these affects. FMI requirements refer to P-ILS and VOR receivers. Protection from VHF voice interference is covered by the ICAO VHF radio requirement and the stipulation that all new 8.33 kHz radios will meet ICAO requirements. Waivers, which are difficult/impossible to obtain, only allow unmodified aircraft to file IFR flight plans. Unmodified aircraft must have suitable avionics for landing in existing/forecasted weather.

FMF – Flight Management Function: A collection of processes or applications that facilitates area navigation (RNAV) and related functions to be executed during all phases of flight. The FMF is resident in an avionics computer and automates navigational functions reducing flight crew workload particularly during instrument meteorological conditions. The Flight Management System encompasses the FMF.

FMS – Flight Management System: A computer system that uses a large database to allow routes to be preprogrammed and fed into the system by means of a data loader. The system is constantly updated with respect to position by reference to designated sensors. The sophisticated program and its associated database insure that the most appropriate aids are automatically selected during the information update cycle. The flight management system is interfaced/coupled to cockpit displays to provide the flight crew situational awareness and /or an autopilot.

Free Flight – A safe and efficient operating capability under instrument flight rules in which the operators have the freedom to select their path and speed in real time.

GAT – General Air Traffic: This designation refers to aircraft flying under civil aviation rules on civil aviation routes. [see “OAT”]

GBAS – Ground-Based Augmentation System: The ICAO defines GBAS as a system that augments ground systems (typically at an airport) with equipment similar in functionality to a GPS satellite. This augmentation allows an aircraft to determine its vertical/lateral position to very great accuracy. The ultimate goal is CAT IIIIC operation. The US LAAS is a GBAS.

GBSAA – Ground-Based Sense and Avoid: The use of ground-based radars, control systems, communications links and procedures to provide for the safe operation of Remotely Piloted Aircraft (RPA)/Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS).

GICB -- Ground-initiated Comm-B: The ground-initiated Comm-B protocol allows the interrogator (e.g., Mode S radar) to extract data from the 255 registers within the aircraft transponder. Registers 1816 through 1C16 are the "GICB Capability Reports" and indicate which of the 255 registers have received data. The "Common Usage GICP Capability Report" (register 1716) indicates the presence of valid information in 29 of the commonly used registers.

GLONASS – Global Navigation Satellite System: Russia’s satellite positioning system. It has 27 satellites currently on orbit. The GLONASS signal format is incompatible with GPS.
Appendix B: CNS/ATM Glossary (cont’d)

GLS – GNSS Landing System: A safety-critical system consisting of the hardware and software that augments the GPS SPS to provide for precision approach and landing capability (much like the ground-based ILS does now). The positioning service provided by GPS is insufficient to meet the integrity, continuity, accuracy, and availability demands of precision approach and landing navigation. The GLS augments the basic GPS position data in order to meet these requirements. These augmentations are based on differential GPS concepts.

GMU – GPS-based Monitoring Unit: The size of a small suitcase, it features an on-board monitoring and recording unit composed of a GPS receiver, computer, and flight deck window antennae. An alternative to the HMU [see "HMU"] as a means to check aircraft for RVSM compliance.

GNSS – Global Navigation Satellite System: GNSS is the ICAO recognized term for space-based navigation systems that provide en route/terminal navigation with non-precision approach and precision approach capabilities. The U.S. system is GPS.

GPS – Global Positioning System: A minimum of 24 satellite constellation in six orbits 11,000 miles above the earth. Positioned so that users can receive signals from six satellites nearly 100% of the time at any point on Earth. Developed by DoD primarily for military purposes. When receiving signals from at least four satellites, a GPS receiver can determine latitude, longitude, altitude and time. Without RAIM [see “RAIM”] and FDE [see “FDE”], the user can not be certain that GPS meets the accuracy, availability, and integrity requirements critical to safety of flight.

GPS-D – Differential GPS: DGPS is a GPS augmentation that uses differential corrections to the basic satellite measurements that are performed within the receiver. DGPS is based upon accurate knowledge of the geographic location of Earth reference stations. This knowledge is used to compute corrections to GPS parameters, error sources, and/or resultant positions. These differential corrections are then transmitted to GPS users, either from a ground-based station (e.g., LAAS) or from a satellite-based system (WAAS, EGNOS, GALILEO, etc.). GPS receivers apply the corrections to their received GPS signals and compute a more optimum position. For a civil user, differential GPS can improve navigational accuracy from 100 meters to better than 10 meters.

GPS-PPS – GPS-Precise Positioning Service: The military maintains exclusive access to the more accurate "P-code" (pseudo random code). PPS is more accurate, and much harder to jam and to spoof. P-code is a pseudorandom number that enables ranging and satellite identification to be accomplished. The P-code is encrypted by another function identified as the Y-code to provide an anti-spoofing capability. Thus the GPS P(Y)-code designation is used to describe the military PPS signal.

GPS-SPS – GPS Standard Positioning Service: One of two levels of GPS service used by both the military and civil aviation community in order to support aircraft navigation and landing. Since a Presidential Order turned Selective Availability off, SPS horizontal accuracy is about 10 meters (vs. about 100 meters when SA is on).

HFDL – High Frequency Data Link: An ACARS communications media used to exchange data link messages between aircraft end-systems and corresponding ground-based HFDL ground stations. Using the unique propagation characteristics of high-frequency radio waves, the ground stations provide data link communications to properly equipped aircraft operating anywhere in the world.

HMU – Height Monitoring Unit: A passive, ground-based system that measures the geometric height of an aircraft for comparison with the geometric height of the flight level at which it is being flown. It consists of a set of ground stations arranged as a central site, with four additional receivers arranged in a square. Each site receives aircraft radar transmissions, from which the aircraft’s three-dimensional position is derived. The HMU calculates altimetry system error using meteorological information and the Mode-C/S height data.

ICAO – International Civil Aviation Organization: A major agency of the United Nations, ICAO codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth. ICAO establishes international standards, recommended practices, and procedures covering the technical fields of aviation.

IFR – Instrument Flight Rules: The rules that govern the conduct of aircraft during instrument flight. These rules can apply when weather is clear and visibility is unlimited (e.g., when aircraft fly at high altitudes or when executing an instrument approach). Sometimes heard in the context of weather conditions at an airfield (e.g., "The field is IFR."). This means that the airfield is below Visual Flight Rules (VFR) weather minimums.

II/SI Codes – Interrogator Identifier/Surveillance Identifier Codes: Mode S surveillance and communication functions are designed to allow Mode S interrogators with overlapping coverage to operate without any real-time coordination. This is made possible partly by the use of 15 II and the new 63 SI codes which uniquely identify each site. Transponders need to be able to support both code formats for the system to work, or SI codes cannot be used until all aircraft in a region of airspace are equipped. Operation with less than 100% equipage will result in overlapping interrogators having incomplete surveillance coverage.
Appendix B:  
CNS/ATM Glossary (cont’d)

**Initial Approach Fix:** The initial approach fix (IAF) is either a waypoint/fix in the en-route structure or a procedure reference that defines the beginning of an approach procedure. The location of the IAF is defined at an altitude by latitude and longitude coordinates for RNAV systems or by course and distance references.

**Initial Approach Segment:** The initial approach segment is defined between the initial approach fix (IAF) and the intermediate fix (IF). The initial approach segment transitions an aircraft from the en-route structure to the approach procedure. An initial approach segment may be straight or constructed with several way points, contain various legs, or require procedure or other types of turns between the IAF and IF.

**Inmarsat**™ – A leading provider of global mobile satellite communications, Inmarsat provides voice and high-speed data services to almost anywhere on the planet – on land, at sea and in the air. Services allow passengers to make calls, access email and the internet – while enabling the pilot to maintain direct contact with air traffic control, receive real-time weather information, access the most fuel-efficient flight paths and transmit the aircraft’s position and maintenance status to ground staff.

**INS – Inertial Navigation System:** A self contained, dead reckoning system that senses the acceleration along the three axes of the aircraft and calculates the distance traveled from a reference point. Accuracy of the system decreases with time from previous alignment of update from a time independent reference system such as GPS.

**Integrity – For Navigation:** Ability of a system to provide timely warnings or shut itself down when it shouldn't be used for navigation.

**Intermediate Approach Segment:** The intermediate approach segment is defined between the intermediate fix (IF) and the final approach fix (FAF). The intermediate approach segment enables the aircraft from various initial approach segments to transition to the final approach. Intermediate approach segments may be straight or constructed with several way points and contain various leg types and/or turns prior to the FAF.

**Intermediate Fix:** The intermediate fix (IF) identifies the waypoint/fix associated with a transition point between the initial segment and the intermediate segment. The location of the IF is defined at an altitude by latitude and longitude coordinates for RNAV systems or by course and distance references for conventional approaches.

**Iridium**® – The second largest provider of mobile voice and data communications services via satellite, and the only commercial provider of communications services offering 100% global coverage. Iridium maintains a constellation of 66 in-orbit satellites and utilizes an interlinked mesh architecture to minimize the need for ground facilities to support the constellation and facilitate the global reach of their services. Aviation-based services include air-to-ground telephony, data communications for email, emergency tracking, weather information, electronic flight bag updates and fleet information.

**IRS – Inertial Reference System:** Uses laser gyroes vice an INS' accelerometers placed on gyro-stabilized platforms.

**Jeppesen** – An American company that specializes in aeronautical charting and navigation services, flight planning, pilot supplies, and aviation training. The company is a subsidiary of The Boeing Company. Jeppesen also publishes related software, some of which is used on its electronic flight bag product line. The Jeppesen navigation database is used in some USAF aircraft but most aircraft use NGA’s DAFIF database that includes military airspace.

**JMPS – Joint Mission Planning System:** The Windows based mission planning system that replaces Portable Flight Planning System. It has the following software components:

- **JMPS Framework** - Contains the map display and combat mission planning functions.
- **Common Capabilities** - Mission planning functions that are integrated with the JMPS Framework based on the aircraft requirements and are also used by other aircraft platforms (e.g., airdrop tool, air refueling tool, etc).
- **Unique Planning Component [UPC]** - Contains the unique aircraft planning functions as well as the software for loading the mission planning data to the data transfer device for transfer to the aircraft.
- **Flight Performance Module** - No change from PFPS or MPS
- **Combat Weapons Delivery Software (CWDS)** - Same configuration as used with PFPS or MPS
- **Precision Guided Munitions Planning Software (PGMPS)** - One mission planning module with planning capabilities for all USAF PGMs.

**JPALS – Joint Precision Approach and Landing System:** A deployable, interoperable, anti-jam system that uses differential GPS for guidance.
Appendix B:
CNS/ATM Glossary (cont’d)

KPP – Key Performance Parameters: Requirements that come under Communications, Navigation, Surveillance, Nav/Safety, Situation Awareness, and Supporting Capability and are listed in the CRD1 and CRD2.

LAAS – Local Area Augmentation System: A ground-based augmentation to the GPS to provide Category I, II, and III (WAAS provides “near CAT I”) precision approaches and precise surface navigation. The LAAS is intended to complement the WAAS and function together. It is the U.S. implementation of the ICAO-recognized GBAS [see “GBAS”].


LNAV – Lateral Navigation: The terminology for a DME/DME or GPS approach where lateral guidance is being provided along a designated course. LNAV incorporates RNP requirements, generally RNP 0.3 accuracy, and all monitoring, alerting, integrity and continuity limits for the navigation system and aircraft.

MASPS – Minimum Aviation System Performance Standards: High level documents produced by RTCA that establish minimum system performance characteristics.

MASS – Military Airborne Surveillance System: An enhancement to ACSS’ TCAS 2000 system that adds rendezvous and formation station-keeping capabilities.

MFD – Multi Function Display: Cockpit display with multiple views that shows aircraft information

Mini-SR&O – Mini System Requirements & Objectives: This publicly releasable document is produced by a USAF aircraft integrator in order to document the specific features, options, and deviations as compared to the baseline FANS-1/A system. This document is utilized by Air Traffic Service Providers (ATSPs) around the world to understand a specific aircraft configuration and attempt to ensure end-to-end interoperability.

Minimum Descent Altitude: The minimum descent altitude (MDA) is the lowest altitude (MSL) that can be safely used for a particular procedure given obstacle clearance requirements for that procedure.

Missed Approach: The missed approach can occur at any point on the approach if the pilot or ATC determines a successful landing is not possible or other problem occurs. A missed approach must be executed at the MAP if visual contact with the approach runway has not been achieved by the pilot. The missed approach procedure provides a pilot a course, fixes, waypoints, navigational facility references and altitude information to safely avoid obstacles in the missed approach area. The missed approach procedure enables the pilot or the pilot with ATC direction to be sequenced back into the air traffic flow.

Missed Approach Point: The missed approach point (MAP) is a waypoint, navigational facility or a fix along the approach that contains the DA. The MAP defines the point where the missed approach must be initiated if visual contact with the approach runway cannot be achieved thus resulting in a successful landing.


Mode S – Mode Select: An evolutionary replacement for the Air Traffic Control Radar Beacon System (ATCRBS). The primary role of the Mode S transponder is to “selectively” respond to interrogations (as opposed to responding to all interrogations) from a ground sensor or a Traffic Alert and Collision Avoidance System (TCAS) to provide airborne data information including identification (24-bit code), equipage, and altitude. [see “DAP” and “II/SI Codes”]

MOPS – Minimum Operational Performance Standards: Standards produced by RTCA that describe typical equipment applications and operational goals and establish the basis for required performance. Definitions and assumptions essential to proper understanding are included as well as installed equipment tests and operational performance characteristics for equipment installations. MOPS are often used by the FAA as a basis for certification.


MSO – Military Standard Order: Like the FAA’s TSO [see “TSO”]. GPSs with an MSO will be considered equivalent to those with a TSO.

NAS – National Airspace System: One of the most complex aviation systems in the world that enables safe and expeditious air travel in the United States and over large portions of the world's oceans.

NATS – North Atlantic Track System: Generated twice a day to provide the most fuel efficient routes for aircraft crossing the North Atlantic. Since the tracks are westbound during the day they are primarily set up to avoid the eastbound jet stream. Similarly at night when the flow of aircraft is mainly from North America to Europe they are generated to take advantage of the jet stream since this high velocity wind is generally flowing from west to east. There are days when the jet stream is not west to east but these are rare.
Appendix B: CNS/ATM Glossary (cont’d)

NATS – National Air Traffic Services: The United Kingdom’s air traffic services are privatized and provided by NATS, a private public partnership owned by a consortium of UK airlines, the NATS staff, and the government.

NAVWAR – Navigation Warfare: Protect military access to GPS in a challenged environment.

NEXRAD – Next Generation Weather Radar: Weather detection/display capability will enable controllers to identify the routes that avoid hazardous weather.

NGA – National Geospatial-Intelligence Agency: A DoD agency that provides imagery, imagery intelligence, and geospatial information (i.e., precise location and attributes of natural or constructed features and boundaries, referenced to positions on the Earth).

NOTAM – Notices To Airmen: Aviation information (e.g., status of airfield lighting, runways; departure/en route/arrival navigation aid status; info on ATC facilities, etc.) distributed to all airspace users.

OAT – Operational Air Traffic: Flights that are operating subject to military ATC rules and procedures, usually off published airways but sometimes on TACAN routes, and usually under military control.

OFP – Operational Flight Program: Software programmed into aircraft’s avionics systems. Each system (e.g., radar, central computer, etc) is reviewed and updated regularly.

ORT – Owner Requirement Tables: The ORT stores specific aircraft and operational data such as speed dialing of telephone numbers, selections of preferred GESs, audio interface characteristics, satellite identification, frequencies of channels, spot beam identification, GES identification, GES spot beam support table, and satellite location.

On-Off – Air Force requirement for operational security that allows the crew to shut off aircraft emitters.

PBN – Performance Based Navigation: PBN is a concept based on the use of Area Navigation (RNAV) systems that defines required performance in terms of accuracy, integrity, continuity and availability. The defined performance includes descriptions of how this capability is to be achieved in terms of aircraft and crew requirements. The general capabilities are defined in International Civil Aviation Organization (ICAO) Doc 9613, Performance Based Navigation Manual Implementation Guidance for National Airspace System (NAS) through Federal Aviation Administration Advisory Circulars.

P-ILS – See FMI

PLS – Precision Landing System: PLS is a general class of systems that provide lateral and vertical guidance for landing operations in instrument meteorological conditions. In general these systems support operation equivalent to instrument landing systems (ILS) Category I as defined in AC 120-29A.

PPS – See GPS-PPS

PSSA – Preliminary System Safety Analysis: Provides preliminary information, through discussion and analyses (e.g. FTA, FMEA, etc.), that the anticipated system design can meet the requirements, qualitative and quantitative, for each hazard. The PSSA process uses system design information as input, while at the same time generating derived safety requirements. The process is therefore iterative, and the document is updated throughout the development. Each version is less preliminary than the prior version. [Ref. SAE ARP 4754]

PSAC – Plan for Software Aspects of Certification: For (each element of) software associated with equipment being proposed for certification, the software developer describes and justifies how, and at what level, they will meet the objectives of DO-178B. [see DO-178B, section 11.1 for the required contents of a PSAC]

PRNAV – Precision Area Navigation, known as RNAV 1: Defines European RNAV operations in terminal areas which satisfy a required track-keeping accuracy of ±1 NM for at least 95% of the flight time. This level of navigation accuracy can be achieved using DME/DME, GPS or VOR/DME. It can also be maintained for short periods using an inertial system. The length of time that a particular IRS can be used to maintain RNAV-1 accuracy without external update is determined at the time of certification.

P-RAIM – Predictive RAIM: Determines RAIM availability for the ETA at the destination airport. While en route to the destination, predictive RAIM is automatically revised as the receiver continually calculates a new ETA. It’s critical to understand that just because the receiver predicts RAIM will be available at the destination, it doesn’t guarantee there will be sufficient satellite coverage on arrival, only that the receiver expects to have sufficient coverage to calculate RAIM. It’s possible, for example, that a satellite could go unhealthy while en route. Or signals from satellites low on the horizon could be masked by terrain (the receiver’s RAIM function has no way of knowing about terrain masking). P-RAIM does not have to reside in the GPS receiver. It can be provided by FAA Flight Service (US NAS only) and other ground-based RAIM algorithms.
Appendix B: CNS/ATM Glossary (cont’d)

RAIM – Receiver Autonomous Integrity Monitoring: RAIM is a two-step process. First, the receiver has to determine if five or more working satellites are above the horizon and in the proper geometry to make RAIM available. Second, it must determine if the RAIM algorithm indicates a potential navigation error, based upon the range solutions from those satellites. In other words, when the receiver indicates a “RAIM-not-available” alarm, it’s saying, “there may/may not be something wrong with the GPS navigation solution, but I don’t have enough satellite information to know for sure.” If it indicates a “RAIM error” alarm, it’s saying, “I have enough satellites available and there’s something wrong with one of them and the GPS navigation solution in general.” Flight in some civil airspace requires RAIM and FDE. [see “FDE”]

RCAT – Reconfigurable Cockpit Avionics Testbed: An ESC/HBAI resource located at MITRE, Bedford, MA that provides the Air Force with a hands-on demonstration, experimentation, training and test center. The RCAT is also used for advanced technology demonstrations that show how CNS/ATM equipment can be used to improve situational awareness and provide new command and control (C2) opportunities. The RCAT allows for a variety of instrumentation to be installed in its cockpit mockup.

RHSM – Reduced Horizontal Separation Minimums: RHSM is the resulting reduction in lateral clearance between aircraft, particularly in oceanic airspace, as a result of implementation of RNP-10 and RNP-4 route requirements. Lateral separations have been reduced to 50 nmi and 30 nmi, respectively. Note, that to be certified for 30 nmi, RNP-4, operations the aircraft must also be equipped with FANS communications equipment.

RNAV – Area Navigation: Rather than fly established airways from one ground navigation aid to another (that possibly results in an inefficient “zigzag” route), RNAV ability allows a flight to go directly from departure to destination using virtual waypoints in space (“ghost” NAVAIDs, as it were).

RNP – Required Navigation Performance: Prescribes the RNAV system performance necessary for operation in a specified airspace, based on its required accuracy (RNP value). The basic accuracy requirement for RNP-X airspace is for the aircraft to remain within X nautical miles of the cleared position for 95% of the time in RNP airspace.

RNP-AR – RNP Authorization Required [formerly Special Aircraft & Aircrew Authorization Required (SAAAR)]: Special FAA authorization to conduct RNAV approaches/missed approaches designated as such. Operators can be authorized for any subset of these characteristics: (1) ability to fly a published arc (also referred to as a RF leg); (2) reduced lateral obstacle evaluation area on the missed approach (also referred to as a missed approach requiring RNP less than 1.0). RNP AR is designated for approaches where the final approach segment procedure requires RNP values less than 0.3 NM.

RNP-RNAV – RNP Area Navigation: A method of area navigation that includes the concept of navigation performance (RNP), area navigation (RNAV) and the elements of containment integrity and containment continuity.

RTCA – A private, not-for-profit corporation that develops consensus-based recommendations regarding CNS/ATM system issues. RTCA functions as a Federal Advisory Committee. Its recommendations are used by the FAA as the basis for policy, program, and regulatory decisions and by the private sector as the basis for development, investment, and other business decisions.

RVSM – Reduced Vertical Separation Minimum: Reduces the vertical separation between properly equipped aircraft to 1000 ft in RVSM airspace FL290-410, inclusive.

SAASM – Selective Availability Anti-Spoofing Module: The next generation security functions for all GPS-PPS [see “GPS-PPS’] users, it is an architecture, not a chip. Selective Availability refers to the variations that the DoD can put in the GPS signal to keep unauthorized users from achieving the full accuracy of the GPS system. Keyed GPS-PPS receivers are capable of removing the SA alterations to the data messages. SA is currently set to zero to allow all users full access to the accuracy of the system. SAASM includes unclassified (black) keys; cryptography that supports direct Y-code acquisition, over-the-air rekeys, and tamper protection for all classified keys and algorithms. SAASM is intended to be 100 percent “backward compatible” (e.g., capable of being used with the current security keys and the existing GPS constellation) and will allow existing GPS receivers to distinguish between genuine and false GPS signals. SAASM will not impact SPS users. Anti-Spoof provides protection for authorized users by encrypting the GPS signal. Only keyed GPS receivers can decrypt and use this signal.

SAMS – Special Use Airspace Management System: A computer database that allows airlines, business aircraft operators and general aviation pilots to access the latest status information on special use airspace.

SARPS – Standards & Recommended Practices: Produced by ICAO, they become the international standards for member states. As the name implies, they are only “recommended” practices. It is up to each member states to decide how/if to implement them.

SATCOM – Satellite Communications: Communication service providing data, voice, and fax transmission via satellite. Allows aircraft to communicate in BLOS areas.
Appendix B:
CNS/ATM Glossary (cont’d)

SBAS – Satellite Based Augmentation System: A complex infrastructure of ground-based monitors and control centers that augments the satellite-based position measurement system to meet accuracy, availability, and integrity requirements for navigation systems. The WAAS in the US, the EGNOS in the Europe, and the MSAS in Japan are examples of an SBAS.

SESAR – Single European Sky ATM Research: European air traffic control infrastructure modernization program. SESAR aims at developing the new generation ATM system capable of ensuring the safety and fluidity of air transport worldwide over the next 30 years.

SID – Standard Instrument Departure: Published instrument departure from an airfield. The SID enables a pre-determined transition into the en route structure. Also identified as DP.

SITA – A European based corporation that provides air transport communications and information technology (IT) solutions. Among other things, SITA is a provider of air-ground data link communication services for use in CNS/ATM environments.

SPARC – Strategic Projection, Airspace Requirements, and Certification: A software application prepared by ESC/HBAI. It displays global and regional maps based on CNS/ATM implementation schedules; displays AFM platform CNS/ATM schedules; analyzes global civilian flight routes; examines non-compliance impacts resulting from CNS/ATM implementations.

SPS – See GPS-SPS

SR&O – (Air Traffic Services) Systems Requirements and Objectives: A certification artifact which describes the aircraft configuration, certain characteristics of the operational environment, and the safety and interoperability requirements for the systems and functions that support ATS via FANS-1/A. [see also “Mini-SR&O”]

SSA – System Safety Assessment: Collects, analyzes, and documents verification that the system, as implemented, meets the system safety requirements established by the FHA and PSSA. The SSA includes such items as the final results of all analyses, a list of safety maintenance tasks and intervals.

STAR – Standard Terminal Arrival Route: Published instrument arrival procedure for an airfield. Smoothes the flow of arriving aircraft.

STARS – Standard Terminal Automation Replacement System: An all-digital, integrated computer system with modern color displays and distributed processing networks. STARS workstation will display air traffic, weather overlays, and traffic flow management information for controllers.

STC – Supplemental Type Certificate: Certificate issued when an applicant has received FAA approval to modify an aircraft from its original design. The STC, which incorporates by reference the related type certificate, approves not only the modification but also how that modification affects the original design. Some military aircraft (e.g., the C-32, C-37, KC-10, E-4) have “type certificate,” meaning the FAA, not the military, provides certificate and the military’s integration contractor provides maintenance and logistics support.

SUA – Special Use Airspace: Airspace that has been identified for military use. Much of SUA is available for general use most of the time. It can be closed to non-military use with a two-hour notice.

SWIFT64 – INMARSAT high-speed data service which provides ample bandwidth for applications such as high-quality voice, email, internet and intranet access, large file transfer, and videoconferencing.

SWIFTBROADBAND – INMARSAT SwiftBroadband allow simultaneous users concurrent access to demanding applications. Data rates can be increased further by using compression and multiple data channels. It supports a choice of contended services and data streaming IP services as well as circuit-switched applications for backward compatibility. SwiftBroadband enables all key cockpit and cabin applications, including in-flight telephony, VoIP, text messaging, email, internet and VPN access, as well as flight plan, weather and chart updates.

TACAN – Tactical Air Navigation: A military L-band navigation aid that provides azimuth and distance information to military aircraft from a fixed ground station. Some ground stations (VORTACs) can be used by both TACAN-only and VOR/DME equipped aircraft.

TAWS – Terrain Awareness Warning System: Generic term for systems, including EGPWS [see “EGPWS”], that provide situational awareness relative to Controlled Flight Into Terrain (CFIT) and protection by providing three functions: Forward-Looking Terrain-Avoidance (FLTA), Premature Decent Alert (PDA) and Ground Proximity Warning.

TCAS – Traffic Alert and Collision Avoidance System: A general term for a family of airborne devices that function independently of the ground-based ATC system and provide collision avoidance protection. TCAS I provides proximity warnings to pilots in the form of traffic advisories (TAs), which display the intruding “transponder-only” traffic relative to the TCAS-equipped airplane. Traffic advisories generally include the range, altitude, and bearing of the intruding airplane. TCAS II provides both TAs and recommended vertical escape maneuvers, known as resolution advisories (RAs). Resolution advisories provide pilots with information to change a vertical flight path or prevent a maneuver that could cause insufficient separation between airplanes. TCAS II also coordinates RAs between two TCAS II-equipped airplanes (i.e., each pilot would receive an RA that would not conflict with the other RA).
Appendix B:
CNS/ATM Glossary (cont'd)

T2CAS – Terrain and Traffic Collision Avoidance System: Integrates TAWS [see "TAWS"] into TCAS [see "TCAS"] resulting in just one LRU for both functions. What that means to operators is that T2CAS will provide avoidance alerts based on the actual aircraft performance, not based on standard climb rates and an assumption that all critical functions are performing properly. This means elimination of nuisance conflict warning and alerts. For example, if an aircraft is approaching a mountain and one engine goes out, T2CAS will factor in the decreased performance while accurately alerting pilots of any potential avoidance maneuvers.

TDMA – Time-Division Multiple Access: A system of multiplexing in which channels are established by sharing a transmission media divided into time slots by an automatic distribution system. Transmission is in the form of a series of frames, each of which is divided into a number of slots. Each slot position across frames is dedicated to a particular transmitter. Frame rates and data rates vary by system.

TERPROM – A proprietary digital terrain system, it provides highly accurate, passive terrain referenced navigation, predictive ground proximity warning, terrain following, and weapon aiming benefits; uses stored digital elevation data which, when combined with navigation system and radar altimeter inputs, provides accurate drift free navigation, by day or night in all weather conditions. Although used on A-10, F-16, and C-17, only the latter is using TERPROM for Nav/Safety.

TIS – Traffic Information Service: There is TIS and TIS-B; both provide transmission of ground-based traffic information to an aircraft. TIS is an alerting service (“intelligence” is on the ground vice the aircraft) and provides automatic traffic advisories from a Mode-S sensor to a Mode S-equipped aircraft. Transmitted data is tailored for specific aircraft. TIS-B is a surveillance service (“intelligence” is in aircraft) that broadcasts surveillance information (e.g., GPS position) from a ground source to aircraft that have appropriate receiver. Ground source and data link do not have to be Mode S. [see “CDTI”]

TLS – Transponder Landing System: A computer-generated localizer and glide slope signal. Enables TIS precision where traditional ILS cannot be used (e.g., airports where nearby hills and/or obstacles can cause interference with the ILS). Required equipment: transponder, ILS receiver and display, and two-way radio. Unlike ILS that requires exact location, TLS can be located hundreds of feet from the desired runway centerline. The FAA has granted type acceptance (for Part 121 and 135 operators that fly with two crewmembers and dual nav/coms) and certified it to Cat 1 minimums.

TOAC – Time of Arrival Control: The TOAC function provides the temporal or speed control that enables 4 dimensional (4D) navigation to be accomplished. This function supports the spacing and metering associated with air traffic management and will be used for NextGen and SESAR operations.

TSE – Total System Error: TSE represents the difference between the true position of the aircraft and the intended path of the aircraft defined by the flight plan. The TSE is the root sum square (rss) of the Path Estimation Error (PEE), the Path Error (PDE) and the Flight Technical or Path Steering Error (FTE/PSE). It is measured in two dimensions; orthogonal to the flight path (cross path error) and along the flight path (long path error).

TSO – Technical Standard Order: A minimum performance standard issued by the FAA for specified materials, parts, processes, and appliances used on civil aircraft.

UAT – Universal Access Transceiver: Operating on 978 MHz, it is one of the two ADS-B link options in the USA. Operations with UAT are limited to below 18,000 in the FAA ADS-B rule.

UHF – Ultra High Frequency: The military uses the UHF band for voice communications (225.0MHZ to 399.75MHz).

VDL – VHF Data Link: Also known as VHF Digital Link, VDL is the LOS sub-network supporting data communications that are sent over VHF frequencies. The traditional VHF voice radio can be used in conjunction with a data modem to send data messages over VHF frequencies.

VDL-2 – VHF Data Link-Mode 2: A data link-only service designed to digitize VHF and improve the speed of the VHF link. VDL-2 will be used within the US and Europe as an interim data link solution for en route ATC functions. VDL-2 provides a 31.5 kbps channel rate.

VDL-4 – VHF Data Link - Mode 4: VDL-4 was developed by Sweden for ADS-B. It has SARPS, MASPS, and MOPS with some level of approval in Europe. It has a broadcast as well as a point-to-point communications capability. It’s single channel digital; uses multiple frequencies. Provides 9.6 - 31.5kbps channel rate.

VFR – Visual Flight Rules: Simply, flight that is clear of meteorological conditions that require use of flight instruments for horizon and directional reference. The rules stipulate minimum ceiling and visibility requirements and distance from clouds.

VHF – Very High Frequency: The radio spectrum from 30MHz to 300MHz. VHF radios for CNS/ATM systems operate between 125.5 MHz and 136.5MHz. New radios must be compliant with ICAO SARPs (Annex 10, Volume 3). Most European states require 8.33 kHz channel spacing capability. All other states require 25 kHz channel spacing for new radios.
Appendix B: CNS/ATM Glossary (cont’d)

VNAV – Vertical Navigation: A capability that allows the aircraft to fly a computed vertical speed profile which associates lateral waypoints with given altitude/speed constraints through the control of FMS, Autopilot and Auto-throttle. The vertical/speed profile can be either entered by the pilot or generated by the FMS. VNAV is not currently a required RNP/RNAV capability; however, ATM upgrades, such as NextGen, will include VNAV requirements. VNAV altitude can be based on either the aircraft’s barometric altimetry system (BARO VNAV) or on GPS. Without differential augmentation (LAAS/WAAS), BARO VNAV will be the primary method of VNAV altitude determination. Since BARO VNAV is affected by nonstandard temperature effects and requires an accurate local altimeter setting, use of BARO VNAV is prohibited on RNAV instrument approach procedures below VNAV DA(H).

VOR – Very High Frequency Omni-direction Range: A navigational system that operates in the VHF band that provides azimuth/course and distance to the VOR ground station. VOR equipped aircraft select a course relative to the ground station that represents magnetic radial transmitted from the ground station. The VOR radials are used to define conventional procedures for jet ways, legs of terminal approach and departures including non-precision approaches.

WGS-84 – World Geodetic System 1984: Developed by the U.S. for world mapping, WGS 84 is an earth fixed global reference frame. It is the ICAO standard.

WAAS – Wide Area Augmentation System: A GPS-based navigation and landing system that will provide precision guidance to aircraft at airports and airstrips where there is currently no precision landing capability. In order to provide "near CAT I" [see "CAT I"] capability, WAAS improves the accuracy and ensures the integrity of information coming from GPS satellites. A complex infrastructure of ground-based monitors and control centers informs the user (by way of geostationary satellites) whether GPS can be safely used. It is the U.S. implementation of the ICAO-recognized SBAS. [see "SBAS"]

Windshear Predictive – Predictive systems are weather radar-based and provide a pilot with anticipatory information on levels of turbulence in the flight path. The radar using Doppler processing extracts the characteristics of precipitation returns to determine if windshear is present. The presence of windshear is presented to the flight crew on the weather radar display.

Windshear Reactive – Reactive Systems use various sensor inputs to identify the presence of windshear once the phenomenon is encountered and provides the pilot with timely warning and adequate flight guidance to improve the probability of recovery from the windshear encounter. A reactive system may also integrate or couple an autopilot and/or auto-throttle systems of the aircraft with an airborne windshear flight guidance system.
This booklet was updated in March 2012
Acknowledgements:
Mr. Michael Harrington
Mr. John Banzhaf
Mr. Ben Brandt
Mr. Mike Bernock
Mr. Richard Donnelly
Mr. Roger Francis
Ms Cindy Freud
Ms. Amy Fritz
Mr. William Hershey
Maj Stephen Horsman
Mr. Joseph Hudak
Mr. Barry Irwin
Lt Matthew Alva
Mr. John Maurer
Ms. Marie Miller
Capt Robert Walker