Federal Aviation Administration

NextGEN

NEXTGEN INVESTMENTS FOR OPERATORS AND AIRPORTS

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NEXTGEN INVESTMENTS FOR OPERATORS AND AIRPORTS

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NextGen is a collaborative effort between the FAA and the aviation community. Benefits depend on all stakeholders investing in the airspace modernization effort. Improvements in aircraft engines, airframes and fuel technologies, advances in avionics capabilities and changes to airport infrastructure contribute just as much to NextGen as FAA ground- and space-based systems.

This pamphlet outlines the investment opportunities open to operators and airports. It also provides an overview of existing and planned capabilities, the benefits these capabilities enable and which technologies and equipment can take advantage of specific NextGen capabilities.

We use the term enablers to describe the technologies required for an aircraft, operator or airport to implement a NextGen capability. Each enabler is defined by performance and functional requirements that allow for market flexibility whenever possible. We provide guidance for operators in satisfying these requirements and deploying the enablers through advisory circulars (AC) and technical standard orders (TSO). Enablers are linked to operational improvements and capabilities that provide benefits and build on current equipage.

For each enabler, icons provide a quick look at key information.

- Target Users: Target users for each enabler can include air carriers, business jets, general aviation fixed-wing aircraft and rotorcraft. These categories represent generalized modes of operation and may not apply to every civil or military operator. The FAA does not limit NextGen capabilities to targeted user groups. In addition to specified user groups, some users may find it worthwhile to invest in a particular enabler to meet their operational objectives.

- Target Areas for Implementation: The general strategy for deployment can be nationwide, in oceanic areas or in metroplexes. Metroplexes are areas with large- and medium-hub airports and satellite airports.

- Maturity: An enabler may be available for operator investment, in development (including standards development) or in concept exploration.

This pamphlet explores several new developments, notably:

- Performance Based Navigation (PBN): In coordination with the International Civil Aviation Organization (ICAO) PBN Study Group, the FAA developed general criteria for advanced Required Navigation Performance (RNP). Additionally, the FAA began work with RTCA Special Committee (SC)-227 to develop navigation standards for Trajectory Operations.

- Automatic Dependent Surveillance–Broadcast (ADS-B): The FAA developed technical standards and installation guidance for In-Trail Procedures (ITP) in oceanic airspace using ADS-B In. The FAA is working with industry to prepare guidance for interval management and traffic situational awareness with alerts (TSAA).

- Data Communications (Data Comm): The FAA will initially support data communications for aircraft equipped with Future Air Navigation System (FANS) 1/A and VHF Digital Link Mode 2 (VDL-2) avionics as well as VDL Mode 0 for departure clearances only.

- Low-Visibility Operations: An Enhanced Flight Vision System (EFVS)-enabling rule is planned for 2014, along with supporting airworthiness and operational guidance.

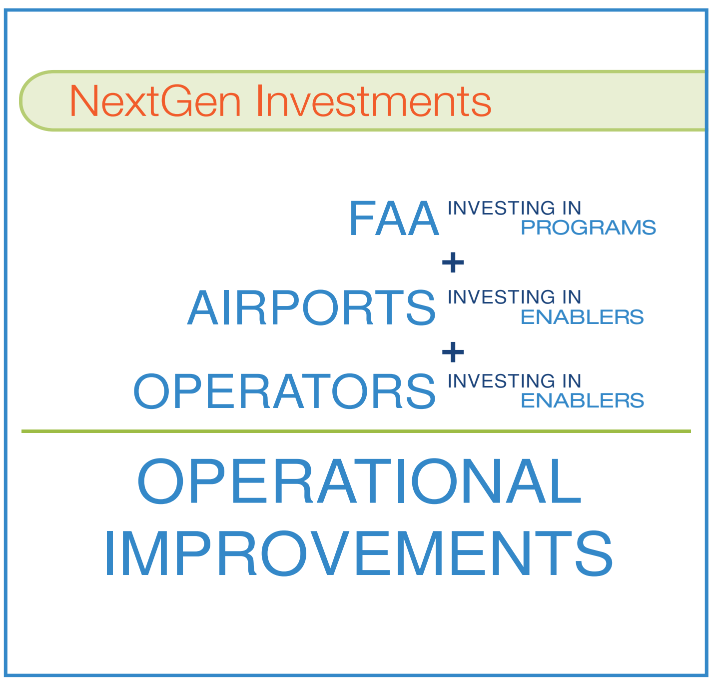
- Flight Deck Enhancements: Electronic flight bags (EFB) continue to play a large role in NextGen flight operations. The FAA published updated operational guidance in 2013.
- Aircraft Engine, Airframe and Fuel Technologies: The agency has partnered with industry through the Continuous Lower Energy, Emissions and Noise (CLEEN)

program to accelerate development of new aircraft and fuel technologies and demonstrate performance gains and environmental benefits. In addition, the FAA plans to study the performance of electric engines in light sport aircraft.

- Airport Enhancements: The FAA continues to evaluate existing arrival and departure procedures at airports with multiple or closely spaced runways. The goal is to safely reduce separation to improve arrival capacity, especially during low visibility.

NEXTGEN CAPABILITIES

NextGen capabilities are usually grouped by functionality, for example, PBN. FAA support for NextGen equipage usually takes the form of standards development, ACs, TSOs and or project-specific policy. A snapshot of avionics enablers, schedules, capability overviews and guidance is provided with the target users, target areas and maturity icons.



PBN

PBN encompasses a set of enablers with a common underlying capability of constructing a flight path that is not constrained by the location of ground-based navigation aids.

Area Navigation (RNAV) is a navigation method that permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids, within the limits of the capability of self-contained aids or a combination of these. PBN defines RNAV system performance requirements in terms of the accuracy, integrity, continuity and functionality needed for operations in a particular airspace environment FAA advisory material identifies performance requirements through ACs and Orders. Equipment must meet requirements outlined in TSOs. ICAO defines these performance parameters through navigation specifications.

Navigation Specifications (NavSpec) are aircraft and aircrew requirements to support a navigation application within a defined airspace concept. Some procedures require GPS augmentation. Wide Area Augmentation System (WAAS) is the FAA's implementation of Satellite Based Augmentation System.

The FAA works to define navigation specifications with a sufficient level of detail to facilitate global harmonization with the ICAO PBN Manual, Document 9613. For example, to assist in this harmonization, the FAA is updating AC 90-105, *Approval Guidance for RNP Operations and Barometric Vertical Navigation (baro-VNAV) in the National Airspace System (NAS)*. The rewrite incorporates material from Order 8400.12C, *RNP 10 Operational Authorization* and Order 8400.33, *Procedures for Obtaining Authorization for RNP-4 Oceanic and Remote Area Operations* to produce a more comprehensive document.

RNP is an RNAV system that includes onboard performance monitoring and alerting capability, for example Receiver Autonomous Integrity Monitoring. RNP Approach and RNP Authorization Required (AR) are two NavSpecs used to design and execute GPS-based instrument approach procedures.

RNP Approach procedures are titled RNAV (GPS) and offer several lines of minima to accommodate varying levels of aircraft equipage:

- Lateral navigation (LNAV)
- LNAV/vertical navigation (LNAV/VNAV)

- Localizer Performance with Vertical Guidance (LPV)
- Localizer Performance (LP)

GPS or WAAS can provide the lateral information to support LNAV minima. LNAV/VNAV incorporates LNAV lateral with vertical guidance for systems and operators capable of barometric or WAAS vertical guidance. WAAS enables pilots to fly to the LPV or LP minima. Procedures with LPV minima rely on GPS signals with WAAS error correction, without added airport infrastructure. The refined accuracy of WAAS lateral and vertical guidance provides an approach capability similar to an instrument landing system (ILS), allowing operations as low as 200 feet above the runway without outside visual references such as runway approach lights.

The FAA can publish LPV approaches to airports without ILS infrastructure and associated maintenance costs. Likewise, RNAV (GPS) approaches are not subject to the ILS challenges of siting the localizer and glideslope antennas and do not require ground traffic to hold outside of an ILS critical area. The FAA can implement LPV procedures where an ILS installation is not feasible. Initial development and procedure implementation began in 2003. As of February 2014, there are 3,375 WAAS LPV approach procedures serving 1,665 airports. There are also 533 LP approach procedures.

RNP AR procedures are titled RNAV (RNP). RNP AR vertical navigation performance is based upon baro-VNAV or WAAS. RNP AR provides benefits at specific locations and is not intended for every operator or aircraft. RNP AR capability requires specific aircraft performance, design, operational processes, training and specific procedure design criteria to achieve the required safety level. These are the most demanding PBN operations, using very precise lateral paths — down to 0.1 nautical miles (nm) accuracy — and can include the application of radius-to-fix (RF) leg segments in the final approach segment (FAS). With proper aircraft equipment, operators may obtain approval to fly these procedures. This approval includes RNP AR training, database validation and operating procedures. RNP AR instrument approaches enable access at airfields with more demanding obstacles, terrain or traffic constraints. The FAA's complete list of RNAV (GPS), RNAV (RNP) and LPV approaches are on the Satellite Navigation Program website.

The RNAV designation refers to navigation accuracy, but can designate other performance and functional requirements. The FAA publishes RNAV Q-Routes, T-Routes, arrival procedures and departure procedures.

For example:

- RNAV 2 requires sustaining an accuracy of 2 nm for 95 percent of flight time during the operation. The FAA uses RNAV 2 for en route operations.
- RNAV 1 requires sustaining an accuracy of 1 nm for 95 percent of flight time. The FAA uses RNAV 1 for arrivals and departures.

As of February 2014, the FAA had published a combined total of more than 870 RNAV Standard Instrument Departures (SID), Standard Terminal Arrivals (STAR) and RNAV routes. The FAA publishes the latest RNAV tally on the Instrument Flight Procedures Inventory Summary website.

RNAV 1 is the mainstay in the terminal area, except where obstacles or airspace conflicts demand the improved performance provided by RNP 1. When a navigation specification includes requirements for onboard performance monitoring and alerting or additional functionality, the FAA designates the application as RNP.

The FAA is expanding RNP use where beneficial. Flying precise curved path RF legs increases the consistency of aircraft tracks. RF leg application is an option where beneficial for SIDs, STARs, RNP and RNP AR operations. However, only RNP AR operations can apply an RF leg segment in the FAS. Expanding the use of the RF leg may help deconflict arrivals and departures in metroplexes and provide more efficient routing in the NAS.
Many aircraft use barometric altitude through the Flight Management System (FMS) to obtain vertical guidance and fly a defined vertical path. This aircraft capability is baro-VNAV. Advisory vertical guidance

helps the pilot maintain an optimum descent profile while complying with an air traffic control (ATC) clearance. However, the pilot is still responsible for complying with all procedure-defined altitude restrictions by referencing the primary barometric altitude source. Controllers can plan traffic flows more efficiently by accounting for vertical guidance capabilities in the design of arrival and departure procedures.

The FAA asked the Performance-Based Operations Aviation Rulemaking Committee — composed of representatives from air carriers, general aviation and corporate operators, aircraft and avionics manufacturers and chart and flight management system developers — to aid us in designing the best instrument approach procedure chart with the most useful text and clearest title. The committee also identified challenges for deploying new combinations of navigation specifications. This joint effort is helping the FAA update guidance for dispatchers, pilots and manufacturers in AC 90-105 and the procedure design guidance in Order 8260.58, *United States Standard for Performance Based Navigation Instrument Procedure Design*.

Most air carrier aircraft can support RNAV and RNP operations. Of these aircraft, half can support RNP AR approaches. The heart of the PBN capability in the air carrier community is the FMS function. The FMS function generally uses multisensor inputs to define aircraft positions. Inputs come from a variety of sources and vary by installation. Most multisensor inputs come from:

- Distance Measuring Equipment (DME) or inertial guidance
- Global Navigation Satellite System (GNSS) using either GPS or GPS incorporating WAAS

The FAA allows DME facilities for use with inertial input and GNSS for RNAV 1 and RNAV 2 capabilities. DME-only navigation has coverage and infrastructure limitations and will not be supported on every published procedure in the current configuration. The general aviation community typically implements PBN enablers in a GNSS navigator on an aircraft's instrument panel. These systems have become increasingly capable. These systems also integrate other types of navigation, voice communication and uplinked weather information. Most of these installations can support RNP, and those equipped with WAAS can support LPV and LP minima. Some general aviation aircraft configurations may be upgradeable to RNP with curved path capability.

Operational advantages provide the primary motivation for equipping with PBN enablers. Operators who equip obtain efficiency and access enhancements from beneficial routes, procedures and approaches. The FAA is not planning to retain as robust a legacy ground infrastructure.

Advanced RNP operations include a set of new capabilities that will enable increased RF leg use without the stringent RNP AR requirements. We envision procedures with scalable accuracy values as low as 0.3 nm and criteria for RNP 2 en route operations. For helicopters, we are developing material for RNP 0.3 departure and en route operations in congested environments, taking advantage of the slow speed and high maneuverability of the rotorcraft.

As the NAS moves toward trajectory operations, new requirements will be allocated to aircraft navigation systems. The widespread use of trajectory operations will require aircraft navigation systems to perform to a new degree of standardization. The FAA is working with industry stakeholders to determine new performance standards for trajectory operations.

The FAA is exploring means to reduce the existing VOR network and a limited number of secondary surveillance radar facilities. The Alternative Positioning, Navigation and Timing project team is investigating alternatives to provide a GPS backup capability.

ADS-B

There are many ADS-B enablers, with different cost and benefit implications. The foundational enabler is ADS-B Out. ADS-B Out uses ground infrastructure and avionics to enable the next generation of ATC and air-to-air surveillance. ADS-B Out avionics broadcast an aircraft's position, velocity and other data. A network of ADS-B ground radio stations collects the broadcast information for integration into

Overview of Aircraft Operator Enablers						
Avionics Enablers	Aircraft and Operator		Capability Overview	Target Users	Target Area	Maturity
	Guidance	Schedule				
Performance Based Navigation (PBN)						
Required Navigation Performance (RNP) 10	Order 8400.12C	Complete	Reduces oceanic separation			
RNP 4	Order 8400.33	Complete	Further reduces oceanic separation in conjunction with Future Air Navigation System (FANS) 1/A			
Area Navigation (RNAV) 1, RNAV 2	Advisory Circular (AC) 20-138D, AC 90-100A	Complete	Enables more efficient routes and procedures			
RNP 1 with Curved Path	AC 20-138D, AC 90-105	Complete	Enables precise departure, arrival and approach procedures, including repeatable curved paths			
Vertical Navigation, or VNAV	AC 20-138D, AC 90-105	Complete	Enables defined climb and descent paths			
Localizer Performance with Vertical Guidance, or LPV	AC 20-138D, AC 90-107	Complete	Improves access to many airports in reduced visibility, with an approach aligned to the runway			
RNP Authorization Required Approaches	AC 20-138D, AC 90-101A	Complete	Improves access to airports in reduced visibility with an approach that can curve to the runway; improves procedures to separate traffic flows			
Advanced RNP, RNP 0.3, RNP 2	AC 90-105A	2014	Enables more accurate and predictable flight paths for enhanced safety and efficiency			
Trajectory Operations Navigation Standard	AC, Technical Standard Order (TSO)	2016	Enhances PBN capabilities			
Alternative Positioning, Navigation and Timing (APNT)	AC, TSO	2018	Provides GPS-independent APNT capability			

the ATC system where air traffic controllers use this precise surveillance information to provide air traffic separation and advisory services.

Beginning in January 2020, aircraft operating in Class A airspace — from 18,000 feet mean sea level (MSL) to and including Flight Level 600 — must broadcast position data with a Mode S, 1090 Extended Squitter (1090 ES). Aircraft operating in designated airspace exclusively below 18,000 feet MSL can broadcast the required information with either 1090 ES or the Universal Access Transceiver (UAT) on 978 megahertz.

Because aircraft can broadcast on one of two frequencies, Automatic Dependent Surveillance–Rebroadcast (ADS-R) is part of the ground infrastructure. ADS-R collects position information broadcast on each frequency and rebroadcasts it on the opposite frequency. Traffic Information Services–Broadcast (TIS-B) is another part of the ground infrastructure. Since it will be some time before all aircraft are equipped with ADS-B Out, TIS-B broadcasts the position of non-ADS-B Out aircraft that ground surveillance radar detects. Combined, TIS-B and ADS-R provide ADS-B In-equipped aircraft with a more complete airspace and airport surface traffic picture. ADS-R delivers traffic data within a 15-nm radius 5,000 feet above or below relative to the receiving aircraft's position. TIS-B provides traffic data within a 15-nm radius 3,500 feet above or below.

Operators can take advantage of the increasing prevalence of ADS-B Out broadcasts from nearby traffic and the ground infrastructure with a number of ADS-B In enablers. The most basic enabler provides enhanced situational awareness, improving the flight crew's ability to identify the location and direction of nearby traffic in the air and on the surface. To view traffic, the ADS-B In aircraft must be equipped with a Cockpit Display of Traffic Information (CDTI). The CDTI may be presented on a new display, or it may be integrated with a conventional Traffic Alert and Collision Avoidance System (TCAS) or navigation display. CDTI graphically displays the relative position of other aircraft and surface vehicles equipped with ADS-B Out. It also receives and displays TIS-B and ADS-R traffic information. In the GA community, this is typically integrated on a portable display.

In-Trail Procedure (ITP) using ADS-B enables increased opportunities to fly at a more desirable altitude in oceanic airspace. The lack of radar in most oceanic airspace requires ATC to maintain large separation distances between transiting aircraft. The separation requirement can prevent an aircraft from changing to a more optimal altitude because of traffic at an intervening altitude. But a flight crew can use a CDTI and ITP software to verify that nearby traffic meets specific distance and relative groundspeed criteria. With ATC approval, the flight crew can safely climb or descend the aircraft to a more desirable altitude. This is possible because ITP allows for reduced separation from the traffic at the intervening altitude while transiting from one altitude to another.

Three U.S. operators are equipped with ITP for an operational trial in the Atlantic Ocean: United Airlines, US Airways and Delta Air Lines. FAA counterparts in Iceland and the United Kingdom are involved in the Atlantic trial, as well. United is also participating in an ITP trial in select airspace over the Pacific Ocean. The FAA is working with its counterparts in Fiji and New Zealand on the Pacific effort. Operational benefits look promising.

Flight Deck Interval Management (FIM) is the airborne component of the interval management enabler. FIM exploits ADS-B Out information to enable more precise spacing between aircraft. FIM aircraft avionics process ADS-B Out information from nearby traffic. When ATC clears the FIM aircraft to follow an ADS-B Out aircraft, the avionics present the FIM crew with speed guidance. By following speed guidance, the flight crew maintains a more precise spacing from the designated traffic than can be achieved with present-day procedures. This reduces inefficient vectoring and speed instructions. The FAA is working with European counterparts and industry to develop avionics standards, which are expected in early 2016.

TSAA is an ADS-B In application that enables improved general aviation safety. By the end of 2014, standards will be complete for aircraft that do not have TCAS. Using ADS-B Out information from nearby aircraft and a robust collision prediction algorithm, TSAA will aurally alert the pilot of a potential collision and indicate the position of the target aircraft on an optional CDTI. The benefit will be an improved alerting system at a reasonable cost.

More advanced ADS-B In applications will be integrated with other capabilities such as Data Comm and a new generation of TCAS. These integrated solutions will support access to closely spaced runways in almost all weather conditions, more advanced FIM and separation similar to visual operations today.

While current FIM provides spacing on a single arrival stream, Advanced Flight Interval Management will allow more consistent spacing for merging from various directions and flight paths. Research continues on the use of ADS-B for paired approaches to parallel runways, where aircraft stay close enough together to avoid wake while maintaining safe separation.

In air carrier aircraft, most operators will implement ADS-B as an upgrade to the Mode S transponder and integrate the CDTI with existing or supplemental aircraft displays. The various ADS-B In capabilities will require different levels of integration with the controls and displays in the cockpit. Situational awareness is available using side console-mounted displays that are not integrated. Instrument panel-mounted displays that are not integrated can provide along-track and speed guidance. More advanced capabilities will require integration with other navigation data and eventually migrate to flight displays as benefits are substantiated.

By providing early benefits such as ITP and TSAA, the agency is encouraging operators to equip portions of their fleets with ADS-B before the ADS-B Out equipage mandate goes into effect on January 1, 2020. As operators experience these benefits, they will have an incentive to accelerate and expand ADS-B equipage to the rest of their fleet.

- For air carriers, this strategy uses memorandums of agreement in which each party provides in-kind contributions critical to the success of the project. Each agreement is unique, reflecting the specific operator's business model, route structure and existing avionics infrastructure, among other factors.
- For general aviation operators, deployment of traffic and weather information uplinked over the UAT will enhance benefits and motivation to equip. This information will be provided by two no-cost broadcast services, TIS-B and Flight Information Services–Broadcast (FIS-B).

The FAA is also evaluating additional locations where surveillance may be expanded by employing ADS-B.

DATA COMMUNICATIONS

The Data Communications (Data Comm) program will provide data communications services between the pilots and air traffic controllers. Data Comm will provide a direct link between ground automation and

Overview of Aircraft Operator Enablers

Avionics Enablers	Aircraft and Operator		Capability Overview	Target Users	Target Area	Maturity
	Guidance	Schedule				
Automatic Dependent Surveillance–Broadcast (ADS-B) Capabilities						
ADS-B Out	AC 20-165A, AC 90-114, TSO-C166b, TSO-C154c	Complete	Enables improved air traffic surveillance and automation processing			
Airborne/ Ground Cockpit Display of Traffic Information	AC 20-172, TSO-C195	Complete	Improves awareness of other traffic			
In-Trail Procedure	AC 20-172A, AC 90-114 CHG 1, TSO-C195a	Complete	Improves oceanic in-trail climb/ descent			
Flight Interval Management	AC, TSO	2016	Displays along-track guidance, control and indications, and alerts			
ADS-B Traffic Awareness System	AC	2015	Displays and alerts crew to airborne conflicts independent of Traffic Alert and Collision Avoidance System alerting			
	TSO	2014				
Closely Spaced Parallel Operations	AC, TSO	2018	Provides guidance information for aircraft participating in paired approaches to closely spaced runways			
Advanced Flight Interval Management	AC, TSO	2017	Provides higher performance along-track guidance, control and indications, and alerts for terminal operations. Ground infrastructure is under way			

flight deck avionics for safety-of-flight Air Traffic Control (ATC) clearances, instructions, traffic flow management, flight crew requests and reports. Data Comm enables efficiencies not possible using the current voice system by providing NAS infrastructure enhancements to support NextGen operational improvements. Data Comm will enhance NAS operations through:

- Reduced impact of ground delay programs, airport reconfigurations, convective weather, congestion and other causes
- Reduced communication errors
- Improved controller and pilot efficiency through automated information exchange
- Enabled NextGen services, e.g., enhanced re-routes and trajectory operations
- Increased controller productivity leading to increased capacity

The FAA has deployed data communications in the oceanic airspace using Future Air Navigation Services (FANS) 1/A avionics.

The domestic program will leverage the oceanic experience using currently available FANS 1/A and VHF VDL-2 avionics. The FAA will provide the ground infrastructure to support communication with aircraft equipped with FANS 1/A and VDL-2, or VDL Mode 0 for departure clearances only.

The FAA has established an avionics equipage incentive program for U.S. carriers to stimulate early use and adoption of Data Comm technology and services in the NAS. Incentives, available for a limited time commencing in 2013, will equip aircraft with FANS 1/A and VDL-2 avionics, providing the foundation of aircraft equipage necessary for delivery of Data Comm services. The incentive offer has been made available to all domestic carriers. As of December 2013, seven air carriers had committed through Memorandums of Agreement (MOA) to equip their aircraft with Data Comm avionics under the incentive program.

We plan to update and supersede AC 120-70B with a 90-series AC to address data communications use by Part 119 and Part 91 operators. This AC revision will harmonize with AC 20-140, as appropriate, and will account for legacy domestic data link operations. To support more advanced data communications services the FAA will support the use of Aeronautical Telecommunications Network (ATN) avionics in the future. The ATN was developed through ICAO to provide a more universally capable and reliable ATC data communication system. Early versions of ATN (Baseline 1) have provided initial data link capabilities in Europe. Europe has a mandate for Baseline 1 (Link 2000+), which operators can retrofit into aircraft without modification of the navigation system. The desired capability for full participation in continental U.S. airspace will be Baseline 2. RTCA SC-214 and the European Organization for Civil Aviation Equipment WG-78 are jointly developing standards to define the safety,

Overview of Aircraft Operator Enablers

Avionics Enablers	Aircraft and Operator Guidance	Aircraft and Operator Schedule	Capability Overview	Target Users	Target Area	Maturity
Data Communications (Data Comm)						
FANS 1/A (Satellite Communications)	AC 20-140A, AC 120-70B AC 20-150A	Complete	Provides oceanic data communications and surveillance, transfer of communications			
FANS 1/A (VHF Digital Link Mode 0, 2)	AC 20-140B, AC 120-70B, TSO-C160a	Complete	Provides domestic data link clearances			
Baseline 2	AC Installation Guidance	2016	Provides clearances, terminal information, and Initial Trajectory Operations			
	AC Data Link Recording	2016	Provides guidance on aircraft recording systems for Data Comm			

performance and interoperability requirements for air traffic services supported by data communications. Data communications will also need to accommodate evolving navigation, surveillance and aeronautical information service requirements to support air-ground functional integration. Finalizing these requirements in 2013 impacted the schedule for Baseline 2 criteria, resulting in a one and a half year slip from guidance. The revised schedule calls for an initial standard in mid-2014 and a final Baseline 2 standard in 2016. Following En Route services deployment in the NAS with FANS 1/A and VDL-2, the FAA will support the transition to Baseline 2.

FLIGHT OPERATIONS CENTERS

The FAA has defined technical requirements for the communications infrastructure that will enable data exchange. This includes the requirements enabling external users to connect to the FAA's System Wide Information Management (SWIM) security gateway allowing the exchange of FAA and flight operations center (FOC) data. In the near term, new flight planning capabilities will allow the operator to provide a prioritized list of trajectory options for each flight. Taking into account operator flight priorities, the FAA's traffic flow management automation will use these lists to determine flow assignments. Collaboration between the FAA and the operator during the flight planning process will become increasingly sophisticated and leverage new automation and data exchange capabilities. FOCs will manage the exchange of their trajectory option sets and regularly re-evaluate them based on their specific business model. FOCs will also provide flight priority information when traffic management initiatives are required because of traffic volume or weather conditions.

The continuing evolution of flight planning support tools and communications infrastructure to support FOC air traffic management and cockpit decision-making will continue to ensure safe and efficient operations.
Airborne Access to SWIM (AAtS) enables in-flight aircraft access to information available through SWIM. AAtS extends these capabilities to the cockpit through third-party communication vendors, providing flight deck Internet access on an EFB, for example. Although AAtS aircraft guidance is complete, AAtS implementation is in development.

Category I			
	Standard	With head-up display (HUD) (or Autopilot or Flight Director)	With HUD & Special Authorization
Runway Visual Range Visibility	1,800*	1,800	1,400
Decision Height	200	200	150
Reduced Ground Infrastructure	No	Yes	Yes

* Requires additional lighting.

LOW-VISIBILITY OPERATIONS

The FAA is supporting several capabilities for operators who need to access an airport during low visibility, when the cloud ceiling is below 200 feet above the runway or visibility is less than one-half mile. At many airports, the FAA has approved the use of a head-up display (HUD) on a precision approach to lower minima. A HUD provides critical flight and navigation data on a transparent screen in front of the pilot. The HUD allows simultaneous viewing of primary flight display information, navigation information and the forward view out the window.

Use of a qualified HUD when flying to a suitable ILS facility will reduce the required runway visual range (RVR) visibility for the approach. Use of a qualified HUD will also increase airport access compared with non-equipped aircraft. The accuracy of these ILS facilities has been verified for this type of operation. In addition, the airport must have the equipment to measure and report the current RVR visibility. The FAA is increasing the number of airports with RVR to expand this capability under the Enhanced Low Visibility Operations (ELVO) program. Other ELVO improvements are described in Order 8400.13D, *Procedures for the Evaluation and Approval of Facilities for Special Authorization Category (CAT) I Operations and All Category II and III Operations*. The FAA permits an Enhanced Flight Vision System (EFVS) to be used in lieu of natural vision to descend below decision altitude/decision height (DA/DH) or minimum DA on straight-in instrument approaches down to 100 feet above the touchdown zone.

At 100 feet, the flight crew must acquire the required visual references with natural vision. EFVS affords a higher level of access, providing a visual advantage for the flight crew to see required visual references using EFVS technology. With an EFVS, access is allowed that otherwise would be denied because of low visibility.

On June 11, 2013, the FAA published a Notice of Proposed Rulemaking that would allow EFVS to be used to touch down on precision approaches and approaches with approved vertical guidance. The proposed rule would also permit certain operators using EFVS-equipped aircraft to dispatch, release a flight or take off under instrument flight rules when the visibility is forecast or reported to be below authorized minima for a destination airport.

Additionally, the proposed rule would permit certain operators using EFVS-equipped aircraft to initiate and continue an approach when the destination airport weather is below authorized visibility minima for the intended runway. Pilot compartment view certification requirements for vision systems using a transparent display surface located in the pilot's outside view would also be revised. This revision would eliminate the need to issue special conditions. This rulemaking action would further increase access, efficiency and throughput when low visibility is the limiting factor.

Another enabler is the Ground Based Augmentation System landing system (GLS). This system uses differential corrections to GPS to support all precision approach categories. Several airports operate non-federal ground systems approved for Category I Operations to as low as 200 feet above the runway. A single ground station can service multiple runways at an airport and does not require critical area taxi restrictions. The FAA is validating baseline ICAO and RTCA standards to support CAT III operations. Changes to ground equipment and avionics are expected. Operational approval for GLS CAT III could begin as early as 2018 based on current manufacturer information.

While not mandated, equipage for these low-visibility enablers continues. The high-end business community has adopted EFVS, and HUD has spread to the air carrier fleet.

FLIGHT DECK ENHANCEMENTS

FIS-B provides terrestrial-based weather data and real-time NAS status information to aircraft equipped with ADS-B In using the UAT and an appropriate display. The FAA intends for these data to improve the safety of general aviation operations. FIS-B products include graphical and textual weather and other aeronautical information such as Notices to Airmen and Special Use Airspace information.

We also envision AAtS functionality. AAtS enables aircraft systems to access data to support collaborative decision making and ensures a common understanding of airspace status, systems

Overview of Aircraft Operator Enablers

Avionics Enablers	Aircraft and Operator Guidance	Aircraft and Operator Schedule	Capability Overview	Target Users	Target Area	Maturity
Low-Visibility Operations						
Head-Up Display/ Instrument Landing System, or ILS	Order 8400.13D	Complete	Reduces minimums at qualifying runways			
Enhanced Flight Vision System (EFVS)	AC 20-167, AC 90-106	Complete	Uses enhanced flight visibility to continue approach below minima			
	AC 20-167A AC 90-106A	2015	Expands operational use of EFVS			
Ground Based Augmentation System Landing System III	Project-specific policy	2018	Provides autoland in very low visibility			

Overview of Aircraft Operator Enablers						
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	Guidance	Schedule				
Flight Deck Enhancements						
Flight Information Service–Broadcast	TSO-C157a, TSO-C154c	Complete	Provides weather and aeronautical information in the cockpit			
	TSO	2015	Provides Universal Access Transceiver link-specific requirements for weather and aeronautical information to the cockpit			
Electronic Flight Bag, or EFB	AC 20-173, AC 120-76B, AC 91-78	Complete	Allows electronic access to paper products			
Synthetic Vision Systems	AC 20-167	Complete	Provides an electric means to display a synthetic vision image of the external scene topography to the flight crew			
Airborne Access to System Wide Information Management (SWIM)	AC 20-177	Complete	Provides flight crews with access to SWIM over non-aeronautical frequency bands			
Airborne Collision Avoidance System ,or ACAS X	AC, TSO	2020	Improves airborne collision avoidance performance with fewer nuisance alerts			

and weather. Information may be displayed by an installed system or an EFB (portable or installed) depending on the application. AAtS must be used to support collaborative decision making to qualify under the NextGen avionics incentive program. For more information on installation of non-required telecommunication equipment, see AC 20-177, *Design and Installation Guidance for an Airborne System for Non-Required Telecommunication Service in Non-Aeronautical Frequency Bands*. EFBs can display aviation data or perform basic calculations such as performance data and fuel calculations. In the past, much of this information was provided via printed documentation, and flight dispatchers performed manual calculations. EFBs also have the ability to send and receive graphical and textual information for use on the flight deck.

Current Equipage Levels of Available Enablers*			
Enabler	Air Transport	Air Taxi	Helicopter
RNP 10 - Oceanic**	99%	99%	N/A
RNP 4**	95%	99%	N/A
RNAV 1	97%	60%	36%
RNAV 2	98%	76%	36%
RNP 1 with Curved Path	52%	3%	<1%
VNAV	58%	20%	<1%
LPV Approach	<1%	15%	1%
RNP AR Approach	56%	2%	<1%
ADS-B Out (rule compliant)	2%	<1%	<1%
Airborne/Ground CDTI, ADS-B In	2%	<1%	<1%
ITP, ADS-B In**	1%	0%	0%
FANS 1/A (SATCOM)**	23%	9%	0%
FANS 1/A (VDL Mode 2)	2%	1%	0%
HUD/ILS	21%	<1%	<1%
EFVS	1%	10%	<1%
EFB	63%	45%	11%

* The reported numbers are derived from multiple sources and are sensitive to fleet composition changes.
** Oceanic enablers numbers reported are based on the subset of aircraft that operate in oceanic airspace.

Airborne Collision Avoidance System X (ACAS X) is a family of collision avoidance systems. ACAS X_A is intended to fill the role of current TCAS, serving as a collision avoidance system for large transport and cargo aircraft. ACAS X_O is intended for specific flight operations of those same users when normal separation may result in excessive nuisance alerts, such as closely spaced parallel operations.

Synthetic Vision Systems, which electronically show external topography, are certified for situational awareness. The FAA is exploring the potential benefits that this evolving technology provides the NAS.

EQUIPAGE LEVELS

The Equipage Level table summarizes equipage levels of mature avionics enablers among:

- Air transport operators (14 Code of Federal Regulations (CFR) Part 121 operators)
- Air taxis (14 CFR Part 91K and 135 operators)
- Helicopters (14 CFR Part 135 operators)

The high penetration of PBN enablers reflects the maturity of these capabilities, some which have been available for more than 10 years. While the general aviation fleet continues to adopt advanced technologies, especially WAAS avionics, equipage numbers are difficult to obtain and are not included. Equipage numbers are based on documented operational approvals for air carriers, air taxi operators and helicopters, and are normalized to the subset of the fleet applicable to the operation.

FOUNDATIONAL AVIONICS ENABLERS

The FAA has evaluated available enablers and identified those that provide the most NAS benefits when a high participation level is achieved in the near term.

The metroplex foundational enablers were selected for providing the greatest impact on metroplex operations and presume high levels of equipage. General foundational enablers target the minimum NextGen capabilities outside metroplex areas. Both capability levels are displayed below. We will update the recommended avionics list when additional enablers become available. Operators may elect to use other enablers that provide benefits but do not require high participation levels.

AIRCRAFT ENGINE, AIRFRAME AND FUEL TECHNOLOGIES

In partnership with industry, the Continuous Lower Energy, Emissions and Noise (CLEEN) program accelerates the development of new certifiable aircraft technologies and alternative jet fuels. Drop-in alternative jet fuels research continues with the intent of developing a range of ASTM International-approved fuels that provide improved environmental

Foundational Avionics Enablers											
Metroplex						General					
Enablers	Target Users				Target Area	Enablers	Target Users				Target Area
ADS-B Capabilities*											
ADS-B Out						ADS-B Out					
Recommended PBN											
RNAV 1, RNAV 2						RNAV 1, RNAV 2					
RNP 1 with Curved Path						LPV					
VNAV						*See requirements in 14 CFR 91.225 and 14 CFR 91.227					
RNP AR Approach											

Overview of Aircraft Operator Enablers						
Enablers	Operator or Airport		Capability Overview	Target Users	Target Area	Maturity
	Guidance	Schedule				
Aircraft Engine, Airframe and Fuel Technologies						
Drop-In Alternative Jet Fuel Blends with Jet A	ASTM standard D7566	Complete	Expands jet fuel specification to allow use of Jet A blended with up to 50% of Synthetic Paraffinic Kerosene from Fischer-Tropsch or Hydroprocessed Esters and Fatty Acids processes			
Electric Propulsion	ASTM standard	2014	Enables certifiable electric propulsion technology with zero fuel burn and lower noise for light sport aircraft			
Additional Drop-In Alternative Jet Fuels	ASTM standards alcohol-to-fuel pathways	2014	Expands jet fuel specification to allow use of Jet A blended with up to 50% of alternative jet fuels from novel processes and feedstocks e.g. alcohol-to-jet and pyrolysis			
	ASTM standards pyrolysis	2015				
New Airframe Technologies	Technology available for product development	2015	Provides demonstrated and certifiable airframe technologies with lower fuel burn, emissions and noise			
More Efficient Engines	Technology available for product development	2015	Provides demonstrated and certifiable turbine engine technologies with lower fuel burn, emissions and noise			

performance without compromising safety or requiring changes in aircraft, engines or fuel-supply infrastructure.

ASTM International has approved for commercial use alternative jet fuels consisting of Jet A blended with up to 50 percent synthetic paraffinic kerosene from the Fischer-Tropsch process or Hydroprocessed Esters and Fatty Acids process. Developers are testing additional advanced alternative jet fuels in support of eventual ASTM International approval. Other pathways such as alcohol-to-jet fuel, pyrolysis, direct sugar to hydrocarbons and catalytic conversion of sugars are under evaluation for future approval by ASTM International.

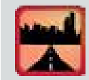
Operator investment will include purchasing alternative jet fuel blends as new fuels become available in commercial quantities. Air carriers and the aviation industry have begun signing long-term fuel purchasing agreements to help facilitate deployment of these alternative fuels.

Operators are mulling other technical advances that will provide both performance gains and environmental benefits. Operators may retrofit some new certified airframe and engine technologies on existing aircraft to speed technology insertion into the fleet, while other new technologies such as the high bypass ratio geared turbofan and open-rotor engines will await future generations of aircraft.

AIRPORT ENHANCEMENTS

Airports are active participants in NextGen implementation across the NAS. While many investments in NextGen technologies are the responsibility of the FAA or aircraft operators, airports also have opportunities to advance NextGen. Since the 1940s, ILS has been the worldwide standard for precision approach and landing. Today, PBN approaches can provide functionally identical approaches to a CAT I ILS. We are developing new PBN approaches to improve airport access, rather than installing more ILS. With GPS equipage on the rise, more aircraft operators are using PBN

Overview of Airport Enablers

Avionics Enablers	Operator or Airport		Capability Overview	Target Users	Target Area	Maturity
	Guidance	Schedule				
Airport Enhancements						
Geographic Information System	AC 150-5300-16,-17,-18	Ongoing	Provides detailed geospatial data on airports and obstructions			
ADS-B for Surface Vehicles	AC 150/5220-26	Complete	Provides ADS-B squitter equipage for surface vehicles operating in the movement area	Airport rescue firefighting equipment, snowplows and inspection trucks		

procedures to reliably access airports during inclement weather.

Airports have the key role of discussing with their users the need for new or additional PBN procedures. A hub airport may serve air carriers that are actively seeking to expand the use of RNAV or RNP procedures, while a general aviation airport may benefit from new LPV approach procedures. An airport can request that the FAA initiate the consideration and design of these procedures. Airport Improvement Program (AIP) grant funding may be available for surveying and obstruction removal needed to achieve lower minima for an RNAV or LPV procedure, if justified by traffic demand.

The FAA plans to reduce the VOR and ILS network but will retain DMEs and investigate expanding the DME network to serve as an alternate means of navigation in the event of a GPS outage.

The FAA is reviewing the compatibility between light-emitting diode (LED) obstruction lights and approach lights with aircraft using EFVS or Night Vision Imagery technology relying on signatures in the infrared spectrum. LED fixtures have not provided this infrared signature. The same issues may be present in LED high-intensity runway edge lights. For these reasons, LED approach lights and LED high-intensity runway edge lights cannot be funded by AIP. Surface surveillance and management is another key area for airport involvement in NextGen. In 2011, the FAA completed installation of Airport Surface Detection Equipment, Model X (ASDE-X) at 35 airports. Data from these systems is available through SWIM. The agency aims to install enhancements to airport surface detection equipment, known as the Airport Surface Surveillance Capability (ASSC), at eight other civil airports between 2014 and 2017. At facilities with either ADSE-X or ASSC, airports can install ADS-B Out squitters on airport-owned vehicles that regularly operate in the movement area. Squitters would broadcast vehicle positions to ATC, aircraft equipped with ADS-B In and the airport operations center. This improves situational awareness and safety, particularly during construction projects and winter weather events. ADS-B Out vehicle squitters can be allowed under AIP.

Some airports have elected to install surveillance systems to complement those the FAA has installed and provide coverage of non-movement areas. There is an overall increase in situational awareness when airports monitor surface operations more precisely. These systems can also support departure queue management concepts. Departure queue management cannot eliminate delays, but it does shift delays from the runway to the ramp or gate area where aircraft can wait with engines off. The FAA continues to research additional technology options for non-movement area surface surveillance, with applicability to surface traffic management as concepts such as those included in the Terminal Flight Data Manager program.

The FAA is continuing to evaluate existing arrival and departure procedures at airports with closely spaced parallel runways. Our goal is to safely reduce separation between aircraft as they approach closely spaced parallel runways. This reduction will improve arrival capacity on those runways, especially during poor-visibility conditions. Analyses of independent and dependent runway standards are ongoing. Revisions to closely spaced parallel operations standards will be incremental throughout the decade and beyond, to incorporate existing and new technologies. Changes like this may give airports greater design flexibility by allowing better use of existing runway layouts.

For many years, the lateral separation standard for independent arrivals required that runways be spaced 4,300 feet or more apart. After determining lateral runway separation can be reduced safely, the FAA in August 2013 made effective a revised separation standard of 3,600 feet for independent arrivals. There are 16 parallel runway pairs at eight airports — Boston, Cleveland, Newark, Memphis, Philadelphia, Seattle, San Francisco and St. Louis — spaced fewer than 2,500 feet apart that are authorized for 1.5 nm dependent staggered approaches. We will continue through 2015 to authorize additional runway pairs at additional airports for this procedure. Also in 2015, the FAA plans to reduce dependent staggered separation behind Heavy aircraft and 757 aircraft operating on closely spaced parallel runways. Ongoing analysis of dependent approaches aims to reduce the 1.5 nm staggered separation required for approaches to parallel runways spaced 2,500 feet or more apart, up to the independent runway separation standard.

In 2015, the FAA expects to reduce wake turbulence separation standards during favorable wind conditions for departures on parallel runways during visual conditions. The FAA is also continuing to work with ICAO to update the wake separation standards based on analysis of wake generation, wake decay and the effects experienced when an aircraft encounters wake turbulence. The new separations will increase capacity while maintaining or enhancing safety by considering aircraft type-specific leader to follower aircraft pairings.

The continued transition of airport layout plans into the Airport Geographic Information System (GIS) application will improve the airport planning process. Airport GIS can also provide the accurate geospatial data needed for surface moving maps and new instrument flight procedures.

The FAA is making significant progress reducing aircraft separation due to wake turbulence. We implemented new aircraft wake turbulence separation categories, referred to as RECAT Phase I, at Memphis and Louisville. Other locations are planned in the near term. RECAT has successfully reduced ground delays and increased capacity while maintaining or enhancing safety. In the future, RECAT Phase II will expand to static aircraft pairing and Phase III will allow for dynamic aircraft pairing by taking advantage of favorable crosswinds. Additionally, the FAA began the use of Wake Turbulence Mitigation for Departures. This system allows reduced wake turbulence aircraft separation during favorable wind conditions for departures on parallel runways during visual conditions.

The FAA continues to work with ICAO to update wake separation standards based on improved scientific methodologies to analyze wake generation, wake decay, and the effects experienced when an aircraft encounters wake turbulence. Research continues that will further reduce aircraft separations with the goal of increasing capacity while maintaining or enhancing safety.

INTERNATIONAL HARMONIZATION

As the FAA and its international counterparts advance toward a harmonized global air navigation system — a system built on modern performance-based procedures and technologies — collaboration is essential to ensure functional integration. The ICAO Global Air Navigation Plan (GANP), which provides an approved framework to implement capabilities that maximize return on investment, and this pamphlet are aligned for global harmonization. Aviation System Block Upgrades associated with the GANP lay out the progression planned for key air traffic management capabilities in five-year increments. They are organized by modules in a matrix of times (blocks) and capabilities (upgrades). Block 0 capabilities addressing airport operations and flexible flight paths have been implemented. Advanced Block 1 capabilities are under way.