Federal Aviation Administration

NextGEN

MINIMUM CAPABILITY LIST TO ACHIEVE OPTIMAL NEXTGEN BENEFITS

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This NextGen Advisory Committee, Minimum Capability List to Achieve Optimal Benefits document is prepared and signed by:

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Foreword

Investments from the aviation community in suitable aircraft equipment are as important to realize the full potential of NextGen as the FAA's investments in ground- and space-based systems. In early 2017, the NextGen Advisory Committee (NAC), an organization of aviation industry leaders, recommended that the FAA focus on the Northeast Corridor (NEC) as a priority area for NextGen modernization. Under the NAC, an NEC Working Group began examining how to successfully implement initiatives to deliver benefits to the NEC. The group identified mixed aircraft equipage levels, and the resulting different levels of aircraft capability, as the major challenge to maximizing benefits of the initiatives in the NEC.

A working group was formed to produce an aircraft minimum capabilities list (MCL) for clear and comprehensive guidance to support equipage across all fleets operating in the National Airspace System (NAS). As such, the MCL's purpose is to:

- Define the minimum aircraft capabilities and associated equipment needed to maximize benefits from FAA investment and operational improvements
- Guide "forward-fit" aircraft equipage and inform operator investment decisions
- Maximize the return on investment for both the FAA and airspace users

This document is the result of extensive collaboration between the FAA and industry on an MCL for communications, navigation, surveillance, and resiliency. The NAC also identified a set of supplemental capabilities that may be beneficial to some operators, depending on individual business cases and operations.

The MCL is about maximizing the return on investment for both the FAA and airspace users. This effort is an excellent example of how the FAA and the aviation community collaborate to achieve NextGen success and optimize benefits. We look forward to the adoption of the MCL to inform future aircraft purchases and upgrades.

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Introduction

This document presents the recommended minimum aircraft capabilities, and associated equipage, needed to derive the maximum benefit from NextGen investments and operational improvements. It is intended as guidance for forward-fit aircraft equipage and is applicable NAS-wide.

Background

The NextGen Advisory Committee's (NAC) objective is to provide independent recommendations to the Federal Aviation Administration (FAA) and to respond to specific taskings received directly from the FAA. These recommendations help the FAA and aviation stakeholders develop concepts, requirements, operational capabilities, the associated use of technology, and related considerations to operations affecting the future of the National Airspace System (NAS) and integration of new technologies.

The NAC coordinates advice from the aviation community and provides consensus-driven recommendations for the FAA's consideration relating to Air Traffic Management System modernization. Through the FAA Administrator, the NAC reports to the Secretary of the Department of Transportation.

The NAC has chosen the Northeast Corridor (NEC), which covers the airspace spanning from Washington, D.C. to Boston, as a priority area. In November 2018, the FAA requested that the NAC identify risks and mitigation strategies for the successful operational implementation of joint commitments documented in the NextGen Priorities Joint Implementation Plan.

The NAC identified mixed aircraft equipage as a primary risk to achieving full NextGen benefits in the NEC and recognized a need for clear, comprehensive guidance material supporting equipage across all fleets.

Development of the Minimum Capabilities List

The NAC partnered with the FAA to develop the Minimum Capabilities List (MCL) to mitigate the mixed equipage risk. An ad hoc NAC working group collaborated across aviation stakeholders to develop consensus on an MCL that:

- Defines the minimum aircraft capabilities and associated equipment needed to maximize benefits from FAA investment and operational improvements
- Includes guidance for "forward-fit" aircraft equipage and inform operator investment decisions
- Applies across the entire NAS, rather than solely to the NEC

The MCL presents capabilities with the understanding that all capabilities should be considered as integral to each other so that no NextGen enabling category in the MCL takes preference over another. The NAC conveyed to the FAA that operators' existing equipage should be maintained, and that the list of MCL aircraft capabilities are not intended to replace current aircraft capabilities such as ILS, VOR, etc. The MCL capabilities should be viewed as beneficial above and beyond the typical avionics suite ordered today.

NAC Recommendation of the MCL

At the NAC meeting in July 2019, the NAC approved the MCL as a formal recommendation to the FAA.

In response to the NAC's recommendation, the FAA is publishing the MCL in this document and adding related information, such as policy references, and explanations of the operational use cases and NextGen benefits associated with each area of aircraft capability.

This document is intended to augment and build upon prior publications including the *Performance Based Navigation (PBN) NAS Navigation Strategy*, released in 2016. The MCL is consistent with this document and intended to provide additional clarity and detail on the minimum capability for optimal navigation.

This document represents version 1.0 of the MCL, a document that is intended to evolve with technology, operator fleets, and the NAS.

The intent of the MCL is to move forward on the continuum of action to operationalize and maximize NextGen benefits. The release of this document is intended to support the application and implementation of the MCL NAS-wide.

How to Use this Resource

This document is divided into four sections. These sections each cover individual capability areas of the MCL:

- Navigation
- Communication
- Surveillance
- Resiliency

Within each section, individual aircraft enabling capabilities for that MCL capability area are listed and described. A sample layout explaining the information presented for each aircraft enabling capability is shown below.

AIRCRAFT ENABLING CAPABILITY:

Overview of Aircraft Enabling Capability		
Avionics Enablers	**Operational Specification[1] (OpSpec)**	**Associated FAA Policy and Guidance**
Avionics capability that will enable the use cases and benefits described below.	Listing of associated operational specifications (OpSpecs) associated with the avionics.	Listing of current FAA Policies and guidance users can consult to learn more about the stated avionics enabler.

Description: Provides a description of the function of the aircraft enabling capability.

Use Case: Provides descriptive examples of the operational situations in which this enabling capability is used, including the associated NextGen operational improvements with which this aircraft capability interacts.

Operational Benefit: Provides a description of the expected benefit mechanisms from the operational improvement enabled by the aircraft capability.

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[1] Note: OpSpec approvals are not necessarily required for all operators or all operations in the NAS. In general, commercial operations require approvals for PBN operations and non-commercial operations only require approval for Required Navigation Performance (RNP) Authorization Required (AR) operations.

Navigation Capabilities

Performance Based Navigation (PBN) is an advanced, satellite-enabled form of air navigation. The FAA has established a network of thousands of precisely defined PBN routes and procedures to improve air traffic flow efficiency to and from airports throughout all phases of flight.

PBN describes an aircraft's capability to navigate in terms of performance standards. These standards, such as Area Navigation (RNAV) or required navigation performance (RNP) navigation specifications (NavSpecs), enable lateral and/or vertical navigation on any desired flight path within the coverage of ground- or space-based navigation aids, or within self-contained navigational capabilities of the aircraft. In general, RNAV and RNP navigation specifications are identical, except RNP adds an onboard performance monitoring and alerting capability. The NavSpec is usually described by a lateral accuracy value (e.g. 1NM for RNP 1) and designates the expected 95 percent lateral navigation (LNAV) performance associated with an instrument flight operation or a particular segment of that instrument flight.

While many procedures in the NAS today are RNAV-based, the MCL recommends RNP capabilities for their higher level of capability and the resulting benefits from the operational improvements and use cases they enable.

The sections below define the minimum recommended navigation capabilities, including NavSpecs, by domain: en route, terminal arrival and departure, and approach.

Required Navigation Performance (RNP) 2

Overview of Aircraft Enabling Capability		
Avionics Enablers	OpSpec	Associated FAA Policy and Guidance
RNP 2	B035	AC 90-105A
	B036	AC 20-138D Change 2
		TSO-C146

Description: RNP 2 is the application of RNP operations to the en route phase of flight. RNP 2 may be used for both domestic and oceanic/remote continental operations a lateral accuracy value of 2NM.

Use Case: The conventional Very High Frequency (VHF) Omnidirectional Range (VOR)-based Jet and Victor airway structure has been advanced with their PBN equivalents, Q routes and T routes, respectively. RNP 2 allows aircraft to fly Q and T routes, which are more direct then the conventional routes since they rely on Global Positioning System (GPS) rather than ground based distance measuring equipment (DME). However, DME's can be used as back up during a GNSS outage or disruption.

Operational Benefits: Improved flight efficiency through more direct, and more flexible, route designs compared to those over VOR-based navigational aids (NAVAIDS). Increased en route capacity results from these additional routes without the need for additional ground infrastructure.

Terminal, Arrival/Departure

Required Navigation Performance (RNP) 1 with Radius-to-Fix (RF)

Overview of Aircraft Enabling Capability		
Avionics Enablers	**OpSpec**	**Associated FAA Policy and Guidance**
RNP 1 with RF	C063	AC 90-105A AC 20-138D Change 2

Description: RNP 1 operations may be applied to the terminal arrival and departures phases of flight and have a lateral accuracy value of 1NM.

Radius-to-fix capability enables an aircraft to execute a turn in the terminal environment that is defined by a radius, arc length, and fix.

Use Case: RNP 1 is an enabler for aircraft to fly RNAV/RNP arrival and departure procedures, including Optimum Profile Descents (OPDs), which allow the pilot to minimize engine thrust along the programmed descent profile with engines idled, keeping fuel consumption and emissions at their lowest.

The addition of RF capability enables computed radius-to-fix turning flight paths, where practicable, that provide a more predictable and repeatable path and that reduces the flown track miles on downwind or to join final.

RNP 1 with RF is also a key enabler of envisioned RNP procedures to laterally de-conflict traffic flows to separate airports within an airspace volume (currently referred to as Multiple Airport Route Separation in research).

Operational Benefits:

Use of RNP 1, can yield the benefits below:

- Improved flight efficiency due to optimized arrival and departure vertical profiles and reduced lateral track distances
- Reduced Air Traffic Control (ATC) task complexity and pilot/controller communications due to reduced radar vectoring
- Increased predictability through repeatable flight paths

- Improved access through additional PBN procedures without the need for additional ground infrastructure
- Reduced emissions and fuel burn through increased flight efficiency

Use of RF legs helps de-conflict arrivals and departures in congested airspace environments as well as reducing track miles flown for improved flight efficiency.

Concepts to use RNP to laterally de-conflict traffic flows to separate airports within an airspace volume are anticipated to yield improved flight efficiency, increased access to preferred runways, and ability to choose higher capacity runway.

Approach

Required Navigation Performance (RNP) Approach (APCH), Coupled Vertical Navigation (VNAV) and either Advanced RNP (A-RNP) (including RF and Scalability) or RNP Authorization Required (AR) 0.3 with RF

Overview of Aircraft Enabling Capability		
Avionics Enablers	**OpSpec**	**Associated FAA Policy and Guidance**
RNP Approach (RNP APCH)	C052	AC 90-105A
		AC 20-138D
Coupled Vertical Navigation (VNAV)	C052	AC 90-105A
	C073	AC 20-138D
Advanced RNP (A-RNP) (including RF and Scalability)	C063	AC 90-105A
RNP AR 0.30 with RF	C384	AC 90-101A
		AC 20-138D

Description:

The basic PBN approach capability in the MCL is RNP APCH, which is used during every segment of the approach phase, including the initial, intermediate, final and missed segments. The MCL recommends additionally that aircraft have coupled VNAV capability and either A-RNP (which includes RF and scalability) or RNP AR (to RNP 0.30 minima) with RF capability. The combination of these capabilities allows operators the widest range of instrument approach configurations and landing minima, which in turn provides the most operational benefit.

RNP APCH operations have RNP values of 1 until the final approach segment (FAS) where the boundaries narrow to RNP 0.3; the RNP value expands back to RNP 1 in the missed approach segment.

Allowing scalability in earlier segments of the approach phase is an advanced RNP (A-RNP) capability. Scalability is uniquely an A-RNP function that allows gradual expansion and decompression of boundaries, between 0.30 and 1, during the initial, intermediate and missed segments of approaches. A-RNP uses RNP APCH, or xLS[2], for the final approach phase.

RF capabilities can also be used during the approach phase. Although RF is not uniquely an A-RNP function, it can be used during initial and intermediate approach segments as well as during the final phase of a missed approach.

RNP AR operations add yet more capability as RF turn capability and lateral values of RNP 0.30 are mandatory features of these operations. Further, RNP AR operations can provide their own final approach segment with RF turns, enabling operations into airports unsupported by other infrastructure.

Additionally, the MCL recommends coupled VNAV (barometric altimeter-aided altimetry) capability. In its most basic form, vertical navigation is the pilot's responsibility. However, by adding coupled VNAV to RNP APCH, it gives the pilot computed vertical angles to fly through the auto flight system on the aircraft.

Use Case:

RNP APCH, coupled VNAV and either A-RNP (with scalability and RF) or RNP AR 0.30 with RF combine as key capabilities for PBN in the approach phase. These capabilities are also enablers for Established on RNP (EoR) and other envisioned future terminal operations in congested airspace, such as utilizing RNP routes and procedures to de-conflict traffic flows to separate airports within an airspace volume.

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[2] xLS, in this case, is a generic term for any landing system, e.g., Instrument Landing System, Global Positioning System Landing System, or Microwave Landing System.

EoR is an air traffic control (ATC) function to reduce the minimum of 1000 feet vertical or 3 mile radar separation between aircraft, once one aircraft is established on an RNP approach.

Similar to the MCL PBN capabilities in the terminal arrival/departure domain, approach capabilities are expected to enable concepts to de-conflict traffic flows to separate airports within an airspace volume.

Operational Benefits: Using RNP approach capabilities, improved route access though additional PBN procedures without an implicit requirement for additional ground infrastructure. RNP approach capabilities also allow aircraft to fly precise paths, increasing navigation accuracy and flight safety.

Improvements in flight efficiency, using EoR, result from the ability to have consistent curved path approaches operating simultaneously to the same runway.

Concepts to use RNP to laterally de-conflict traffic flows to separate airports within an airspace volume are anticipated to yield improved flight efficiency, increased access to preferred runways, and ability to choose higher capacity runway.

Communication Capabilities

Data Communications (Data Comm) is a key NextGen technology that enables digital communication between controllers and pilots in equipped aircraft, supplementing voice communications. Data Comm provides a digital link between ground automation and flight deck avionics for air traffic clearances, instructions, traffic flow management, flight crew requests, and reports.

Additionally, air carrier flight operations centers receive data simultaneously, providing shared situational awareness. Data Comm technology is critical to the success of NextGen as it enables efficiencies not possible with the current voice system.

Future Air Navigation System (FANS) 1/A Over Multi-frequency VHF Data Link (VDL) Mode 2 with Push to Load

Overview of Aircraft Enabling Capability		
Avionics Enablers	**OpSpec**	**Associated FAA Policy and Guidance**
FANS 1/A Over Multi-frequency VDL Mode 2 with Push to Load	A056	AC 120-70C AC 90-117 TSO-C160a TSO-C159C

Description: FANS 1/A is an avionics system that enables controller-pilot data link communications (CPDLC). Messages are sent over a line-of-sight VHF network (using VDL mode 2).

Use Case: FANS 1/A over VDL mode 2 works with Data Comm services developed by the FAA. With Data Comm, air traffic controllers and pilots can transmit clearances and other essential information digitally as typed messages rather than through complicated radio voice exchanges.

Data Comm allows air traffic controllers to send pilots instructions to read, accept, and load into their flight computers with minimal button pushes.

Data Comm is particularly useful when re-routes are issued, for example, during times of high congestion or to avoid a major weather event. A re-route causes another round of instructions from air traffic controllers, and some situations may require multiple re-routes. Data Comm increases pilot and controller efficiency and reduces potential for errors in these situations.

For departure clearances, the FAA supports Data Comm for aircraft equipped with FANS 1/A and VDL Mode 0 and Mode 2 avionics. For en route services, VHF Data Link Mode 2 avionics will be the media used. As a result, for an aircraft to be able to work with Data Comm in both domains, Multi-frequency VDL Mode 2 with push to load is the recommended minimum in the MCL.

Tower Data Comm Services are currently available at 62 airports across the CONUS. En route Data Comm services are currently in field testing at the first two Air Route Traffic Control Centers (ARTCC) in the deployment waterfall. Once deployed, this system will support a range of controller-pilot communication functions, including allowing for efficient re-routes while reducing the time it takes for route entries.

Operational Benefits: The following benefits can be obtained using Data Comm:

- Improved recovery from service disruptions, mitigate propagated delay, and improve schedule reliability; improved controller efficiency leads to increased sector capacity.
- Improved flexibility by enabling NextGen capabilities such as the delivery of airborne reroute clearances to aircraft via digital data communications.
- Increased throughput/efficiency and reduce delays by reducing communication time for delivery of altitude clearances with altimeter setting information and airborne reroutes; it also improves controller and flight crew efficiency.
- Reduced taxi delays and more efficient reroutes will reduce fuel burn and emissions.
- Improved communication accuracy and safety with digital communication (i.e., reduced read/hear back errors, reduced loss of communications events).

Surveillance Capabilities

Surveillance modernization is accomplished by moving the NAS from radar-based surveillance to surveillance based on satellite positioning via a key technology: Automatic Dependent Surveillance–Broadcast (ADS-B). ADS-B functions with GPS satellite technology to more accurately observe and track air traffic. An aircraft equipped with an ADS-B Out transmitter sends its position, altitude, direction, ground speed, call sign, and International Civil Aviation Organization (ICAO) identifier once per second. This information is received by nearby aircraft and a network of ground stations that relay the information to air traffic control displays.

ADS-B Out provides nearby aircraft with direct information that can be used by pilots with ADS-B In systems. ADS-B Out also provides air traffic controllers with real-time position information that is, in most cases, more accurate than the information available with current radar-based systems.

Automatic Dependent Surveillance – Broadcast (ADS-B) Out

Overview of Aircraft Enabling Capability		
Avionics Enablers	**OpSpec**	**Associated Policy and Guidance**
ADS-B Out	-	AC 20-165B
		AC 90-114B
		TSO-C154c
		TSO-C166b
		DO-260B
		DO-282B

Description: ADS-B Out, a base-level enabler, is mandated by rule as of January 1, 2020, for aircraft operating in most airspace classes within the NAS. To comply with the mandate, aircraft operating in Class A airspace (18,000 – 60,000 feet mean sea level (MSL)) must broadcast position data with a Mode S 1090-megahertz extended squitter (1090 ES) transponder. Aircraft operating in designated airspace exclusively below 18,000 feet MSL can broadcast the required information with either a 1090 ES transponder or Universal Access Transceiver (UAT) on 978 MHz.

Use Case: ADS-B Out will be used for surveillance in airspaces listed in the Federal Regulation 14 CFR § 91.225.

Operational Benefits: FAA will use the new operational enhancements to improve safety, capacity, and efficiency in the following manner:

- Improved surveillance: The high accuracy and greater update rate ADS-B surveillance provides will supplement and improve existing surveillance information. ADS-B also provides additional operational resiliency to any traditional surveillance radar issue.
- Improved Air Traffic Control Automation and Safety Functions: The information provided by ADS-B will improve surveillance system performance and support implementation of advanced ATC automation functions and Traffic Flow Management (TFM) decision support tools.
- Improved Separation Services: ADS-B will support surveillance-based separation standards in non-radar coverage areas. High accuracy ADS-B surveillance information will facilitate the use of a common separation standard for all service domains and may lead to reduced separation standards in select situations.
- Improved Planning and Traffic Flow Management Services: ADS-B surveillance (message set elements) provides accurate, real-time information for traffic flow management, fleet management, and other planning functions.

Operators will gain benefits in the following ways:

- Reduced separation below flight level 230 ADS-B Out enables expanding use of 3NM separation
- Gulf of Mexico coverage: Reduced helicopter separation in this airspace, allowing increased Part 135 operations as well as routing efficiencies through this airspace.
- Increased awareness of flights in distress: Improved surveillance accuracy leads to better flight profile tracking.

Further Benefits - ADS-B In[3]: ADS-B Out is the foundational surveillance capability on which ADS-B In will build to deliver expanded benefits. ADS-B In enables an aircraft to receive ADS-B data and display the data for use onboard the aircraft. It provides an operational benefit to operators who choose to upgrade their aircraft beyond the basic mandate of ADS-B Out rule. ADS-B In is a significant advance that may provide efficiencies in airborne operations and on the surface. Some applications of ADS-B In are available today, such as Cockpit Display of Traffic Information Assisted Visual Separation (CAVS) and In Trail Procedures (ITP). CAVS assists pilots in maintaining separation from ADS-B Out equipped aircraft during visual separation. ITP is designed primarily for use in non-radar oceanic airspace to enable appropriately equipped ADS-

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[3] Additional information about ADS-B In and its approved applications can be found in the following documents: AC 20-172B, TSO-C195b, and OpSpecs A354 and A355.

B In aircraft to perform flight level changes previously unavailable with procedural separation minima applied. Future applications under study and development include advanced flight interval management (A-IM), in which ADS-B In capability enables management of the spacing between aircraft, using equipped aircraft's awareness of nearby aircrafts' positions. More information about ADS-B In can be found in Appendix A - Supplemental Capabilities.

Resiliency Capabilities

Resiliency is the ability of the NAS to maintain safety and an acceptable level of service when a system fails or facility is degraded, and to prevent or mitigate impact to air traffic operations. Resiliency for aircraft navigation is two-fold:

On the ground, the FAA will retain and expand the Distance Measuring Equipment (DME) infrastructure as necessary to support continued PBN operations in the event of Global Navigation Satellite System (GNSS) service disruptions. DME/DME navigation with this enhanced ground infrastructure is intended as the primary method of resiliency for continued PBN operations in the event of GNSS disruptions.

On the aircraft, Inertial Reference Units (IRU) function as a key enabler for sustained PBN operations during short periods when GNSS is not available to the aircraft and an aircraft is passing through any gaps in DME coverage.

Inertial Reference Unit (IRU)

Overview of Aircraft Enabling Capability		
Avionics Enablers	OpSpec	Associated Policy and Guidance
IRU	-	AC 20-138D DO-229D, Change 1 DO-316, Appendix R

Description: Inertial Reference System (IRS) is a solid-state unit of three-ring laser gyros detecting accelerations in three dimensions. The IRU is a computer that integrates IRS outputs and provides inertial reference outputs for use by other navigation and flight control systems, including the Flight Management System (FMS). Outputs include the aircraft's pitch, roll, yaw, true and magnetic heading, true air and ground speed, latitude, longitude, altitude, wind speed and direction, drift angle, and vertical speed and rate.

Use Case: IRU will be used as a backup system during short periods of GNSS outage or disruptions in situations where an aircraft is in a gaps in DME coverage.

Operational Benefits: Resilient NAS operations during short periods of loss of GNSS (jamming or hardware failure) occurs and in locations where there are gaps in DME coverage. This provides an additional layer of resiliency to allow pilots to continue to continue PBN operations, maximizing the benefits of PBN during these off-nominal conditions.

Summary

The FAA recognizes the NAC's extensive efforts to develop the MCL for the aviation community. The NAC's Northeast Corridor NextGen Integrated Working Group identified mixed equipage as a risk, and coordinated with the aviation community to provide the FAA with a community-wide and NAS-wide solution.

Both the FAA and the NAC recognize the MCL as an example of the NAC's consensus-driven approach on behalf of the aviation community.

The FAA looks forward to continuing to work with the NAC and all aviation community operators to identify and achieve maximum benefits from NextGen investments across the NAS.

Appendix A – Supplemental Capabilities

In addition to the set of minimum aircraft capabilities identified in the body of this document, the NAC identified in its recommendations an additional set of supplemental capabilities. These supplemental capabilities are categorized as requiring analysis by individual users to determine if each capability is beneficial for their individual specific operations, fleet, and business case.

Information on supplemental capabilities, as provided by the NAC in its MCL recommendations, is provided below, with some clarifications provided by the FAA. The addition of the FAA status column speaks to the current/completed work and/or the support FAA has provided towards the supplemental capabilities.

NextGen Enabling Category	Aircraft Enabling Capability	Benefit	Example Use Cases	FAA Status
Surveillance	ADS-B In	Flight Interval Management applications of ADS-B In enable more precise final approach spacing, reducing the need for buffers, allowing for up to a 20% increase in arrival throughput.	Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS), In Trail Procedures (ITP), Flight deck Interval Management (FIM), Interval Management same runway arrival and approach, Interval Management.308 (IM.308), Paired Approach	CAVS: Currently available for user implementation based upon individual operational needs and business case. ITP: Currently available for user implementation based upon individual operational needs and business case. FIM: Minimum operational performance specification (MOPS) is in development and on track to complete in FY2020. The system will then go through investment analysis to develop specific FIM applications.

NextGen Enabling Category	Aircraft Enabling Capability	Benefit	Example Use Cases	FAA Status
Navigation	RNP Authorization Required (AR) Approach lower than 0.3	Safety enhancements at runways in mountainous areas where no other procedure is possible, Improved access in reduced visibility due to lower landing minimums, de-confliction of traffic flows by using precise paths, environmental considerations	RNP AR Approach allows for turns close into the runway. These approaches are effective when needing low minimums at terrain or airspace constricted airports, closely spaced runway operations, similar benefits as A-RNP with potentially lower minimums	Procedures currently available at some locations in the NAS. Further application at additional sites to be determined based upon specific operational needs.
Navigation	Localizer Performance with Vertical Guidance (LPV)	LPV adds resiliency for Category (CAT) I Instrument Landing System (ILS) operations, access where ILS is non-existent	LPV provides possible CAT I-like operations to runway ends at least 3,200 ft in length and otherwise qualified per AC 150/5300-13A.	Currently available for user implementation based on individual operational needs and business case.
Navigation	Ground Based Augmentation System (GBAS) Landing System (GLS) (CAT I/II/III)	Low Visibility approaches using auto land or heads up display (HUD), deployable worldwide. System not prone to common ILS errors such as beam bending, false localizer and glideslope. System compatible with ILS operations but does not require ATC to monitor critical areas on the ground. Possibility to cover multiple airports inside GBAS service volume	Airports with closely spaced parallel runways, airports unable to site ILS at runway, airports with high traffic and low weather, low visibility approaches	The FAA will not pursue Federal acquisition of GBAS ground systems at this time. However, the FAA will partner with industry to continue investigation of GBAS capabilities, taking into account the capabilities provided by ILS and PBN approaches. The future of ILS in the NAS will be part of the decision-making process for future Federal acquisition of GBAS. Users can apply through the FAA Flight Standards Service for operational credit for lower visibility minimums.

NextGen Enabling Category	Aircraft Enabling Capability	Benefit	Example Use Cases	FAA Status
Navigation	HUD	Allows simultaneous viewing of primary flight display information, navigation information and the extended scene, Ability to perform approved operations to 100 feet above the runway, Reduced required runway visual range (RVR) visibility for the approach and increased access compared with non-equipped aircraft. More precise hand flying, better acquisition of runway environment	Low visibility approaches without auto land. Reduced hard landing, tail strike, and over/under R rotation. Reduced long landing.	Currently available for user implementation based upon individual operational needs and business case. Users can apply through the FAA Flight Standards Service for operational credit for lower visibility minimums.
Navigation	Enhanced Flight Vision System (EFVS)/Combined Vision System (CVS) (for credit)	Approved operations to lower ceilings and visibility minimums without the need for ground based NAVAIDs, access during low-visibility conditions, ability to perform approaches to straight-in landing operations below decision height, or minimum descent altitude	Low visibility approaches without ILS/GLS to any airport. Ability to see runway environment/ obstacles through weather/night conditions.	A rule, published in 2016, allows EFVS operations at visibilities no lower than 1000 runway visual range (RVR). The FAA will consider allowing EFVS operations in visibilities lower than 1000 RVR when sufficient system reliability and proper EFVS system redundancies are realized.

NextGen Enabling Category	Aircraft Enabling Capability	Benefit	Example Use Cases	FAA Status
Navigation	Tightly Couple IRU	Ability to meet ADS-B out mandate without Wide Area Augmentation System (WAAS). Resiliency for RNP operations with ability for low Actual Navigation Performance (ANP) after loss of GPS. Mitigates need for Predictive Receiver Autonomous Integrity Monitoring (RAIM) / Service Availability Prediction Tool (SAPT).	Resilient NAS operations when loss of GPS (GPS jamming or hardware failure) and lack of DME coverage. Ability to complete GPS-based approach during any loss of GPS.	Currently available for user implementation based upon individual operational needs and business case.
Navigation	Time of Arrival Control (TOAC)	The use of time of arrival controls is intended to provide an increased certainty of an aircraft arriving at a fix at a required time. TOAC may alter, where allowable, the lateral and vertical paths in space, and associated containment/vertical path performance limits to reflect changes in aircraft path and speed. Key component in Trajectory Basd Operations (TBO).	To reduce delay vectors or holding, TOAC could be used by the controller to tell a pilot when to cross a fix. The pilot then programs the time at the fix and the aircraft would adjust speeds to comply.	Available in different production flight management systems today. However, there is no defined standard across systems.

Ongoing discussions and work on levels of precision and accuracy required for specific applications. |
| Surveillance | Airborne Collision Avoidance System (ACAS)-X | Reduced nuisance warning, reduced separation operations, broader aircraft participation | Reduced go-arounds in simultaneous parallel operations, continuity in high density airspace operations | Minimum Operational Performance Standards (MOPS) are complete. FAA is working towards associated Advisory Circular (AC) and Technical Standards Order (TSO). |

NextGen Enabling Category	Aircraft Enabling Capability	Benefit	Example Use Cases	FAA Status
Navigation, Low Vis Ops, Surveillance	Position Source - accuracy, integrity, continuity, availability	Improved resiliency for RNP or HUD operations. Multi-frequency, multi-constellation global "SBAS like" coverage.	All PBN operations	FAA has established guidelines for use of non-U.S. constellations with GPS-Based GNSS in Advisory Circular AC20-138D. However, to date no non-GPS based constellation equipment has been approved for use in the NAS. For commercial multi-constellation GNSS user equipment to be acceptable for aviation use, it must meet technical standards to ensure safety. Currently, the U.S and other countries are developing ICAO Standards and Recommended Practices (SARPs) for multi-constellation GNSS, but those standards are not complete.
Information Sharing	Airborne Access to System Wide Information Management (SWIM)	Access to the FAA SWIM system to support collaborative decision-making and ensure a common understanding of status of airspace, systems, and weather.	Can receive information beneficial to operational control and situational awareness of single flight. Example of information that can be provided: Create, update, and cancel Ground Delay Program (GDP)/ Unified Delay Program (UDP), Update Airport Runway Configuration and rates; Create, update, and cancel Airspace Flow Program (AFP)	Currently available for user implementation based upon individual operational need and business case.

Appendix B – Advisory Circulars (AC's), Technical Standard Orders (TSO's), and Operational Specifications (OpSpecs)

RNP-2

- OpSpec B035 Class I Navigation in the U.S. Class A Airspace Using Area or Long-Range Navigation Systems
- OpSpec B036 Class II Navigation Using Multiple Long-Range Navigation Systems
- AC 90-105A Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace
- AC 20-138D Change 2 Airworthiness Approval of Positioning and Navigation Systems
- TSO-C146 Airborne Supplemental Navigation Using GPS

RNP-1 with RF

- OpSpec C063 U.S. IFR RNAV Departure Procedures, RNAV Routes, and RNAV Standard Terminal Arrivals
- AC 90-105A Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace
- AC 20-138D Change 2 Airworthiness Approval of Positioning and Navigation Systems

RNP APCH

- OpSpec C052 Straight in Non-Precision, APV, and Category I Precision Approach and Landing Minima
- AC 90-105A Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace
- AC 20-138D Change 2 Airworthiness Approval of Positioning and Navigation Systems

Coupled VNAV

- OpSpec C052 Straight in Non-Precision, APV, and Category I Precision Approach and Landing Minima
- OpSpec C073 IFR Approach Procedures Using Vertical Navigation
- AC 90-105A Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace
- AC 20-138D Airworthiness Approval of Positioning and Navigation Systems

A-RNP

- OpSpec C063 U.S. IFR RNAV Departure Procedures, RNAV Routes, and RNAV Standard Terminal Arrivals
- AC 90-105A Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace

RNP AR 0.3

- OpSpec C384 Required Navigation Performance Procedures with Special Airplanes and Aircrew Authorization Required
- AC 90-101A Approval Guidance for RNP Procedures with AR
- AC 20-138D Change 2 Airworthiness Approval of Positioning and Navigation Systems

FANS 1/A Over Multi-frequency VDL Mode 2 with Push to Load

- OpSpec A056 Data Link Communication
- AC 120-70C Operational Authorization Process for Use of Data Link Communication System
- AC 90-117 Data Link Communication
- TSO-C160a Very High Frequency (VHF) Digital Link (VDL) Mode 2 Communication Equipment
- TSO-C159C Next Generation Satellite Systems Equipment

ADS-B Out

- DO-260B: Minimum Operational Performance Standards for 1090 MHz Extended Squatter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)
- DO-282B: Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast
- AC 20-165B Airworthiness Approval of Automatic Dependent Surveillance-Broadcast (ADS-B) Out Systems
- AC 90-114B Automatic Dependent Surveillance-Broadcast (ADS-B) Operations
- TSO-C154c Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency 978 Megahertz (MHz)
- TSO-C166b Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Service-Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)

IRU

- DO-229D Change 1: Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment
- DO-316: Minimum Operational Performance Standards (MOPS) for Global Positioning System/Aircraft Based Augmentation System Airborne Equipment
- AC 20-138D Change 2 Airworthiness Approval of Positioning and Navigation Systems